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Design Culture for Urban Artificial intelligence. Technology, Ethics and Sustainability in the age of AI Urbanism

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ABSTRACT (English)

The aim of this dissertation is to explore the conceptual sources and urban implications of the urban application of Artificial Intelligence (AI). The term AI urbanism refers to a new urban paradigm that is emerging as a result of the increasingly widespread application of AI systems in the urban fabric: robots, AVs and software agents are becoming part of the urban experience of millions of citizens. In order to investigate this phenomenon, this thesis uses an interdisciplinary approach, based mainly on the relationship between philosophy of technology and urban studies, which can take into account the socio-technical and environmental complexity of AI urbanism. This investigation is developed in five chapters, respectively dedicated to mapping the conceptual sources of AI urbanism, exploring the relationship between cybernetics and design in technologically driven urbanism, the possibility of an ethical use of urban AI, the potential sustainability of this new urban paradigm, and the urban digital twin (UDT) as a crucial tool in this new socio-technical context.

The first chapter is devoted to analysing three conceptual sources of AI urbanism (Modern Urbanism, Cybernetics and Smart urbanism) and exploring their spatial implications. The aim is to demonstrate how an understanding of the former can influence the way in which the latter is approached.

The second chapter deals with cybernetics as a conceptual source of AI urbanism and explores the internal possibilities of a quantitative approach to design through a historical analysis of urban modelling (US and UK based) and architectural technology (Italy). The aim is to reveal how the science of the city is a discipline rich in alternative possibilities.

The third chapter regards the relationship between AI ethics and urban ethics. These two disciplines, inherent in the philosophy of technology and urban studies, are brought together by showing the possibilities of a fruitful dialogue. The aim is to understand how an ethical approach can be expressed in the design of urban artificial intelligence.

The fourth chapter focuses on the connection between urban AI and environmental sustainability. The objective is to critique the current approach to this relationship through an interdisciplinary approach based on the philosophy of Bruno Latour. Building on this critique, the chapter reflects on an alternative and sustainable design for Urban AI from a different design culture.

The last chapter is dedicated to the urban digital twin (UDT) as a fundamental tool of AI urbanism. UDT is explored starting from its conceptual sources and then situated in the problematic relationship between smart and AI urbanism. This chapter also includes a case study, namely the Bologna Digital Twin. This project is examined as a possible model for an alternative relationship between technology and urban space in the age of AI.

Overall, this thesis is dedicated to reflecting on the design culture behind the application of AI Urbanism. A culture composed of conceptual sources and theoretical inspirations that generate evident and substantial consequences in the design practice. The first objective of this thesis is therefore to highlight this dimension, which is interdisciplinary by nature, as crucial to the field of AI urbanism. Furthermore, the various chapters propose interdisciplinary languages capable of addressing specific issues related to this urban paradigm. Certainly, this thesis does not claim to have solved these problems. However, the idea is to have identified highly relevant issues and to have started the definition of languages and methods that can be implemented to address them.

ABSTRACT (Italian)

L'obiettivo di questa tesi è esplorare le fonti concettuali e le implicazioni urbane dell'applicazione urbana dell'intelligenza artificiale (IA). Il termine AI urbanism si riferisce a un nuovo paradigma urbano che sta emergendo come risultato dell'applicazione sempre più diffusa dei sistemi di IA nel tessuto urbano: robot, AV e agenti software stanno diventando parte dell'esperienza urbana di milioni di cittadini. Per indagare questo fenomeno, questa tesi utilizza un approccio interdisciplinare, basato principalmente sul rapporto tra filosofia della tecnologia e studi urbani, in grado di prendere in considerazione la complessità socio-tecnica e ambientale dell'urbanistica dell'IA. Questa indagine si sviluppa in cinque capitoli, dedicati rispettivamente alla mappatura delle fonti concettuali dell'urbanistica dell'IA, all'esplorazione del rapporto tra cibernetica e design nell'urbanistica tecnologicamente guidata, alla possibilità di un uso etico dell'IA urbana, alla potenziale sostenibilità di questo nuovo paradigma urbano e all'urban digital twin (UDT) come strumento cruciale in questo nuovo contesto socio-tecnico.

Il primo capitolo è dedicato all'analisi di tre fonti concettuali dell'AI urbanism ("Urbanistica moderna", "Cibernetica" e "Smart urbanism") e all'esplorazione delle loro implicazioni spaziali. L'obiettivo è dimostrare come la comprensione delle prime possa influenzare il modo in cui vengono affrontate le seconde.

Il secondo capitolo affronta la cibernetica come fonte concettuale dell'AI urbanism ed esplora le possibilità interne di un approccio quantitativo alla progettazione attraverso un'analisi storica della modellazione urbana e della tecnologia dell'architettura. L'obiettivo è rivelare come la scienza della città sia una disciplina ricca di possibilità alternative.

Il terzo capitolo riguarda il rapporto tra etica dell'IA ed etica urbana. Queste due discipline, inerenti alla filosofia della tecnologia e agli studi urbani, vengono avvicinate mostrando le possibilità di un dialogo proficuo. L'obiettivo è capire come un approccio etico possa essere espresso nella progettazione dell'intelligenza artificiale urbana.

Il quarto capitolo si concentra sulla connessione tra IA urbana e sostenibilità ambientale. L'obiettivo è quello di criticare l'approccio attuale a questa relazione attraverso un approccio interdisciplinare basato sulla filosofia di Bruno Latour. Partendo da questa critica, il capitolo riflette su un progetto alternativo e sostenibile per l'IA urbana a partire da una cultura progettuale diversa.

L'ultimo capitolo è dedicato al gemello digitale urbano (UDT) come strumento fondamentale dell'urbanistica dell'IA. L'UDT viene esplorato a partire dalle sue fonti concettuali e poi situato nel rapporto problematico tra urbanistica intelligente e AI. Questo capitolo include anche un caso di studio, ovvero il gemello digitale di Bologna. Questo progetto viene esaminato come possibile modello per un rapporto alternativo tra tecnologia e spazio urbano nell'era dell'IA.

Nel complesso, questa tesi è dedicata a riflettere sulla cultura progettuale che sta alla base dell'applicazione dell'AI Urbanism. Una cultura composta da fonti concettuali e ispirazioni teoriche che generano conseguenze evidenti e sostanziali nella pratica progettuale. Il primo obiettivo di questa tesi è quindi quello di evidenziare questa dimensione, per sua natura interdisciplinare, come cruciale per il campo dell'AI urbanistica. Inoltre, i vari capitoli propongono linguaggi interdisciplinari in grado di affrontare questioni specifiche legate a questo paradigma urbano. Certamente, questa tesi non pretende di aver risolto questi problemi. Tuttavia, l'idea è quella di aver identificato questioni molto rilevanti e di aver avviato la definizione di linguaggi e metodi che possono essere implementati per affrontarle.

Table of contents

Introduction

1.AI and Urbanism p.1

1.1Theoratical framework p.5

1.2 Motivations and risks of interdisciplinarity p.11

2. Structure and Overview p.13

3. Research questions p.18

Bibliography p.20

Chapter 1: Charting AI Urbanism: Modern urbanism, Cybernetics and Smart City

1.Cultural sources of an emerging phenomenon p.23

2.Time p.25

2.1. Towards a science of the city: from modern to AI urbanism p.25

2.2. The seductiveness of mechanical autonomy: cybernetic sources of AI urbanism p.29

2.3. Smart sources of AI urbanism p.33

3.Space p.37

3.1. Materializing urban AI p.37

3.2. The (urban) geography of relational intelligences p.41

4. Conclusion p.45

Bibliography p.48

Chapter 2: Cybernetic Chronicles: Urban modelling and architectural technology as sources for AI urbanism

1.Cybernetics as a source p.55

2. A contested legacy p.57

3. Models and the city p.60

3.1. Optimism and its problems p.60

3.2. A paradigm shift p.67

3.3. Down to AI urbanism p.69

4. The architect among the machines p.72

4.1. Technical intellectuals in Italy p.72
4.2. A Technological Culture for the Project and a Project for a Technological Culture p.75
4.3. Technical intellectuals and urban AI p.80
5. Conclusion p.83
Bibliography p.86

Chapter 3: URBAN AI and Ethics

1.A possible relationship? p.90
2. Transitions in AI ethics p.93
2.1. A search for ethical principles p.93
2.2. A possible lesson from urban studies p.96
3. Urban Ethics p.98
3.1. Defining Urban Ethics p.98
3.2. Ethics from Smart to AI Urbanism p.103
4. Ethics for Urban AI p.106
4.1. The need for Ethics in AI Urbanism p.106
4.2. What kind of ethics? p.108
4.3. A different idea of control p.112
4.4. Justice and Disorder p.116
5. Shaping a relationship p.122
Bibliography p.125

Chapter 4: Designing sustainable urban AI: from matter of fact to matter of concern.

1. AI and Urban Sustainability p.133
2. Smart and Eco urbanism: an unstable foundation for sustainable urban AI p.135
2.1. Conceptual sources of smart and eco urbanism p.138
3. On the path towards sustainable urban AI with Latour: modernity, science and nature p.141
3.1. A Copernican counter-revolution: facing modernity p.141
3.2. «Go tell your masters that scientists are on the warpath»: a new role for science p.143
3.3. Characterising Gaia: an ecology beyond the concept of nature p.145
4. A design theory for a sustainable urban AI p.147
4.1. Beyond matters of fact p.147

4.2. Towards a non-modern theory of design p.150
5. AI Urbanism as a matter of concern p.154
Bibliography p.157
Chapter 5: Urban Digital Twin. A tool for the future of urban planning
1.A tale of smartness, AI, twins, and brains p.162
1.1. A clash of conceptual sources p.163
1.2. Digital Twins in manufacturing p.164
1.3. Urban Modelling p.167
1.4. Between Smart and AI urbanism p.171
1.5. Models and brains p.173
2.Bologna Digital Twin p.179
2.1. An unorthodox approach p.179
2.2. Bologna City of Knowledge p.183
2.3. The shape of the Twin (5 actors x 3 years) p.187
2.4. Toward a platform neo-municipalism in Bologna p.192
2.5. Power balance, knowledge, ethics and participation p.195
2.6. An ambitious project p.201
Bibliography p.203
Conclusion
1. AI, City and Interdisciplinarity p.208
2. Five answers for a work in progress p.211
3. Future research and limitations p.218
Bibliography p.222

Index of figures

Figure 1 The general outline of the chapters....p.14

Figure 2 Schematic diagram of the concept of Charting AI urbanism....p.24

Figure 3 Diagram of past conceptual source of AI Urbanism....p.26

Figure 4 Diagram of the relationships between Urban AI and urban space p.37

Figure 5 The Nature/Person/Society/Technology system by Ciribini....p.74

Figure 6 Connections between signs, specifications, concepts and objects....p.79

Figure 7 Diagram representing different means of ethics in architecture and urban planning p.100

Figure 8 Diagram of ethical issues related to urban AI....p.106

Figure 9 Diagram of the relationship between Justice and Disorder p.121

Figure 10 The difference between smart and eco city in terms of design culture p.141

Figure 11 Urban AI as a matter of fact and as a matter of concern....p.148

Figure 12 Diagram of the characteristics of Latour's design theory....p.151

Figure 13 Scheme representing the key characteristics of product life cycle management and urban modelling with regards to the urban digital twin p.164

Figure 14 Diagram of the different types of Digital Twins....p.166

Figure 15 Diagram of the Gemini Principles p.170

Figure 16 Scheme of the nine differences between AI and smart urbanism p.172

Figure 17 The diagram shows the alternative possibilities of the Urban Digital Twin....p.177

Figure 18 Bologna City of Knowledge p.186

Figure 19 The actors involved in the Bologna Digital Twin project....p.188

Figure 20 The three initial use cases of Bologna Digital Twin p.191

Figure 21 Diagram summarizing the fundamental concepts useful for reverse enveloping highlighted in this research work p.216

Index of tables

Table 1 The seven main pitfalls of large-scale models highlighted by Lee in 1973 ..... p.63

Table 2 Paradigm shift in urban modelling p.69

Table 3 The list of some key ethical issues related to each component of an Urban AI p.110

Introduction

1. AI and Urbanism

The aim of this research is to explore the contemporary situation concerning the relationship between technology and urban space from an interdisciplinary perspective. Indeed, the current moment of the digital revolution, characterised by the emergence of artificial intelligence (AI), is generating a series of innovations and changes in both urban planning and the urban experience. To map and understand some of these transformations this thesis adopts an interdisciplinary approach that is both dictated by the issue addressed and by my background characterised by a hybridisation between philosophical perspective, urban studies and architecture.

This approach does not focus on technological innovation applied to the city from a technical point of view. Instead, the attention is on the ways in which technological innovation can be guided by an urban and planning culture, and on the implications it can bring to urban transformations. This cultural approach to technological innovation in architecture and urban planning has been applied nationally and internationally to describe crucial moments in the recent history of urban studies. Some of the scholars who have applied this methodology have been widely cited in this thesis and constitute models for the present work.

Starting from chapter two, which focuses in part on an Italian debate on the relationship between architecture and technology, the aim was to explore new technological possibilities within the boundaries of a standpoint that was already aware of the social and environmental criticalities highlighted by the capitalist system. In this context, scholars such as Zaffagnini, Ciribini and many others (Foti & Zaffagnini, 1969; Ente Autonomo Fiere di Bologna and Associazione Italiana Prefabbricazione per l'edilizia industrializzata, 1971) developed an interdisciplinary vision oriented towards the future and the social and environmental management of technological innovation. The same chapter traces the history of a decisive paradigm shift in the history of urban modelling, in which technological innovation was at the centre of an epistemological shift from a linear worldview to the openness brought about by the emergence of complexity theories. Batty, who took his first steps in this cultural milieu, has subsequently produced a vast amount of studies on the relationship between technology and the city, mentioned in this dissertation, culminating *The computable city* (2024). This book links the development of digital technology to urban development, highlighting its fundamental characteristics and the possibilities still open to it (Batty, 2024). From a more architectural perspective, Carpo (2011; 2017) indicated

how digital technology has changed not only the practical possibilities of architecture, but also its way of thinking, opening up qualitatively different forms of creativity through the power of computation. Ratti (2014; Ratti & Claudel 2017) has extended the consideration of the new possibilities opened up by digital technology to the urban scale, suggesting a new possibility of participation and co-design of the urban experience based precisely on technological innovation. Finally, Picon (2015) has subjected the smart city paradigm to a cultural analysis, concluding that, based on a different cultural contextualisation of technology, it is possible to interpret the same paradigm in a completely technocentric and control-oriented way or in a more participatory and horizontal way. These few examples demonstrate the analytical and explanatory power of a cultural approach applied to technological innovation in urban studies. In the case of AI urbanism, this interdisciplinary effort has only recently begun and is already bearing its first results. This thesis aims to follow this line of thought by defining the implications of this new reality through the themes of technology, ethics, and sustainability. As will be shown in chapters 1 and 2, AI urbanism certainly derives from the smart city paradigm, but as will be illustrated in chapters 3 and 5, it also opens up different challenges.

Artificial intelligence (AI) is nowadays a common buzzword in both academic and public discourses. AI certainly belongs to the radical technologies that are capable of fundamentally altering the material composition and our interpretation of everyday life (Greenfield, 2017). The aim of this dissertation is not to contribute to the debate concerning the technological development of AI, but rather to increase the comprehension of the stakes concerning the relationship between this technology and the city.

In fact, this connection is deemed by many scholars to be the next driver in urban development, sparkling at the same time hope and harsh criticism (Kassens-Noor & Hintze, 2021; Batty, 2018; Cugurullo, 2021; Kitchin 2014; Willis & Aurigi 2017; Bratton 2021; Cugurullo et al., 2023; Luusua et al., 2023; Batty, 2023; Cugurullo et al., 2024 Yigitcanlar et al., 2021; Sanchez et al., 2023). By the term AI we generally mean a category of artefacts capable of acquiring information from the surrounding environment and making rational decisions autonomously and even in situations of uncertainty (Coeckelbergh 2020).

The tools in use today are narrow AIs-that is, systems capable of dealing with specific domains and problems for which they are trained. The urban impact that these technologies is extremely significant. The very functioning of cities may be changed by the use of these tools in various domains: economy (making processes more efficient and increasing productivity), society (community health monitoring and autonomous mentoring systems), environment (optimization of material and immaterial flows),

governance (decision support systems, surveillance and cybersecurity) (Bratton 2021; Golubchikov & Thornbush, 2020). However, these great opportunities imply that equally significant challenges need to be addressed not only from a technological perspective but also by developing a cultural and project-based understanding of the relationship between AI and the city.

Recently, an increasing number of studies on AI urbanism have adopted an interdisciplinary perspective (Luusa et al., 2020). The motivation behind this approach becomes evident when one considers the definition of Urban Artificial Intelligence (UAI):

> Urban AIs are autonomous artefacts capable of gaining knowledge about the surroundings urban environment and making sense of acquired data, using it to act rationally according to pre-defined goals in complex situations and spaces (Cugurullo 2021, p. 159).

In this definition, an Urban AI is described in terms of characteristics traditionally reserved for humans, namely the ability to acquire knowledge and act rationally. However, in this case these capabilities are associated with an agent that is described as an autonomous artefact. These capabilities, and the fact that they are attributed not to a human being but to an artefact such as an AI, immediately require a reference to the philosophy of technology to be addressed and understood. Indeed, the understanding of what it means for an artefact to be autonomous, and in what sense it can acquire knowledge and act rationally, are questions and issues that have traditionally been addressed and discussed in the field of philosophy of technology. This approach has paved the way for directions of research that will be very relevant in the development of this thesis, such as AI epistemology, AI ethics, and studies on the social and environmental implications of this technology (Crawford 2021; Coeckelbergh 2022; Floridi 2022). Thus, it can be stated that the reference to the philosophy of technology is internal to the very definition of Urban AI, which requires the contribution of this discipline in order to be understood.

The relationship between philosophy and the city has a long tradition. According to Henri Lefebvre – a key author for urban ethics and for the evolution of this thesis – the relationship between philosophy and the city is essential and originates in the Greek polis (Lefebvre, 2014). Subsequently, this connection develops throughout Western history until it is embodied in the modern industrial context analysed by the French philosopher in his writings on the city. The perspective of this dissertation shares Lefebvre's identification of the fundamental link between philosophy and the city and proposes to extend his approach by using philosophy to clarify the nature of the connections between AI and the city.

Notwithstanding, by definition an Urban AI is not just an AI. Thus, philosophy of technology alone cannot represent a valuable standpoint in this analysis. Indeed, the definition of an UAI refers to the urban environment as the context in which this autonomous artefact is deployed. As I will argue in this

thesis, the context in which AI is deployed is crucial not only in terms of the implications associated with the use of these technologies, but also in determining how they function. Indeed, on the one hand, urban studies are necessary to understand the impacts of AI on the urban fabric; on the other hand, this perspective is also central to grasping the rationale, design, and functioning of specific urban AIs that are conceived, designed, and produced precisely to operate in cities. Thus, the relationship between the philosophy of technology and urban studies is a necessity dictated by the very definition of the object of study, namely AI urbanism.

Moreover, as will be shown in the chapters that follow, the study of AI urbanism is not an abstract perspective far removed from the materiality of the contemporary city. In fact, starting from the first chapter, I will show how an immaterial interpretation of digital technology and AI is currently considered outdated. Nowadays AI urbanism takes the form of various material objects and tools, which will be mentioned in several occasion in this dissertation. Following the work of Cugurullo et al. (2024), it is possible to identify four categories of objects that have been studied in the context of AI urbanism. The first three are Robots, Autonomous Vehicles (AVs) and Software Agents. The first category concerns robots, which can be present in public and private spaces and which, thanks to AI, achieve unprecedented levels of complexity in their interaction with the environment. AVs are vehicles that can drive partially or totally autonomously using sensors, cameras and AI to monitor the road. Software agents refer to a number of urban AIs that have recently gained prominence and that, by analysing large amounts of data, provide analyses and forecasts in various urban areas. Some examples are urban security, housing market, healthcare and architectural design.

This geography is changing due to the rise of a fourth category: large-scale digital platforms that are able to integrate (in different combinations) the three objects already mentioned. The two best known examples are City Brain and Urban Digital Twin (UDT). Typically, the former is a very successful tool in Asia and the latter is more widely used in the West, particularly in Europe. Both of these tools are designed for the planning and management of large parts of a city and are implemented thanks to an extensive capacity for data collection and analysis, which is used for urban forecasting and simulation. These complex objects are particularly promising for the study of AI urbanism: on the one hand, they greatly increase its scale and ambition, and on the other hand, they are able to systematise the other tools I have mentioned. The prospect described by Cugurullo (2021) of autonomous cities, or rather cities managed and designed by computational intelligences, seems more concrete when looking at such tools. In chapter 5 I will point out the similarities and differences between these City brains e urban digital twins. In fact, this chapter is dedicated to Urban Digital Twin (UDT), namely to the analysis

of the origin of this tool and to the analysis of a case study, namely the Bologna Digital Twin (BDT) developed in and by the city of Bologna (IT).

The relationship between AI and cities, and therefore between technology and urban studies, is also key in another respect. Indeed, cities are the source of an enormous amount of data needed to develop and train artificial intelligences (Luusa et al., 2020). This means that the link between the urban context and AI is necessary at a technological level, since an extremely relevant amount of the relationships between humans and non-humans, which can be reduced to data and thus used to train AI, take place in urban spaces. Moreover, as I will illustrate in this dissertation, cities are also the places where most economic and cognitive resources are concentrated, and thus central locations for technological innovation. Thus, a twofold dynamic can be described: on the one hand, the city has become a key domain for the future development of AI and, on the other hand, AI is altering the material and conceptual structure of the city.

1.1. Theoretical Framework

Langdon Winner, in his essay on autonomous technologies (Winner 1977), argues that modern science was born with the explicit purpose of modifying reality, thus becoming logically inseparable from technology. This inextricability of the scientific and technological dimensions is also supported by Jonas, who identifies it as one of the fundamental differences between ancient and modern science. (Jonas, 1990). On the basis of these philosophical assumptions, in this thesis science and technology will be considered as components of a unified mentality aimed at the modification of reality by human intervention. This choice is also motivated by the fact that in the literature on AI urbanism, science and technology are inextricably linked as fundamental components of this urban paradigm. In fact, what Batty (2012), for example, defines as the new science of the city would be completely incomprehensible without reference to the technologies (sensors, IoT, AI) that make it possible.

As I will argue in the first chapter of this thesis, Francis Bacon's thought can be seen as the symbolic beginning of this shift, which is not coincidentally accompanied by the design of an urban utopia, the *New Atlantis* in 1626. At the beginning of this shift in scientific mindset - from a contemplative to a technological science - the city immediately emerges as a context for the application of this new world view. According to Winner, at the heart of modern technology lies the desire to control reality, but this control takes place in a particular way, namely by structurally modifying the environment that has to be controlled. This science-technology divides reality through meticulous analysis and recomposes it in a

way that is productive for its own purposes, generating artificially chains of links between means and ends.

Basic conception can be stated as follows: technologies are structures whose condition of operation demands the restructuring of their environment. Again, the point has nothing to do with obscure force. It is simply a matter of specifying what needs to take place before an instrument is in working order (Winner, 1977, p 100).

According to this perspective, science-technology does not only act at the epistemological level, that regards the way in which we interpret reality. Rather, it also acts at the ontological level, which means that it modifies the reality to which it is applied. More precisely, it could be said that this practice establishes a necessary relationship between ontology and epistemology: in fact, the modification of reality becomes a necessary condition for its understanding. This new scientific approach promises to control reality only at the price of radically modifying it.

Nowadays it is common to describe digital technology as radical and disruptive, highlighting its potential to transform the most diverse spheres of our everyday lives (Greenfield, 2017). When it comes to AI, this disruptive nature is even more pronounced, given that this technology is not applied to a specific field, but is used in the most diverse areas, from medicine to logistics, from finance to journalism and, of course, in the city. However, the disruptive nature of AI is not limited to its applicability in different fields. According to Floridi (2022), the recent progress made by AI in terms of efficiency is not only due to a change in architecture and increased computing power, but also to a work we humans do on reality. Borrowing a term from engineering, Floridi (2014) calls this process *enveloping*, in other words modifying reality to make it readable and interpretable by AI. According to the philosopher, therefore, AI has not suddenly become intelligent, but instead must be interpreted as a formidable form of agency facilitated by this enveloping effort. This conception brings AI into line with Winner's view of technology. In fact, enveloping is nothing more than the modification of reality necessary to make a technology effective, the ontological modification that makes it possible to gain epistemological control over reality.

This relationship between the ability to interpret reality and its modification has been analysed in urban studies in relation to digital technology. In fact, according to Batty (2024), the proliferation of technology in cities, with the aim of understanding them more precisely, is also fundamentally changing them. Following Batty, we are therefore faced with a paradox: the technology that should ensure our understanding and control over urban reality ends up changing it, forcing us to face new challenges that did not exist before the appearance of the technology itself. This simple paradox means that urban technol-

ogy, and urban AI in particular, should not be considered as a tool capable of solving the urban equation, but as another element in the complexity of the city.

However, as I will demonstrate several times in this thesis, urban AI is often considered by technicians, in line with a modern interpretation of technology, as a tool capable of organising an urban reality understood as a chaotic context (Cugurullo, 2021). This interpretation is based on a significant underestimation of urban history and the current geography of ethical, social and environmental relations that characterise urban spaces (Bratton, 2021: Lynch & Del Casino, 2020). Urban AI is therefore understood as a tool capable of bringing order and efficiency to the most diverse urban systems in an autonomous and objective way regardless to the specific contest.

This apparent independence from the contexts of application makes it possible to use Winner's concept of autonomous technology, which defines an autonomous agent as one that is not subject to rules and is not influenced by anything other than itself (Winner, 1977). From this standpoint AI seems to be an autonomous machine capable of bringing order to our chaotic urban spaces. The notion of autonomy is highly relevant to the debate on AI urbanism. Indeed, Cugurullo (2021) argues that the ability of urban AI to act increasingly independently of human decisions is a fundamental characteristic of this stage of the relationship between technology and the city.

However, I argue that enveloping and a full autonomy are two contradictory concepts, especially when it comes to urban AI. As I will show in more detail in Chapter 3, urban AI can certainly act in ways that are increasingly autonomous from human decisions, but full autonomy in the sense suggested by Winner is largely a myth. In fact, enveloping highlights the functional dependence of the technological tool on its context of application: AI can only be effective if its context of application is modified. Ai agency is therefore not autonomous from the context; on the contrary, it is absolutely rooted in it and limited by it. The very notion of envelopment breaks down the wall that separates urban AI from urban dynamics, and weaves an essential relationship between the two. This first step should already direct the study of urban AI away from a purely technological perspective towards a socio-technical and urban standpoint, in which the modifications of space necessary for the functioning of AI (the results of enveloping) are studied as essential components of urban AI itself.

This research work takes an additional step in defining the relationship between AI and the city. In fact, even if enveloping remains a fundamental element in understanding the relationship between AI and cities, focusing solely on this aspect hides a risk. This perspective conceals the danger of interpreting the city as a passive entity, as something that is simply modified by technology, a modifiable backdrop

in which to situate the AI. Indeed, the mainstream narrative on urban AI often presents the city as a chaotic context in need of technologically imposed order. The idea is that the city is a system to be rationalised through technological integration of the many infrastructural, social and environmental subsystems that characterise it. The enveloping process here regards the modification of these systems so that they can be manipulated and then controlled by AI. However, as I will show in more detail in Chapter 3, this urban ontology is extremely simplistic and has been cobwebbed by a vast array of studies in urban ethics. In fact, the city is not a chaotic system waiting for a technologically imposed order, but a complex context historically capable of producing orders and geographies of diverse and articulated relations that have made it the most important hub of technical, social and political innovation in human history.

According to Lefebvre (1996), the city is both a product and a means of production: a product of the capital, technological and cultural flows that tend to determine it from the outside; but at the same time a means of production capable of rejecting, modifying or accommodating these flows thanks to the potential developed by its internal relations, be they social or ecological. Cities are certainly partly determined by external forces, but at the same time they have the potential to creatively influence these forces.

This active ontology of the city - the fact of understanding it as a field of forces capable of organising itself at different levels - makes it possible to understand that the relationship between AI and the city cannot be unidirectional. Certainly, *enveloping*, understood as the modification of the city as a function of AI, is an ongoing process that needs to be explored. However, there is also an opposite movement, which I will refer to in this thesis as *reverse enveloping*. This process acts in the opposite direction - from the city to AI - and concerns the possibility of urban contexts influencing the development and application of technology. Precisely because urban AI is not autonomous from the city, but requires its modification in order to function (enveloping), the possibility opens up for the city to influence the technology (reverse enveloping). I argue that the communication channel between the two entities – AI and the city – must be interpreted in both directions. Reverse enveloping, that is, the urbanisation of AI, should be a crucial issue for urban studies today. Indeed, this movement regards the possibility of making AI useful for the concrete needs of cities, it concerns the still ongoing transition between simple technological innovation applied to the city and urban innovation.

This reverse enveloping concerns the actions that different urban actors can take to influence a particular urban AI. At a first level, this process is often already happening without efforts. Indeed, many ur-

ban AIs are based on data collected in urban spaces, and therefore the behaviour of many urban actors contributes to shaping the data and thus to training the models that make these tools effective. Throughout this thesis, however, I will explore other more intentional forms of reverse enveloping, which fall into two categories.

On the one hand, there are possibilities for direct actions of reverse enveloping. These are the viable actions that various urban actors can take to gain control and power over urban AIs. This category will be dealt with in particular in chapters 3, 4 and 5. In chapter 3, the theories of design justice and design disorder will provide principles for urbanising urban AI from an ethical point of view, that is to bring it closer to the geometry of social relations between communities that characterise the urban fabric. In Chapter 4, Latour's design principles will be contextualised within the field of AI urbanism to promote environmentally sustainable design of Urban AI. Finally, in Chapter 5, through the analysis of the Bologna Digital Twin (BDT) case study, I will trace the ways in which a reverse enveloping process is taking shape in a real project that is still in progress. In this first category, the concept of design is certainly crucial. In this thesis, the use of this term remains broad and inclusive of multiple practices. In fact, according to Costanza-Chock (2020) and the paradigm of design justice, the concept of design can be applied in two ways: on the one hand, it refers to the scientific and specialised practice of those who work as designers (urban, product, etc.); on the other hand, design is also the way in which humans modify their environment in a way that is effective for their purposes. Moreover, according to Bruno Latour (2008), the concept of design has undergone a historical evolution that has led it from a practice dedicated to superficial and often aesthetic modifications of industrial products to a practice of modifying objects and assemblages of different sizes, such as cities and landscapes. Building on these authors, this thesis interprets design as a form of direct action that various urban agents can perform to influence urban AI.

The second category of action is indirect or cultural and concerns the possibility to influence current AI urbanism through reverse enveloping, using some ideas from the history of urban studies. This means that the city, as a theoretical and historical object, has been at the centre of a number of reflections that can contribute to a greater awareness in the contemporary panorama of AI urbanism. Given the subject of this research, I decided to use concepts and reflections from different historical moments of technologically driven urbanism, such as the beginnings of modern urban planning, the history of urban modelling linked to cybernetics and systems theory, and the smart city paradigm. These histories have been implemented to highlight concepts and ideas that can be useful today clarify AI urbanism. This historical approach was used largely in chapters 1, 2 and 5. Indeed, in Chapter 1 I traced the main conceptual

sources of AI urbanism, in Chapter 2 one of these sources has been examined in relation to two different episodes in the recent history of the relationship between urban studies and technology, finally in Chapter 5 I used two different theoretical sources (urban modelling and product lifecycle management) to define the urban digital twin (UDT).

This second category better specifies how the concept of design has been implemented in this dissertation. In fact, this this thesis is not directly related to urban design as a design practice involving the analysis of a series of specific case studies. The focus is more on design culture, which is a set of material and immaterial objects (including concepts) that influence actual design. This is the level of abstraction at which this work operates. The focus of the reflection is on how frameworks and concepts from different literatures, which are relevant to the field of AI urbanism, can foster the reverse enveloping of cities on AI and modify a design culture of AI urbanism that is currently strongly linked to a technocentric perspective, as I will show several times in this thesis.

These considerations undoubtedly foster a more relational ontology of urban AI, capable of moving this field away from a technocentric view in which this tool is only considered on the basis of its internal efficiency, with little relevance to its implications and without a real socio-technical perspective of its essence and use. This change of perspective is explored in Chapter 4, in particular, through Latour's distinction between matter of fact and matter of concern. According to Latour (2004), the former is the modern way of defining objects, which, as I will argue, coincides with the technocentric vision of urban AI, while the latter is the way in which objects should be considered in order to overcome some of the distortions of modernity. This second approach will be analysed in Chapter 4 in relation to the relationship between urban AI and environmental sustainability, but will appear several times throughout the thesis as a fundamental part of the conceptual framework.

In summary, the theoretical perspective of this thesis aims to overcome an interpretation of urban AI based on a modern vision of technology as an autonomous tool for controlling (urban) reality. I will argue that it is possible to directly and indirectly influence the design cultures of urban AI by promoting a non-technocentric perspective that is attentive to ethics and sustainability. However, this reverse envelopment needs to draw on different disciplines to address the complexities inherent in the nexus between AI and the city.

1.2. Motivations and risks of interdisciplinarity

The approach of this thesis is interdisciplinary, based on the relationship between the philosophy of technology and urban studies. The dialogue between these two disciplines is required by the very definition of urban AI, and how both dimensions are fundamental to forming a concrete and effective perspective on this class of objects. As the text progresses, the relationship between these two fields of study will develop in different ways, involving a number of related disciplines, as will be explained in detail describing the structure of the thesis. As far as the philosophies of technology are concerned, it is certainly possible to mention the philosophy of AI, AI ethics and the history of technology as subdisciplines. Furthermore, sociological perspectives on technology and STS (Science and Technology Studies) should be considered within this field of reflection. In fact, following Latour (2007), I argue that the excessive distinction between these disciplinary fields is often detrimental to reflection. With regard to urban studies, it is certainly necessary to mention architecture and urban planning, including urban design and technological design applied to the city, architectural technology and urban modelling and urban ethics. Moreover, the literature in urban and digital geography has been pivotal. Finally, it is necessary to mention product design, the history of which will only be used in Chapter 5 to better understand the urban digital twin. These different literatures have not been treated in their entirety, but have been explored in dialogue with experts in each field, identifying the studies that could be useful for addressing some specific problems in the debate on AI urbanism. The interdisciplinary approach of this thesis is therefore not based on a quantitative comparison of literatures, but on a qualitative selection aimed at addressing key issues that have emerged in urban studies regarding the relationship between cities and AI.

Notwithstanding, interdisciplinarity, which is necessary to understand AI urbanism, entails at least two risks that this thesis has tried to avoid. Firstly, that of using a specific philosophical framework to analyse and explain the whole phenomenon of AI urbanism. Second, that of thinking that the conceptual interpretation of AI urbanism can take precedence over, or even replace, the concrete planning and design practices that this paradigm generates. In the first case, there is the risk of forcing an extremely articulate and still-forming phenomenon into the rigid canons of a particular philosophical position. In the second case, there is the danger of believing in the possibility of creating a strange philosopher-designer hybrid capable of solving the problems it analyses. Both of these solutions of apparent interdisciplinarity are avoided in this thesis.

As I have already shown in the conceptual framework, the perspective of this thesis is not uniquely derived from the thought of a single thinker or philosophical current, and therefore its interdisciplinarity does not develop into a mechanical application of a conceptual grid to a phenomenon. Certainly, some thinkers such as Winner, Latour, Lefebvre, Sennett and Floridi have influenced the proposed perspective, but this thesis cannot be interpreted as a transposition of the perspective of one of these thinkers to the field of urban AI. This approach, which is certainly legitimate, has not been followed in order to avoid forcing an emerging phenomenon such as AI urbanism into a predefined conceptual grid. The chapters of this thesis deal with different themes within AI urbanism, and each time it was necessary to mobilise some ideas to address a specific problem. Thus, the way in which the philosophy of technology has been integrated into the text is not a top-down imposition of a conceptual perspective, but a bottom-up dissemination of ideas that might be useful in framing problems that have emerged in the urban studies literature.

The term design culture in the title of this thesis is aimed to avoid the second risk, that of substituting philosophical analysis for concrete design practice. In fact, design culture represents the level of abstraction at which the analyses in this thesis are situated. That is, to clarify some of the ideas and cultural paradigms that drive the practice of AI urbanism, and at the same time to attempt to modify some of these ideas that animate this concrete practice. Reflecting on design culture then means questioning the cultural sources that drive us to design objects, buildings, parks, neighbourhoods, cities or regions in particular ways. Such reflection is by no means intended to replace design, but to seek to understand, explain and contribute to the transformation of the culture that informs this pivotal practice. In the case of AI urbanism, it is therefore necessary to understand what ideas, conceptual sources and cultural perspectives are driving the implementation of this paradigm: it is key to grasp how this design culture influences design practice and orients it towards solutions that may or may not be in line with the outcomes that are considered desirable in terms of urban efficiency, social and environmental sustainability, justice and ethics. Highlighting the ideas that are currently shaping the design of AI urbanism is useful both to increase our mastery of this new urban model and to change the direction of our action when it becomes clear that the direction we are taking is not leading to the desired outcomes.

In fact, transforming the culture of AI urbanism design means contributing to the modification of the way this paradigm is currently applied by promoting an interdisciplinary debate on the guiding ideas and objectives being pursued. Therefore, the methodology followed in this thesis is mostly theoretical and dedicated to a conceptual analysis aimed at isolating themes and elements useful for modifying the design culture of urban AI. This conceptual analysis questions the role of technology in the city from

different literatures which are used to answer specific research questions that inform each chapter. As will become clear throughout the thesis, this methodology has been followed both in the recent history of urban studies (chapters 1 and 2) and in strictly contemporary debates on AI urbanism (chapters 3 and 4). Chapter 5 is the only one that follows a methodology that is more empirical and focused on a case study, namely the Bologna Digital Twin project. There are two reasons for the decision to include only one case study in a largely theoretical thesis. Firstly, the BDT is a project that is still in the development phase and focuses mainly on the technological, social and ethical principles that will underpin the urban digital twin. This focus on the theoretical framework makes it particularly interesting from the perspective of this research, which focuses on the design culture that influences actual technological development. Secondly, the BDT project is internationally recognised for its focus on the social and ethical component, which is often absent or poorly represented in similar projects. Again, this specificity makes the project interesting for a study that is focused on how the ethical and social components that emerge in cities can influence technological development. Therefore, as will be explained in chapter 5, the case study should not be considered as representative of the way in which urban digital twins are developed in general, but rather as a specific in-depth study of a case strongly characterised by an original approach and in line with the general perspective of this thesis. This experimental and still ongoing project was studied through interviews with apex figures of its governance, the analysis of all available public documents and participatory observation. The analysis of this case study is not the primary focus of the thesis and therefore this methodology is limited to this chapter. The aim of this final part of the thesis is to show how many of the issues raised in the more theoretical sections come to the fore in the early stages of setting up an ambitious project such as the one undertaken by the Municipality of Bologna.

2. Structure and Overview

This thesis is divided into five chapters [Figure 1]: the first one highlights the importance the conceptual sources of AI urbanism; then there are three chapters devoted in depth to the issues of technology, ethics and sustainability in the context of AI urbanism. Finally, the last chapter is dedicated to the topic of urban digital twins (UDTs) as an emerging frontier of this urban paradigm and the analysis of a case study, namely the Bologna Digital Twin (BDT) project. At the end of each chapter there is a specific bibliography that lists the main studies used in it. Some titles are repeated in the different bibliographies because they have been used in different domains, or because they concern elements common

to several chapters. This choice has been made to facilitate thematic consultation of the interdisciplinary bibliography that informs this thesis.

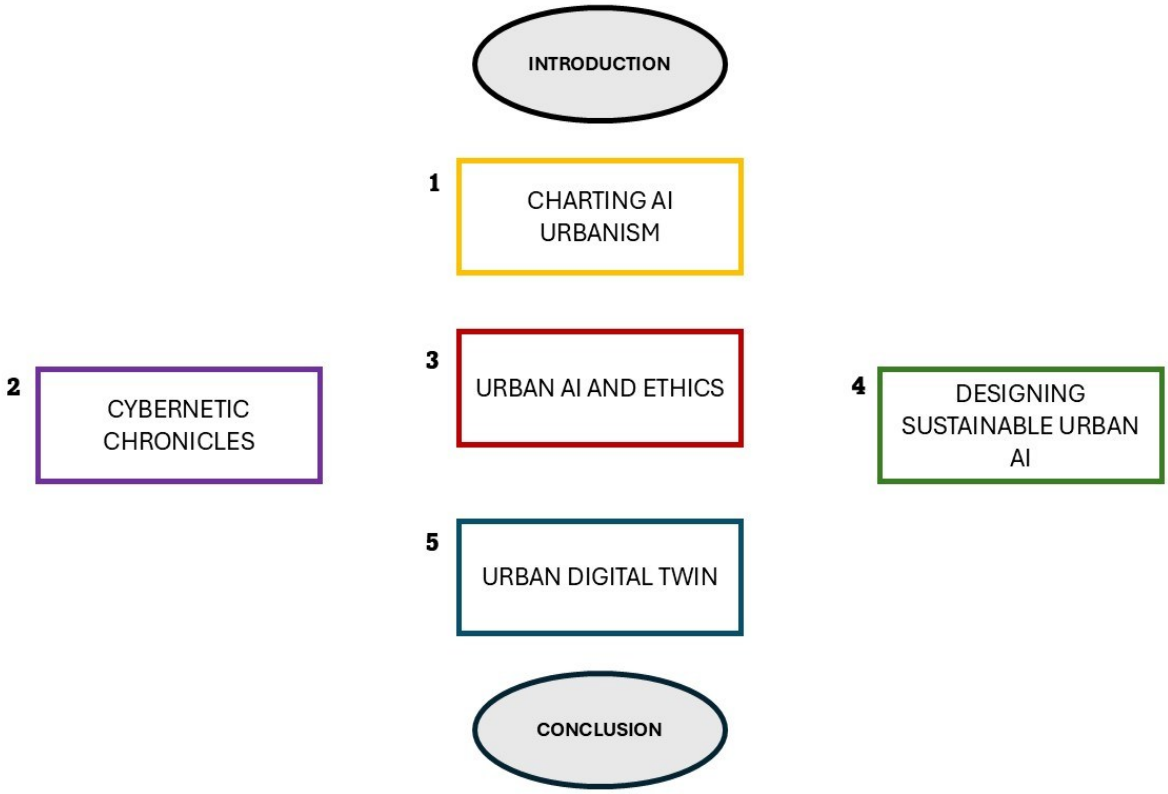

Figure 1. (Author's original) This is the general outline of the chapters that constitute this thesis. The first chapter presents an interdisciplinary perspective on a number of relevant problems in the field of AI urbanism. Chapters 2, 3 and 4 are specific analyses of three of these problems, aiming to shed light on related issues of design culture. Chapter 5 is more empirical, describing the urban digital twin as a crucial tool in AI urbanism and considering the case study of the Bologna Digital Twin.

The aim of the first chapter is to chart some of the key issues concerning the relationship between AI and urbanism. The analysis will not focus on the technological development of artificial intelligence systems but on how their application can affect urbanistic thinking and vice versa. The chart that is produced by this method is based on two fundamental axes: time and space. AI urbanism will then be inquired first through key turning points in the history of the relationship between technology and the city (modern urbanism, cybernetics and the smart city paradigm). Secondly, the spatial implications of urban AI will be investigated from the point of view of the concrete applications of this technology to the city (Robots, AVs, Software agents) and their impact on the relationships between different urban actors. This chapter draws extensively on the literature on technologically driven urbanism produced in urban studies, with particular reference to that on modern urban planning and the smart city paradigm. In addition, a significant number of urban geography studies have been used to map the tools that char-

acterise AI urbanism and to interpret the relationship between artificial agency and forms of biological intelligence. As far as the philosophy of the technology is concerned, studies on the philosophy of AI have been applied, aimed at clarifying the nature of this artificial agent and its main characteristics. In addition, philosophical literature has been used in the section on cybernetics. The chapter follows two methodologies. On the one hand, conceptual analysis is applied to AI urbanism in order to understand which conceptual sources have influenced its design culture. On the other hand, a review of the geographical literature to map the materiality of the actually existing AI urbanism. This structure has two objectives: to begin the process of indirect and cultural action of reverse enveloping through the cultural sources of AI urbanism, and to map some fundamental themes of the concrete interaction between urban AI and cities.

In the second chapter, I will focus on cybernetics as the conceptual source of AI urbanism by analysing two episodes in the history of the relationship between technology and the city in which this discipline has been prominently featured. The first investigation concerns the history of urban modelling in the US and the UK in the second half of the last century. In this section I will argue that this quantitative approach to the city has undergone profound theoretical modifications and paradigm shifts as a result of the evolution of cybernetic thinking, which was its original inspiration. A second section is devoted to some research in architectural technology carried out in Italy in the 1970s and 1980s. This chapter represents an in-depth extension of the conceptual analysis methodology used in the first chapter. In fact, the chapter is essentially based on the literature on architectural technology and urban modelling. As for the studies on the philosophy of technology, they focus on the interpretations of cybernetics. The aim of this chapter is to understand what concepts can be drawn from two decisive moments in the history of technologically driven urbanism to promote indirect or cultural reverse enveloping actions.

The third chapter focuses on the question of the desirable ethical use of urban AI. Ethics is a cross-cutting theme, generally concerned with the quality of relationships between different agents in a given context. AI ethics is interested in the changes in the quality of these relationships caused by the intervention of artificial agents, while urban ethics is engaged with the significant relationships that exist between agents in an urban context composed of buildings, environment, institutions, infrastructures, and urban projects. In this chapter, these two dimensions are brought together to understand how the artificial agents studied by AI ethics enter into the dynamics of the relationships studied by urban ethics. First, the recent history of the development of AI ethics will be traced, from a principles-based approach to a focus on the concreteness of the power relations that lie at the heart of AI design and development. It will then propose urban studies as a privileged field of research in this transition, given the

particular focus it has traditionally given to the relationship between design and power, due to an interdisciplinary dialogue that has already taken place in the smart city debate, and because of a particular conception of urban ontology that is fundamental to the study of urban ethics. Then, by drawing some connections between AI ethics and urban ethics some specific ethical issues concerning AI urbanism will be pointed out. Finally, I will emphasize how a constructivist and design-oriented ethics can be interpreted as a promising way of conceptualizing the ethics of urban AI, by combining two paradigms taken from urban and technology studies: design disorder and design justice. This chapter draws equally on literature, philosophy of technology and urban studies: regarding the former, the focus is on AI ethics and its recent developments, while for the latter, urban ethics. Methodologically, the focus of the chapter is on the comparison between these two different types of literature and the search for a common language. The aim of this chapter is to propose a framework for the ethical design of urban AI, which can provide a path for direct reverse enveloping by the various urban actors.

The aim of the fourth chapter is to investigate the relationship between AI urbanism and sustainability[1] by drawing upon some key concepts of Bruno Latour's philosophy. The idea of a sustainable AI urbanism – often understood as the juxtaposition of smart and eco urbanism – is here critiqued through a reconstruction of the conceptual sources of these two urban paradigms. Some key ideas of smart and eco urbanism are indicated as incompatible and therefore the fusion of these two paradigms is assessed as an unstable basis for shaping sustainable AI urbanism. The concepts in question – modernity, science and nature – are subsequently redefined following Latour's philosophical perspective, in an attempt to point out a different theoretical basis for a sustainable AI urbanism in the Anthropocene. Finally, the principles of a design philosophy shaped by Latour are implemented to modify the design culture that informs AI urbanism towards a more sustainable practice. This chapter is largely based on urban studies literature, in particular on the smart city and eco-city paradigms. The philosophy of the technology component is represented almost exclusively by an extensive use of Bruno Latour's thought. The aim of this chapter is to promote a framework for active reverse enveloping aimed at ensuring greater environmental sustainability of AI urbanism.

[1] Sustainability is an extremely complex concept that traditionally invests ecological, social and economic dimensions together (Caradonna, 2022). However, as far as Chapter 4 is concerned this topic has been treated considering almost exclusively the ecological aspect. This choice is determined by the fact that the literature on which the chapter is based concerns the topic of eco-city, which is more focused on urban ecology. In addition, the social theme has been addressed in Chapter 3 through considerations of ethics and at several times in the other chapters touching on some of the critical issues of AI urbanism. Finally, the economical aspect of AI urbanism is not the focus of this thesis. However, a partial investigation of this aspect can be found in Chapter 1 (section 2.3) and Chapter 5 regarding the relationship between private companies and municipalities in the BDT project.

The final chapter is divided into two sections. The first is a more conceptual one, and it aims to highlight the Urban Digital Twin (UDT) and describe it as one of the most ambitious incarnations of AI urbanism. This description is articulated in two steps: First, the conceptual history of the digital twin concept will be reconstructed by tracing the parallel trajectories of product lifecycle management and urban modelling that have contributed to the conceptualisation and realisation of the idea of the Urban Digital Twin as we currently know it. Secondly, the role of AI within this tool will be explored, highlighting how Urban Digital Twin is an entity still in transition from the Smart City paradigm that has dominated the last 20 years of urban design towards AI urbanism. Finally, in order to better define this nexus, the urban digital twin will be interpreted in relation to two tools that are emerging in the field of AI urbanism, namely the City Brain and the Deep Map. This further articulation can open up the possibility to intend the urban digital twin as a tool still situated between the top-down, technocentric and predictive approach of the City Brain and the bottom-up, participatory and civic approach of the Deep Map. This first part is based on urban studies and product life management literature. In the first case, it deals with literature from urban planning and urban geography regarding the relationship between cities and technology, while in the second case, the focus is on the concept of digital twin (DT) and its origin in the manufacturing sector. Methodologically, this section of chapter 5 implements conceptual analysis to deepen the understanding of the urban digital twin. The objective is to clarify some aspects of this tool to better prepare the analysis of the case study.

The second section of the analysis of the urban digital twin concerns a case study, namely the Bologna Digital Twin project. First of all, the context in which the current city administration has placed the project will be defined, namely within a master plan called Bologna City of Knowledge, which should lead the city to become a European model for research and civic science in the near future. Next, the composition of the project's governance and the three-year implementation plan are analysed, focusing on the themes of technological development, ethics and participation. Thereafter, it will be demonstrated how this project can be interpreted through the paradigm of platform neo-municipalism, through which some cities are trying to regain a space of sovereignty and participation with regard to the implementation of digital technology. This chapter draws almost exclusively on the urban studies literature on urban digital twins and neo-municipalism. The methodology is composite, as it uses a literature review, desk-based analysis, participant observation and qualitative interviews. The aim of this part of the fifth chapter is to show a currently ongoing process of direct reverse enveloping through which the municipality of Bologna is trying to secure a greater portion of technological sovereignty in the era of AI urbanism.

Chapters 1, 2 and 4 are developments coming from articles published during the PhD in international journals in different disciplines, namely architecture and urbanism, artificial intelligence and ethics of technology).[2] In contrast, chapters 3 and 5 were written from scratch for this thesis. The chapters derived from published articles are not literal reproductions. In fact, in all three cases, the original articles have undergone significant changes: elimination of sections written by other authors and modifications of text and structure in order to be in line with the general argument of this research work. The different chapters therefore reflect the range of approaches to the subject of AI urbanism that have been adopted over the three years of the PhD programme and are also influenced by the constant innovation to which this topic is currently subject. Since the beginning of the PhD, my aim has been to produce a broad reflection capable of mapping some of the fundamental issues raised by the emergence of this urban paradigm and to indicate some possible ways to promoting interdisciplinary analysis.

3.Research questions

The overall aim of this thesis is to explore the emergence of AI urbanism through an interdisciplinary approach, and to promote an urbanisation of urban AI. That is, direct and indirect reverse enveloping. This broad goal is articulated into specific research questions that relate to the chapters into which this dissertation is divided.

1. The aim of the first chapter is to identify some of the main conceptual sources that inform the theory and practice of AI Urbanism (Modern Urbanism, Cybernetics and Smart City) and to understand if and how analysing the history of these conceptual roots can provide useful insights into contemporary design practice. Question: *which concepts taken from the cultural sources of AI urbanism can be useful to actualize an indirect reverse envelopment of urban AI*?

2. The second chapter focuses on cybernetics as the conceptual source of AI urbanism. the aim is analysing some key defining moments in the relationship between cybernetics, urbanism and architecture. Question: *What issues from the relationship between cybernetics, architecture and urbanism can guide the reverse envelopment of urban AI*?

3. The third chapter focuses on the ethical perspective in the use of UAI, explored through a dialogue between the philosophy of technology and urban studies. This reflection is carried out by relating recent developments in the fields of AI ethics and urban ethics. Question: *through*

[2] The three articles are listed in the bibliography at the end of the introduction: Palmini & Cugurullo, 2023; 2024 and Zaffagnini & Palmini, 2022.

which ideas is it possible to make ethical reflection on urban AI more concrete and direct its reverse enveloping in this direction?

4. The fourth chapter promotes a critical examination of the current approach to the relationship between AI urbanism and sustainability, based on the juxtaposition of smart and eco-urbanism. The aim is to demonstrate how a real connection between AI urbanism and sustainability requires a fundamental rethinking of some of the pivotal categories of modernity. Question: *what are the limitations of the current relationship between urban AI and environmental sustainability*? *What principles can be used to change this relationship*?

5. The fifth chapter is divided into two parts. The aim of the first section is to define the concept of the Urban Digital Twin in relation to two urban paradigms (Smart City and AI Urbanism) and two new tools emerging in the contemporary urban context, City Brain and Deep Map. The research question is: what is the role of the Urban Digital Twin in the contemporary landscape of the relationship between digital technology and the city? The second part concerns the Bologna Digital Twin project and the ambition to build an Urban Digital Twin without the help of private companies and by putting urban knowledge production and participation at the centre. The research question is: *through which processes is the BDT project attempting to carry out a reverse enveloping of its urban digital twin*?

This articulated jigsaw of questions aims to interrogate the design culture that informs current AI urbanism. This perspective will allow a deeper insight into this new urban paradigm and, at the same time, the development of interdisciplinary conceptual tools capable of modifying its epistemology and, consequently, its application.

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CHAPTER 1

Charting AI Urbanism: Modern urbanism, Cybernetics and Smart City

1.Cultural sources of an emerging phenomenon

The research question that informs this chapter: *which concepts taken from the cultural sources of AI urbanism can be useful to actualize an indirect reverse envelopment of urban AI?*

This question aims to trace, through the methodology of conceptual analysis, some ideas present in the recognised cultural sources of AI urbanism that can favour an urbanisation of AI. That is, concepts that are useful for interpreting urban AI from a more relational and less technocentric perspective. This operation is carried out through a preliminary analysis of different literatures. This chapter is divided into two parts: the first is dedicated to three key conceptual sources of AI urbanism, and the second focuses on the materiality of urban AI. These two parts - time and space - are inserted differently in the general structure of the thesis. In fact, the first part, dedicated to conceptual sources, aims to isolate some concepts that can be used to modify the design culture of urban AI towards a non-technocentric perspective, learning from the recent history of the relationship between technology and cities. The second, on the other hand, aims to identify some critical themes through an interdisciplinary analysis of urban AI and its materiality. These themes will then be developed further in this thesis, for example ethics and sustainability.

Indeed, this chapter represents a more horizontal investigation propaedeutic to highlight issues that will be explored in depth in the next chapters. In fact, the relationship between cybernetics, AI and urbanism will be developed in Chapter 2 through references to urban modelling architectural technology. Ethics will be at the heart of the analysis in chapter three, through a comparison between AI ethics and urban ethics. The environmental sustainability of urban AI, interpreted through some of Bruno Latour's concepts, will be the main theme of chapter 4. Finally, chapter 5 is dedicated to the theoretical and case study investigation of a concrete embodiment of urban AI, namely a urban digital twin. This chapter contributes to the conceptual framework by showing how it is possible, through the methodology of conceptual analysis, to isolate concepts useful for the indirect reverse enveloping of urban AI from three of its main recognised convective sources. In terms of interdisciplinarity, this chapter draws extensively on the urban studies literature on smart and AI urbanism produced in both architecture and geography. In terms of the philosophy of technology, it mainly draws on broader studies on the philosophy of AI to highlight some specific features and implications of this technology.

Because of all these reasons charting AI urbanism here does not mean enumerating the empirical loci (cities, regions, states) where this relationship is taking place, but mapping some research trends and their conceptual sources. Charting this relationship means exploring how certain structural elements of AI may affect the way we understand the city and, also, considering how a certain interpretation of urbanity may affect the manners in which this technology is deployed. This chart is meant to be a critical conceptual tool applicable to a relationship, that between AI and the city, which contemporary debates often understand as natural, fluid, and frictionless, by highlighting its depth and problematic relevance [Figure 2].

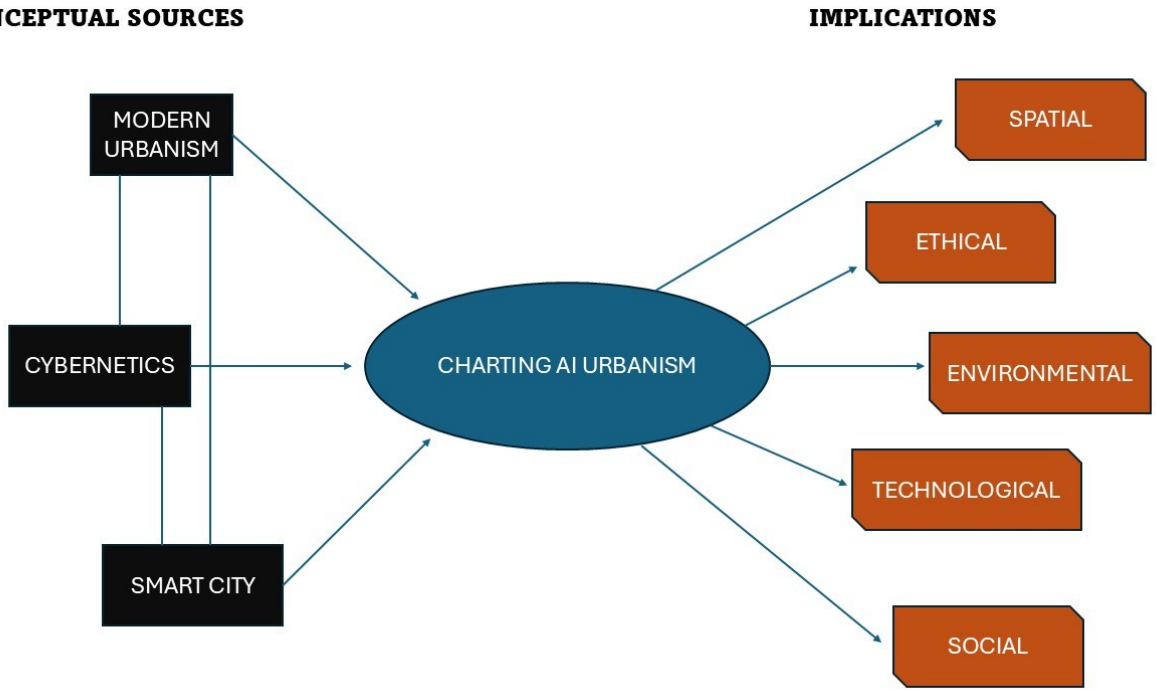

Figure 2 (Author's original). Schematic diagram of the concept of Charting AI urbanism in which conceptual sources become a key element in interpreting the implications of this urban paradigm

In the remainder of the chapter, the coordinates of this map will be time and space. Time understood as a set of theoretical models, afferent to both urban studies and philosophy of technology, that influence the relationship between AI and urbanism. The spatial coordinate, on the other hand, will concern as much an investigation of the urban materialization of AI as its influence on all those relationships among humans, the built environment and nature that constitute the flash of the urban fabric. Thus, from a temporal point of view the aim will be to comprehend how certain historically determined conceptual sources exert an influence on the relationship between AI and urbanism.

First, this relationship will be interpreted through some key features of modern urbanism. Particular attention will be devoted to the relationship between scientific knowledge and the city by pointing out continuities and discontinuities between the science of the city as conceived by modern urban planners and the one structured around Big Data and AI. A second focus will be on the role of cybernetics as a conceptual source of AI urbanism. The cybernetic theoretical framework, developed since the middle of the last century, will be interpreted as a valuable conceptual source that can clarify some aspects of the notion of autonomy that imbues the relationship between AI and cities. The section on time will complete the chart by considering the most recent model of AI urbanism, namely the smart city paradigm. Here the focus will be on the economic dynamics that have marked the rise of this paradigm and how the massive deployment of AI in the urban context can learn some lessons from the academic debate that has developed over the past fifteen years on the relationship between digital technology and urban issues. This first section devoted to providing a historical background of the relationship between AI and urbanism will be followed by one dedicated to understanding its spatial impacts. First, some characteristics of AI that make the very use of this technology spatially determined will be highlighted by connecting them to its urban incarnations, paying attention to how these can alter the contemporary urban experience. Finally, the second section on space will consider how AI is placed in relation to other urban intelligences (human and natural).

2.Time

2.1. Towards a science of the city: from modern to AI urbanism

It is well known that urbanization processes are deeply connected to technological development (Mumford, 1961). The ability to construct buildings, to develop infrastructure, to seize space from the natural world and to annex it to the urban realm are factors that can only be understood by paying close attention to the technological development of societies (Mumford, 1934). In this section I will analyse three conceptual sources of AI urbanism from the recent past [Figure 3], starting with modern urbanism.

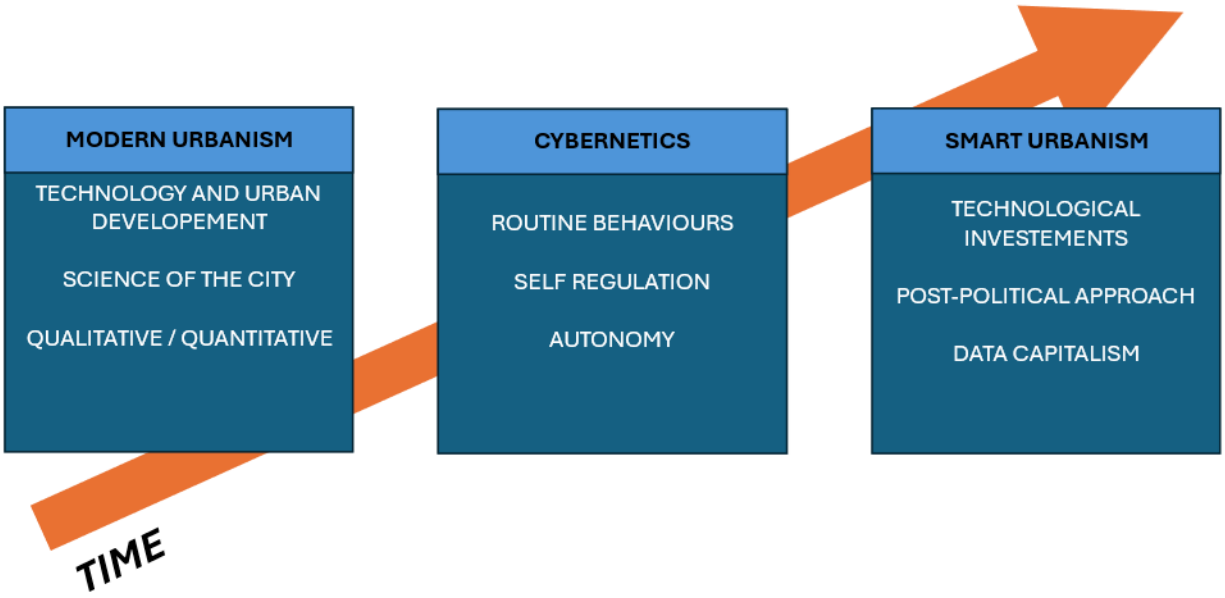

Figure 3 (Author's original). Diagram of past conceptual source of AI Urbanisms (Modern Urbanism, Cybernetics and Smart Urbanism) analysed with main themes that may be useful for interpreting AI urbanism.

In Western Modernity we have been witnessing a shift in the quantity and quality of the relationship between technology and society. The turning point that marked this decisive shift in Western cultural history and in the history of urban theory is represented by the work of Francis Bacon (1561–1626), who can be considered as a forerunner of the current understanding of the relationship between technology and society that today affects our attitude towards AI in cities (Cugurullo, 2021). Indeed, in his urban and social utopia called the *New Atlantis*, Bacon portrays science and technology as the engine driving the improvement of society. Here technology is no longer just an important factor in the urbanization process: it becomes society's governing principle and the dominant force capable of promoting human development. In his philosophy, Bacon replaces Plato's philosopher kings with a class of scientists capable of governing the urban realm and keeping it healthy, in virtue of their technical and scientific expertise. In Bacon's depiction, *New Atlantis* is considered the most functional, powerful and happy city in the world exactly because it is governed by scientists. Science and its technological applications thus become the key elements of a rational and ordered urban development. A development that is no longer based on chance or contingency, but on the certainty of a scientifically guided, rational development.

As Coeckelbergh (2022) remarks, the idea that today AI enables an objective and impartial process of decision-making that should be placed at the centre of society is nothing more than a technologically

advanced version of this century-old utopian thought. In fact, an uncritical consideration of AI could lead to the belief that, given the great availability of data and the increase in computational power, these technological tools have achieved a degree of rationality and impartiality of judgement incomparably higher than human ones.

This rhetoric was already present in the narrative about the smart city paradigm. For example, let us note how Rometty, former CEO of IBM, considered the transition from previous governance models to the smart model as a transition «from gut-feeling and impressions to knowledge» (Eren 2018), or how other top figures in the company understood this type of model as the «next logical step in governance» since it would finally be possible to have an informational completeness on urban reality. Furthermore, «It is claimed that can now be made on objective, comprehensive and rational evidence, as opposed to anecdotes, intuitions, populist promises, or partial selective and ideological evidence» (Eren 2018).

As I will illustrate in chapter 5, a very similar ideology nurtures also the City Brains model, one of the most disruptive applications of AI urbanism, which relies on the fact that AI technology is vastly superior to humans in terms of its rational and predictive power (Zhang et al. 2019) and entrusts much of the urban decision-making power to AI platforms. The rest of this dissertation will illustrate that it is imperative to move away from this techno-utopian perspective for at least three different reasons: 1) the data that feeds AI are not the reality, but representations of it, mediated by a large number of abstraction and codification processes (Benanti 2018; Kitchin 2021); 2) AI-based decision-making is anything but impartial and objective. It is as much influenced by the quality and quantity of available data as it is by the quality of the computational models, and to date many studies agree on the biased nature of these decisions (Zambonelli 2020). 3) The city does not correspond to the data that represent it, many crucial aspects of urban reality escape the quantitative-computational perspective (Mattern 2021).

Notwithstanding, this Baconian seed sprouts powerfully in 19th-century urban planning. More specifically, modern theorists understood the city as a process of turning chaos into order, by means of scientific inquiry and technological innovation (Cugurullo, 2021). Moreover, the spatiality of the modern city was then deeply informed by the scientific and technological disruptions triggered by the industrial revolution (Benevolo, 2022). Already at the origin of modern urban planning, for example in the work of Idefonso Cerdà (1815–1876), there is an aspiration for an articulate scientific approach in the urban realm (Cerdà, 1984). Statistical surveys, topographical representations and written descriptions form the basis of this new mode of investigation (Zucconi, 2022).

In this context, the need is to develop an instrument of analysis and a language as objective as possible to describe and thus intervene in the urban fabric. This desire for objectivity dialogues with scientific methods and with the technological innovations of the nineteenth century, in the attempt to establish a true science of the city. In this century characterized by the development of analytical and historical sciences, these two dimensions contribute to structuring a new objectivity for urban analysis. According to Duarte and Alvarez (2019), this nineteenth century logic is also at work in the era of Big Data and artificial intelligence. In fact, both the ability to store data through IoT systems and the power to analyse it through AI mechanisms would allow us to develop a new science of the city (Karvonen et al., 2021; Lobo et al., 2020). This would be a digital and algorithmic urban science with different methods and analytical tools than Cerdà's but one with a similar intention. This idea has been extremely influential in the history of modern and contemporary urbanism. Richard Sennett (2018), for example, considers the Athens Charter (1933) and Le Corbusier's design practice fully within this conceptual trajectory, establishing a precise relationship between technology and urban reality, using the former's ability to impose order to reduce the latter's spatial disorder.

In this contemporary model, cities become the optimal context for using artificial intelligences due to the large amount of data they express, and artificial intelligences become decisive because they provide solutions to articulated problems that are too extensive for other types of analysis. Just as statistics had been able to contribute to the objectivity of modern analysis, today the ability of AI to generate knowledge becomes decisive for a new representation or construction of urban reality (Coeckelbergh, 2022). The struggle for objectivity that characterised the nineteenth century was certainly driven, as we have seen previously, by the application of new scientific methods of analysis and technological innovations. However, quantitative analysis— inherent to statistics and topography—was then supplemented with the qualitative character of iconic written descriptions. The power and evocative capacity of Engels' descriptions or the novels by Zola and Dickens are certainly decisive for the representation of the industrial city by bringing out a missing aspect in mere statistical data. Zola's descriptions of the atmospheres created by the new organisation of space and the relationships established in it, for example, have contributed to the understanding of Haussmann's Paris. In Dickens' pages the counter-history of the industrial city takes shape bringing to light the misery, exploitation and insalubrity hidden under the veil of glittering progress. Similarly, from the descriptions of Engels, we have a glimpse of the living conditions of the urban proletariat, a new class destined to enter history in a disruptive way It is no coincidence, then, that currently in the face of the vast amount of quantitative analysis that artificial

intelligences are capable of conducting, one key issue is how to strike a balance between this quantitative approach and qualitative aspects (Duarte & Álvarez, 2019).

As Coeckelbergh (2022) claims, when it comes to political judgements (which are intrinsic to urban planning interventions) scientific knowledge is necessary but certainly not sufficient. Hence, any new AI-based science of the city should be constituted by an interdisciplinarity capable of balancing the quantitative parts with qualitative analysis. However, this dialogue must not only be conducted ex post, after quantitative analyses. It is necessary to include the qualitative dimension provided by the social sciences and humanities in the process of codification of artificial intelligences. From an ethical point of view, there are two interesting and complementary approaches: ethics by design and ethics in design (Floridi & Cabitza, 2021). The former consists of consciously embedding ethical principles within autonomous decision-making mechanisms; the latter concerns cultural training that includes ethics for technicians working on the technological design of AI. The relationship between AI and the social sciences also needs to be deepened. Indeed, the latter should not only work on the implications and consequences of the application of the former. The social sciences must be brought into the design and governance of artificial intelligences to formulate conceptual models and to reflect, already at the coding stage, on possible medium-term issues (Cohen et al., 2020).

The path to a new science of the city, capable of balancing quantitative and qualitative approaches, also involves transdisciplinarity. Not only interdisciplinarity, that is the connection between various disciplines, but also transdisciplinarity as a two-way movement between society and specialisms (Karvonen et al., 2021). The democratic involvement of society in structuring such new science will be pivotal not only as a feedback mechanism but also as a vector for identifying problems and designing solutions. This first act of charting AI urbanism via modern urbanism should stimulate us to achieve a hitherto missing balance between quantitative and qualitative urban aspects, between the algorithmic ability to give solutions and the social capacity to understand problems and shape different possibilities. Moreover, this historical perspective should warn us against a deterministic drift in the science of the city and spur us to think about a hybrid and truly multidisciplinary approach to urban development.

2.2. The seductiveness of mechanical autonomy: cybernetic sources of AI urbanism

The challenge of balancing a quantitative approach with a qualitative one is present, in a different form, at another fundamental step of the modern history of technology. In the middle of the twentieth century, starting with the seminal work by Bigelow, Rosenbleuth and Wiener in 1942, cybernetics took shape

(Heims, 1991). This discipline, based on the concepts of control, information, feedback and entropy, aims not only to explain the functioning of certain types of machines, but above all to become the common ground for interpreting the behaviour of both organisms and machines (Wiener 1965).

This new perspective is based on what Wiener calls the second industrial revolution. This new disruption does not merely involve the mechanical replacement of human physical force, as in the previous industrial revolution. What Wiener (1965) refers to is an unprecedented technological innovation that makes it possible to mechanically replace functions that have traditionally been attributed solely to the human brain. The new machines described by Wiener can communicate with their environment through sensors and correct their behaviour in relation to a purpose, through feedback mechanisms. According to cyberneticians, this scheme would be able to explain teleologically oriented patterns of action (intended as purpose-driven actions) regardless of whether these are carried out by a machine or an organism. This is because the scheme is abstract and consists of concepts, such as system, control, information, feedback, input and output, that are independent of the material composition of the acting subject (Grigenti, 2021). In fact, by means of these concepts it is possible to address a machine, a body or a city just as effectively. Following the reflections of Jonas (1999), it is possible to claim that this characteristic allows cybernetics to present itself not only as a new theory for machines, but as a unified theory of reality.

As I will illustrate also in the next chapter, cybernetics was born and developed in a historical and geographical context in which stability became the main goal for society (Barns, 2021; Heims, 1991). This new discipline provides a model of automatic regulation that is particularly attractive from this perspective. However, Wiener himself had been critical of the social application of cybernetics. In fact, he believed that the great complexity of the problems and the scarcity of data would limit the practical use of cybernetics (Wiener 1965). The subsequent technological development, in terms of the ability to acquire data and the capacity to analyse it, led to the idea of a possible cybernetization of urban reality. A reference model is certainly Jay Forrester's Urban Dynamics (1969), which, however, still suffers from a significant dissonance between an idealized technological representation and the reality of cities. Nevertheless, this theoretical-interpretative paradigm has remained the foundation of a viable connection between technology and the city. Moreover, its claims have become more realistic in the contemporary scenario marked by an increased computational power coupled with a huge capacity to acquire data (Picon & Hill, 2020).

Dwelling on the definition of urban artificial intelligences (UAIs) that I have already analysed in the introduction, it is possible to recognise the influence of cybernetic concepts on the way AI is today implemented in the urban realm: «UAIs are autonomous artefacts capable of gaining knowledge about the surrounding urban environment and making sense of acquired data, using it to act rationally according to pre-defined goals in complex situations and spaces in which some information might be missing and, above all, humans are not steering their actions» (Cugurullo, 2021, p. 159). Thus, today UAIs are machines capable of interacting with their environment and regulating their behaviour in relation to pre-defined goals, in line with the ideals theorized by cyberneticians in the past century. In fact, some scholars (urban scholars in particular) have noted a direct connection between the application of AIs in cities and the history of cybernetics (Barns, 2021; Hnilica, 2020; Mellas, 2021; Picon & Hill 2020). Two elements emerge prominently from these studies. Firstly, the interpretation of the city as a set of purpose-driven actions in the cybernetic sense, routine behaviours, which can be replicated, predicted and analysed by UAIs (Barns, 2021; Picon & Hill, 2020). Secondly, AI systems can be interpreted as mechanisms capable of coordinating and stabilising all agents present in the urban context under the same logic, which is a perspective that resonates with cybernetics as the science of control meant to harmonize predictable routine behaviours (Mellas, 2021).

However, this perspective raises some critical issues. Firstly, it should be noted that routine behaviours are indeed a core part of what happens every day in the city, but they are not everything. The urban fabric is also made up of contingencies, unpredictability and non-harmonizable relationships (Mattern, 2021). Focusing only on the former and underestimating the latter leads to a misunderstanding of urban reality that overshadows its potential for creativity and unpredictability (Barns, 2021; Sennett, 2018). Furthermore, critical urbanists have pointed out that in most cases AIs operate on the basis of datasets that refer to past actions and choices, and this can lead to an autonomous perpetuation of bias and omissions (Barns, 2021). The risk is to perpetuate discrimination and inequality, which is an already present urban issue that has been identified when AI has been applied to housing market (Rosen et al., 2021) and predictive policing (Shapiro, 2019; Tulumello & Iapaolo, 2021). In fact, in these cases, AI-enabled software agents have hidden discrimination and bias behind the rhetoric of a more rational and efficient allocation of resources. These problems result from a flawed assumption concerning the very notion of autonomous technology.

From the Philosophy of technology perspective, according to Langdon Winner (1977), a technology is autonomous if it is not controlled by something external to it. For example, a technology is not autonomous if it is controlled by human will. Winner explicitly mentions the cybernetic perspective as an

eminent framework for this conception of technology. Today this claim to autonomy returns in the age of artificial intelligences equipped with more computational and predictive power than in the 1970s (Cugurullo, 2021; Mora & Bolici, 2016). As I will demonstrate in chapter three, this autonomy of AI does not mean that this form of agency is completely independent of human labour, but rather that it possesses a highly relevant capacity to carry out actions without the supervision of human intelligence. Indeed, while it is important to emphasise that AI is the product of human labour (Crawford 2021), it is also necessary to point out that machine learning mechanisms today work much more efficiently than previous machines and in ways that are not entirely comprehensible to the human intellect (Coeckelbergh 2020).

However, as Jonas (1999) had already noted, from the very beginning cybernetic refection suffered from a confusion between machines capable of serving a purpose and machines capable of having one. According to Jonas, cybernetic machines can fulfil the former function but not the latter: the impetus for the pursuit of a purpose never comes from a necessity intrinsic to the machine but always from an input external to it. This perspective has also been reiterated in philosophy of technology with regards to AI systems (Ferraris, 2021). This kind of confusion about what purposes should be pursued also affects the use of AI in the urban fabric. Indeed, in the case of UAI, this line of reasoning risks overshadowing two things: on the one hand, the fact that a city does not have a single purpose to pursue but has several ones that emerge through discussions or conflicts between urban actors (Greenfield, 2013); on the other hand, the fact that a future in which UAIs will be able to act in an unsupervised manner could be affected by the structural problems of this technology (partiality of data, bias and discriminations) or even lead towards the end of the city as something traditionally designed by humans for humans (Cugurullo, 2021).

This second cybernetics section of our chart leads us to question the idea that the city can be interpreted as a homogeneous and discrete matter. This problematic idea conceives the city as an autonomously calculable entity, and this leads to the belief that algorithmic and autonomous decisions are devoid of partiality. This logic legitimates a utopia in which autonomous decision-making mechanisms can replace humans' planning capacity. However, as I will illustrate in the next chapter the analysis of the history of cybernetics can also be used to propose alternative models of the relationship between AI and the city. This discipline has had its own historical evolution marked by fractures and conceptual innovations that are still ongoing today (Hörl, 2013). Even if the reference to cybernetics in urban studies is often linked to the notions of control, stability and the absence of freedom, this is not a mandatory route. As I will argue in the next chapter, the search for a radical, open cybernetics that is attentive to

the dynamic connection between different intelligences instead of their forced harmonisation is still open (Contingent Collective, 2021; Fabbris, 2021; Hörl, 2013; Mellas, 2021; Scholte & Sweeting, 2022)

2.3. Smart sources of AI urbanism

As I have demonstrated in the first two sections of our charting process, the relationship between the city and technology has deep roots and it has gained new impetus from the modern age onwards (Cugurullo 2021; Zucconi, 2022). I have also observed how the emergence of cybernetics influenced this connection by generating projects aimed at the computational management of the urban context (Hnilica, 2020; Picon & Hill, 2020). However, if we refer to digital technology as we understand it today, the first reflections on its use in cities date back to the 1990s (Willis & Aurigi, 2017).

From a sociological standpoint, Castells (1996, 1997, 1998) had already pointed out in the closing years of the last century that the explosion of the network society would have important implications for urban organization. In this perspective, first of all, the flow of information redefines urban boundaries, going beyond a purely physical dimension. This interconnectedness creates a mutual interdependence between cities that are physically widely separated from each other, but that constitute nodes of financial, economic and technological relations. Moreover, Castells had already identified the existence of a virtual urbanisation, made up of digital services and spaces that integrate the physical dimension in terms of the internal space of cities. This integration had already taken on an ambiguous connotation in the 1990s, opening up great possibilities for increasing and enriching the urban experience, but also implying risks in terms of social control. From a more architectural perspective, in the same years Mitchell (1996) reflected on the role of digital space as a new dimension of the urban experience, highlighting how in the City of bits a significant part of the relationships between citizens could migrate to virtual space. From a similar perspective, Maldonado (1997) instead considered how digital technology would certainly not replace the physical component of the city, but could act as an infrastructure of infrastructures with the aim of optimising the physical dynamics of cities. However, only the rise of the smart city paradigm in the first decade of the twenty-first century marked the real turning point of the connection between digital technology and the city in terms of the amount of investments, projects and diffusion of ideas (Bria & Morozov, 2018; Söderström et al., 2014; Karvonen et al., 2019). IBM, one of the leading companies in the field, used to define a smart city on the basis of three criteria: instrumented, interconnected, intelligent (Harrison, 2010). While it is not easy to find an unambiguous definition

of smart city, it is certainly true that smart urbanism is enabled by the use of ICT to tackle and supposedly overcome a number of urban issues such as mobility, waste and energy management, governance, economic growth, participation in social life, and security (Abino et al. 2015; Coletta et al. 2018).

The rise of this paradigm and the beginning of the promotions of smart solutions by some companies has emerged in the post-crisis economic situation of the late 2000s in a context in which public administrations were struggling to invest. In this context, private companies proposed their technological tools to policy makers as solutions to the problems of waste of resources and various systematic inefficiencies within cities (IBM, 2012). Moreover, this process was accelerated by the necessity of cities to brand themselves as smart and at the cutting edge of technological innovation in order to obtain favourable loan interest rates (Bria & Morozov, 2018) and to increase their chances of accessing European or government funds (Willis & Aurigi, 2017). In this rationale of international competition between cities, the only way to go with the flow of smart urbanisation seemed to resort to private capital. According to the narrative created by the big companies that dominated the smart city market in the first decade of the century (IBM, Cisco, Siemens, for example), the urban fabric should have been understood as a system of systems that had to be made as efficient as possible through the use of ICT (Söderström et al. 2014; Kitchin, 2014). The implementation of digital technologies was presented as a technical development, without political or economic implications, towards a new era of urban liveability (Picon & Hill, 2020).

However, the other flip of the coin of this process is that the implementation of essential digital infrastructure is managed by private companies and thus legitimately driven by a desire for profit (Söderström et al. 2014; Perng & Maalsen, 2020). Furthermore, this approach to the relationship between the city and technology has been criticised by various scholars for a reductionist conception of the city (Clever et al., 2018; Greenfield, 2013; Sennett, 2018), for issues related to a lack of consideration of the social demands expressed by citizens (Trencher, 2019; Vanolo, 2016) and for the risks associated with surveillance and the possession of data (Galdon-Clavell, 2013). In fact, this post-political approach to urban development, unable to grasp changes in political and economic power relations, has paved the way for a development of the smart paradigm centred on the actions of private companies and on neoliberal economics (Allam, 2021; Söderström et al. 2014).

This logic led to a situation where vital urban infrastructure was owned by private companies and where private platforms proposed themselves as market alternatives to fundamental issues such as housing (Söderström & Mermet, 2020) and mobility (Bria & Morozov, 2018). In all these cases there

was an extraction of value from cities on the part of these companies under the banner of a politically and economically neutral technological development (Greenfield, 2013; McFarlane & Söderström, 2017; Trencher, 2019). Many of these issues are related to the possession and use of data produced in urban contexts (Galdon-Clavell, 2013). In fact, when the digital infrastructures and platforms operating in the city are privatized, the collection and use of data are inevitably available to private companies and not to communities (Shelton, et al., 2015). Understandably, given the common lack of technological infrastructure, digital literacy and investment capacity, it is very difficult for cities to do otherwise. However, one of the salient features of the case study that I will examine in Chapter 5 concerns this very point. Indeed, the Bologna Digital Twin (BDT) project aims to develop a platform for the city in three years without the use of private technology companies. The relationship with these private actors will be postponed to a later stage - aimed at ensuring the financial sustainability of the project in the medium to long term - when certain foundations of the project will already be consolidated and thus no longer negotiable. This approach aims to negotiate with the technology action not purely commercially (selling a tool), but collaboratively (investing in a project). As I will show, this approach is made possible by certain peculiarities in the composition of the project governance.

The relationship between technology companies and cities cuts across the literature on smart urbanism and is key to understanding the contemporary relationship between AI and urbanism. This ability to generate massive amounts of data makes the city a decisive component in the future evolution of AI. In this technical and economic context, the abundance of data and thus cities become crucial for companies both to create value in this phase of capitalism (Zuboff, 2019) and to boost the potential for AI development (Lee, 2018). The impact of AI on the economic dynamics of capitalism is still uncertain. However, the risks of its deployment in the context of existing neo-liberal economic discourse are already visible (Mezzadra & Neilson, 2017; Korinek & and Stiglitz, 2019): monopolistic tendencies, price discrimination, increasing preexisting social inequality (Korinek & Stiglitz, 2021), but also privacy issues, political manipulation, bias and discrimination, (self-) disciplining by data (Coeckelbergh, 2022). Under these conditions it seems difficult to ignore the problems created by the smart city paradigm and then replicated in AI urbanism.

Even outside the Western context, these issues do not lose importance. An interesting case study is Hong Kong which formalised its smart city programme in 2013 and in 2018 recognised AI as a key asset to invest in (Hong Kong Government, 2018). However, the projects related to these initiatives have proven to be fragmented and poorly connected to the social and environmental context mainly because of a lack of public regulation of private actors and the preponderance of a neoliberal approach (Cugu-

rullo, 2021). On the basis of these findings, it is crucial to develop a model for analysing the impact and economic management of AI that is capable of taking into account the altered industrial environment, the new ways of producing value and the resulting different social structure. Indeed, these elements inform the production of contemporary urban space. Harvey (2010) had already identified technology as a key force in the impact of capitalism on urban life, capable of damaging the most fragile communities through the privatization of public space and services. However, Harvey never provides a unilateral interpretation of technology, highlighting how platforms can also be a place for organizing and experimenting with urban resistance movements aimed at challenging the order imposed by capital (Harvey, 2012). By updating Lefebvre's perspective, Harvey interprets the city as a field of forces that, through organization, can gain room to operate within the capitalist reality, asserting the right of citizens to influence the organization of urban reality. A viable perspective to expand this perspective regards the concept of digital commons in the sense of data commons and the idea to make public investments to put computational power at the service of communities (Verdegem, 2022). This approach refers to the common and distributed ownership of digital assets (Birkinbine, 2018) that allows citizens to access and use data as a common good (Bria, 2018). Barns (2024) has been recently applied to AI urbanism focusing not only on the privacy implications of one's data but on alternative models of their management based on the commons paradigm. This perspective is in dialogue with the notion of data justice, which pursues the avoidance of unfair outcomes in the use of data, the focus on the creation and accessibility of data sets, and the problems of privacy and rights violations associated with the use of data (Heeks & Renken, 2018). In a broader sense this approach is referring to an update of Levebvre's famous concept of the Right to the City (1996), the idea being to involve citizens in the production of urban space through active and conscious use of digital infrastructure (Currie et. al. 2022). The importance of data in the development of AI is well known. Indeed, if cities gained more power over their data they would certainly be able to change the trajectory of technological innovations that invent their territory.

In addition to these processes, which have already been experimented in urban contexts (Bass et al. 2018; Grossman et al., 2016), investment in the education of professionals and decision-makers who are competent and aware is also pivotal. Thus, from this section of the chart it is possible to understand that the future of the relationship between AI and the city passes through a rethinking of the political economy that has informed the smart city paradigm. The narrative of a necessary connection between technological development and social welfare must be replaced by a structural analysis capable of relating specific technological solutions to the economic, social and environmental contexts of application:

stakeholder engagement and network, agility issues connected with AI agency, monopoly risk, lack of ethical frameworks for urban AIs, need for public regulation, the aspiration of an AI for social good (Yigitcanlar & Cugurullo, 2020).

3. Space

3.1. Materializing urban AI

After investigating AI urbanism through time via modern urbanism, cybernetics and the smart paradigm the next two sections focus on space. The relationship between AI urbanism and space will be drawn by examining firstly its material embodiments and secondly its influence on the intangible relationships that innervate the urban fabric [Figure 4].

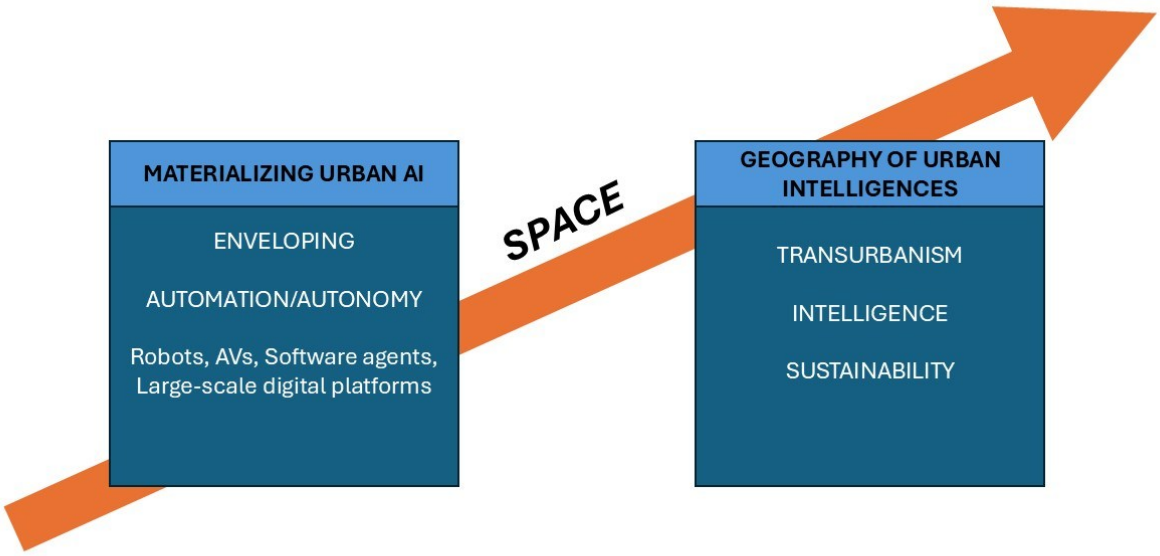

Figure 4 (Author's original) Diagram of the relationships between Urban AI and the material and immaterial space of the city with related key themes.

Substantial technological transformations have always had a major impact on the organization of urban space (Graham & Marvin, 2002; Mumford, 1961). Cities' economies, the built environment, and urban social relations themselves have often been reshaped in relation to technological shifts (Mattern, 2017). This aspect was particularly evident in industrial modernity and its spatial unfolding in the first half of the last century (Benevolo, 2022). Certainly, the digital revolution has triggered a disruptive change affecting multiple spheres of our experience (Floridi, 2014). However, especially in the passage from

the 20th to the 21st century, the supposedly immaterial nature of information technologies seemed to undermine the material impact of this particular technological disruption. This has led to the interpretation of a new, light and fluid modernity that has had in Bauman (2013) its most eminent theorist. Despite their pervasiveness, ICTs did not have a significant material impact on cities at least until the beginning of the new century (Hall, 2002), thereby justifying some interpretations regarding the possible disappearance of the material centrality of the city in the age of interconnected economies and digital space (Pascal, 1987; Pawley, 1995).

However, as early as 1996 in *City of Bits*, a landmark book for digital urban studies, a tension emerged between immateriality and materiality in the digital hybridization of the city (Mitchell, 1996). While Mitchell highlighted a potential digital despatialization, he was already thinking about how to interface physical and digital space by indicating a new and promising way forward for urban design. This relationship was also addressed by Tomas Maldonado (1997) who, in focusing on the infrastructural role of digital technologies, hypothesised a symbiotic relationship between the physical and the digital. A relationship in which the physical infrastructure would be managed, monitored and extended by the power of the digital technology. Thus, as early as the 1990s, reflections on the relationship between technology and the city challenged the idea of digital technology as an immaterial world without consequences for physical reality. The concepts of hybridisation and the infrastructural power of the digital already address the problematic integration between real and virtual space, paving the way for many of the issues I will discuss in this paper such as ethical and ecological urban interactions.

This tension between the materiality and immateriality of digital technology also marks the contemporary AI debate: AI certainly constitutes a radical technology capable of pervasive insertion into our everyday experience (Greenfield, 2017); moreover, it is possible to chart a material atlas of the fabrication and concrete implications of this technology (Crawford, 2021). Even though the allusion to intelligence enhances the perception of immateriality and lightness, the concept of artificial points to something manufactured, to a material assemblage and, ultimately, to something transformed through labour into an artefact. This tension is even stronger when it comes to UAI (Bratton, 2021; Cugurullo, 2020). In this context, recent empirical studies highlight a materiality that is difficult to underestimate. An extensive body of literature on urban robots (Mintrom et al. 2022; Tiddi et al. 2020), autonomous vehicles (Dooling & McGuirk, 2020, Brovarone, et al. 2021; Cugurullo, 2023), and software agents (Shapiro, 2019) exposes specific material embodiments of this technology, strongly rejecting the perception of immateriality. For example, Valdez, Cook and Potter (2024) describe small autonomous vehicles that have been used to transport groceries in Milton Keynes (UK). This type of urban AI can carry 10kg at a

maximum speed of 6km/h and navigate the urban fabric autonomously. Lynch and Del Casino (2024) analyse the role of algorithms capable of estimating the value of homes, such as Zillow, which have had a disruptive effect on the property market, particularly in the United States. Cugurullo and Xu (2024) describe a city brain in Haidian district in Beijing. This large-scale platform consists of 14,000 CCCV cameras, 20,000 sensors and a large data centre. All the information collected is processed in digital clouds and physical data centres to provide predictions on a wide range of urban phenomena such as environmental risk management, traffic management and public security. These new artificially intelligent urban actors come in contact with our urban existences in different ways, thus raising the issue of regulating interactions that can safeguard their functioning but also our liveability.

Moreover, it is necessary to consider another spatial characteristic of AI. Philosopher Luciano Floridi (Floridi, 2014; 2019; 2022) argues that the increasing efficiency of AI is due to a specific spatial action. In fact, the recent successes of AI systems not only depend on an increased technical performance that enables a better understanding of the world, but also on the actions that we undertake to make reality more intelligible to these systems. Floridi refers to this feature as enveloping. In this kind of reshaped spaces an AI is facilitated to gain information and act rationally and effectively. This process of AI spatialization establishes a necessary connection between AI functioning and spatial modification, thereby contributing to a material interpretation of this technology. When it comes to UAIs, the modes of this spatialization are the decisive background for a fundamental difference between automated and autonomous technologies.

Automated technologies are enveloped in a space entirely dedicated to their action: a simple space not shared with humans or with anything that might perturb machines' functionality; in contrast, autonomous technologies act in complex spaces, shared with other forms of intelligences (Cugurullo, 2021). The envelope of automated technologies can be entirely designed according to the functional requirements of the machine. The designer has to focus only on increasing the efficiency of the system through a topography capable of maximizing its potential. The case of autonomous technology is quite different: technological envelopment must deal with other forms of independent agency (humans in particular). These actors have their own and specific purposes, which are not limited to maximizing the efficiency of the technical system.

Take for example the case of an AV supposed to operate in a common urban street. Certainly, the designer will adapt the space to the requirements of the AV. However, this is not the only form of agency occurring in an urban street: pedestrians, cyclists, shopkeepers and plants are also decisive elements of

this environment. These are just some of the potential actors whose agency is obviously unrelated to the efficiency of the action of AVs. Thus, the design of the spaces in which autonomous technologies are embedded cannot be limited to technological efficiency; it must consider a significant amount of variables and make precise design choices to address the problems of coordination among multiple urban actors (Robbins, 2020). These are common issues in urban experiments where small parts of cities, or entire urban areas, are used as testbeds for the implementation of UAI. It has been rightly argued that the problems to be addressed in these spaces are not only technological, since they also concern the physical composition of space, the geography of relationships between actors, governance, legal aspects related to the use of new technologies, and the ethical issues due to the interplay between different forms of agency (While et al., 2021).

Recent technical breakthroughs in AI have made it smoother for these systems to operate out of confined and restricted spaces (Sejnowski, 2018), by facilitating the transition from automated to autonomous UAIs. The increasing use of robots in the urban context is triggering a new direction of research on Robot City Interaction (RCI) that considers the possibilities of interaction between different types of robots and certain dimensions of the urban experience (Tiddi et al. 2020); human–robot interaction (HRI) in public spaces, taking into account the trust that these agents should inspire in citizens, the integration of robots into the actual design of public spaces, and finally the equal distribution of the value generated by these agents (Mintrom et al. 2022; Sumartojo et al., 2022). Research on AVs has also been investigating the relationship between human agency and AI systems by focusing on the possible uses arising from the encounter of these two forms of agency. For example, this is the case of how the use of the new space within AVs may affect the relationship between labour and non-labour time (McCarroll & Cugurullo, 2022). Finally, the increasing use of drones has also been investigated in urban studies with a focus on the risks of widespread surveillance and governmentality of common spaces (Jackman & Brickell, 2022).

Based on the first spatial section of the chart, it is possible to draw the conclusion that AI, like many other disruptive technologies, has an extensive material component. When it comes to UAI, this materiality is particularly evident in enveloping processes and in the multitude of embodiments through which AI systems acquire their own agency in the urban fabric. This undeniable impact on urban space means that we must consider UAI not simply from a technological perspective. Designing spaces just for the sake of increasing the efficiency of technological systems is already difficult in the case of automated devices, and it is certainly harmful when it comes to autonomous ones. I argue that teasing out the materiality of UAI and its possible implications for urban spaces is key to properly set up the debate

on its integration into everyday urban experiences. Conversely, treating UAI as an immaterial technology can only lead to a socially and environmentally detrimental design. Indeed, as I will argue in chapters 3 and 4, the role of design is fundamental to situating urban AI within the ethical and environmental contexts of our cities. From an ecological point of view, recognising the materiality of these objects is crucial to weighing up their costs in terms of production against their potential to actually increase overall urban sustainability. From an ethical point of view, the presence of these new forms of agency must follow specific design rules in order to be integrated into urban spaces. In Chapter 3, I will propose a connection between two perspectives from technological and urban design, respectively design justice and design disorder. The first perspective aims to situate urban AI design as much as possible within the needs of the community that will be affected by this agency, while the second focuses on the need to leave margins of indeterminacy in the design in order to encourage a multiplicity of uses, even by different communities. In chapter three I will show how the combination of these seemingly contradictory principles can structure design options that can be applied to different urban situations.

3.2. The (urban) geography of relational intelligences

The spatial impact of AI on the urban fabric does not only involve material spaces. As I have discussed in the previous section, it is certainly relevant to consider the material impact of this technology. However, it is also worthy to inquire how UAI may affect urban space from a relational perspective. That is, the quality and number of intangible relationships between urban agents that contribute to structuring the flows of knowledge and practices that characterize a specific urban realm. In other words, the impact of AI is perceptible not only on the *ville*—the physical components of the city—but also on the *cité*, that is the way inhabitants experience urban space (Sennett, 2018).

AI is often understood as a form of intelligence that rationalizes the interaction between different agents in the urban context (Bratton 2021). Indeed, in different spheres of urban life, which can be considered as socio-technical assemblages of interactions, AI interventions are intended as ordering and efficiency-bringing. This is because AI skills are considered to be superior to human ones and capable, therefore, of establishing greater rational efficiency. This relational preponderance through which AI is interpreted is based on a precise theoretical framework. Indeed, building on the notion of transhumanism (Bostrom, 2008)—the possibility of going beyond human limits and abilities through technology—this approach to the city has been called transurbanism (Cugurullo, 2021). This approach promotes AI technology as a solution framework for urban questions, while overshadowing other intelligences (hu-

man and non-human) acting in the urban context. This perspective is based on a moot assumption: namely, that artificial and human intelligences are comparable and that, for this reason, one can quantitatively or qualitatively surpass the other. As I will elaborate in Chapter 5, this perspective decisively informs the City Brain, which is particularly relevant in the Asian context (Zhang et al. 2019). This AI-enabled platform is designed to manage parts of cities or entire urban contexts by collecting and analysing data with the aim of autonomously predicting and solving urban problems. This powerful tool is precisely described as intelligence that outperforms human intelligence and is therefore necessary today for urban contexts that are increasingly complex and therefore unmanageable for a limited intelligence such as the biological one (Zhang et al. 2019).

Notwithstanding, it has been pointed out that there is limited theorization on the concept of intelligence involved in the notion of AI, especially in urban studies (Lynch & Del Casino, 2020). The supposed intelligence attributed to AI is based on a cognitivist interpretation that is questioned within the psychological debates themselves as a model for interpreting human intelligence (Lynch & Del Casino, 2020). In addition, sociologists and philosophers of technology have been strongly questioning, even from different standpoints, the notion of intelligence as an appropriate metaphor to understand the powerful output-giving skills inherent in AIs (Esposito, 2022; Floridi, 2022). According to Floridi (2022), for example, AI's recent successes are not based on the growth of intelligence, but on a divorce between the ability to perform complicated tasks and the need to be intelligent to do so. AIs then should be understood as new effective forms of agency, not intelligences. Also, according to communication sociologist Elena Esposito (2022), the recent triumphs of AI are not motivated by the pursuit of intelligence. Indeed, programmers in their daily work neither aim to mimic human intelligence nor to build machines that can surpass it, but they rather target specific problem-solving techniques. Through this perspective, AIs have become important communicative partners for humans even in the absence of any kind of intelligence. In both cases, regardless of the differences in approach, AI is considered not as an intelligence but as an entity (agent or communicative partner) with which to relate but unable to surpass or be comparable with human intelligence.

However, in the urban context the technocentric view has led to considering AI as the only or predominant intelligence in the urban future (Lynch & Del Casino, 2020). This perspective grounds urban development on the quality and quantity of technological advancement (Cugurullo, 2021). The more technology is pervasive and capable of effective agency, the more urban development will follow a desirable and rational direction. AI urbanism seems to suffer from a misrecognition of the various forms of intelligence already present (the series of already established interactions among humans, the natural

and the built environment) in urban systems, by rarely taking into account the ways in which UAIs might relate to these in a nonreductive way (Bratton, 2021). A very promising perspective to overcome this technocentric approach is certainly to consider the city as a process whose rhythm is marked by the relations between different forms of agency (Farías & Bender, 2009; Farìas, 2011). This perspective instead of hierarchically reducing urban actors invites the tracking of social-technical-natural assemblages through an operation in continuity with the mapping proposed by the present paper. Assemblage theory focuses on the variegated composition of urban entities paying attention to the practices and networks in which they are situated (Farìas, 2011).

Following this path would be as useful from both a theoretical and practical perspective (Farías & Bender, 2009). Indeed, from a theoretical point of view, technological reductionism would be avoided, and from a planning perspective projects could be based on a comprehensive knowledge of the relationships in which they should be embedded. One example of this misrecognition and technocentric approach concerns urban sustainability that will be addressed in the fourth chapter of this dissertation. The reflection on this topic has very different conceptual sources in comparison to the technocentric perspective that informs the discourse on smartness and AI urbanism, and today there is a debate regarding the relationship between these two visions of the urban (Ahvenniemi, 2016; Haupt, 2021; Yigitcanlar & Cugurullo, 2020). Focusing our attention on AI, we can see how, on the one hand, this technology is referred to as a decisive tool for achieving sustainability. On the other hand, its very implementation and use are interpreted as serious threats for a sustainable vision of human development. Admittedly, AI can be crucial to the efficiency of various types of systems and toward a reduction of squander and an optimization of energy trade-offs. From an urban point of view, for example, we can refer as much to waste as to water or electricity management, all the way to traffic flow management. Furthermore, the predictive capabilities of this technology can help city managers to cope with extreme weather events and reduce industrial and agricultural emissions (Coeckelbergh, 2021).

However, the link between AI and sustainability is not so peaceful. In fact, the material production of these technologies involves mining critical raw materials (Crawford, 2021); in addition, data processing and data storage are certainly not ecologically neutral (Coeckelbergh, 2022); finally recent studies are quantitatively emphasizing the considerable amount of emissions caused by the training of machine learning systems (Van Wynsberghe, 2021). These elements make it difficult to conceive the connection between AI and sustainability in a linear and streamlined way (Dauvergne, 2022). An AI for sustainability that uses this technology to achieve sustainable goals needs to be coupled with a sustainable AI approach that can deal with emissions and ecological issues related to the entire life and production cy-

cle of this technology (Van Wynsberghe, 2021). Based on the above, it would be unwise to assume that an urbanism based primarily on increasing the capacity of UAI can in itself steer urban development toward sustainable goals. Recent efforts in the philosophy of technology and AI ethics to build frameworks that can hold AI and sustainability together witness a complicated nexus (Coeckelbergh, 2021; Van Wynsberghe, 2021)

The simple equation more technology equals more sustainability is fallacious. Indeed, a decisive theme in the literature on urban sustainability concerns the notion of balance. Steering urban development toward sustainability requires a balanced relationship between the technological component and the other components that inform the urban fabric (social, environmental, and economic issues) (Haupt, 2021). The technocentric urban equation appears unbalanced and therefore ineffective when it comes to sustainability. Certainly, UAIs can be used to achieve economic, environmental and social, sustainability goals (Yigitcanlar & Cugurullo, 2020), however as we have seen, a purely technological approach is insufficient, and AI can thus become an obstacle instead of a means to achieve sustainability. The technocentric perspective is not capable of balancing the various urban elements. AI is conceived as the predominant urban intelligence, capable of ordering and rationalizing all other components (Bratton, 2021). These components are not understood as intelligences, different from the artificial one, and capable of influencing its functioning and also thus giving direction to urban development.

This last section of our charting process represents and invitation to question and change the technocentric theoretical paradigm of AI implementation. This shift in perspective appears necessary to bring AI urbanism and sustainable urbanism together in the near future. A more promising theoretical framework seems to be that of the city understood as an ecology of intelligences, that is a paradigm supposed to interlink the various forms of urban agency and study their articulated relationships instead of attempting to reduce them all to the computational language of AI systems (Lynch & Del Casino, 2020). In this way, the application of UAIs must be calibrated against the needs of a specific set of urban agents and not deemed beneficial and necessary in every case. This perhaps more crafted and empirical approach capable of evaluating the pros and cons of UAI on a case-by-case basis, will only be made possible by questioning the technocentric paradigm. A sustainable approach to urban development in the digital age requires an ecological approach to the problem of urban intelligences, which can then guide the future of urban design.

4.Conclusion

This preliminary charting makes it possible to answer the research question that has guided this chapter, as well as to introduce some themes that will be the focus of the following chapters. The first part of the mapping, concerning time, allows us to answer the research question, while the second, concerning space, opens up connections that will be developed in the following chapters.

Research question chapter 1: *Which concepts taken from the cultural sources of AI urbanism can be useful to actualize an indirect reverse envelopment of urban AI*?

This is the question that this chapter seeks to answer. In doing so, three fundamental aspects emerge from the examination of three different conceptual sources: modern urban planning, cybernetics, and smart cities. The first source highlights that the idea of using science in the city has its roots at the dawn of Western modernity, specifically in the thought of Francis Bacon and his urban utopia, The New Atlantis. The main idea of this perspective concerns the possibility of tackling urban problems with a scientific and objective approach that can be maximally effective thanks to the power of calculation. The development of modern urban planning shows how this philosophical idea was consolidated in the 19th century through the urban use of new tools such as statistics, topography and photography. This scientific vision of the city continued, not without changes, throughout the 20th century and has come to define the relationship between cities and digital technology in the era of AI urbanism, where the availability of data and computing power are the new forces capable of ensuring the objectivity and effectiveness of urban planning. However, it has been shown that even the science of the city proposed at the beginning of modern urban planning was enriched by qualitative elements, such as narratives, newspaper articles, and written accounts that captured those aspects of urban life that did not fall within quantitative calculation. The science of the city was thus partly holistic, bringing qualitative and quantitative aspects into dialogue. This dialogue seems to have been interrupted in the era of AI urbanism, where the great quantitative power of calculation seems to leave little room for other approaches. However, as I will show in various parts of this thesis, a technocentric, purely quantitative approach risks obscuring fundamental aspects of the urban experience by reducing its complexity. The first concept that emerges from the conceptual sources is therefore that of regaining the balance between quality and quantity, not only by using a qualitative approach to consider the implications of urban AI, but also by introducing this perspective into the contemporary vision of the city and into the design of this new urban technology. The ethics by design and in design approaches aim to address the contamination of different knowledge at each stage of technological development. In addition, the consideration of socio-

logical aspects related to the use of technology could certainly increase the effectiveness of predictions related to the impact of urban AI in urban contexts (Coutard & Guy, 2007; Stilgoe, 2018; Tennant & Stilgoe, 2021). Finally, the transition from interdisciplinarity to transdisciplinary would favour the involvement of society and thus democratic control over technological development (Karvonen et al., 2021).

The second source is cybernetics, an interdisciplinary perspective that developed after World War II and based on the concepts of information, feedback, and control. This perspective has been identified by various studies as the conceptual source of the contemporary relationship between digital technology and the city (Barns, 2021; Hnilica, 2020; Mellas, 2021; Picon & Hill 2020). The analysis of this conceptual source must be aware of two fundamental risks: a) considering the city as a calculable entity, b) thinking that the city can be generated exclusively by machines with an increasing degree of autonomy. In this chapter, I have shown that both of these statements are fallacious, and that the modern dream of an autonomous machine capable of ruling society in an objective way must remain just that, given, for example, the biases that characterize the functioning of AI. This second source thus problematises the idea of the autonomy of urban AI. Furthermore, this investigation opens the field for a different consideration of the relationship between cybernetics and urban studies, which will be developed in chapter 2.

Finally, the smart city paradigm is analysed as the closest conceptual source of urban AI, particularly in relation to the relationship between private technology companies and municipalities. The recent history of the smart city shows how a set of technology companies has gained enormous influence over our urban life by privatizing public assets, making their digital capabilities indispensable to cities, and appropriating the management and ownership of the data generated in cities. This situation of power imbalance between public and private could also be replicated in the context of AI urbanism, as AI seems to follow very similar oligopolistic development dynamics to those observed in the smart city paradigm. In this case, then, it is the relationship between municipalities and private companies that is problematised. A different formulation of this relationship, as I will show in chapter 5, is at the centre of the Bologna Digital Twin project.

These three concepts - a different balance between qualitative and quantitative, a critique of AI autonomy, and a critique of the public-private relationship - emerged from the study of three conceptual sources. These concepts can be useful for the reverse enveloping of Urban AI by cities, because taking them into account would modify the design and implementation of Urban AI, moving it away from a

technocentric perspective. In this case, therefore, the recent history of technologically driven urbanism becomes the source of an indirect reverse enveloping in which some themes can be reactivated and serve as conceptual tools for modifying the contemporary relationship between AI and cities.

In the second part of the mapping, two aspects were considered that will guide the research in the following chapters. The first relates to the materiality of AI. Indeed, through the concepts of enveloping and highlighting the material incarnations of AI urbanism, it was shown how an immaterial interpretation of the digital revolution is not useful in the context of this analysis. Indeed, it is only by considering the material impact of this technology that it becomes possible to realize how problematic it is, for example, to argue for its uncritical application with the aim of environmental sustainability, as will be shown in Chapter 4 (Coeckelbergh, 2021; Van Wynsberghe, 2021; Van Wynsberghe et al. 2022). Moreover, the very fact that in AI urbanism the city is populated by forms of artificial agency raises new and profound ethical questions, as I will show in chapter three. This misunderstood materiality is linked to a view of the technology as intelligent. Again, it has been shown how fallacious this view is and how it can lead to an underestimation of the biological intelligences that already populate the urban fabric (Coeckelbergh, 2020; Esposito, 2022; Floridi, 2014; Floridi; 2022). Again, chapters 3 and 4 can be seen as developing this position from an ethical and environmental perspective.

In conclusion, like any chart the one shaped in these pages is a tool in the hands of those who will use it. Such tool allowed us to interrogate the relationship between AI and urbanism by raising a number of crucial questions for the future of its development. However, like all maps, this one does not exhaust the object it represents, and the paths indicated here can be followed, redeveloped or even challenged to further advance our understanding of AI urbanism. Situating the relationship between AI and urbanism within various cultures in order to understand their potentials and risks is an urgent task today if our goal is to transform mere technological development into a really sustainable urban innovation. The remainder of this thesis can be seen as a development of this map as early as the next chapter in which the cybernetic conceptual source will be further explored by opening up its use not directed to a merely technocentric perspective in the era of AI urbanism.

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Chapter 2

Cybernetic Chronicles: Urban modelling and architectural technology as sources for AI urbanism

1.Cybernetics as a source

As I have shown in the previous chapter, cybernetics can be traced back as one of conceptual origins of AI urbanism, by looking at the very definition of Urban Artificial Intelligence (UAI). Indeed, by definition (Cugurullo, 2021; Bratton, 2021) an UAI is an autonomous artefact, capable of acquiring information and acting according to pre-defined purposes in complex environments. This rationale is certainly reminiscent of the cybernetic idea of a machine capable of self-regulating its own behaviour, since it has an active relationship with its environment. Furthermore, I have illustrated how this cybernetic conception of the city in the era of AI urbanism carries risks: first, the idea of interpreting the city as a series of predictable and algorithmically harmonizable routine behaviours (Barns, 2021); second, the belief that the city can be interpreted as a machine with a single purpose (Greenfield, 2017).

These two risks, combined with a lack of awareness of the bias of AI's decision-making capacity (Coeckelbergh, 2022), could lead to a technocentric vision of the city. On the one hand, this perspective fails to take into account a whole range of fundamental elements of the urban experience that cannot be reduced to data and analysed algorithmically (Mattern, 2021). On the other hand, it hides the fact that the purposes that regulate urban life are not unambiguous and determinable by technology, but multifaceted and determined by the dynamics of urban politics (Greenfield, 2013).

This is the research question of this chapter: *What issues from the relationship between cybernetics, architecture and urbanism can guide the reverse envelopment of urban AI?*

This question contributes to the conceptual framework by exploring the role of cybernetic thought as a source of AI urbanism through the analysis of two moments in which this paradigm has inspired urban planning and architectural practice. This analysis will bring to light some useful concepts in the indirect reverse enveloping of urban AI. These concepts are particularly interesting for this thesis because they will not emerge from histories and traditions against the use of technology in urban planning and architecture. On the contrary, these ideas will emerge from those who have supported this approach. This demonstrates how the history of technologically driven urbanism is not simply flattened into a technocentric perspective, but can be used as a living subject to overcome simplistic visions and reductionist

interpretations of AI urbanism. Philosophically this chapter draws on the literature of cybernetics and some of its contemporary developments. In the field of urban studies, the chapter is based on the literature on the history of urban modelling in the US and the UK in the second half of the last century, and on the activity of a research group in architectural technology active in Italy in the 1970s and 80s. Finally, the contemporary literature on AI urbanism has been used to understand the current repercussions of the conceptual paradigms analysed.

The contemporary debate on the relationship between cybernetics and design is situated in a new technological background characterized by the exponential increase in computational power, the decreasing dimension of devices, and the new data collection and sharing possibilities opened up by internet of things (IoT) (Floridi, 2014). These developments have certainly fostered experiences of collaborative design and interdisciplinary thinking; however, they have also highlighted the risk of technologically deterministic and self-referential approaches (Giallocosta, 2011). Current considerations on cybernetics in architecture and urban planning can be defined as neocybernetics not due to a theoretical modification, but because of its implementation in a changed technological background. This approach seems to be divided into two opposite positions: on the one hand, cybernetics as a science of control capable of harmonizing technology, nature and society; on the other hand, cybernetics as a theoretical justification for a society of ubiquitous control and preservation of the *status quo* (Contingent Collective, 2021).

In this chapter, I will discuss how cybernetics has been considered as the conceptual source of the contemporary relationship between digital technology and the city, highlighting how this lineage very often ends up being interpreted in a dualistic way. Indeed, cybernetics is perceived by many as a source of the desire to control the city, and by others as an epistemology that can finally guarantee a holistic approach to urban studies (Picon, 2015; Ratti & Belleri, 2021). The main objective of this chapter is to demonstrate that the relationship between cybernetics and AI urbanism can be developed in a more articulated manner by looking concretely at some of the episodes in the history of the relationship between technology and the city.

To this end, the chapter highlights two historical moments in which cybernetics was understood as a theory of reality useful for urban planning and architecture. The first episode regards urban modelling, with reference to the US and UK contexts. Here the focus will be on the optimistic period of the 1960s and then on a paradigm shift triggered by some critical perspectives that emerged in the 1970s. This reconstruction will look at cybernetics as a model of urban management, focusing on the fact that cer-

tain epistemological modifications in systems theory have led to different approaches to the science of the city, which cannot be interpreted as a univocal discipline.

The second episode concerns the Italian context of the 1970s, particularly with regard to architectural technology. Here the focus will be on the work of a research group that was particularly attentive to cybernetic culture, implementing it as a theoretical model to promote the modernisation of Italian industrial culture. In this context the difference between first-order and second-order cybernetics denotes a critical approach to technological innovation that allows a cooperative relationship to emerge between quantitative and qualitative approaches and a relevant space for the ethical dimension.

Ultimately, remarkable insights will be extracted from these two inquiries for the contemporary debate on AI urbanism, which can testify to the potential richness and usefulness in terms of design culture of an interdisciplinary consideration of cybernetic oriented urban studies.

2. A contested legacy

The idea of considering cybernetics as a conceptual source in urban studies is not a novelty exclusive to the discourse on AI urbanism. Indeed, it is embedded in the tradition of critical reflection on technologically driven urbanism. As I argued in the previous chapter, this tradition has its roots in the birth of modern urbanism and the idea of producing a science of the city capable of addressing urban reality with a rigorous and predominantly quantitative approach. The idea of a mathematisation of the urban experience lies at the heart of the science of the city that characterises technologically driven urbanism (Kitchin, 2016). A perspective in which mathematical language is understood to be the privileged key to grasp urban dynamics. The collection of quantitative data, the construction of mathematical models and the mathematical analysis of data represent the fundamental steps of this epistemology, which has developed in the recent history of urban planning in line with the mathematical tools available. As I have shown, statistical analysis was crucial to the birth of urbanism in the nineteenth century (Zucconi, 2022), cybernetic epistemology dominated urban modelling after the Second World War (Picon & Hill 2020), and the digital revolution has opened new frontiers in the possibility of quantitative interpretation of the city. Following Picon and Hill:

> What distinguish each of the three historical moments we discuss here [Modern Urbanism, Cybernetics and Digital Revolution] is a significant expansion in the features of urban life that can be measured: and correspondingly, an intense development of new mathematical methods for analysing and studying the relationships between these newly measurable quantities (Picon & Hill 2020, p. 30).

According to Hnilica (2020), cybernetic epistemology has played a key role in the development of ways of understanding the city. Indeed, from this perspective, the city is no longer seen simply as a machine, a set of interconnected and coordinated gears, but as an intelligent machine, namely an artefact capable of understanding its environment and adapting its behaviour. This difference echoes the distinction made by the cyberneticist Norbert Wiener (1965) between a first industrial revolution, which mechanically replaced and augmented human physical strength, and a second revolution, the cybernetic one, which sought to artificially replace the capacities traditionally attributed to the human mind, namely intelligence. This reference to intelligence immediately points to another source of AI urbanism, which I analysed in the previous chapter, and which has emerged as the first urban incarnation of the digital revolution, namely the smart city paradigm. As already illustrated in Chapter 1, and as will be further explored in Chapter 4, the smart city relies on the use of ICTs in the urban context to address and hopefully solve a wide range of urban problems (Willis & Aurigi, 2017).

According to Townsend (2013), the smart city represents the contemporary development of a trend in technologically driven urbanism that has a founding moment in cybernetics. Indeed, he argued that leading companies in the field of smart urbanism, such as IBM, have re-actualised the cybernetic dream of a mathematical model for understanding the city, developed since the 1950s, in the socio-technical context of the digital revolution. Townsend (2013) interprets the smart city as a new version of Jay Forrester's *Urban Dynamics* (1969) and as an heir to the tradition of urban modelling that I will discuss in this chapter:

> The year 2011 witnessed cybernetics redux when IBM resurrected urban dynamics and installed it in Portland. While the simulation efforts of the 1960s had to cope with severely limited computers and data-collection capabilities, with virtually limitless processing power and vast stories of digitalised data at its disposal, IBM developed a computer model of Portland that dwarfed Forrester's (Townsand, 2013, p. 82).

It seems clear that this perspective runs the risk of radically reducing the urban experience to quantitative parameters, and even in a technological context such as the digital revolution, this approach can underestimate crucial aspects of understanding urban reality. However, cybernetics has met two opposite fates in the subsequent development of the debate on the smart city, which has influenced that on AI urbanism.

A first trend concerns what Antoine Picon has defined as the «neo-cybernetic temptation». According to Picon (2015), this perspective is based on the reductionist essence of early cyberneticians, who understood, for example, the human brain as a machine with discrete states, similar to a computer. The urban version of this mentality would understand the city as a cybernetic machine that operates with a strong reduction of complexity in order to achieve greater efficiency in certain parameters. This ten-

dency, according to Picon (2015), runs through urban studies of the last century, tracing a continuity between the reflections on urban modelling of the 1950s and 1960s and the control rooms that characterised the beginning of the history of smart cities, such as the one developed in Rio de Janeiro in 2010.

Following Picon: «When it reigns unchallenged, the neo-cybernetic temptation is founded on an exaggeratedly simplified approach to the city» (Picon 2015, p. 77). In this case, the risks do not relate to a particular technology, but to an underlying mentality that understands the city as an entity that can be fully represented quantitatively and thus algorithmically controlled. In the digital revolution, therefore, the cybernetic dream has developed quantitatively and qualitatively: the possibility of reducing the city to a set of data has greatly increased, and the belief that it can be managed autonomously by technology has been fostered: «The assumption that seems to underlie many of these smart city approaches today is that our models do not simply approximate reality […] they are in fact numerical reflection of reality» (Picon & Hill 2020, p. 40).

However, there is also an interpretation that is the opposite of this. Indeed, cybernetics has been also considered as a common ground wherein to optimize the relationship between artificial and natural environments:

> The new ecology incorporates the traditional feedback mechanisms of natural systems – from plant growth to insect migration – but moreover, it harnesses the power of the digital world to extend them into the Anthropocene. Ecosystems only function when every element is responsive to the rest, and digital sensors, actuators, and artificial intelligence can contribute to achieving that objective (Ratti and Belleri, 2021, p. 18).

In this perspective, AI and IoT are used to animate the built environment, making it responsive and connected to the human and non-human context in which it is immersed. In this case, cybernetics is understood as a common ground able to connect the natural and the artificial, interpreting both through the concepts of system, information and feedback. Here, the idea of total coordination achieved through the cybernetic paradigm seems to be in the process of being realised through the technological advances that have marked the various stages of the digital revolution from the end of the Second World War to the present day.

Both perspectives demonstrate that cybernetics remains an important reference in the debate on the relationship between digital technology and the city nowadays. Whether one understands this relationship as the contemporary version of a total technocratic control over the city or as a new possibility for harmonious coordination between nature and the artificial, the cybernetic background remains a pivotal conceptual framework. However, in both cases cybernetics has been considered as a compact framework that should be rejected or adopted. From this point of view, it seems that the only possible critique

of the cybernetic model is from the outside, that is, by negating it, which would re-establish a tension that has been present throughout the history of urbanism:

> On the one hand, there is what could be called a "romanticist" view, a belief in the city as a fundamentally beyond the powers of human comprehension and thus best apprehended through qualitative means. Opposite this is a quantitative tradition committed to the belief that the structures, patterns, and dynamics of cities can be reduced to numbers (Picon & Hill 2020, p. 29).

In the next two sections of this chapter, I will examine two examples that do not adhere to this clear opposition, but which develop a critical and original perspective on the relationship between quantitative and qualitative approaches, also following the same internal developments in cybernetic thinking. The first example concerns the history of urban modelling, mainly in the US, where this discipline, which is certainly characterised by a quantitative approach, has developed certain paradigm shifts that are useful for interpreting more clearly the relationship between cybernetics and the science of the city. The second example concerns the Italian context of the 1970s and 1980s, in which a group of architects and planners developed a peculiar and critical relationship with the cybernetic paradigm, reflecting on the role of the architect in the information society. The first example has more to do with urban planning, the second with architecture, but both recover some of the complexity inherent in the relationship between cybernetics and design.

3. Models and the city

3.1. Optimism and its problems

The emergence of cybernetics as a discipline can be traced back to the period immediately after the Second World War in the United States. The cultural background was then characterized by a high degree of interdisciplinary collaboration, with mathematicians and physicists often working with social scientists and engineers to solve specific issues during World War II (Heims, 1991). It is well known that cybernetics, as it was defined in the Macy conferences (1946-1953), is an embodiment of this approach, bringing together a wide range of different disciplines (mathematics, engineering, biology, sociology and psychology) around the common idea of analysing various types of systems in terms of communication, information and feedback. However, the US cultural context after the Second World War was not only characterised by a strong interdisciplinary drive, but also by a way of thinking marked by reductionism, positivism, pragmatism, combined with an essentially conservative tendency (Heims, 1991). The overall rationale was therefore to approach extremely complex matters from an interdisciplinary perspective, but with a strongly positivist and reductionist stance (Dupy, 2009).

The basic idea of cybernetics was to study and understand the behaviour of systems (biological, mechanical or social) by constructing machines that could reproduce their essential logic. In this sense, it is easy to understand that for cyberneticians, knowledge meant building a mathematical model of the object (Dupy, 2009). This constructionist and engineering conception of knowledge proved to be applicable to a wide range of disciplines, not only because of the cultural milieu that favoured interdisciplinarity, but also because the basic concepts of cybernetics (communication, information, feedback and control) were so general that they could be applied to a large number of objects, even overcoming the distinction between natural and artificial (Grigenti, 2021).

It was in this atmosphere that, according to Picon and Hill (2020), the discipline of urban modelling developed, based epistemologically on the idea that the construction of mathematical models was the high road to knowledge, and technologically on the spread of the first computers. This combination would give rise in the 1960s to what Batty (1994; 2024) calls the optimistic era of urban modelling, in which planners were convinced that they could respond to increasingly complex challenges by applying greater technological power. Following Batty:

> It was widely regarded that this kind of complexity required powerful computers to generate predictions both for short- and long-term future, and out of the early transportation studies came a flurry of proposal for different type of land-use transportation model. Nobody suggested that computers could not or even should not be used for such purposes or that their predictions might be flawed (Batty, 2024, p. 215).

Thus, in the socio-technical context of the 1960s, large-scale urban models were developed and used with extremely ambitious goals. The idea was that these models could understand, evaluate, predict and even control urban development (Lee, 1973). That is, to provide a rational data base to support decisions, to highlight possible relationships between different planning schemes, to predict the evolution of urban phenomena from a given situation, and to direct urban development towards desired goals. These objectives testify to the confidence that this generation of planners placed in a type of knowledge based on the construction of mathematical models capable of representing and manipulating urban phenomena. This confidence was grounded as much on the progress of technological development as on epistemology and the scientific temper fostered by the cybernetic paradigm, which held that a scientific-physical and quantitative approach could be the solution to a wide range of human problems.

Cities were no exception. Indeed, they were intended as «complex systems composed of multiple interacting entities whose distant and profound repercussions on one another ware impossible to detect and track without an appropriate science and technology» (Batty, 1994, p.7). It is interesting to note that a similar approach is still used, both from the perspective of City Brains and in some considerations of urban digital twins. The idea of having a complete and perfectly efficient model of the city is not com-

pletely disappeared, even if some developments within the theory of urban modelling itself have undermined such a techno-optimistic perspective. In fact, as I will show in Chapter 5, the real challenge for urban digital twins will be to retain some of the quantitative characteristics inherited from a techno-centric perspective, while hybridising them with an epistemology more oriented towards complexity and with greater attention to the themes of ethics and civic participation.

From an historical point of view, this optimistic era ended in 1973, when Douglass B. Lee jr. published an article in the *Journal of the American Institute of Planners* with a suggestive title, namely *Requiem for Large-Scale Models*. In this article, Lee lists what he sees as the limitations of these models and laments the fact that their effectiveness in clarifying and solving urban problems has been greatly diminished. Lee (1973) identifies the seven deadly sins of this approach and declares that the era of optimism is over [Table 1].

Table 1 (Author's original). The seven main pitfalls of large-scale models highlighted by Lee in 1973 with their respective definitions.

I	Hypercomprehensiveness	The overly comprehensive structure of existing large-scale models has two aspects: (1) the models were designed to replicate too complex a system in a single shot, and (2) they were expected to serve too many purposes at the same time (p.164)
II	Grossness	The notion persists that combining different purposes generates sufficient economies of scale to be able to reach a significantly higher plateau, i.e., a general-purpose model (p. 165).
III	Hungriness	Data requirements of any model that purports to realistically replicate a specific city are enormous (p. 165).
IV	Wrongheadedness	The impression is often given that the structure used in a given model is adaptable to any kind of system performance that might be encountered, but, in fact, a specific model may absolutely preclude some alternatives and combinations, and it may substantially distort many others (p. 165).
V	Complicatedness	A central idea in modeling is that if components, whose behavior is known, are hooked together in a known set of relationships, the behavior of the resulting system can be explored [...]Whatever the components of a city or a model city are, their microscopic behavior is largely unknown (p. 166).
VI	Mechanicalness	It is all too easy to become immersed in the trivial details of working with a problem on the computer, rather than think it through rationally. The effort of making the computer understand is then mistaken for intellectual activity and creative problem solving (p.168).
VII	Expensiveness	The cost of most of the modeling efforts ran into the millions of dollars. While it is difficult to identify the specific costs of any particular model, a rule-of-thumb estimate for a full-scale land-use model is probably at least $500,000. This includes the design and development costs, hence the marginal cost of addition- al usage goes down (p.168).

These large-scale models are flawed by their claim to capture all facets of the city in a single system, by their lack of detail and purpose, by the constant need for gigantic amounts of data, by the complexity of their structure, which makes them difficult to understand, by the idea of including more and more elements and relationships, by the still frequent errors in mechanical computation, and by the high cost of implementation.

According to Batty (2024), this period of optimism came to an end not only because of the technical limitations of these large-scale models, but also, and above all, because the way in which they approached the problems they were designed to solve, did not take into account certain crucial features of urban problems. Indeed, the models of the 1960s understood urban problems as classical scientific problems that could be approached through an epistemology borrowed entirely from the quantitative sciences. As early as 1969, however, Rittel and Webber warned the planning community that urban problems were problems of a different kind that could not be approached solely in terms of efficiency. According to Rittel and Webber:

> Many now have an image of how an idealized planning system would function. It is being seen as an on-going, cybernetic process of governance, incorporating systematic procedures for continuously searching out goals; identifying problems; forecasting uncontrollable contextual changes; inventing alternative strategies, tactics, and time-sequenced actions; stimulating alternative and plausible action sets and their consequences; evaluating alternatively forecasted outcomes; statistically monitoring those conditions of the publics and of systems that are judged to be germane; feeding back information to the simulation and decision channels so that errors can be corrected all in a simultaneously functioning governing process. That set of steps is familiar to all of us, for it comprises what is by now the modern-classical model of planning. (Rittel & Webber, 1969, p. 159).

According to these two authors, this cybernetic model of planning had to be overcome because, when it comes to urban issues, planners have to deal with a particular kind of problems, namely wicked problems. One could list a long series of characteristics that distinguish this specific category of problems, although here it will suffice to mention three of them to understand how they mark a distance between the nature of urban problems and the epistemology with which they were approached in the optimistic era of urban modelling.

1) An exhaustive formulation of all the information needed to solve a wicked problem cannot be given. This is because the information needed to solve a wicked problem depends on the solution adopted to solve it. Problem framing and problem solving are in a reciprocal relationship of mutual influence: «The formulation of a wicked problem is the problem! The process of formulating the problem and of conceiving a solution (or re-solution) are identical, since every speci-

fication of the problem is a specification of the direction in which a treatment is considered» (Rittel & Webber, 1969, p. 161).

2) Unlike solving a mathematical equation, there is no stopping rule to solving this type of problems. In fact, the consequences of attempting to solve the problem produce effects that have to be taken into account later, and it is almost impossible to stop this causal chain. Indeed, «The planner terminates work on a wicked problem, not for reasons inherent in the "logic" of the problem. He stops for considerations that are external to the problem: he runs out of time, or money, or patience. He finally says, "That's good enough," or "This is the best I can do within the limitations of the project," or "I like this solution," etc. » (Rittel & Webber, 1969, p. 162).

3) The solution to these problems cannot be binary: true or false. In fact, planning problems are about improving the quality of people's lives and therefore involve a very diverse and complex set of viewpoints, interests and perspectives, which makes a binary approach essentially useless: «for wicked planning problems, there are no true or false answers. Normally, many parties are equally equipped, interested, and/or entitled to judge the solutions, although none has the power to set formal decision rules to determine correctness » (Rittel & Webber, 1969, p. 163)

The impossibility of obtaining all the information and rules for tackling the problem before taking action to solve it, the idea of never being able to declare a problem solved once and for all, and the difficulty of assigning a clear value judgement to a proposed solution are sufficient to understand the distance between planning issues and the positivist and reductionist spirit that animated the first formulation of cybernetics and, consequently, the period of development and use of urban models in the 1960s.

This set of issues challenged the cybernetic paradigm in at least two ways: the importance of problem framing and the relevance of ethics. These two issues are intimately connected. In fact, the emergence of value issues within cities related to discrimination, poverty, social justice and sustainability undermines the belief in decision-making models based on an exclusively quantitative epistemology. The more the fundamental problems of the city move away from efficiency, the more a cybernetic and quantitative approach loses its relevance. The issues of urban ethics are wicked problems, and to approach them as if they were classical mathematical problems is to apply a fallacious epistemological dilemma.

Thus, the fact that these problems emerge as central urban issues *de facto* casts doubt on the optimistic era approach. When the perspective of efficiency is replaced by that of value, power distribution and equity, the neutral, managerial perspective of cybernetic derivation shows all its abstractness (Lee,

1973). As early as 1954, philosopher Hans Jonas pointed out the limitations of a cybernetic conception of society based on the concepts of communication, feedback and control, arguing that it was completely empty because it did not take into account all that is important in society, namely values and the ethical dimension (Jonas, 1999). From an urban planning perspective, Rittel and Webber come to a similar conclusion: «Planning is a component of politics. There is no escaping that truism» (Rittel & Webber, 1969, p. 169). The idea of urban planning as a technical problem-solving process aimed at achieving equilibrium was strongly opposed by John Forester in his now classic *Planning in the Face of Power* (Forester, 1989). Although he embraced the idea that planning is a communicative process - and therefore gave great importance to the concept of information - Forester argued that the only way to be rational in planning was to be political: that is, to take account of the power relations and differences that characterise urban contexts. A purely technical analysis would therefore be irrational. As we will see in the next chapter, this conviction is also at the heart of an important line of research in contemporary urban ethics, which challenges a purely functionalist paradigm that characterised much of the thinking of the 1980s and 1990s. The valorisation of differences, the centrality of power relations and urban conflicts will also emerge in the case of urban AI as the real urban context in which to situate this technology.

That this link between planning, ethics and politics was obscured by a cybernetic model should come as no surprise. In fact, the cultural debate in the United States at the time of the birth of cybernetics was characterised by a strong attitude of positivism and conservatism. This perspective was focused on opposing any prospect of radical social change. The scientific neutralisation of political conflict prevailed, and for this reason the behaviourist social sciences and functionalist sociology were heavily subsidised, in contrast to the more critical humanities. This atmosphere was contagious and marked the birth of cybernetics, whose exponents between 1948 and 1953 were hardly confronted by critical political thinkers (Heims, 1991). From an epistemological point of view, this view was embodied in the importance that the first formulation of cybernetics gave to the concepts of equilibrium, control and negative feedback. The basic idea was to provide a system with rules that would ensure the restoration of equilibrium through negative feedback when certain environmental conditions changed (Bertuglia & Vaio 2011). It is then clear why cybernetics attracted interest and funding in post-war United States, as it was explicitly aimed at structuring self-regulating mechanisms for systems to maintain equilibrium.

3.2. A paradigm shift

While Lee's *Requiem* marked the conceptual end of the optimistic era, the practice of urban modelling was not abandoned. Indeed, the years after 1970 saw a paradigm shift, partly imposed by the critical spirit of Lee's reflections: in 1994 the same *Journal of the American Planning Association* that had published *Requiem* in 1973 hosted a discussion on the state of urban modelling. In that context, Michael Weneger (1994) argued that the use of urban models had not stopped after 1973 and had even advanced due to significant technological and theoretical innovations that greatly relativized Lee's critique. Weneger (1994) also listed twenty examples of urban models in use around the world in 1994 to support his thesis that from Australia to the United States, from England to Japan, from Italy to South America, the practice of urban modelling was in good health.

In the same journal issue, Batty (1994) attempts to historicise Lee's perspective and trace the history of the use of urban models. According to Batty, the practice of urban modelling did not stop after 1973, nor did its theory. On the contrary, some theoretical breakthroughs had breathed new life into urban modelling: the introduction of the gravitational model capable of linking transport and location, but above all the abandonment of the notion of equilibrium as the epistemological centre of modelling. Batty argued that:

> Moreover, the somewhat backward-looking paradigms used earlier had emphasized cities in equilibrium, and thus the planning process itself had adopted analogous notions, preparing plans to impose such order and constancy on the world. However, in the 1960s developments in the mathematics of dynamical systems began to reveal that many seemingly simple systems hitherto considered in equilibrium, and thus fully understandable, were in fact full of variety and not subject to simple dynamics as assumed. In the 1970s, these new insights were synthesized under the idea of discontinuity or 'catastrophe theory'; models were built to predict how smooth change might suddenly dissolve or erupt into the catastrophic change characteristic of stock market crashes, the outbreak of war, the collapse of political systems and so on (Batty, 1994, p. 12).

It is interesting to note how this epistemological shift followed the internal developments of cybernetic thought, which had meanwhile been transformed by the advent of second-order cybernetics, which introduced concepts such as autopoiesis, self-organisation, into the framework (Hayles, 2024). This new perspective focused not so much on the ability of a system to maintain equilibrium in the face of external stimuli, but rather on how the emergent interactions between the components of a system could give rise to regimes of momentary order according to the quality of their relationships (Fabbris, 2021). This different perspective made it possible to generate a different modelling theory that was able to escape some of the criticisms made by Lee in 1973.

By the turn of the 1970s, urban science had undergone a fundamental epistemological shift that did not aim to argue the futility of urban modelling *per se*, but began to rethink the way in which this model-

ling should be carried out. This internal shift was not an opposition to the use of technology and the quantitative approach, but rather an internal correction to the science of the city, changing its epistemological framework to better suit its object. It was necessary to stop considering the city as a top-down organised system whose purpose was to maintain an equilibrium through negative feedback mechanisms that had to be ensured by planning. Indeed, according to Batty:

> Cities do not exist in benign environments and cannot be easily closed from the wider world, they do not automatically return to equilibrium for they are forever changing, indeed they are far-from-equilibrium. Nor are they centrally ordered but evolve mainly from the bottom up as the products of millions of individual and group decisions with only occasional top-down centralised action. In short, cities are more like biological than mechanical systems and the rise of the sciences of complexity which has changed the direction of systems theory from top down to bottom up is one that treats such systems as open, based more on the product of evolutionary processes than one of grand design (Batty, 2011, p. 9).

It is therefore possible to assert that at the turn of the eighties and then in the nineties, the theory and practice of urban modelling underwent a profound modification, not only as a result of technological development, but also thanks to an internal, highly interdisciplinary conceptual maturation that followed the evolution of cybernetic thinking (Bertuglia & Staricco, 2000; Bertuglia & Vaio, 2011). In fact, the new forms of modelling consider the city as a complex system formed by non-linear interactions between actors (competition, cooperation, complementarity and symbiosis), by the multidimensionality of possible descriptions depending on the point of view of the observer and the disciplinary perspective (economic, social, political, spatial, etc.), by the diffusion of decision-making processes, which are not centralised but distributed among actors of different types and strengths, by the co-presence of different levels of organisation (between individuals, between urban groups and between cities) and by the different temporalities of the life cycles of urban components (Bertuglia & Staricco, 2000).

To sum up [Figure 5], from a paradigm that had a reductionist epistemological background, the concept of equilibrium as its centre, and a total technological optimism as its cultural environment, there was a shift to one characterised by complexity theory, a more critical view of technology, and dominated by the concepts of disorder and autopoiesis (Batty, 2024). This shift also led to a focus on small-scale models characterised by a bottom-up approach that sought to simulate how the interaction between different actors in a spatial domain could, over time, generate states of order useful for the analysis of urban phenomena (Batty, 2024).

MORPOLOGY OF URBAN MODELLING	Before 1970	After 1970
EPISTEMOLOGY	Urban Phisics	Complexity Theories
CULTURAL MILIEU	Technological optimism	Implications of technology
KEY CONCEPT	Equilibrium	Transformation
SCALE	Large scale models	Small scale models
APPROACH	Top-down	Bottom up

Table 2 (Author's original and based on Batty 2024; 1994). Main elements in the difference in approach to urban modelling before and after the 1970s: Epistemology, cultural milieu, approach, key concept, and scale

3.3. Down to AI urbanism

This brief journey into the history of urban modelling illustrates how difficult it is to understand the relationship between cybernetics and the city, by projecting the contemporary debate on AI urbanism in terms of a conceptual source of a conception of the city as a system of absolute control (Picon, 2015) or techno-ecological harmony (Ratti & Belleri, 2021). The history described in these pages tells a story of greater articulation. This story does not contrast a scientific approach to the city with a romantic one in which quantitative data is deemed useless, but shows how the science of the city itself has been subject to relevant epistemological developments and catastrophes.

In accordance with chapter 1, AI urbanism is embodied in various technological objects (Robots, AVs, and software agents) that are already transforming the urban experience of millions of citizens worldwide. One of these technological objects has a very close relationship with the history of urban modelling, as will be shown in Chapter 5. The Urban Digital Twin (UDT) is a digital model of the city that has a dynamic relationship with its physical counterpart (Batty, 2018). This twin is built using data produced by cities and can in turn generate information and knowledge that can be used to modify, manage and plan the real city (Weil et al., 2023). Current applications of this tool mainly concern the material flows of cities (infrastructure, transport, energy), but many researchers have highlighted the need to

include data on social and ethical relations in UDTs (Ferré-Bigorra, 2022; Noctha et al., 2021). It is worth noting that, on the one hand, the UDT tool certainly has close affinities with the history of urban modelling, being conceived as a digital model of the city (Batty 2020), and that, on the other hand, the current application of this tool takes very little account of the conceptual evolution described in this chapter. Indeed:

> There are many theories as to how cities are structured and how they evolve, and most of them relate at some juncture, their socio-economic functioning primarily to their physical aspects. This also applies to digital twins, which tend to ignore the extensive complexity of a world, where psycho-social, economic, physical, and environmental features are deeply entangled and cannot easily separated out (Caldarelli et Al. 2021, p. 4)

The current approach to urban digital twins (UDTs) seems to reproduce a reductionist epistemology similar to the one criticised by Lee's 1973 *Requiem*, in which the city has been reduced to its physical components and understood as a hierarchical system that can be represented and managed by a single model. Thus, while sensational technological advances during the digital revolution have increased the computational power of modelling tools, the theoretical situation still seems to reflect debates that should be historicised by now. In this situation, it is useful to note how some of the concepts expressed in the debate I have summarised can be useful today in relation to the issue of urban digital twins.

As already mentioned, in 1994 Lee was invited to make a further reflection on urban models. In 1994 the scholar (Lee, 1994) enumerated the polemic targets of his 1973 paper, and two of these themes seem to be still relevant in the debate on AI urbanism: transparency and the specific purpose of these models. To characterise the first theme, Lee in 1994 used a term that is now well known in the AI debate: «black box». In Lee's words, «My contention was [in 1973] that non even the modelers could understand what was going on inside their models» (Lee, 1994, p. 36). In Lee's vision, transparency was a fundamental requirement for the credibility of urban models. Indeed, in a transparent model, the assumptions that underpin its operation and the implications that follow from its use can be evaluated by all actors involved in and affected by its use. Effective communication between technicians, politicians and citizens was considered fundamental to the effectiveness of a tool designed to manage and control the urban experience. This issue becomes even more relevant in the era of AI urbanism. Indeed, in the philosophy of technology, there is an extensive debate about the black box nature of AI decision-making processes (von Eschenbach, 2021): the inherent nature of machine learning systems makes it extremely difficult for the human observer to control, step by step, the way in which an AI arrives at a decision.

From an urban point of view, this means that AI urbanism could generate urban planning and management decisions that are not fully comprehensible to all the actors that will be affected, thus severely un-

dermining the capacity for meaningful communication between the relevant urban actors. One can think, for example, of the traceability of predictive policing systems used to reduce crime in cities (Shapiro, 2024), or of the algorithms involved in the allocation of homes in the housing market (Rosen & Garboden, 2024), or finally of the systems involved in the estimation of the value of real estate (Lynch & Del Casino jr., 2024). In all these cases, AI-enabled systems are involved in highly relevant decisions in the urban experience, without ensuring a real level of transparency.

In addition, when it comes to urban AI, and specifically urban digital twins, the idea is also to stimulate the possibility of participation in urban decision-making by the various actors involved, starting with citizens. Therefore, to recapture Lee's perplexity in an updated version, we must ask ourselves whether, in addition to working on the technological efficiency of these models, we should not also work on the issue of transparency and explicability of these UAIs. If the answer to this question is negative, we could argue that the history of urban modelling itself has been ignored in contemporary practice and that a more active role for it would certainly be crucial in the near future. Indeed, so far, the role of the social component of the city is hardly taken into account in the UDTs and the relationship between this tool and citizen's participation seems to be more enunciated than practised. The originality of the Bologna Digital Twin (BDT), the case study that will be analysed in chapter 5, lies precisely in the desire to combine the technological tool of the UDT with a greater focus on the social and participatory component of the city. As my analysis will show, these characteristics place the BDT in an extremely interesting position in the world panorama of technologically driven urbanism, characterised by an explicit political will to radically modify the characteristics that prevent a truly civic and participatory use of the UDT.

Lee's second perplexity, expressed in 1973 and confirmed in 1994, concerns another term that now appears in the AI debate with a different meaning: general purpose. With this term, the scientist wanted to emphasise the fact that models must be used in relation to specific, concrete problems that can be circumscribed and addressed. Targeting a particular urban challenge can facilitate the retrieval of data by avoiding its excessive proliferation, make it easier to identify the urban actors that need to be involved in the decision, and also make it controllable whether or not the final output has contributed to tackling the problem in question. Lee suggested to «Start with a particular policy problem that needs solving, not a methodology that needs applying» (Lee, 1973, p. 176) and added «Planning is in the unique position of being oriented around urban problems rather than around any discipline or science» (Ibidem).

In the era of AI urbanism, one must be very careful not to think that it is possible or useful to pursue the creation of a model that seeks to represent a city in its entirety. In fact, this ambition, largely dictated by a new version of techno-optimism, is unrealisable due to a series of technical and logical problems already highlighted in the debate on complex systems (Batty 2012). The city is, in fact, an open, non-trivial, chaotic and autopoietic system in which the management of uncertainty is crucial. Contemporary UDTs should abandon this ambition due to measurement, computational, mathematical, data analysis and internal limitations of the ML mechanisms themselves (Aracaute et al. 2021). Moreover, focusing on specific urban problems would reduce the mass of data and its management costs (environmental, computational and economic) and subject these tools to greater scrutiny by both policy makers and citizens (Ivi). Indeed, the former would want to understand how this tool can really help to manage the urban experience, and the latter would need observable criteria to assess the real impact of this tool. Once again, the history of the relationship between the city and cybernetics is useful to illuminate a line of research that does not aim to resist technological development, but rather to transform it into urban innovation.

4. The architect among the machines

4.1. Technical intellectuals in Italy

A marked interest in cybernetics and its application to the built environment can be also observed in the 1970s and 1980s in a research group focused on architectural technology in Italy. During a period of great technological innovation and significant political and cultural upheaval, this working group considered a new way of responding to the challenges of modernity in a «[…] world which was experiencing a deep transformation, starting to acknowledge the scarcity of resources and the urgence of finding solutions even before understanding the causes of those phenomena» (Antonini, 2013, p. 44). During these years, cybernetics was employed as a potential common language to promote the interdisciplinary approach that was deemed necessary. Giuseppe Ciribini – one of the leading theoretic figure in this group – translated this need into the aim of training technical intellectuals, figures capable of bringing culture into the field of design by combining the achievement of technical goals with a critical approach (Turchini, 2013, p. 155).

Collected books such *La Sfida Elettronica*[3] (Foti et al, 1969) and *Un Pianeta da Abitare*[4] (Ente Autonomo Fiere di Bologna and Associazione Italiana Prefabbricazione per l'edilizia industrializzata, 1971) are a valuable source for understanding the design culture of the group, which aimed to provide concrete answers to the challenges of their time through a conscious use of technological innovation. These reflections were not just academic and theoretical, but were intended to create tools for renewing Italian industrial culture, bringing it up to date with the information age and integrated process management. The aim was to train technical intellectuals capable of contributing to the modernization of the national productive system.

La Sfida Elettronica (Foti et al., 1969) is dedicated to understanding the emerging relationship between architecture and computers. This connection, which today seems obvious and trivial, posed a major challenge to a design culture that was deeply rooted in traditional methods and approaches. Indeed, a partial automation of design process and the possibility of an unprecedented computational and graphic representation power were elements of absolute novelty. It is interesting to note that even in this work the research group distinguished itself for a critical and conscious approach to the use of this new tool, which first had to be understood and then consciously integrated into the established culture of Italian design.

This approach is extended in the second book – *Un Pianeta da Abitare* (Ente Autonomo Fiere di Bologna and Associazione Italiana Prefabbricazione per l'edilizia industrializzata, 1971) – where technological innovation was considered as a tool that must be embedded in a network of relationships capable of cooperatively holding together the ethical, social and natural dimensions [Figure 6].

[3] *The electronic challenge - Realities and perspectives of the use of computers in architecture* (Author's translation).

[4] *A planet to inhabit - Requirements and performance of the built environment* (Author's translation).

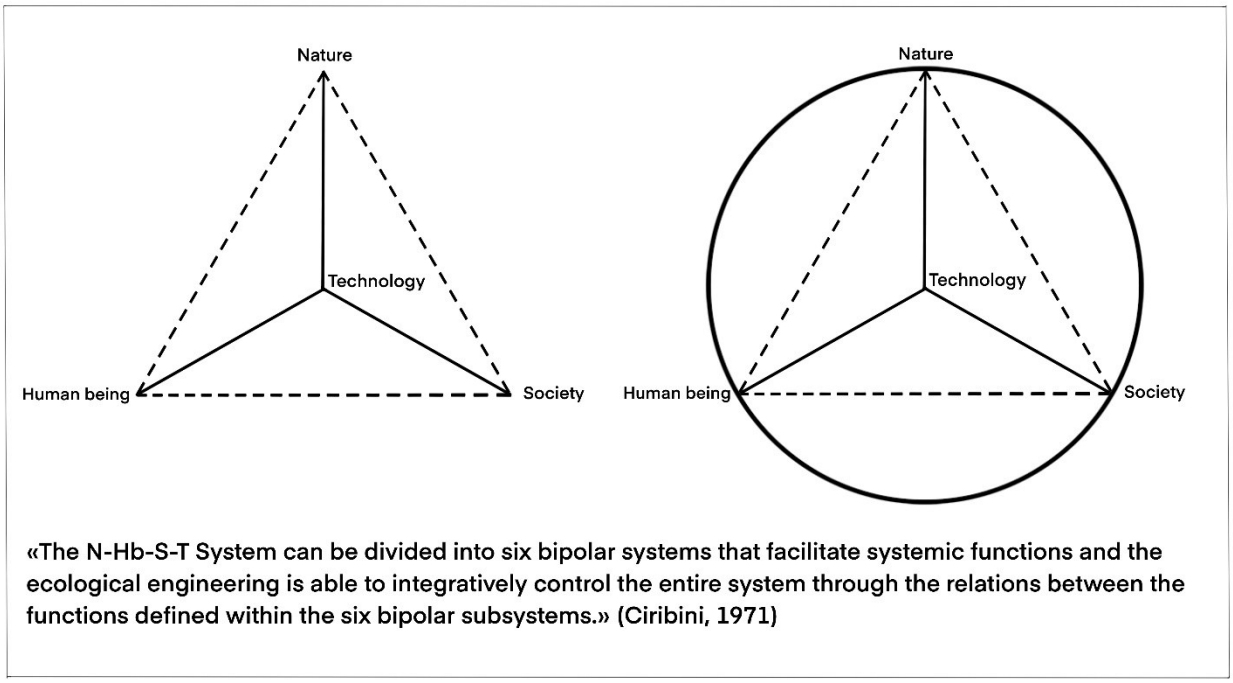

Figure 5 The Nature/Person/Society/Technology system by Ciribini, (Edited by the author) (source: Ente Autonomo Fiere di Bologna and Associazione Italiana Prefabbricazione per l'edilizia industrializzata, 1971).

Technology must therefore be ethically and politically oriented, moving away from an idea of progress as endless profit-driven growth, and situated in a new environmental awareness attentive to the limits of development and the socio-ecological implications of innovation. Technological innovation alone – without a new culture to support it – was considered insufficient to address pressing issues such as the biological integrity of humans and non-humans, psychological health, and social inequalities.

According to Ciribini (1971), in this situation, systemic approach and cybernetics could be considered as a new methodology capable of bringing the disciplines into dialogue in order to pursue these ambitious goals. In fact, as I have shown, cybernetics was born in close relation to information theory and the emergence of the new machines, and also presented itself as a discipline capable of acting as a bridge between different disciplines reshaping their epistemologies. This twofold characteristic increases the interest of the research group, which sees in this approach the idea of a renewed theory for the management of technological innovation.

Ciribini showed a particular attention to the relationship between humans and machines in a new technological context. Indeed, he argued that an undeniable technological innovation had not been followed by a change in theoretical categories capable of making the actors involved understand the new potential of machines. In order to clarify this concept, he interpreted some critical reflection of philosopher

Gilbert Simondon (2017) in 1958. In this work, the philosopher pointed out an alienated relationship between humans and machines, that is represented by a lack of intelligence of the machine on the part of the humans who should relate to it. According to Ciribini (1971), in the Italian industrial context, workers, capitalists and technicians had not acquired sufficient intelligence about machines to be able to employ them effectively for new purposes. This alienated relationship and this lack of intelligence about new technical objects were, for Ciribini, the first problems to be addressed.

This interpretation connecting Simondon and Ciribini is based on their mutual understanding of technology as a process inherent to human praxis, an historical development that has to be both followed and directed. Thus, the actual issue becomes creating a synchronised connection between human actors and machines in the cybernetic era. This new period was dominated by the second industrial revolution described by Norbert Wiener and characterised by the possibility of replacing mechanically certain operations traditionally attributed to the human brain (Wiener, 1968). In fact, according to the father of cybernetics, if the first industrial revolution succeeded in mechanically replacing physical force in industrial processes, the cybernetic revolution set out to mechanically replace certain operations of managerial intelligence traditionally associated with human thought. These new machines could communicate with their environment through sensors and regulate their purpose-driven behaviour through feedback mechanisms. In this new paradigm, the concepts of information, feedback and control became the fundamental epistemological principles for understanding reality.

For all these reasons, Ciribini (1971) considered cybernetics as a systemic and structural philosophy capable of providing a new scientific model he was searching for. He understood that information was likely to be the raw material of future societies, and systems theory could be the rationale for it. The systems theory, hence, becomes the model to establish a dialogue between nature, humans and society employing technology (Ciribini, 1971). Cybernetics becomes both the paradigm through which one can interpret reality and the system of assumptions and rules that guides a proper rational agency (Ciribini, 1971, p. 35; Hammoudi, 2021).

4.2. A Technological Culture for the Project and a Project for a Technological Culture

This new conception of reality required a new formulation of the relationship between technological tools and human rationality, a connection that, according to Ciribini, concealed at least two major risks:

firstly, reducing all problems to technological ones; secondly, the uncertain relationship between human action and thought and the computational power and effectiveness of machines.

Simondon is still a model for Ciribini: regarding the first issue, according to the philosopher, it is necessary to beware of the all-encompassing claim of cybernetics, which seems capable of substituting the human capacity for judgement by technologically arranging the ability to orient means to ends, that is, to replicate purpose-driven behaviours. Ciribini (1971) was aware of this danger, considering technology as a positive force, but refusing an acritical approach to it, especially when it comes to its impacts on society and environment. This awareness was developed by Simondon and Ciribini in their respective field of research, namely philosophy of technology and design theory.

A key issue concerns the ability of the cybernetic machines to pursue a goal autonomously, without the need for continuous human intervention. As I have already mentioned, this capacity is based on the ability of these machines to be able to perceive their environment and to regulate their behaviour by means of feedback mechanisms. However, according to Simondon:

> If finality becomes an object of technics, then there is something beyond finality in ethics; Cybernetics, in this sense, frees man from the unconditional prestige of the idea of finality […] One could undoubtedly say that it is not a veritable finality that animates the processes of recurrent causality with negative reaction; at the very least this technical production of teleological mechanisms enables the most inferior, most primitive aspect of finality to leave the magical domain behind (Simondon, 2017, p. 120-121).

The philosopher considered the specific kind finality automatable through feedback processes as the most inferior, most primitive aspect of finality. If this aspect becomes an object of technics, then there is something beyond finality, namely ethics (Simondon, 2017). The partial automation of finality provided by cybernetics reveals this different and superior aspect of human's agency. This philosophical remark resonates with another critique mentioned in Chapter 1, namely that of the philosopher Hans Jonas. According to Jonas (2009), many supporters of cybernetics confuse the fact that these new machines can serve a purpose with the fact that they have one. Jonas reminds us that these machines follow purposes dictated by humans, and that they evidently have no vital interest in pursuing or not pursuing a purpose. In a nutshell, the cybernetic machine has no purpose because it is not interested in pursuing it as a human is, and because the purpose it does pursue is always programmed by others.

For these reasons, Simondon considers absurd to claim that the cybernetic machine is a problem-solving machine. Since it cannot perceive a problem, what the machine perceives is a set of data that automatically triggers behavioural mechanisms according to a predefined scheme:

> For the machine, there are no problems, only data that modulate the transducers; several transducers that act upon one another according to commutable schemas, such as Ashby's homeostat, do not constitute a problem solv-

ing machine: the transducers in a reciprocal relation of causality are all within the same time; they condition one another in actuality [dans l'actuel] they are never confronted with a problem, something thrown down before them, something that is in front of them and that they will have to step or leap over. To solve a problem is to be able to step over it, to be capable of recasting the forms that are given within the problem and in which it consists of (Simondon, 2017, p. 156).

Thus, it is not a matter of an alleged threat to the uniqueness of the human being, but of how human beings can relate to objects other than themselves – cybernetic machines – in order to deal with and solve problems. There is a need of technical intellectuals – as Ciribini called them –capable to understand the machine to the extent that they know that its autonomy cannot be separated either from an ethical direction given by the human being, or from the human ability to circumscribe, define and frame a problem.

Ciribini originally interpreted and employed this philosophical framework in the field of design theory, developing the relationship between technology and human rationality in relation to both finality and prediction in architectural design. Indeed, he distinguished two different types of finalities. The first, concerns the overall sense and meaning of the project, its ethical component, and is therefore not reducible to cybernetic automation. The second, on the contrary, concerns the harmonisation of means to ends and the sequence of operational connections, and it is therefore technologically manageable (Ciribini, 1971). Ciribini thus re-proposes Simondon's conceptual scheme, in which the automation of certain meaningful relations does not lead to the replacement of the ethical component of the project, but to its clarification. The cybernetic approach allows the designer to organise the problem and give it an ethical direction, programming a series of automatic functions that respond to the overall sense of the project, increasing its efficiency, precision and comprehensibility. In this articulated conception the architect and the machine co-operate to achieve a more efficient process.

Furthermore, Ciribini (1971) addresses the problem of forecasting, following the same rationale and distinguishing between two types of predictions: possible futures and desired futures. The first is a mechanical forecast, which takes into account a given situation and predicts its possible effects according to given parameters. The second, on the other hand, concerns desired futures, namely those variations that result from value choices that do not correspond mechanically to the originating *status quo*. In this case, the future completely reconfigures the relationships between the significant facts of a given domain, breaking the causal links with the past and thus making prediction more complex and less mechanical. Thus, possible futures concern the mechanical implications of a situation and are technologically addressable. On the contrary, desired futures concern changes in the state of a situation and thus refer to an ethical and extra-technological dimension.

These considerations reveal a proper interdisciplinary work of adaptation of Simondon's critical approach to cybernetics in which humans own a meta-technical capability to frame the problem to be solved. A capability that, by consciously assuming a model, organises the network of relevant facts and connections for a specific operation. Hence, technological and human dimensions are not in opposition but in a close and biunivocal relationship. According to Ciribini, when it comes to the design process the intentional, non-technologically determinable aspects must first be translated into qualitative assertions and then into quantitative criteria capable of determining the performance of a machine (Ciribini, 1971, Figure 7). These technological elements must always be situated in a context already marked by certain qualitative conditions and they must have the aforementioned conditions and objectives (purposes, goals or aims) as inputs (Ciribini 1971).

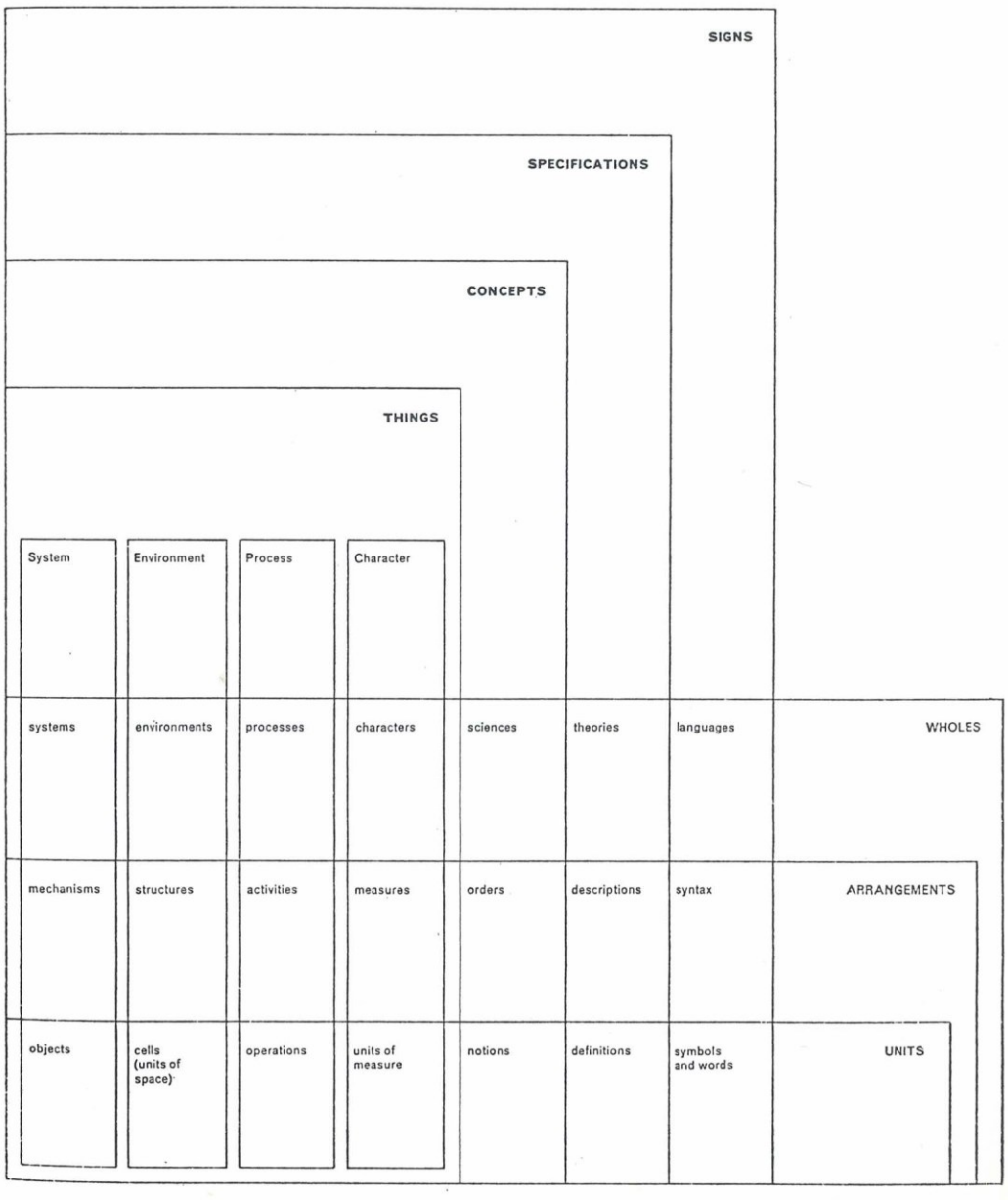

Figure 6 'Connections between signs, specifications, concepts and objects, image taken by (source: Martin, 1971).

On the bases of these considerations, it is possible to claim that Ciribini certainly considered cybernetics as a model of analysis, prediction and action, yet in his approach, the ethical dimension never loses importance. This approach, promoted by Ciribini in the 1980s in Essay *Tecnologia e Progetto – Argomenti di Cultura Tecnologica* (1984), has become pivotal for generations of designers seeking new languages to integrate technological innovation and the new demands of architecture on an industrial scale.

4.3. Technical intellectuals and urban AI

As in the case of urban modelling, cybernetic concepts in design theory seem to escape the simplifications that we have seen characterise their consideration in contemporary debates on the relationship between digital technology and the city. Indeed, as I have shown, cybernetics is considered a conceptual source of both the smart city paradigm and AI urbanism (Townsend 2013; Picon, 2015; Krivy 2018; Picon & Hill 2020; Ratti & Belleri 2020; Barns, 2021). However, its consideration oscillates between two opposite poles: on the one hand, the cybernetic approach refers to a situation of total control, repression of the freedom and creativity of the individual, and technocratic reductionism; on the other hand, it is considered as an epistemology of a possible harmonious coupling between the different components of the urban fabric. However, these two apparently opposing perspectives share a fundamental assumption. In both cases, cybernetics is understood as a science of control capable of restoring order to the city, which is interpreted as a system to be restored to a state of equilibrium. From a critical perspective, this is interpreted as a reductionist and limiting approach to freedom and creativity, while from a more optimistic perspective it is read as a possibility for positive harmonisation.

Both of these interpretations seem to refer more to first-order cybernetics as a framework capable of harmonizing differences (both between humans and nature and between the parts of the city) within a broader comprehensive top-down rationale. In both cases, the cybernetic epistemology is considered as an automatic control mechanism of the urban space, understood as a system of systems in which all the parts are harmonised to an overall efficiency that can be evaluated either positively or negatively, according to a critical or technocratic approach.

However, this is «[...] a narrow use of cybernetics – a pragmatic, therapeutic use – to mobilize it as the art of *gubernatio/navigatio* of complex systems, as the coordination and steering of the parts in accordance with the whole, and as the homoeotechnical frame of an enlightened ecohaking» (Fabbris, 2021b). This therapeutic use is certainly a possible interpretation of cybernetics. However, it greatly undermines the autonomy of the parts/systems that enter into relationships, and thus the possibility of a certain degree of freedom and independence in the quality and modality of these relationships themselves. In short, when order and equilibrium are imposed from above, there is a minor degree of freedom for the parts that are harmonised.

A serious consideration of second-order cybernetics should prevent this holism, which can be either utopian or dystopian depending on the point of view. In this perspective, each system must be consid-

ered as an operational difference that does not communicate with other systems following a part/whole structure, but in a continuous emergence of system/environment polarities capable of mutually connecting or not connecting (Fabbris, 2021a). When this resonance persists over time it results in a compound that in turn operates as a system and can relate to others. «No conductor composes these voices, no *kubernetes* can conduct, guide and harmonise them» (Fabbris, 2021b, p. 49). In this framework, the city is conceived as a bottom-up assemblage of entities, actors and communities that can come into contact with each other and give rise to states of provisional order that are functional for a given purpose. This perspective overturns the idea of a city with clear hierarchies and relationships that can be seen from above by moving towards an ontology of functional and temporary relationships.

In this approach, the design moves out of the perspective of totality – it abandons cybernetics as full synergy or ubiquitous control – and steps into the challenging perspective of mediation that is intended as the design of interfaces between systems capable of functional, situated, and contextualized pairings. In this 'craft' practice, in this holism made of difference and mediation, designers can regain their role among machines (neither above nor under) suggested by Simondon and Ciribini. Indeed, here the relationships between systems are not imposed from above and automatically harmonised. On the contrary, the space for humans and designers lies precisely in the shaping of communication spaces between systems, such as buildings, urban communities, assemblages of human and non-human intelligences that populate urban contexts.

In this framework, the role of ethics, which characterises Simondon and Ciribini's reflections (Simondon, 2017; Ciribini 1971), re-emerges. Ethics understood as the set of values through which the planner sets out to design couplings between systems that can yield results with respect to a specific urban problem. Values that are not absolute and transcendent, but functional to these functional couplings and able to make them last the time necessary to address and develop the wicked problems that arise in the city. As I have pointed out, these problems do not admit of definitive solutions, but only of partial targeted developments.

These considerations are of interest when it comes to AI urbanism. Indeed, as I argued in Chapter 1, in this urban paradigm the relationship between technology and the city is often considered in an extremely reductive and top-down way: technology is understood as a principle of order to be imposed on an urban matter that is inherently chaotic. This purely modern view (Cugurullo, 2021) leads one to conceive of the relationship between cybernetics and AI urbanism in terms of first-order cybernetics, in which technology's role is to provide stability to a system. This perspective underestimates the fact that

the urban fabric is already full of intelligent agents of functional orders, systems that define its morphology and dynamics and that should not be technologically reduced to equilibrium (Bratton, 2021; Lynch & Del Casino Jr, 2020). The introduction of UAIs, be they robots, AVs or software agents, must take into account this articulated state of affairs that characterises the city and fit in as a system between systems, trying to define functional couplings with existing contexts and not trying to reduce them to a single logic.

There are already some cases in which the implementation of urban AI-based systems, such as robots or autonomous vehicles, has generated serious issues in the socio-technical texture of urban spaces. In San Francisco – an iconic city in the digital revolution – street robots have been banned for food and beverage delivery since 2017. This digital integration of space has failed because of its inability to engage productively with the margins of its technological action: the narrow space of sidewalks and the relevance of walkability for inhabitants (While et al., 2021). In this case, the issue was not the internal efficiency of the robots, but their ability to integrate productively with what was already happening in the city: the physical system of mobility infrastructure and the intangible system of walkability as a value for citizens. The intervention was guided by the certainty of the internal efficiency of the technological system, but without considering its ability to weave functional couplings with the context. This is where the ethical dimension illuminated by Simondon (2017) and translated by Ciribini (1971) in terms of problem framing and imagining possible futures should suggest a different approach. A perspective that focuses more on the relationships between systems than on their internal efficiency. These kinds of examples highlight the necessity of a constitutive role for social sciences in both the design and implementation of technology (Cohen and al., 2020), a role that can foster the ability to meaning fully integrate technology into the urban fabric.

In this light, one of the most fascinating challenges concerns City Brains that will be analysed also in chapter 5. A technology designed by Alibaba in 2016 to manage traffic in Hangzhou by embedding an AI within a specific urban digital platform (Caprotti & Liu, 2020). This “brain” acquires data from sensors spread across the city and can harmonize flows generated among urban actors. The interest in this technology concerns its applicability in different urban domains. This flexibility foreshadows the possibility of using its predictive and decision-making skills in urban planning and management (Cugurullo, 2021a). It would become technologically conceivable to have artificial and unified management of urban reality (Cugurullo, 2021b) enabling a sparkling new version of the first-order cybernetic dream we referred to.

In this perspective, retrieving Ciribini's ideas, it will be crucial to understand the relationship between this possible future and our desired ones. It will be pivotal to understand the relationship between these predictive skills of technology and the ethical and design capacity of planners and communities. The alternative approach to the cybernetic paradigm sketched before is remarkably relevant regarding the discussion of a different vision of cities and therefore for a different implementation of these technologies; a vision that does not reduce the city to an artificially managed data source but contributes to the inclusion of these 'artificial brains' within the articulated geography of the forms of intelligence that inhabit urban areas.

5. Conclusion

The aim of this chapter has been to show how the relationship between cybernetics and AI urbanism is complex and articulated, rooted in a series of interdisciplinary experiences over the last 70 years. This complexity has been narrated in order to highlight the internal articulations of a technological and scientific approach to the city that has evolved and changed and cannot be considered as a univocal phenomenon. An interdisciplinary approach to the science of the city must not only highlight the limitations of the quantitative approach, but also understand its evolution.

The history of urban modelling in the US and UK and the example of architectural technology in Italy have shown how cybernetics has often acted as an active and dynamic theoretical model in these two fields. Indeed, in both cases, certain internal developments and critical positions of the cybernetic model have stimulated significant changes in the approach to the city and the project. In both cases, interdisciplinarity has been implemented in a real way, incorporating and adapting certain concepts from the philosophy of technology and following their internal evolution. The two historical reflections that make up this chapter allow one to answer the research question in an articulated way, continuing the search for concepts capable of influencing the design culture of AI urbanism towards a greater adherence to urban needs.

Research question chapter 2: *What issues from the relationship between cybernetics, architecture and urbanism can guide the reverse envelopment of urban AI?*

The history of urban modelling has shown that the quantitative perspective in the study of the city is not characterised by immobility in terms of theories and practices. On the contrary, the epistemological disruption described testifies to an internal liveliness in this field, capable of questioning its own as-

sumptions and criticizing a merely technocentric perspective, even within its own field of study. First of all, the concept of transparency, already mentioned by Lee in 1973, has emerged as crucial in order to make computer models really useful from an urban point of view. This concept refers to the possibility for different urban actors to be able to look inside the models and understand how they work, their objectives and their limitations. As we will see in the next chapters, the extent to which the characteristics of urban AI are made public plays a crucial role in the ability of cities to control it. However, even pre-AI models did not ensure such transparency that objects could be considered under control. Transparency, a necessity in the history of urban modelling, must therefore be a value in the era of AI urbanism. A value made more difficult to pursue by the black-box nature of some AI decision-making mechanisms, but one that must be pursued by making explicit everything that can be made clear, both in terms of the technological properties of the machine and in terms of the implications it can have on the city.

The second element is related to the first and concerns the need for urban models to have a precise purpose, a problem to be addressed or solved, and not to be developed as models in themselves. This critique was aimed at anchoring technological innovation to urban innovation without allowing the former to become self-referential. The current development of urban AI is proceeding at a very fast pace, and our cities are already dotted with new artificial agents. It is necessary to ensure that these agents have precise, shared, verifiable and contestable purposes. As will be the case in chapter 4, in Latour's design theory, a presumed generalised efficiency of the urban fabric remains too vague as an aim, leaving the field open to a technocentric perspective and uncontrolled technological development that is useless in addressing urban problems. Every time we hear about efficiency as a goal, we must ask ourselves: efficiency of what? for whom? at what cost (economic, environmental and social)?

This theme is linked to the lesson that can be drawn from an analysis of the thinking of Ciribini and the Italian research group mentioned. In fact, in this case too, the use of non-dogmatic cybernetics overcame the idea of technology as a dimension for controlling the complex dynamics of the project. Technology was seen as an indispensable element for automating certain processes and increasing their speed and precision. However, these considerations have highlighted the need for technical intellectuals, namely individuals with a cultural background who are prepared to communicate with machines, organize their objectives and place them in context. The ethical dimension, which will be the focus of the next chapter, is not superseded by technological innovation, but it is redefined and made more complex. In fact, as I will discuss in more detail shortly, the emergence of artificial agencies in the city

requires a reconfiguration of ethical frameworks to include the possibilities opened up by technological innovation.

In summary, transparency, focus on purpose, and ethics are crucial concepts for the urbanization of AI. Indeed, they will be included in the frameworks that I will propose in chapters 3 and 4. In this chapter I have shown how it is possible to find, within perspectives that positively evaluate the use of technology, concepts capable of modifying a design culture that is simply technocentric and focused solely on technological development. These concepts contribute to the indirect and reverse cultural enveloping that a serious reflection on the history of urban and design culture can promote. These traditions must become part of the design culture of urban AI in order to make it more articulate, aware and urban, and to help generate a technological design that is truly capable of helping designers face the urban challenges of the present.

These considerations, which articulate the relationship between cybernetics and AI urbanism, help us to understand that the real goal of an interdisciplinary approach is not to oppose a qualitative vision of the city to a quantitative one, a romantic vision to a scientific one, but to work internally on conceptual and design paradigms in order to generate tools that are useful in the contemporary context.

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Chapter 3

URBAN AI and Ethics

1.A possible relationship?

Research question: *Through which ideas is it possible to make ethical reflection on urban AI more concrete and direct its reverse enveloping in this direction?*

The answer is developed by first considering two types of literature through a comparative methodology. With regard to the philosophy of technology, the recent history of AI ethics is taken into account. With regard to urban studies, the focus regards some key authors of urban ethics. The topic of ethics acts as a bridge between the two literatures, enabling a dialogue necessary for a full consideration of AI urbanism. This dialogue highlights the fundamental importance of design as a key aspect of urbanising AI. The aim is to provide a framework for direct action in the reverse enveloping of urban AI, taking into account the ethical relationships between urban intelligences. Unlike the previous chapters, this is not focused on deal concepts taken from urban history that can (indirectly) influence the urbanisation of AI culturally, but with a real practical framework that can be adopted by urban actors for direct action on technology.

In a seminal book on philosophy of technology, Langdon Winner wrote that the effectiveness of modern technology rests on one precise characteristic: «taking the world apart and putting it back together in productive ways» (Winner, 1977, p. 182). Technology works by means of «precise divisions» and «intricate reconnections», reshaping the contexts where it is applied. Winner's approach went beyond the purely instrumental conception of technology, which left both the user and the environment unaffected. Increasingly, it is the quantity and quality of this artificial restructuring of the environment that determines the effectiveness of the technologies that Winner described as autonomous in the 1970s.

These intuitions from the last century are essential to interpret the digital revolution as an ontological reorganisation of our reality and not a shift in the way in which communicate. The same rationale also applies to the recent development of Artificial Intelligence (AI) which certainly depends on increasing computing power (Vipra, Myers West, 2023), but also on the continuous practice of making reality analysable and legible for these systems (Floridi, 2019b). Indeed, as has been illustrated in the first chapter of this dissertation this process of enveloping, in which the context has to be adapted to the tool so that it functions effectively, reproduces Winner's insights into the nature of technology in the context of AI.

When it comes to the relationship between AI and urbanism, this ontological feature is even more striking. Indeed, cities are increasingly populated with new AI-based urban actors such as robots, AVs (Autonomous vehicles) and software agents that are materially restructuring our urban experience (Luusa et al., 2023; Batty, 2023; Bratton, 2021; Kassens-Noor & Hintze, 2020). As it has been shown the development of this process, which is referred to by scholars as AI urbanism, is also raising relevant questions on the ways in which we interpret and understand urban dynamics (Aurigi, 2023; Cugurullo, 2021; Barns, 2021; Lynch & Del Casino, 2020). Indeed, the arrival of these artificial agents does not only alter the ontological composition of the city but also affects human capacity to conceptualise it. Decision support systems in planning and governance change the way we manage urban complexity (Du et al., 2023; Son et al., 2023; Caprotti & Liu, 2022), Robots and AVs radically redefine the current way of moving around and experiencing public and private spaces (Sumartojo et al., 2023; Golubchikov & Thornbush, 2020; Dooling & McGuirk, 2020), various types of software agents mediate the ordinary way of interacting with services, infrastructures and institutions in the urban fabric (Rosen et al., 2021; Tulumello & Iapaolo, 2021).

In the light of this, the ontological impact of AI is inseparable from its epistemological consequences in urban contexts. These urban phenomena pose a paradox to the philosophy of technology. Indeed AI – which is certainly the result of the desire for control over the world that Winner (1977) pointed out as a key aspect in the evolution of modern technology – has handed us a renewed capacity to act. However, this was achieved at the price of a diminished capacity for control. Firstly, this is due to the fact that contemporary AI based mainly on Machine Learning (ML) has not only increased tremendously its efficiency but also the opacity of its operations, thereby becoming an impenetrable black box. Indeed, if John von Neumann in 1957 (Von Neumann & Kurzweil, 2012) could legitimately boast of a large degree of logical control of the human programmer over the operations of his calculators, today the debates on the black box essence (von Eschenbach, 2021) of AI has radically changed the cultural landscape within which AI technology is (mis)understood.

Furthermore, looking at AI Urbanism, it is particularly evident that the embedding of these forms of artificial agency in the urban context, in order to ensure its control, has ended up generating a new context that is more complex and thus in need of new interpretations (Batty, 2024). The notion of control seems to be in a non-peaceful relationship with the ontological essence of digital technology. When the world needs to be massively re-ontologised to control it, it is unlikely that the interpretive paradigms that preceded this change can be effective.

This context highlights the need for a new epistemology for this mature phase of the implementation of digital technologies and, in particular, of AI (Floridi, 2014; Lee, 2018). This task obviously involves a wide variety of disciplines and approaches. As far as this chapter is concerned, the aim is to explore the intersection between AI ethics and AI urbanism. Indeed, a considerable number of studies on AI urbanism are encouraging a structurally interdisciplinary approach to address the sources and implications of this phenomenon with particular reference to ethical issues (Batty, 2023; Luusa et al., 2023; Cugurullo et al., 2023a; Cugurullo et al., 2023b). Moreover, the need to confront concrete problems of urban ethics compels philosophical discourse to develop concepts that can be applied to the design of actual urban projects.

First, I will describe the recent development in the field of AI Ethics from the reflection on principles to the attention to practice. Indeed, I illustrate both the achievements and the criticism of the Ethics of principles applied to AI in order to highlight the consolidation of a new phase, after principlialism, of the discipline. In addition, I argue this new wave of AI ethics should be in dialogue with urban studies for several reasons including the key understanding of objects as fields charged with ethically characterized forces.

Then, an illustration of Urban Ethics will be proposed. In this context will be decisive to understand the rationale of this discipline and the recent articulations which challenged a functionalist approach and gave importance to the differences between communities and their situated knowledge. What is more, the key features of the ethical debate on smart city will be highlighted, as well as some pivotal novelties emerged in AI era.

Ultimately, the key ethical issues related to UAI will be enumerated, and an ethical approach based on makers' knowledge will be proposed. Design will emerge as the essential filed to urbanize AI. Thus, two significant design theories – Design Justice and Designing Disorder – will be explored with regards to AI urbanism. Overall, the chapter will point out that an interdisciplinary effort between AI Ethics and urban Ethics should be positive for both. In addition, the arguments in this chapter aim to promote a different mode of ethical control over design than that conceived in modernity, capable of bringing technology closer to the needs of citizens.

2. Transitions in AI ethics

2.1. A search for ethical principles

AI ethics is a relevant part of the new epistemology that the radicality of AI's impact requires. As a sub-discipline pf philosophy of technology, AI ethics regards the values that should inform the relationships between this technology and the individuals and communities that come to interact with it. The history of this discipline has already produced a significant amount of literature and debate since at least the second decade of the 2000s.

One of the most influential approaches in both academic and policy making debates is centred on the identification of principles through which to ethically regulate the use of AI (Floridi et al., 2018). This endeavour has been decisive for at least two reasons. Firstly, it posed the ethical question as an unavoidable issue in the AI debate: dealing with AI must also mean taking into consideration the ethical implications of its development and application. AI must therefore be studied as a socio-technical system with considerable ethical implications. The more the debate on the ethical principles of AI becomes established, the less AI will be seen from a merely technological perspective. Secondly, the high-profile nature of the debate has been a stimulus for policymakers, businesses and other actors to be aware of ethics and develop ethical principles. Such pressure has been useful in nudging all stakeholders in the AI industry to at least consider the ethical values and implications associated with AI development and deployment.

In order to assess the real impact of this approach, it is useful to consider a comparative (of 84 ethical frameworks) study that has highlighted some key features of these efforts to formulate principles (Jobin et al., 2019). In this context it emerged that no single principle is common to all guidelines, however transparency, justice and fairness, nonmaleficence, responsibility and privacy are the most common principles among the documents considered. Scrolling down data, we realise that issues such as environmental sustainability and solidarity are only sparsely addressed in drafting AI guidelines. Furthermore, the geographical origin of these ethical frameworks reveals a striking preponderance of economically most developed countries, with a notable absence of guidelines from, for example, Africa or South America. In addition to these specific issues, this study expresses a general concern about the implementation of this set of principles, based on the difficult transition from principles to practice and the often-conflicting interpretation of the same principle depending on the guidelines.

In recent years many specific criticisms have been levelled at this type of approach. Firstly, there is a growing body of literature on the lack of rigorous consideration of the environmental impact of AI de-

velopment and implementation, capable of mapping the ecological consequences of the various production phases of this technology in order to make informed decisions about its design and implementation (Roche et al., 2023; Brevini 2023; van Wynsberghe, 2021). These studies indicate that there is considerable interest in implementing AI to make a certain system (urban, industrial, etc.) more sustainable, but less attention is paid to assemble, train and deploy AI in a sustainable manner (van Wynsberghe, 2021). Moreover, in many research and guidelines, sustainability is seen primarily as a matter of reducing emissions, narrowing our perspective on the broader material impact of AI (Brevini, 2023). As will be shown in the following chapter, the relationship between AI and urban environmental sustainability implies a re-examination of some fundamental concepts that have informed Western culture. In the next chapter I will use Latour's thought to show that without questioning the concepts of modernity, science and nature that have guided modern Western culture, it is extremely difficult to integrate technological development with the problems posed by climate change.

Another structural shortage regards the universalist view that informs the ethics of principles which seems to struggle to address and identify the concrete power dynamics that shape the development and use of AI (Maas, 2023; Munn, 2022). Munn (2022) suggests that the principles are too abstract and therefore cannot come into friction with the real power dynamics at play in our societies. Companies and governments can easily twist the interpretation of these principles to justify their behaviour. Maas (2023) states that the relationship between developers, users and end-users of AI systems is characterised by a deep and articulated power imbalance that is beyond the reach of abstract principles. Considering the principle of fairness, Birhane et al (2022) demonstrate the distance between abstract conceptualisation and the actual communities that are affected by algorithmic injustice. The principles are rarely shaped by the concrete issues and experiences of these communities and therefore remain meaningless in their everyday experience. This problem is also relevant when it comes to Urban AI. Indeed, citizens that are affected by these tools are rarely involved in the design phase (Popelka et al., 2023).

This shortage is also linked to the Western-centred approach to ethical issues, as it is reported that ethical principles that do not originate in the global North and within a Western framework remain underrepresented. (Roche et al., 2023). In addition, empirical research shows that ethical issues have unfortunately not entered programmers' every day and working practices, and where they have, they are reduced to technical problems that can be solved by technical solutions (Hagendorf, 2019).

This array of concerns does not undermine the relevance of ethical reflection on AI, but instead forces the scientific community to rethink the conceptual tools that should be adopted to craft an effective eth-

ical approach to this technology. The aim is to trigger widespread awareness that the first generation of AI ethics has come to an end and that it is necessary to move forward (Gill, 2023; Prem, 2023; Morley et al., 2020): from principles to practices, from ethics to power relations, from the level of abstraction of guidelines to the analysis of concrete processes of AI assembly and use.

The urgency of this step forward has begun to be understood by the AI ethics community. Crawford (2021) has shown how AI must also, if not primarily, be considered as an assemblage of forms and power relations concerning the fields of labour, classification systems, the extraction of natural resources, and infrastructural-logistical systems. Coeckelbergh (2022) has expanded the analysis of the spectrum of social issues effected by AI highlighting how major political issues that structure our associated living are modified by the agency of AI (Freedom, equality and justice, democracy, power, and the relationship with non-humans) Following a similar rationale Floridi (2023b) argues that technological artefacts appear stable because they are the result of a composition of ethically characterised forces that determine their materiality and possible uses. Through this framework it is made explicit that «the design of any technology is a moral act. The neutrality thesis tries to hide this fact, and the responsibilities that it implies» (Floridi, 2023b).

Thus, in this new perspective, the idea is to map the ethical choices that act as force vectors in the composition of technological artefacts. In chapter 5 of this thesis, for example, the ethical and political motivations behind the Bologna Digital Twin are described ad decisive elements of the project. Considering the research on principles, a process towards greater concreteness has started. Prem (2023) following the path opened up by the research of Saltz and Dewar (2019) and Morely et al. (2020) has divided the process of AI development into nine stages (from business and case-use development to monitoring) and highlighted specific ethical issues for each of these. Birhane et al (2022) register a slightly increase in concrete and situated research taking into consideration two major conference in AI Ethics in time span 2018-2021. The transition to more concrete AI ethics seems to be underway even if much remains to be done. As I will show at the end of this chapter, it is vital that the communities affected by AI are involved in the design of this technology.

However, following this literature this involvement will only be effective if AI ethics follows the path of concreteness: 1) avoiding a technocentric perspective; 2) recognising the abstractness of pure principlism; 3) unpacking principles through the whole process of AI design and implementation; 4) working with values and ethical frameworks shared within the communities affected by these systems. This is a departure from the simple principialism that had animated the first phase of AI ethics. Considering

technological objects and AI in particular as ethically charged fields of forces and possibilities entrusts philosophical reflection with two active tasks: 1) grasping the direction and intensity of the forces shaping the provisional stability of technological objects; 2) modify this state of affairs to achieve ethically desirable configurations. This new perspective is certainly a step forward in the process towards a concrete AI ethics, however, as we will see, there is a need to push the bar even further, and a look into urban studies can be a useful way to take an additional step towards better AI ethics.

2.2 A possible lesson from urban studies

The direction taken by AI ethics research suggests a possible fruitful relationship with urban studies for three main reasons. Firstly, the relationship between design and power is particularly evident in the urban domain. Langdon Winner (1980) famously highlighted that «artefacts have politics» by referring to the controversial example of the Long Island access bridges designed in the first half of the 20th century by the well-known urban planner Robert Moses. According to Winner, the low height of these bridges, which prevented the passage of public transport, was a deliberate design choice. It was intended to make Long Island an exclusive place, inaccessible to the less affluent classes. In this case, an ethical choice, which in turn prevents or allows certain behaviours, is imbued into the very materiality and dimensionality of the designed artefact. Design is both the product of an ethical charge and a means of enabling certain behaviours to occur.

Richard Sennett's interpretation of the rise of modern urbanism is along the same lines. Sennett (2018) illustrates a specific objective that is a cornerstone of Hussmann's design for the new Masterplan of Paris in the second half of the 19th century. The new urban structure was undoubtedly crucial in providing wider public spaces and a healthier environment. However, the replacement of the dense medieval grid of small streets with a series of large boulevards ensured easier military control of the streets. Indeed, on the one hand, it was more problematic to erect barricades in the new boulevards, and on the other hand, they were easier for soldiers on horseback to traverse and for cannons to be easily moved in the event of an insurrection. As these examples briefly shows, the link between ethical choices and design has been a crucial one in the history of urbanisation. This relationship between technical choices and social repercussions in planning is at the centre of Forester's (1989) analysis in *Planning in the face of power*. From this perspective, every planning decision produces technical results but also reproduces social relations: the technical realisation of a new urban project modifies the geometry of

the relations of knowledge, trust, power and accessibility of a given context. The link between the technical and the ethical is therefore crucial.

The second reason concerns the recent history of urbanism. Indeed, the link between ethics and urban design has also been evident in the literature on the paradigm of the smart city. As we have seen in the first chapter, precise political and economic choices are at the core of the corporate narrative on the smart city. The 20-year debate on the smart city has increasingly highlighted the importance of the ethical dimension (Trencher, 2019; Sennett, 2018; Kitchin, 2016). An initial formulation of this paradigm driven by technological solutionism was strongly criticised for a lack of attention on power dynamics and an ideologically neutral interpretation of technology (McFarlane & Söderström, 2017; Söderström et al., 2014).

This literature is pivotal in the dialogue between AI ethics and AI urbanism because it constitutes a solid starting point in which certain issues have already been addressed with a strong consideration of the ethical dimension. Moreover, there is a significant body of interdisciplinary research in the smart city debate which bring philosophy and urban studies into dialogue in order to deal with articulate urban issues (Cook & Karvonen, 2024; Cugurullo, 2021; Klauser et al., 2014). For all these reasons this body of literature constitutes a solid baseline for the future relationship between AI ethics and urban studies in the era of AI urbanism.

These two elements – the connection between ethical values and urban planning, and the development of this connection in the smart city debate – are already enough to understand why another step forward to concreteness is needed. Indeed, following these reflections one can understand that technological artefacts are not only double-charged from an ethical point of view. We do not have a good force versus an evil one, or a right perspective versus a wrong one. This binary approach, which remains too abstract, needs to be overcome. In complex issues like technology or urbanism, it is often difficult to draw a line between right and wrong. These objects are surely charged, but they are multi-charged: they receive impulses from a number of different directions and interests. This articulated nature is widely recognisable in urban projects. Haussmann's masterplan in Paris was simultaneously driven by urban health issues, military and security concerns, and a new conception of public space. There is no mythical realm where good and evil are battling it out, the situation is more concrete and therefore less simple. There exists a complex geography of forces that help to shape technological objects and urban projects.

This brings the reflection to the third reason as to why a productive relationship between AI ethics and urban studies is possible. Indeed, this idea of an ethical multi-charged of objects was strongly present at the very beginning of the reflection on urban ethics, namely in the philosophical perspective of Henri Lefebvre on the city in the second half of the last century. According to him, urban space is both a product and a site of production (Lefebvre, 1996). The city is the product of a multiplicity of forces (natural, economic, technological, ideological, etc.) and at the same time it is the site in which these forces can be changed and bended. On the one hand, the apparent stability of the urban fabric is the result of the action of force vectors, it is the reification of these movements; on the other hand, the same city has the power to change this status quo through the action of its citizens. Precisely because the status quo is something produced by certain forces, it is possible to modify it by unleashing other forces. In the city, according to Lefebvre, a battle is fought between global vectors of force that want to reduce the urban to a homogeneous, functional, and neutral space and vectors represented by the various forms of agency that populate the city and that can resist, redirect or support the former.

In summary, I argue that urban studies are an extremely valuable terrain in the transition from principles to processes that AI ethics is going through. Indeed, the city represents a context in which the relationship between design and power has always been considered decisive. The smart city debate has already indicated a possible interdisciplinary terrain between ethics and the urban application of ICTs, and the new ontology underpinning urban ethics shares some fundamental assumptions that we have seen characterise AI ethics. AI ethics can therefore play a crucial role in addressing certain issues that arise in the urban application of AI. An ethical reflection on AI urbanism that does not take into account AI ethics would certainly be deficient in terms of understanding technology and its potential implications.

However, the specificity of the urban context requires further elaboration. Considering urban ethics is another pivotal step in our effort to understand an appropriate level of action for the interaction between the philosophy of technology and urban studies in the context of AI urbanism.

3.Urban Ethics

3.1 Defining Urban Ethics

Richard Sennett (2018) expresses through the relationship between *Ville* and *Cité* the polarity that defines urban ethics in the modern history of urban planning. The *ville*, the Latin *urbs*, regards the built environment, while the *cité*, the *civitas*, concerns the way citizens experience urban spaces. According to Sennett, the intersections between these two axes shape urban ethical relations: certain spaces favour

or disfavour particular kinds of behaviours, and specific ways of dwelling adapt to or reject the predispositions imposed by definite urban projects. Building on Sennett's position, I argue that urban ethics regards meaningful relationships between urban actors (human and non-human) in active contexts made of buildings, environment, institutions, infrastructures and urban projects.

As it is illustrated in Figure 8 from the perspective of architects and urban planners – the designers of the *urbs* – ethical considerations generally concern three distinct areas: professional ethics, the ethical value of a construction, or the ethics of the design process (Schrijver, 2013). The first aspect is about the obligations, limits and responsibilities connected with the profession of architect or urban planner (Marcuse, 1976); the second concerns the relationship between the aesthetics of a construction and the moral message it wishes to convey (Alexander, 2013); the third regards the sense of responsibility towards the built environment and the very process of design (Schrijver, 2013).

Although AI can have a major impact on all of these areas, this chapter will focus on the third, as it concerns urban ethics more generally and is not limited to professional ethics or the aesthetic-artistic dimension of design. Following the path of a dialogue between design and philosophy, it is possible to further analyse this third aspect. Chan (2018a) identifies three specifications in the relationship between ethics and the design process: a) the ethical issues related to the rules and norms that guide specific design projects; b) the questioning of the decision to design or not a specific object or space; c) the consideration of how a design object or space can modify our ethical behaviour.

When it comes to AI urbanism, one can easily identify specific issues related to these three dimensions. With regard to the first dimension (a), one can immediately think of the data issue: what kind of policy is applied to the collection and use of data, which is key for any urban AI system, both in the training phase and its deployment. The second aspect (b) concerns the actual need for a specific technological solution. For example, one could think of reducing traffic-related emissions by introducing autonomous electric vehicles, but the same purpose could be achieved by increasing the use of bicycles and public transport. In this case, we are faced with an ethical choice at the very beginning of the project. Finally, the third dimension (c) is evident in the cases of AI nudged behaviour: how does one's behaviour change in a space scanned by AI-powered cameras? How can sustainable behaviours be promoted through AI-enabled soft mobility gamification? In a proper consideration of urban ethics in AI urbanism, all these specific issues are at stake.

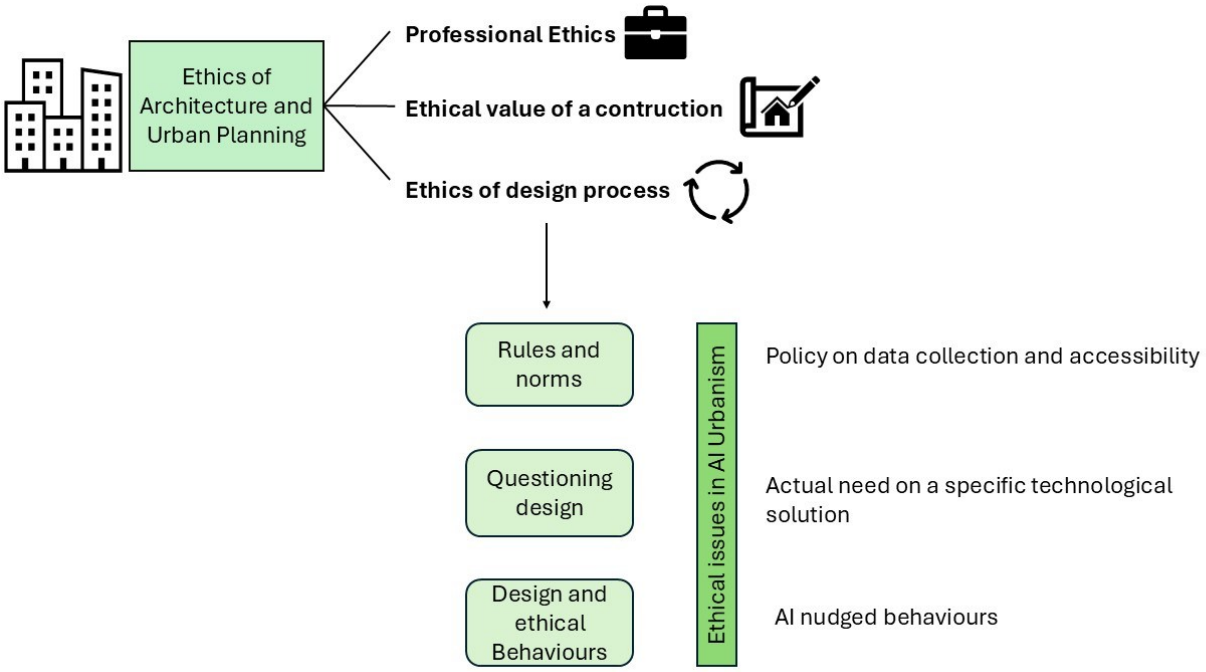

Figure 7 (Author's original based on Schrijver 2013 and Chan 2018a) Diagram representing different means of interpreting ethics in urban planning and architecture with a fucus on the ethics of design processes in relation to AI urbanism issues.

Moreover, it is also pivotal to reflect on a general shift in the guiding idea through which we grasp the very concept of the city. The guiding ideas of the city that have changed over time are of massive importance in the ethics of urban design. They provide the epistemological background against which the dynamics of ethics in a particular context are to be interpreted. For instance, the paradigm of the industrial city has given rise to decisive reflections on housing conditions and spatial organisation at the dawn of urban planning (Benevolo, 1971), the modernist perspectives of functional design of the city in accordance with the technological spirit of the early 20th century paved the way for many interventions in the middle of the last century (Sennett 2018). More recently, the crisis of the Fordist city has given rise to a series of paradigms, from the creative city to the global city to the smart city, as an attempt to rearticulate an organic reflection on the urban (Rossi & Vanolo, 2011).

In all these examples, a pivotal concept (industry, the creative class, global exchanges, or smart technology) is understood as the architectonic idea through which to articulate the urban reality and its relations. As we will see in the context of AI Urbanism, AI is becoming the pivotal idea that suggests new scenarios for our urban futures. Therefore, in order to shape incisive interventions in contemporary urbanism, it will be imperative to understand both the technical rationale and the ethical implication of this technology.

Going back to the analysis of the post-industrial city, urban ethics insisted heavily on global competition between cities, efficiency, increased quality of life and coordination between stakeholders as central elements of analysis. Most issues in urban ethics seem to have morphed into issues of governance in which the reduction of bureaucracy, simplification of models, impartiality of decision-makers, stability of rules and agility of regulations play the leading role (Moroni, 2013). The cultural sources of this trend are variously indicated in the neoliberal ideology applied to the urban context (Brenner & Theodore, 2005). By neoliberal ideology here one must not only refer to the economic theories of economists such as Hayek, von Mises and Friedman, but to the political form of neoliberalism that has dominated the last season of Western politics (Williams & Gilbert 2022). Individualism, competition, and the reduction of real social programming have been fundamental concepts of this cultural temperament permeating even the urban culture of creative or global cities.

Even the first steps of the smart city paradigm - which is the most recent model of AI Urbanism - have not deviated from this model, selling out to criticism that identifies in its logic a continuation in the context of the digital revolution of an urban ethics marked by neoliberal ideology (Greenfield, 2013). However, the acceleration of urbanisation in recent years has not led to a balance and improvement in overall urban conditions, but has coincided with an increase in urban inequalities, social exclusion, and increasingly evident divisions. Furthermore, the issue of urban conflicts arising from land use, political consequences of planning and differences between ways of inhabiting has become critical (Chan, 2018b). The urban ethics perspectives based on the paradigm of governance and efficiency that attempted to come to terms with these contradictions are destined to fail because they are based on philosophical frameworks that shared at least three assumptions with neoliberalism: 1) the individual as the fundamental component of society; 2) a conception of morality as an aggregate of individual choices and preferences; 3) a marked anthropocentric vocation (Watson, 2006).

From a philosophical standpoint, these positions shared the idea in which the only social programming to be done is to make the various individual projects feasible and compatible (Floridi, 2023a). This idea of society obviously owes much to the neoliberal economic and philosophical perspective in which the great complexity of individual relationships finds an almost automatic harmonisation (Dupuy, 2001). Moreover, this view suffers from a radical incompleteness regarding the absence of collective and communitarian projects that can orient society or part of it towards certain common goals (Floridi, 2023a). A paradigm in which planning is intended as an impartial and universalizable science capable of mediating individual needs towards the goal of efficiency appears to be deeply problematic in the present days.

It is straightforward to notice a shared logic that ties together this urban ethics perspective and the principialism that we have identified as the starting point for AI ethics. Pure rationality based on clear principles is envisaged as the silver bullet to introduce order into the chaos of socio-technical systems. These principles can be applied to all citizens because they are equal, regardless of their belonging to a specific community and they are correct because they are derived from a universal knowledge that is independent of both geographical areas and social status. As we have seen in the previous paragraph, this approach falls short when it comes to analysing the real dynamics that are the flash and the blood of any given socio-technical system, including cities. This principialism - in both AI ethics and urban ethics - is blind to the myriad of different perspectives that constitute the ever-changing scenario of the urban fabric, and the distance between pure principles and actual dynamics will always lead to ineffective actions anticipated by ineffective discourses.

In order to face this situation, the new course of research in urban ethics has been focused on the decisive role of communities and collectives as fundamental urban actors, and on the need for ethics to become the terrain of relations between interests and needs that cannot be harmonised through an efficient distribution of resources from above (Dörr et al., 2020; Ege, 2020). With regard to issues as housing, environmental justice, access to services, availability of public spaces and social inequalities it is almost impossible to find solutions that fits for all, due to the fact that urban contexts are informed by profound differences between communities (Watson, 2003).

These radical differences concern the ways of living of communities, the ideas and habits through which they make sense of their urban experience. This variegated context cannot be resolved at a higher level of abstraction that claims to harmonise it from above. The mechanical city that had been the dream of modern philosophy explodes into a pluriversal urbanism (Moreno-Tabarez et al., 2023) in which different and values-oriented communities are the true matter of the urban fabric claiming a substantial democratisation intended as the need to see their own vital values shaping the city (Iverson & Tattersall, 2023).

From this point of view, knowledge is a product of the meaningful relationships within the community, which are a pre-existent reality that the designers need to elicit and foster, rather than something that professionals bring into the community in order to regulate it. Knowledge that is situated and embedded in the meaningful relationships of a given context replaces the impartial and objective knowledge that characterised the universalist approach (MacIntyre, 1988; Haraway, 1991; Watson, 2006; Costan-

za-Chock, 2020). In this case, urban ethics is undergoing a transformation similar to that of AI ethics outlined above.

3.2. Ethics from Smart to AI Urbanism

As it has already been mentioned, the relationship between technology and the city has emerged as a central issue in the era of the digital revolution. The discussion of the smart city paradigm has occupied a massive space in academic reflection, public debate and also in the financing and implementation of urban projects all over the world (Morozov & Bria, 2018). The evolution of this debate has led to a critique of a purely technocentric perspective with little awareness of the epistemological, social, environmental and political implications (Trencher, 2019). This reorientation of research has encouraged the development of ethical reflection applied to the smart city.

Rob Kitchin (2016), for example, has highlighted how this urban model is imbued with a realist and simplistic epistemology regarding data and its objectivity, which is the consequence of a reductionist positivism that drastically underestimates the ethical dimension. Adam Greenfield (2013) had already drawn attention to these issues, analysing how a smartness driven solely by Big Tech runs the risk of being detrimental to citizens. Richard Sennett (2018), in his reconstruction of the modern history of urban ethics, also devotes a chapter to the smart city, stressing that it is the choice of values, and therefore ethics, that decides between a smartness capable of empowering citizens and one capable of depriving them of power. Following Rob Kitchin's definition of the smart city as the real-time city (2014) and the resulting urbanism as data-driven urbanism (2011), it is not surprising that data is at the centre of ethical reflections on this urban model.

Mappings of ethical problems related to the smart city focus heavily on this issue, highlighting, for example, all the risks associated with the collection and storage of data, and the need for its protection, access and sharing (Claver et al., 2018). Indeed, unethical data management carries risks of control and surveillance, as well as discrimination against certain categories of citizens (Ziosi et al., 2023). This debate has made choices of values, and thus the ethical dimension, central to what was initially presented as an essentially technological context. Data was transformed from an objective and neutral tool of urban governance into a field of ethical contention. The collection, management and use of the vast amounts of data produced by cities have emerged as crucial socio-technical processes (Kitchin, 2021), capable of giving rise both to a post-political and technocentric government (Ziosi et al., 2023) or to new struggles over the right to the city (Cardullo et al., 2019).

Indeed, updating Lefebvre's perspective, the right to the city nowadays has its terrain in the digital infrastructures driven by data, which sustain an increasing range of urban phenomena (Currie et al., 2023). From predictive policing to migration control, from data-driven capitals to mobility management, data is at the very heart of urban rhythms (Ivi). For example, Metcalfe (2023) argues that in UK the interoperability of different data sets has been used to track, identify immigrants with the explicit aim to shape a hostile environment for them. From a lefebvrian perspective this is a digitally mediated reduction of the right to the city. On the contrary, Feldman (2023) shapes a comparative work on how urban activist (movements of squares, 2010-2016) have used digital technologies in order to bluid and promote their perspective on society. In a nutshell, the battle between urban alienation and urban activism is currently being fought in a hybrid space in which data is playing an increasingly central role (McGregor, 2022).

AI urbanism is certainly closely related to the smart city paradigm. In fact, as we have seen in the previous chapters, some of the concepts useful for analysing the former can be derived from the literature on the latter. However, it is also pivotal to investigate the discontinuities between smart and AI urbanism. Indeed, AI is emerging as the fundamental technology of this latest phase of the digital revolution. Recently, some scholars have highlighted nine specific differences that would mark a paradigm shift between these two urban models (Cugurullo et al., 2023).

Three of the elements that have been identified as capable of distinguishing smart and AI urbanism are particularly interesting for the ethical considerations addressed in this chapter [Figure 9]. First, the ability of AI to produce simple narratives that can guide knowledge and action (Cugurullo et al., 2023). It is easy to consider models such as ChatGPT or Bard that can shape narratives and models already used in architecture and urban planning to represent both built and natural environments in the design process (Rane et al., 2023). As we have seen, in the previous section, the concepts underlying urban paradigms are important in providing the background against which ethical relationships between actors can be interpreted. In AI Urbanism, of course, the guiding concept is artificial intelligence, and it is extremely interesting that this tool can produce simple narratives that may be able to influence the way people understand and imagine the city.

Secondly, Urban AIs are not automatic technologies, they are autonomous ones. That is, they make decisions with varying degrees of autonomy without human supervision, rather than simply repeating a task in an automated manner. This raises, firstly, the ethical issue of balancing artificial autonomy with human control, but above all, it makes it very difficult to interpret these forms of agency as mere tools:

in the smart city paradigm, the idea was to collect data to improve the quality of decisions made by policymakers, while in AI urbanism, planners must decide which decisions need to be made autonomously by AI and which need to involve humans in the process.

A final element of differentiation allows us to interlink the reflections of this chapter. From a temporal point of view, smart urbanism is concerned with the present, while AI urbanism is focused on the future (Cugurullo et al., 2023). The aim of the former is to collect data in real time, while that of the latter is to predict and create scenarios and models of action that extend urban governance into the future. The future is the fundamental time of urban design, which by its very nature seeks to direct the development of dynamics towards certain outcomes.

AI is a very powerful tool in urban design and management because of its ability to make autonomous decisions, its power to create narratives, and its possibility to shape models and scenarios. In the Chinese context, City Brains (Caprotti & Liu, 2022) are already helping to design and manage entire sections of cities, and with some specific differences, this trend can also be seen in European and American Urban Digital Twins (Weil et al., 2023). As will be highlighted, the relationship between human agency and AI-enabled tools is at the centre of theoretical and practical discussions of urban digital twins. From this point of view, for example, the difference between a model based solely on the concept of prediction and imbued with a narrative of competition between human and artificial agency, and one based instead on the concept of scenario building and a cooperative relationship between human and artificial agency, will be highlighted. This theoretical difference will be embodied in the analysis of the Bologna Digital Twin project, which explicitly rejects the idea of a technological overcoming of the ethical dimension. In fact, as will become clear from the documents and interviews, the digital twin is always defined as an aid to ethical decision-making, and is therefore subject to it. This perspective is in positive dialogue with the reflections of Simondon and Ciribini, presented in chapter two, on the relationship between ethics and cybernetics. In fact, according to Simondon, greater automation does not correspond to a reduction of the ethical sphere, but rather to the possibility of a greater clarification of it. These considerations show that the role of ethics can remain central, even within a reflection that positively evaluates technological innovation and the increasing automation of certain processes.

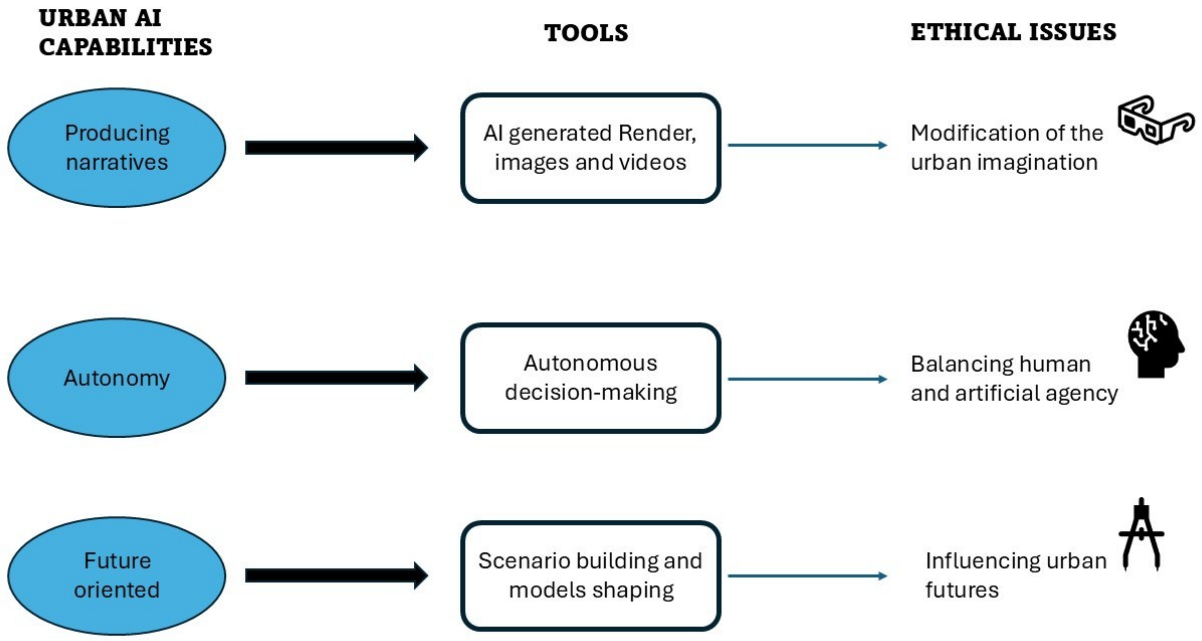

Figure 8 (Author's original) The diagram depicts three prominent aspects of AI urbanism, highlighting the tools through which they are made explicit and the ethical issues they raise.

4. Ethics for Urban AI

4.1 The need for Ethics in AI Urbanism

Taking into full account the three characteristics of AI mentioned above - narratives production, autonomy and being future-oriented - is paramount to understanding what is at stake in the ethics of AI urbanism. The urban fabric has historically been influenced by some key concepts that have been able to dictate the tempo of its development and management. Industry, creative class, global exchanges: all these ideas played a decisive role in shaping the destiny of urban development in the modern era (Rossi & Vanolo, 2011). Their symbolic power has contributed to the actual design of entire cities, influencing the urban agenda; the industrial city was developed by and for the industrial sector (Benevolo, 1971), similarly the global city was shaped by some characteristics of finance-based globalization (Sassen, 2001).

Nowadays, AI is a legitimate candidate to be the next driving concept in urbanism in terms of investments, appeal, and efficiency. This technology has some peculiarities: it can act autonomously, shape

narratives, and to some extent predict the evolution of the context in which it is applied. These three aspects alone can give rise to unprecedented ethical challenges in the urban realm. From this perspective, the discourse is quite frightening. If we imagine urban AI as a superintelligence capable of running, predicting and acting on the city as it pleases, then we are immediately catapulted into a sci-fi scenario.

Notwithstanding, AI is not autonomous in an absolute sense. In fact, a wide range of workers (from miners to programmers), knowledge (statistics, mathematics, computer science), rare materials and institutions (companies, research foundations, universities, states) are involved in shaping this artefact (Crawford, 2021; Joque, 2022; Pasquinelli, 2023). AI is not an alien intelligence separate from us. The ability to act rationally embedded in this artefact is made up of human efforts, and therefore also of human errors, limitations and contradictions. We are not facing a compact, solid and transcendent intelligence, but rather a diversified, articulated and terrain-bound capacity to act. Furthermore, as it has been highlighted in the introduction to this chapter, following Winner (1977) and Floridi (2022), AI's capacity to act is intimately related to our capacity to modify the world in a specific way that is readable by that artefact. Enveloping the city to make it an AI-friendly context will be key in the near future.

However, if urban planners and policy-makers want to go down this road, the ethical criticalities are destined to increase drastically. Indeed, urban reality will be seen simply as a set of routine behaviours that an AI can predict (Barns, 2021), urban actors will be considered only as a source of data (Vanolo, 2014), and the current biases that shape society would be replicated automatically (Eubanks, 2017). Hence, it will be harder to imagine a rich and diverse future for the city. In order avoid this scenario, and to have a proper grasp of the relationship between cities and AI, it is crucial to consider urban areas as active *milieus*. It is remarkably reductive to conceive the city as a passive context waiting for the agency of an intelligent ruler, or simply as a chaotic matter in need of an external rationale. Urban areas are milieus already teeming with agency (human and non-human), organised in complex structures and forms, composing and articulating a geography of relationships. This is where the possibility of reverse enveloping lies . Indeed, this technology is neither the only, nor the main agent in the urban, and therefore it must establish relationships with the other forms of intelligence that permeate the built environment.

Recently, Cugurullo et al. (2024) have highlighted six ways in which the city influences urban AI, which can be summarised in three main areas: a) The capacity of the city (council, stakeholders and citizens) to shape, deploy or reject the use of urban AI (Cugurullo & Acheampong, 2023; Kelly et al.,

2022); b). The fact that urban AIs only come to an actual functioning when they are applied to a context from which they can learn. Hence, the urban environment, perceived as data, is crucial in shaping the rationality of these machines (Sumartojo, 2024; Valdez et al., 2024); c) The urban action of this technology must deal with the urban context in which it is situated, and in the deployment of its agency it has to mediate with other intelligences (Lynch & Del Casino, 2024).

From these three areas, it is possible to derive three distinct spheres of ethical issues, related to the capacity of urban AI to be steered by urban values, to the need to feed these AIs with urban data full of ethical choices, and finally to the power of urban actors to mediate with the consequences of AI decision-making.

These three areas affect the entire life cycle of Urban AI. In fact, as a city manager or as a community, one can refuse to adopt an Urban AI because of the specificity of its construction, in terms of the condition of the labour force involved or taking into account the environmental sustainability of the process. What is more, one can reflect on the data that will shape this agency and understand if there is a pertinent fit between these data and the urban goals that a community aims to achieve. Finally, it is possible to consider the relationship between the actual deployment of Urban AI and the current dynamics of both the *cité* (the way people live) and the *ville* (the built environment). At this juncture, a pressing question is imperative. What kind of ethics is appropriate to carry out these reflections? Indeed, as we have argued, a simple principialism is doomed to fail to grasp all these dimensions, and urban ethics must seriously take into account the concrete needs of communities and stop designing for an abstract and isolated individual.

4.2 What kind of ethics?

The urgency to overcome the distance between principles and practice has been highlighted in both AI ethics and urban ethics. From a philosophical standpoint, the aim is to work at a level of abstraction between pure principles and actual practice. Indeed, on the one hand, pure principles have already shown their ineffectiveness, and on the other hand, it is impossible to carry out a proper philosophical analysis of individual events. The actual uniqueness of an event is beyond the reach of conceptualisation, because to conceptualise is to relate it to something else. Therefore, in order to shape an ethics for urban AI it will be pivotal to inhabit this in-between level of analysis, at the intersection betwixt philosophy of technology and urban ethics. Not the level of philosophy of technology and its principles, nor the layer of urban ethics and the actual individual ethical relationships that occur in a specific urban context.

Philosophy of technology is trying to reach a more concrete level by moving from the consideration of principles to the concrete isolation of the ethical issues linked to all the components of AI. Specularly, urban ethics is reflecting on how to embed the values of specific communities in general rules. In both cases, one can notice a conceptual design effort to distribute the principles in the concreteness of the technology, or to abstract some rules from the actual urban dynamics. Thus, it is compelling to emphasise the role of conceptual design to bridge the gap between principle and practice. Indeed, conceptual design implies an active approach to knowledge, in which to understand something is to grasp how it is structured and constructed.

More than ten years ago, Floridi proposed the idea of considering philosophy as a maker's knowledge to be conceptually effective in the digital revolution (Floridi, 2011). Floridi thought about overcoming the Platonic distinction between *episteme* (Knowledge/Science) and *techne* (Practice/ technology), and pointed to Francis Bacon, Thomas Hobbes, Immanuel Kant, and Charles Sanders Peirce as philosophical sources of this way of thinking. In a nutshell, following Floridi:

> If genuine knowledge is knowledge of the intrinsic nature of the object known (Knowledge of the ontology of the known), and if there is no innate acquisition of such blueprint, then knowing a phenomenon, an artefact, or, in our case, gaining information and being able to account for it, means being able to produce and reproduce it, to assemble and disassemble it, to build and dismantle it, to improve it and answer question about it, and all this for right reasons. For knowledge to be possible, mimesis must be replaced by poiesis. (Floridi 2011, p. 290).

More than ten years after that statement, one can see that this approach resonates with the productive nature of the digital revolution. In fact, a multitude of new digital tools and instruments have been produced in recent years, and if one wants to really grasp their rationale, it is crucial to understand how these artefacts are designed and built. As we have seen in the case of AI, it is remarkably important to have in mind all the components and the phases of its construction in order to shape effectful ethical guidelines. Indeed, according to Floridi and Sanders (2005), this makers' approach has also significant implications for ethical reflection. Indeed, ethics must focus on the actual production of artefacts, rather than on isolating principles or abstract moral values. The idea is to exercise control and stewardship within design processes, and therefore to be deeply involved in all stages of this activity. This initial intuition in information ethics is consistent with the recent development in AI ethics that we have been following. From principles to practice, sometimes going further means going back to the origins. A similar logic can be applied to Urban AI. Popelka et al. (2023) have recently proposed an anatomy of Urban AI that divides this artefact into eight layers, namely urban infrastructures, sensors and data collection, network infrastructures, data storage, data processing, data visualisation, algorithms and ma-

chine learning, and decision making. Following this work, it is crucial not only to isolate specific ethical issues in all these levels, but also to propose some proactive ethical approaches [Table 3].

Table 3 (Author's original based on Popelka et al., 2023). A list of some key ethical issues related to each component of an Urban AI with reference to possible approaches.

Parts of UAI	Ethical Issues	Approach
Urban Infrastructures	Identify a clearly defined urban problem	Participation and stakeholders' engagement
Sensors and data Collection	Privacy and accessibility	Anonymized and informed collection
Network infrastructures	Security and access	Physical security, Cybersecurity and Interoperability
Data Storage	How long to store the data and data management	Relevant data and accessibility
Data Processing	Grouping data	ML experts + domain experts
Data Visualization	Information accessibility	Infrastructures, education and participation
Algorithms and ML	Off-the-shelf, AI platforms and bespoke applications	Consequences of AI selection
Decision Making	Adaptation and communication	Feedback loops, performance metrics and collaborative design

First of all, following Table 3, it is essential to identify a specific issue that requires the use of UAI. This issue has to be felt by the community as relevant for the everyday urban experience. In addition, it should be key to recognize the array of stakeholders that can help in shaping tools and solutions. This first step regards the reasons and the adherence of a given technological solution to the actual processes of the urban. Not only, ethics is implied in the choice of the issue because it must be situated in the habits and values of the community, but also in the recognition of actors involved in the project. Indeed, stakeholders must be in harmony with the idea of the project without undermining its essence.

Then, there are three steps related to the collection, transmission and storage of data. In all these passages security, privacy and accessibility are paramount. There is a need of an anonymized and informed data collection that can guarantee the non-trackability of individuals and an understanding of why we are giving our data. Moreover, security (physical and cyber) and interoperability are necessary in the transmission of these data in order to ensure a safe and effective sharing of information between different systems. Also, the storage of data has ethical implication, for instance, with regards to sustainability. It is clearly unsustainable to store everything due to the fact that data storage requires space, energy and water. Thus, there is a need to select what we want to preserve and for what purpose. These are ethical choices with an impact on the sustainability and on the effectiveness of UAI.

Data processing is a pivotal step to obtain clean and usable data sets via cleansing, aggregation, de-identification, extrapolation and merging. These processes could be performed both in manual and automated ways. Already in this phase we can see that AI is implicated in the construction of other AIs. In a recursive fashion AI is used to shape the datasets for another AI. Therefore, it is paramount to consider which kind of AI we are using to build a dataset. What is more, it could be useful to include domain experts already in this phase along with ML expert, in order to have also a context specific understanding of the data. Data visualization should be the step in which citizens are able to see, understand and possibly use data. To obtain this goal a user-friendly design of data visualization tools has to be coupled with digital education processes. Only in this way could we achieve a real participation in projects.

The last two steps regard algorithms and decision making. With regards to the first, there are three kind of solutions that can be used in an Urban AI project. Off-the-shelf AI software are ready-made solution designed by the vendor. Although they are ready to use, they could not fit for a specific problem because they are shaped without adherence to that context. On the contrary, AI platforms offer solutions that must be partially customized by the user. In this case some technical skills are required to obtain a

more tailored system. Finally, building bespoke applications is the most difficult and expensive process to obtain an UAI that is designed and built bottom-up for a specific use case. Here relevant technological skills and a vast amount of resources are needed. The choice between these models has ethical implication in terms of control, privacy, security, effectiveness and accessibility.

All these steps are oriented to increase the quality of urban decision making via technology. When an UAI is deployed it is pivotal to keep humans in the loop both to have feedback and to eventually change something. Indeed, an autonomous process could become ineffective because something has changed in the context. In addition, some malfunctions and unexpected outcomes are evident only after the actual start of the project. In this case a participative and collaborative environment is pivotal to keep the project on track.

4.3. A different idea of control

This perspective ensures a certain degree of control over the urban AI design process. However, the notion of control is highly problematic in the context of AI for at least three reasons. First, because of the black box nature of contemporary AI (von Eschenbach, 2021); second, because of the dispersed nature of AI production and governance (Cugurullo, 2024); and third, because of the opacity of AI solutions, which are often shrouded in industrial secrecy. It seems that we are stuck in a paradox. In fact, AI is a technology that is linked to the modern desire to control reality, and yet AI is, by design, nature and law, uncontrollable to a certain degree.

The urban version of this aporia, as I mentioned in the introduction to this chapter, concerns the idea of bringing order to urban chaos through Urban AI, and at the same time achieving a more articulated urban fabric because of the presence of this technology. Langdon Winner (1977) confronted this paradox in his 1977 discussion of autonomous technology. According to him, contemporary technology is a direct product of the human desire for control. Winner noted that technology operates through a powerful modification of reality. The production of artefacts is a gradual modification of the world, and the explicit dream of modern technology is to control the environment through artefacts. In a more radical fashion, the aspiration is to intend the environment itself as a controllable artefact. Hence, the core idea is to rebuild the world from the ground up on purely rational principles (Winner, 1977). If humans can produce an artificial reality based on rational principles, they can finally take control of their environment.

From this standpoint, artefacts are, by definition, controllable because they are built according to rational and compressible rules. In spite of this aspiration of control, this key idea was already in crisis in the last century. In fact, the scientific development of an ever-increasing specialisation has exceeded the capacity of the human being to fully understand it and, therefore, to control it (Winner, 1977). In the AI era, this idea of being out of control is even more pronounced because of the specific nature of this technology. Human beings have built an object that they cannot fully understand. Consequently, they cannot exercise the degree of control that shaped the dream of modern technological development.

Building on these considerations, it is highly problematic to interpret the relationship between AI and the city in terms of control and rationalisation in which UAI is the tool to solve the urban equation with. Hence, I argue that attention should be focused not only on the process of making the city readable for Urban AI (Enveloping), but also on how urban culture might influence both the technical composition of AI and our understanding of this object: reverse enveloping. As mentioned above, Cugurullo et al. (2024) have described some ways in which the urban can influence AI. All these ways are rooted in a layer that is directly related to ethics. In the discussion of urban ethics, we have seen that starting from Lefebvre (1996) the city has been conceived as an ethically charged fabric, full of different ethical forces which constitute the very essence of the urban. These forces have different directions, objective, and they are representative of instances that are coming from specific collectives and communities. The notions of conflicting rationalities (Watson, 2003) and pluriversal urbanism (Moreno-Tabarez et Al., 2023) point exactly to this aspect of the urban highlighting the multifaceted, diverse, and even conflictual essence of the city.

Thus, this logic of the diversity should be the essential aspect of the reverse enveloping (from the city to AI) that the ethics of Urban AI must pursue in the actual technological design. It is mandatory to adapt the technological design of Urban AI to this essence of the urban, avoiding a technosolutionist perspective. The aim of urban AI must be the enrichment and even articulation of this diversity, not its reduction, and the promotion of a standardised peace in the urban environment.

One can notice this change of perspective for example by considering the debate on the biased nature of AI agency. It is well known that this issue concerns some of the assumptions and prejudices that are embedded in the datasets or algorithms which are key to making AI work (Eubanks, 2018; O'Neil, 2017). These biases are responsible for specific discrimination in the decisions taken or proposed by AI. In the design of Urban AI, the risk of biases is located in all the layers mentioned above.

Designers and policymakers could experience bias issues starting from the first choice regarding which kinds of urban phenomena they aim to analyse through technology, down to the decision-making phase in which one has to interpret the data in order to impose and actual modification in the urban fabric (Popelka et al., 2023). In addition, a bias could emerge in the selection of training data sets, in the actual training of data sets, in the algorithms, and in the decision based on spurious correlations (Coeckelbergh, 2020). One urban example regards predictive policing. Indeed, several scholars have pointed out that these tools, which should have been designed to increase the efficiency and accountability of police forces, have ended up reinforcing different kinds of discrimination in the city (Shapiro 2024; Richardson et al., 2019). Often, this malevolent output is derived from a wide range of biases embedded in different stages of the production of this specific urban AI.

Notwithstanding, biases are not exclusively a technical issue. Indeed, it is surely pivotal to avoid biases in all the stages described as much as we can, but an unbiased urban decision is a dangerous utopia. Decisions are by definition acts which select from all the possible choices some specific directions. Therefore, in every decision we can notice the promotion of certain possibilities, and the abandonment of others. In this sense every decision is biased, that is to say that every decision discriminates in an ethical sense (Coeckelbergh, 2020). Moreover, according to Forester (1989), every urban planning decision certainly produces a technical result and at the same time reproduces a set of social relations including power relations. Some citizens and communities are helped by a specific decision, and others are not. This problem of discrimination occurs decision after decision due to the fact that the urban is a plural entity made of ethically charged differences.

From this standpoint, an unbiased decision is an illusion. Thus, ethically speaking, the aim must be to understand the biases that are involved in every urban decision, make them transparent and accessible to democratic evaluation, and consequently choose in which direction citizens want to steer the urban agenda. On the one hand, designers and policy makers must avoid implicit biases, on the other hand, they have to decide which kind of urban development they desire, and so they have to discriminate among urban futures.

For instance, the automated racial discrimination carried out by algorithms in the US housing market (Rosen & Garbonen, 2024) is an implicit bias that needs to be confronted and fixed. Indeed, in this case, racial discrimination is not the explicit and public goal of this AI-driven process. On the contrary, discrimination is a malicious output of this socio-technical system that needs to be addressed. This bias is not a property of Urban AI that is open to public debate, but a hidden characteristic of a system that

is presented to be rational and impartial. In the field of housing, one can envisage an AI-powered system for allocating housing to low-income families and individuals. Obviously, such system would be biased. There would be a specific discrimination against high-income families and individuals in that particular segment of the housing market. However, this bias is the explicit rationale of this socio-technical system, and it is necessary to achieve the expected outcome. In this second case, the democratic debate can evaluate the possibility of implementing this biased system in order to achieve a goal that is perceived as just and desirable.

Returning to Winner's question of control, one can notice that making the biases explicit and public could ensure a certain level of control over Urban AI. The more we abandon the notion of control as a perfectly rational and unbiased artificial transformation of the urban, the more we achieve real control over these imperfect and partial socio-technical systems that are currently designed. In this sense control involves the visibility, participation and accessibility of the design choices, rather than the idea of shaping UAIs by following a universal and infallible rationality. These observations on control can be understood from a conception of objects that goes beyond the modern perspective I have considered so far. In the next chapter, I will draw on Latour's thought to implement this overcoming in the field of environmental sustainability. However, the Latour's ontology also allows us to better focus on the issue of control. In fact, according to Latour, modernity has a tendency to hide the way in which artifacts are assembled as hybrids of science and politics. One of the fundamental tasks of a way of thinking beyond modernity is to make this production and the morphology of artifacts explicit, democratically visible, and thus controllable. In the case of the urban AI we have used as an example, making the nature, purpose, and extent of the bias explicit would help to make the tool democratically controllable. However, as we will see in the next chapter, this shift in perspective implies a radical change in the way we conceive of objects, from matter of fact to matter of concern.

From a design point of view the real challenge is to tailor a specific solution for a given active milieu made of different intelligences in order to reduce injustice and to promote a blooming urban experience. This notion of control is both technical and political; something is under control if its characteristics are clear and visible, its development is debatable and open to change, and its deployment is based on shared values and needs. Perhaps here too, as in the case of sustainability, it is necessary to go beyond modernity and a theory of control understood as the construction of a perfectly supervised and functional artificial environment. Perhaps Hobbes' Leviathan is not the best model for imagining the relationship between AI and the city.

4.4 Justice and Disorder

Building on these premises, a reflection on how the urban can modify the design of UAI is needed. A reverse enveloping to urbanize AI, rather than the classic enveloping aimed to make the city readable for AI systems. This different idea of control implies a new vision of urban AI: not an object external to the city that is delegated to its control, but a part of the city that is essentially influenced by its morphology and the power vectors that characterize it. As I will show in the next chapter, this change in the way objects are understood can be interpreted through the transition defined by Latour (2004) as a matter of fact (the modern way of conceiving objects) to a matter of concern (a non-modern way of doing so). However, the central issue here is to understand how the city can exercise a degree of control over urban AI through different processes of reverse enveloping. Not simple enveloping, understood as the set of modifications necessary for a space to become interpretable by a given technology, but its opposite, or rather the set of modifications that the technology can undergo given the space to which it is applied in order to be truly useful for the development of that context. An urbanization of UAI that has to occur in the design phase of UAI, not only before (principles), nor after (regulation). From this perspective, it is mandatory to recognize design as an essential domain to pursue this different kind of control of UAI. Indeed, design has an ontological power; it can create, promote, and direct some specific ways of being (Escobar, 2011). Via design we can influence the environment in radical ways through ethical decisions on what kind of forces we want to develop or hinder.

The next chapter will highlight how design is also crucial in Latour's thinking for understanding how to intervene in the context of climate change. However, I have already shown in this chapter how design is fundamental to the maker approach to ethics. In fact, focusing on design allows us to grasp the real materiality of the object and thus its implications. Now we need to understand how design can be the means by which AI can be urbanized. Two design theories seem to be remarkably relevant in incorporating the diverse and plural essence of the urban into the design of UAI, namely *Design Justice* and *Design Disorder*. These two theories are particularly appropriate because they both reject a perspective based on abstract principles and inspired by a functionalist vision of the city and technology. Furthermore, the role of communities and situated knowledge is highly emphasized in both cases. Finally, both standpoints derive from a conscious conceptual critique of modern technological and urban design.

Design Justice is a standpoint born in the field of technological design, theorized by a vast array of practitioners and formalized in a recent book by Costanza-Chock (2020). The overall rationale is to de-

sign justice and not only efficiency, by situating the technological innovations in the needs and projects of the communities that are affected by these tools. In this case we are facing the urgence to situate technology in a specific context; it is a vertical axis aimed to tailor a technical solution deep into a particular place. Designing Disorder has been formalized by the sociologist Richard Sennett and the urban planner Pablo Sendra (Sendra & Sennett, 2020). Here, one can notice that the principle of disorder is preferred to the idea of a unique rational order that we have treated in the theory of AI urbanism. Indeed, disorder regards the idea of designing places that can promote the communication between different communities, namely multifaceted spots in which these differences can find a way to coexist. Thus, it depicts a horizontal axis through which the diverse forces that constitute the urban fabric can communicate in fruitful ways. These two different axes can be interpreted as extreme points that are paramount to design ethical UAIs finding the appropriate balance between tailored and an open form, between justice and disorder.

The first axis regards justice. In the framework illustrated by Costanza-Chock (2020), design is described in two different manners. On the one hand, it is a highly specialized practice acted by experts at different scales (objects, buildings, cities etc.). Therefore, there is a scientific design that implies a remarkable professionalization and a set of strict rules and procedures. On the other hand, design is also the way in which people modify their own environment to obtain a rational and effective order. In this second sense, design is a universal propriety shared by humans (and non-humans). Never has design been only about specialized figures. On the contrary, it is pivotal to consider the knowledge embedded in the everyday experience of communities that shape their contexts by their day-by-day small activities.

Because of these reasons, the design justice approach is grounded on the concept of situated knowledge. Building on Dewey and feminist tradition Costanza-Chock argues that real knowledge is situated, partial, and perspectival. There is no universal knowledge that can base its assumptions on a purely rational and objective view, every knowledge is a situated one. When it comes to design, shaping solution for all (design for all) actually means excluding all the specificity via a standardized universality. In a nutshell, the standard is discriminatory, because it is based on an abstract knowledge that overlook the specificity of the communities that are affected by these solutions (Costanza-Chock, 2020). This perspective resonates with the turn in AI ethics and urban ethics that we have considered before: from principles to practices (AI Ethics), from efficiency to pluriversal urbanism (Urban Ethics). According to Constanza-Chock (2020), when considering algorithmic fairness, transparency and ac-

countability, the ideas of symmetrical treatment and unbiased decisions should be overcome. In fact, this logic implies treating all individuals equally, regardless of present and past discriminations.

Following this path, there would be a high risk of reproducing inequalities and discriminations in an automated way (Eubanks, 2018). On the contrary, in order to design justice, we need to focus on specificity, to empower marginalized groups and individuals who are affected by technological objects. Beyond inclusion and fairness, design UAI must mean shape autonomy, justice and sovereignty (Costanza- Chok, 2020). It is worthy to consider the actual definition of justice from this standpoint:

> Design justice is about the fair distribution of design's benefit and burdens; fair and meaningful participation in design decisions; and recognition of community-based design traditions, knowledge and practices (Costanza-Chock 2020, 165).

This definition is composed by three aspects that are remarkably relevant ethically speaking: a) distribution of benefit and burdens, b) participation, c) recognition of knowledge. The first aspect claims that there is no way to be beneficial to all. Consequently, the real issue regards the choices that we made about benefit and burdens, namely the ethical choices. This consideration is paramount in order to avoid the idea that a specific AI can be beneficial for all (Principle of Beneficence), and that an Urban AI has to help always the overall efficiency of the city. On the contrary, in order to be ethical a UAI must be coded and designed considering burdens and benefits of its deployment and making this ethical decision explicit and public. Therefore, participation (b) is key in the design process. The idea is to shape ways in which citizens can decide on their own environments. Is a UAI really needed? Why is it needed in a specific place? What kind of problems should this object solve? These questions must be addressed taking into consideration the knowledge of the community. In addition (c), the design of a UAI has to be conceived through this knowledge in terms of data, goals and interaction with the context. The data must be taken on a voluntary base and according to privacy standards, the goals have to be shaped by communities, and the humans-machine interaction needs to be designed according to the habits of who are affected by the technological tool.

The second axis regards disorder. The urban use of this concept has been rooted into Sennett's reflection since 1970. In *The Uses of Disorder* (Sennett, 1970), the author claimed that a city has to be diverse and plural. Because diversity ethically educates mature individuals to be capable of having a proper and fruitful relationships with other people. According to Sennett (1970), modern urbanism has planned cities with the explicit aim of reducing diversity; always considering the cities as a whole and planning places for determined and unique social uses. This trend that has been at work since Haussmann (1787-1876), was based on a mechanical conception of unity and efficiency. In this mechanical

fashion, although all the parts of the city are different, they are at work only to create a single function. According to Sennett:

To make modern cities serves humans needs, we shall have to change the way in which city planner work. Instead of planning some abstract urban whole, planners are going to have to work for the concrete parts of the city, the different classes, ethnic groups and races it contains (Sennett, 1970, p. 102).

This passage testifies a link between disorder and justice. Indeed, in both cases one can notice an attention to specificity and a contestation of an urban planning based uniquely on the efficiency of the whole city. This approach is still present in the updated theory of disorder, namely in *Designing Disorder* (Sendra & Sennett, 2020). According to Sennett (Sendra & Sennett, 2020), the contemporary city suffers for a problem of overdetermination of spaces and functions, and this issue could be exacerbated by a technocentric use of urban technologies.

As we have seen in the chapter on Cybernetics as a source of AI urbanism, the risk is to conceive the city as a closed system that impose a rigid order. On the contrary, following Sendra (Sendra & Sennett, 2020) designing disorder regards a flexible and community-based perspective that must contest the imposed order and open up new possibilities. Notwithstanding, when it comes to disorder the focus is on the possible relationships between communities. While justice is a vertical axis that tailor the technological solution into the needs of a community, disorder opens up a horizontal dimension. Designing disorder means shaping places and tools that are useful for a real encounter between diverse communities. Consequently, building on the theories of the biologist Jay Gould, the attention is concentrated on borders intended as spots in which different groups interact, and not as places where something simply end. Thus, the focus is shifted, from the centre and the verticality into the values of a specific community, to the border in which different ethical values have to come into contact. Instead of designing tailored solutions, here the idea is to shape open forms aimed at promoting «negotiations, agreements, collective awareness, and different form of interactions – even conflicts – in the public realm» (Sendra & Sennett 2020, p. 103).

This standpoint is perfectly represented by the theory of infrastructures developed by Sendra. According to Sendra & Sennett (2020), infrastructures have two main goals: create conditions and provide possibilities. In both cases they are intended as open systems that allow the addition of new pieces, progressive updates and adaptability. Disorder means also a certain degree of uncertainty that could provoke nonlinear and complex interaction between different groups. Indeed, according to Sennett the real maturity of citizens regards the ability to deal with alterities in complex systems. This every-day

practice is ethically useful in order to enrich individuals and to produce a proper urbanity, which is by nature made of differences and difficult relationship. The idea of resolving this complexity via technology in both dangerous and illusory. Dangerous because decreasing complexity determine a downward trend in the citizens' ethical capacity to act, and illusory because as we can notice on the daily bases the technological solutions based on overall efficiency does not eliminate alterities, conflicts and inequalities.

These theories help us to shape in a different fashion the three characteristics of UAI mentioned above, namely narratives production, autonomy and being future-oriented. Indeed, through Justice and Disorder, the city can urbanize these features of AI; now a UAI makes sense in the context of a narration performed by a specific community or by an array of them. By the same token, UAIs, designed via justice and disorder, are autonomous only in a technical sense. Indeed, they depend on a vast array of choices and values that emerge from the urban context. Finally, the forecasting power of these tools in a relevant but limited component of a broader vision of the future shaped at the political level.

These considerations are by no means an argument against the use of AI in cities. The historical analysis conducted in Chapter 2 suggests that many of the things said in that chapter are developments of ideas and proposals present in the tradition of technologically driven urbanism. For example, it is interesting to read about the principles of justice and disorder based on the notion of transparency cited by Lee (1994) in the issue of the Journal of the American Planners Association devoted to urban modeling. This concept concerned precisely the possibility of evaluating a given technology by the communities affected by its functioning. Similarly, the difference between possible futures and desired futures by Ciribini (1971) concerns precisely the necessary coexistence of simulations and forecasts based on AI and the characterization and political choice of the values that these models must pursue and help to realize. It is clear, then, that this line of critique of the technology does not fall back on a romantic and ahistorical vision of the city, but aims to focus on the possibility of contesting some of the flaws of AI urbanism, starting from the tradition from which it emerges.

In order to explain clearly how these principles – justice and disorder – can be mixed we can refer to the Figure 9. As we can see only in one portion there is the possibility to mix justice and disorder, namely the second one. Indeed, in the first quarter there are justice and closure. In this case a system is extremely tailored to the needs of someone, and its design leaves no room for interaction or plurality of uses and interpretation. Not only, this grade of justice without disorder is dangerous because these kinds of systems structurally obstruct the possibility of communication also within the same communi-

ty, but also because a given community can change over time and a closed system is recalcitrant to change at the same time. Here the risk is to design solipsistic UAI. Quarter number three mixes closure and abstraction. Therefore, a closed design is merged with abstract principles that are distant to the actual needs of communities. This is the worst output, closed systems combined with a sideral distance from the real urban processes. Indeed, it should be considered senseless to design UAI following this direction. Then, in the fourth quarter the abstraction of principles is coupled with disorder. However, in this case disorder becomes confusion due to the facts that it tries to put in relationships principles that have nothing to do with the specific context of application. Only in the second quarter one can try to mix justice and disorder taking into account the optimal fits in different situations.

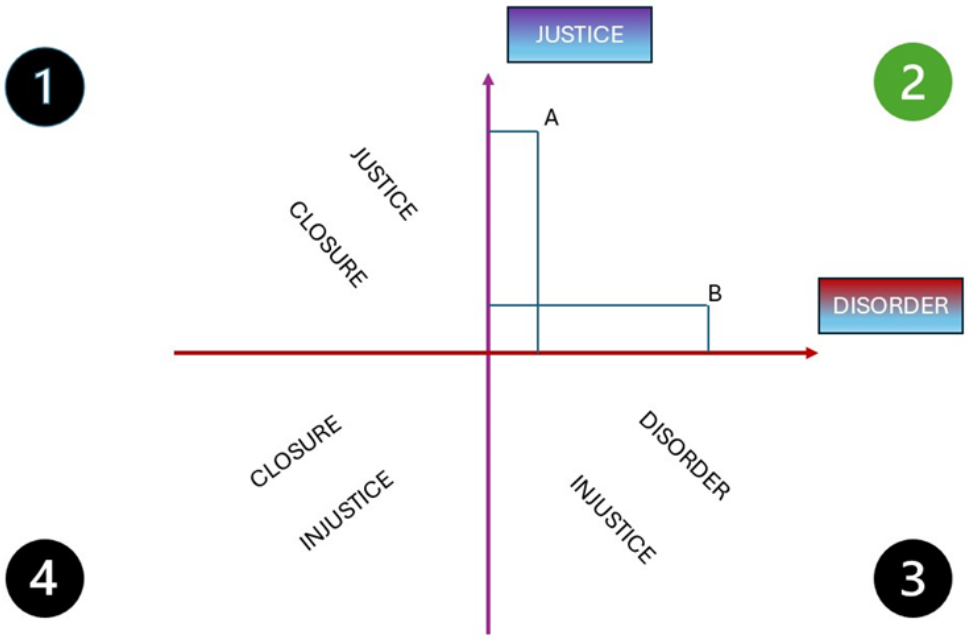

Figure 9 (Author's original). The diagram illustrates the potential relationship between the principles of design justice and disorder. The y-axis runs from justice to injustice, indicating the degree of proximity or distance of the technological solution from the needs of the affected community. In contrast, the x-axis goes from disorder to closure. The latter indicates that a technological solution has little multi-usability, meaning that it has an extremely predefined and rigid mode of use. Disorder, on the other hand, refers to the usability by multiple actors and communities, and thus to an elastic and adaptable design.

Let us imagine an UAI made of an array of robots in the public space surrounding the entrance of an hospital. The idea is to facilitate the entrance and to steer the flux of users into the right direction. In this case justice is more relevant that disorder (Point A in Figure 9). Indeed, the design has to be simple and user-friendly to accomplish the aim. In addition, due to the fact that the target is represented by people who have to find their way into the geography of the hospital, there should be no space for con-

flicts is terms of goals or possible use. On the contrary, justice is pivotal. The hospital is a community made of doctors, nurses, health workers, clerk and patients and it must be essential to tailor the design of robots with regards to the actual needs of these actors, and to the overall aim of improve healthcare. Hence, the vertical axis of justice has to be pushed, and combined with a lower amount of disorder.

Notwithstanding, changing the context of robots could change the proportion drastically. Let's think about an array of robots aimed to improve the qualities of a public park shared by different communities (Point B in Figure 9). In this case, disorder should be more relevant than justice. Indeed, it would be relevant to avoid urban AIs aimed at dividing the park in a bunch of closed space dedicated to specific communities, a sort of segregation by design. Here, the idea is to promote a relationship between communities. Therefore, following Sendra these robots have to be considered as infrastructure that can be used by diverse actors for different purposes with an hight amount of interactivity.

5. Shaping a relationship

I started this chapter with a quote on modern technology works, namely «taking the world apart and putting it back together in productive ways» (Winner 1977, p. 182). Now, one can argue that ethics of UAI works in a similar manner. Indeed, to think about an effective ethical discourse in this field it has been necessary to taking the object UAI apart and putting it back together in a productive way. That is, to show all the relationships between AI and the city and exploring ways in which the latter can influence the former. As I will demonstrate also in the case of the quest for a sustainable urban AI (Chapter 4), it is pivotal to conceive this object as an assemblage of different things and forces. This approach allows us to investigate a vast array of socio-technical intersections and nodes which are the core of a realistic consideration of the urban impact of this technology.

Regarding ethics, this chapter has highlighted the necessity of a dialogue between AI Ethics and Urban Ethics in order to establish a solid reflection on the ethical concerns related to the emergence of AI Urbanism. In both AI Ethics and Urban Ethics, a transition from abstract to concrete has been pointed out. On the one hand, from principle to practice and from practice to power relationships. On the other hand, from the search of rules for a frictionless urban dynamic to the mediations needed in a pluriversal conception of urbanism. A convergence between these two trajectories has been proposed as a starting point to promote a fruitful interaction in the near future. Indeed, on the one hand, AI is emerging as the next driving force in urbanism, and it is mandatory for Architects and Urban Planners to gain a deep grasp of this tool in order to do their job in an effective and conscious manner. On the other hand, the

city represents a privileged domain to understand that the actual body of AI is made of a vast array of ethical forces in battle.

The first step to avoid a purely technocentric approach is to gain a proper knowledge of a specific technology. As we have seen, this knowledge could guarantee a certain degree of control on a technological object. Nevertheless, in the case of Urban AI the unpredictability remains high due to the multifaceted essence of urban contexts and to the black box essence of AI. Thus, we have argued to abandon a modern notion of control as an artificial reduction of complexity via technology, to embrace a different kind of control made of democratic surveillance over the design and the deployment of technology.

The design dimension stood out as a pivotal one to avoid that ethics is applied only before (principles) or after (regulation) the actual shaping of technology. Design is the domain in which the urban can perform the reverse enveloping on AI by incorporating its values in the technological development.

Research question chapter 3: *Through which ideas is it possible to make ethical reflection on urban AI more concrete and direct its reverse enveloping in this direction?*

This is the research question that has guided this chapter, and the reflections that have been undertaken have highlighted design as the domain in which to find an answer. Design has to be considered as a fundamental means in the direct reverse enveloping that different urban actors can operate with respect to urban AI, that is, a field of action through which it is possible to urbanize this technology. In this chapter, as in the next, frameworks are proposed that aim to influence the design actions of urban AI. In the case of this chapter, the framework is the result of a relationship between two literatures (AI ethics and urban ethics) and is based on two principles (justice and disorder) whose different combinations can be applied to different urban AI projects to consider the new ethical challenges that emerge in this new socio-technical scenario.

The first is a vertical one, aimed to tailor AI into the needs of the communities affected by its agency. Thus, it is pivotal to overcome a strict separation between designers and communities. The science that shapes the different projects needs to be a compound of specialisms and situated knowledge. On the contrary, disorder is a horizontal axis that has to promote UAI as a tool of communication between different communities and values. As shown in chapter two, which extends Ciribini's reflection in the age of AI urbanism, the space of ethics remains crucial in setting up the relations between socio-technical systems (in which human and artificial action are connected). Justice and disorder are principles of connection between systems, through which the action of urban AIs in the urban fabric can be set up. However, they are not abstract principles that consider the city as a homogeneous surface and from the

perspective of overall efficiency. Justice and disorder consider the city as an active element, as a differentiated force field, and all the possible combinations between these two poles correspond to the diversity of needs of the various systems that make up the city and the possible relationships between them. These principles do not exempt the designer from making political and divisive choices, but rather aim to make these choices measurable and explicit in order to increase their accountability.

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Chapter 4

Designing sustainable urban AI: from matter of fact to matter of concern.

1.AI and Urban Sustainability

Artificial intelligence (AI) is proving to be a disruptive and radical technology capable of fundamentally redefining the fields to which it is applied (Greenfield, 2017; Coeckelbergh, 2022). As I have illustrated, urban studies are coming to terms with the emergence of AI urbanism and thus with the implications and impacts of this technology on the urban experience, on the built environment and on urban design (Batty, 2023; Bratton, 2021). In this context, there is an urgent need for empirical research aiming to shed light on the actual uses of AI technology in the city. However, as has been demonstrated in the previous chapters a conceptual reflection is equally useful (Simon, 2021): starting from the assumption that technology is not neutral this chapter investigates the cultural, philosophical, urban planning and architectural conditions that inform the use of AI at the urban scale (Nagenborg et al., 2021).

Research question of the chapter: *What are the limitations of the current relationship between urban AI and sustainability? What principles can be used to change this relationship?*

As in the previous chapter, the aim of this one is to isolate ways of directly reverse-enveloping urban AI. In this case, the focus is on the environmental sustainability of urban AI. In addition, this chapter includes two sections based on Latour's thinking that help to clarify the conceptual framework of this thesis through the distinction between matter of fact and matter of concern, and an in-depth analysis of the characteristics of Latour's concept of design. In order to answer the research question, this chapter first draws on two urban studies literatures, namely those on smart cities and eco-cities. The component of the philosophy of technology is essentially focused on Latour, making a precise choice. That is, those concepts of the French thinker that are linked to the critique of modernity and its conceptual structure are privileged. ANT (Actor-Network Theory) is deliberately excluded from this analysis. In fact, according to Latour (2007a), ANT is a methodology aimed at analysing an empirical object or a case study. Certainly, some of the things argued in this chapter can support an ANT analysis of a case study, but this is not the specific purpose of this work. Instead, Latour's ideas have been used to critique sustainable AI urbanism and to propose some principles that can help designers to bring technology and environmental sustainability closer together in a more concrete way in our urban future.

This chapter focuses on the relationship between AI urbanism and its potential sustainability.[5] This relationship inherits a well-known tension in the recent history of urban studies (Yigitcanlar, 2018; Haupt, 2021). On the one hand, there is a perspective that is focused on technology as an analytical tool and as a problem-solving force. On the other hand, there is a long-standing history of urban ecology marked by an attention to the limits of urban development and the balance between urbanisation and nature. The possibility of a relationship between AI urbanism and sustainability is rooted in the contradictions that oppose these two models, namely smart and eco urbanism. In terms of design culture this opposition is particularly evident in the ideas of modernity, science, and nature.

It is therefore useful to analyse them through the philosophical perspective of Bruno Latour who has dedicated a significant portion of his work to the concepts of modernity, nature and science. Here, a closer examination of these three concepts will reveal the necessity for a radical rethinking of modern design culture in order to pave the way for a possible relationship between urban AI and sustainability. This focus on design and thus on the need to shift the way we act in the space that surrounds us is powerfully present in Latour's work (Latour, 2008). In fact, from the perspective of the French philosopher, criticising the concepts of nature, science and modernity is not just a genealogical exercise, but rather a medium for transforming the principles underlying our ability to design society and nature (Latour, 2004).

This critical path through the philosophy of Latour is aimed at developing a twofold argument. First, the fact that a simple juxtaposition between technocentric and ecological perspectives – that is between smart and eco urbanism in cities - provides a weak foundation for a possible relationship between AI and sustainability in the urban context. Secondly, that Latour's new design philosophy can be a useful conceptual ground for thinking about an ecological implementation of AI urbanism and addressing some of the critical issues that have already emerged in its contemporary application.

The next section therefore retraces the conceptual sources of the eco and smart city paradigms, highlighting similarities and differences in order to understand whether this juxtaposition is a solid foundation for designing an AI urbanism for sustainability. This analysis will reveal that there are clear philosophical differences – regarding the concepts of modernity, science and nature, in particular - between these paradigms, that prevent a frictionless fusion. The following section builds on this reflection by analysing the concepts of modernity, science and nature through the work of Bruno Latour. Through

[5] As already explained in note 1 of the introduction in this chapter the topic of sustainability is mainly addressed by looking at environmental sustainability.

Latour's reflection it will become evident how the shaping of a true urban political ecology requires a radical modification of these notions. Finally, the last section examines the characteristics that the French philosopher assigns to the practice of design by referring to their application in the field of AI urbanism. The aim of this section is to stimulate a discussion on design culture – that is, the principles and perspectives that should guide this practice – that can provide a more stable basis for thinking about a sustainable AI urbanism as a form of reverse enveloping.

This chapter is based on the critical literature that various complementary disciplines, such as urban studies, urban political ecology and geography, have produced on smart and eco-urbanism over the last twenty years. Such literature has resulted in an interdisciplinary effort that, in turn, has produced a highly articulate description of these two paradigms. The proposed reinterpretation of many of the concepts that have emerged in this debate through Latour's thought thus builds on a long-standing critique of smart and eco-urbanism, and has a twofold objective: (1) to show how the critical issues that have emerged in these debates are rooted in certain concepts that have been fundamental to the development of Western thought; (2) to highlight a constructive role for philosophy as an important level of abstraction for the discussion of concepts that can have a profound impact on urbanism.

2. Smart and Eco urbanism: an unstable foundation for sustainable urban AI

AI urbanism is in the spotlight today because of both the hype surrounding AI and the predominant role that cities have assumed in global socio-environmental changes. In this context, the hopes and fears that AI raises in philosophical and cultural debates about technology are translated into as many possibilities and issues when it comes to the urban context. Definitions of AI urbanism is thus concerned with the changes that this technology can bring on the urban fabric both in terms of everyday experiences and the built environment (Batty, 2023; Cugurullo, 2021; Bratton, 2021). Indeed, the radical urban impact of AI is affecting interpersonal relations, interaction with institutions and service providers, and the way in which infrastructures, buildings and neighbourhoods are planned, constructed and managed (Son et al., 2023; Golubchikov & Thornbush, 2020; Shapiro, 2019; McCarroll & Cugurullo, 2022).

The scientific literature on AI urbanism is increasing in volume and complexity, highlighting themes already addressed in the smart city debate as well as new ones (Batty, 2018; Cugurullo et al., 2023). The relationship between AI technology and the city appears to be extremely articulated and increasingly in need of interdisciplinary approaches capable of situating the technological datum in a social and environmental context. As anticipated in chapter I, the theme of the relationship between AI urban-

ism and sustainability is one of the central issues. Furthermore, highlighted in Chapter Three, the relationship between AI and environmental sustainability is one of the most underestimated aspects of the ethical frameworks that have emerged within contemporary AI ethics. In this chapter, I will show that addressing a complex problem such as environmental sustainability cannot be resolved by the application of a single principle, but rather involves questioning some fundamental ideas that have characterised the development of modern Western culture. From this point of view, this chapter can be considered as a further specification of the previous one but focused on the amount of conceptual work necessary to really think about the relationship between AI and sustainability, or rather between AI and one of the issues that has remained marginal in AI ethics.

This issue is of particular relevance given that studies linking AI and the achievement of sustainability goals have been growing in recent years (Vinuesa et al., 2020; Gill & Germann, 2022; Floridi, 2022). In urban studies, this convergence is expressed in the effort to bring smart and eco urbanism into dialogue (Ahvenniemi et al., 2017; Bibri, 2019, 2020; Bibri et al., 2023; Yiyi Su & Di Fan, 2023). The smart city in which ICTs are used to solve a wide variety of urban problems is associated with the need to make cities more sustainable in the Anthropocene.

Institutions are also paying special attention to this connection, as it is exemplified by the fact that the United Nations officially supports smart city policies in both the 2030 Agenda for Sustainable Development and the New Urban Agenda (Mora et al., 2021; Son et al., 2023; Caprotti et al., 2017). That urban AI is considered as a positive factor for urban sustainability stems from this approach. Indeed, AI is seen as a technology capable of optimising urban systems: supporting data analysis for planning, animating robots capable of managing public and private spaces, optimising traffic flows (through the introduction of AVs, for example), electricity consumption and waste management. Therefore, if in a neocybernetic perspective (Hnilica, 2020; Picon & Hill, 2020; Ratti & Belleri, 2020; Picon, 2015) it is possible to understand the city as a set of flows that can be interpreted as information, AI becomes a powerful tool for analysing and managing urban flows sustainably.

However, the academic literature on the connection between smart and eco urbanism has already pointed out a number of critical issues in this seemingly frictionless narrative towards an artificially obtained sustainability. Indeed, much empirical research has shown over time that cities that have applied smart policies have not necessarily achieved sustainability goals (Yigitcanlar, 2018; Cugurullo, 2018; Yigitcanlar & Kamruzzaman, 2018; Cugurullo, 2013). This is because technological development is not sufficient to take the road to sustainability. Technology must be understood as part of a broader socio-

technical system and as one element of a triadic relationship with the natural environment and society, in order to advance the sustainability of cities (Mora et al., 2021; Colding & Barthel, 2017).

Moreover, when one considers the evolution of this relationship in the context of AI urbanism, it is necessary to take into account some environmental problems related to the construction and use of AI that are nowadays particularly evident. The amount of carbon dioxide emitted for the training of AI systems, the energy and consumption of data centres and their cooling, and the amount of e-waste that is piling up, are now unaddressed issues in the assessment of AI's sustainability (Sætra, 2023b; Brevini, 2021; Brevini, 2023; Crawford, 2021; Coeckelbergh, 2021; van Wynsberghe et al., 2022; van Wynsberghe, 2021). These material components of digital technology and their environmental impacts remain poorly considered even at the institutional level, given that the European Union, for example, speaks extremely frictionlessly about a transition that will be both digital and ecological (Pitron, 2022). The apparent dematerialisation that these technologies propose is in reality a different materialisation made up of data centres, rare materials, enormous submarine cables and e-waste that must be managed (Pitron, 2022; Crawford, 2021).

Thus, the idea of simple juxtaposing smart and eco urbanism and using this relationship as the foundation of an urban AI for sustainability appears fragile for several empirical reasons. However, the relationship between urban sustainability and urban AI appears necessary given that the former must be a goal if we want to survive the Anthropocene (Bulkeley, 2021; Elmqvist et al., 2019, 2021; Pickett et al., 2016; Wo, 2014; Hodson & Marvin, 2010), and the latter is certainly a pervasive radical technology that is here to stay (Greenfield, 2017; Batty, 2023, Bratton, 2021, Cugurullo, 2021). It is necessary, therefore, to understand how to relate digital and natural environment, the green and the blue to use Luciano Floridi's words (2020). According to Floridi, philosophy has a major task in this delicate transition, namely, to make conceptual design (Floridi, 2019): to produce concepts from which we can derive actions capable of fostering the interaction between the green and blue. This insistence on design is particularly interesting in the context of this chapter. Indeed, many of the studies cited here lament the inadequacy of the juxtaposition between smart and eco urbanism, calling for a different perspective on urban design, capable of going beyond this dichotomy (Mora et al., 2021; Elmqvist et al., 2019; Yigitcanlar, 2018).

In addition, as I will illustrate in the following paragraphs, Bruno Latour too, in his attempt to theorize a new mode of agency in the Anthropocene, grants great importance to the concept of design (Latour, 2008).

2.1. Conceptual sources of smart and eco urbanism

However, before identifying the concepts through which urban AI design culture can change, it is essential to understand the ideas that characterize design nowadays. The smart city paradigm has been extensively investigated over the last three decades, receiving criticism and underdoing developments that have not left its face unchanged (Harrison et al., 2010; Söderström et al., 2014; Trencher, 2019). However, for the purpose of this paper, what is of interest is the main tenet of smartness, namely that technology, especially digital technology, is the solution to urban issues.

Such credo is rooted in the longstanding relationship between technology and urbanisation that took, as I have showed, a decisive turn at the beginning of Western modernity with the work of Francis Bacon (1561–1626). In Bacon's urban utopia, science and technology are not just some of the factors of urbanisation: they are its centre (Cugurullo, 2021). The city will be efficient, happy and just, so the story goes according to Western modernity, if it relies on scientific knowledge. The philosopher of technology Langdon Winner described Bacon's science with these words:

> Science, then, succeeded first as a way of knowing and as a vision of the world. Only later, as scientific technology, did it triumph as a means of control and manipulation. In the end, however, its ultimate success must be accounted to its fulfilment of Baconian ambition – the delivery of power» (Winner, 1977, p.24).

The idea of science behind smartness is not conceived as a mere means, but as a comprehensive world view. It is not interested in the contemplation of nature but in its manipulation and control. Finally, it does not have its purpose in abstract knowledge but in concrete power.

This idea has imposed itself as one of the cornerstones of Western modernity (Winner, 1977; Latour, 2012) and as a fundamental component in the birth and development of modern urbanism (Cugurullo, 2021; Karvonen et al., 2021; Duarte & Álvarez, 2019). Particularly in the West, being modern implies also, if not above all, developing a scientific knowledge of nature that ensures its control and gives humans the power to transform it. As mentioned in the introduction and in chapter one, this interpretation of scientific knowledge as immediately linked to the power and manipulation of nature establishes an essential and inseparable link between science and technology. The science that Bacon inaugurated and that underlies the smart city paradigm is immediately technological. This is obviously not the only way of interpreting the relationship between science and technology, but it is certainly the dominant one in the conceptual trajectory at the centre of this thesis.

The theoretical foundation of eco-urbanism follows a different path. The conceptual relationship between ecology and the city from a simple interest in the health of cities' ecosystems to the implementa-

tion of the ecosystem concept as an interpretative model of the urban fabric (Pickett et al., 2016; Wu, 2014). Thus, the focus is not only on how to enhance natural ecosystems, but also on the advantages of interpreting the internal (between different communities and different spaces) and external relationships of the city (with the countryside, with natural elements or with other cities) as ecosystemic relationships.

From an urban planning point of view, after the first insights of the urban sociology of R.J. Park and the Chicago School, from the beginning of the 20th century many city models have contemplated a positive relationship with nature, particularly as an alternative to industrial urbanisation (Fu & Zhang, 2017; Sharifi, 2016; Gandy, 2015). In this context, the science of the city is a type of knowledge capable of harmonising urban development within the limits of its natural context (Cugurullo, 2021; Endlicher, 2007). Sustainable urban development means urban expansion within the limits of a bioregion capable of providing resources for the city (Register, 1987). Bookchin (2021), one of the fathers of urban ecology, regarded modern urbanisation as detrimental to the design of a happy and just city. The modern city driven by industrial technology acts as a reducer of the ecological diversity that characterises a thriving city (ivi). This drift of urbanisation can, in Bookchin's view, only be countered by returning to pre-modern models of urban design or to historical cases in which a not yet fully-formed modernity has hinted at different alternatives (ivi). It can be inferred from these reflections that technology is not at the core of the tradition underpinning eco-urbanism.

Technology has appeared as an important element in this context only in the last two decades (Brevini, 2023; Sharifi, 2016; Hodson & Marvin, 2010). In fact, it was only after the emergence of the smart city paradigm that the topic of technology began to be predominant in the conceptualisation and practice of eco urbanism. It emerges as central in the attempt to bring together smart and eco cities but not in the tradition of urban ecology. This is not surprising given that urban ecology seems distant from the technosolutionism (Sætra, 2023a; 2023b) inaugurated by Bacon and now prominent in the smart city paradigm.

Hence, science, modernity and nature are pivotal concepts for the two paradigms we have considered, namely eco and smart, but their development is markedly different. Smartness is based on a science seeking to control and transform nature. In urban ecology, however, science is interpreted as knowledge of the limits of human action and the search for harmony with nature. The first paradigm is heir to a modernity understood primarily as techno-scientific progress; the second traces its models before that modernity or in alternative possibilities to that. In the first case, nature is a resource to be manipulated,

in the second a context to live in. An active margin with which to synchronise the conditions of human inhabitancy [Figure 10].

Upon reflecting on these theoretical and empirical considerations, one can see that the simple juxtaposition of smart and eco-urbanism is an unstable basis for an urban design supposed to pursue sustainability in the age of urban AI. This first part of the chapter – which builds on an interdisciplinary critical literature on the two urban paradigms examined – has shown that different empirical elements and conceptual roots contribute to digging a chasm between smart and eco urbanism. The second part will show through the philosophy of Bruno Latour how these concepts can be understood differently. Indeed, rethinking modernity, nature and science is crucial in order to have a solid theoretical basis for sketching out a theory of urban design capable of drawing AI and sustainability together.

The centrality of the concept of modernity has been reiterated several times in this thesis, starting with the introduction, where Winner's thought was mentioned regarding how modern technology is interpreted in Western culture as a tool for controlling reality, in continuity with the ideals of a certain philosophical modernity. In the first chapter, this idea was also applied to the development of modern urban planning and its formulation of a science of the city, and in the second chapter, the idea of control was followed in its cybernetic variant applied to urban modelling. In this chapter, following Latour's critique of modernity, some crucial conceptual changes are outlined that are necessary to radically modify the design culture that nourishes AI urbanism: science, modernity, nature and, finally, the very way of defining objects with the transition from matter of fact to matter of concern. These changes, which are explained below, are crucial in order to truly consider the urbanisation of AI in terms of reverse enveloping, the ability of the city to influence the design and application of this technology.

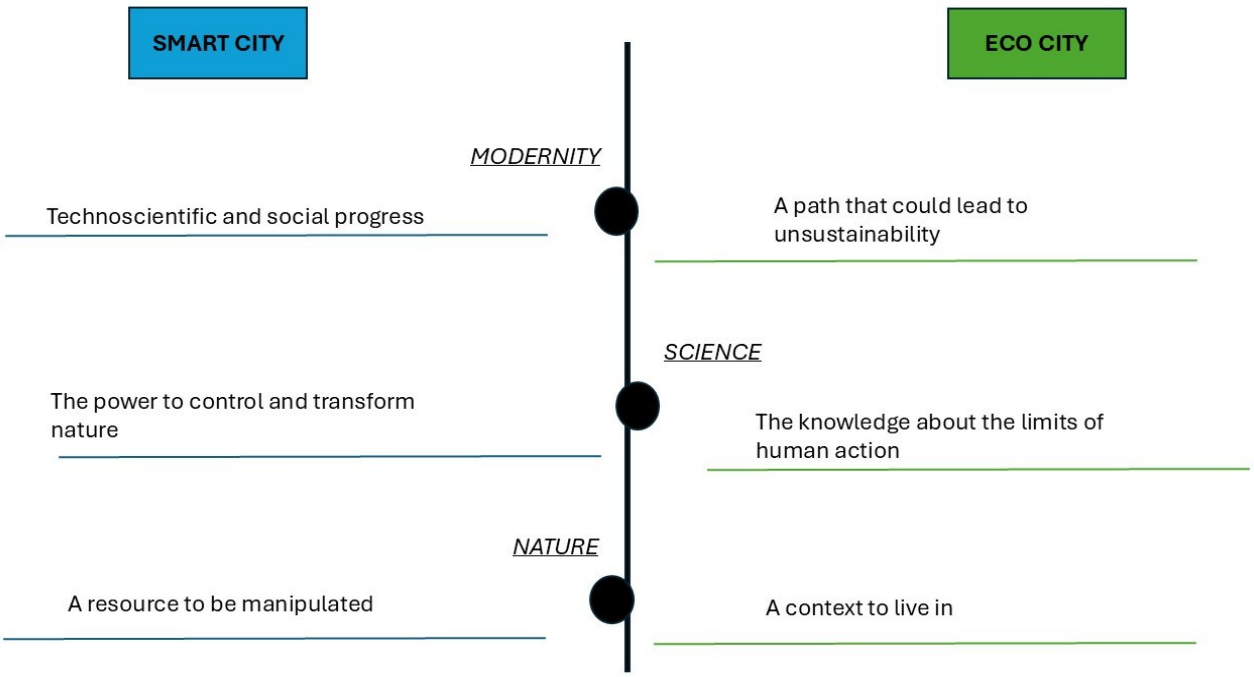

Figure 10 (Author's original). The figure points out the radical differences in terms of design culture between the Smart City and Eco City paradigms. Modernity, science and nature are interpreted in opposite ways by these two urban traditions, making it very difficult for their juxtaposition to provide a solid foundation for sustainable AI urbanism.

3.On the path towards sustainable urban AI with Latour: modernity, science and nature

3.1.A Copernican counter-revolution: facing modernity

The three concepts addressed in this paragraph, namely modernity, science and nature, are deeply interconnected. The concept of modernity can be interpreted in many directions, but in Latour's thinking it emerges as a certain relationship between science and nature. In a similar way, according to the French Philosopher, nature is the result of the modern conception of science and finally science is the consequent practice of the modern conception of nature. The aim of this section is to unpack this complexity, essential for the foundation of an AI urbanism for sustainability, and to investigate how Latour's thought can open up a path capable of taking us beyond the aporias outlined in the previous section.

According to Latour, modernity - a period that begins approximately in the 17th century - consists of a twofold movement: on the one hand, the exponential increase in the assembly of hybrid objects of nature and culture; on the other, a narrative that firmly separates these two spheres of existence (Latour, 2012). In this period, the then new experimental science capable of mobilising ever larger multitudes of objects is presented as politically neutral and objective, while the political body constructed by humans

through social contracts is presented as devoid of all those non-human entities that populate it and make it possible. Because of a science that disproportionately multiplies human power and a politics that increasingly permeates nature, the "moderns" have imposed a separation between exact science and the exercise of power. By separating politics from science but always basing force on reason and reason on force, the moderns became for Latour (2012) invincible. They colonised large portion of the world and became a tremendous political power, but they did so in the name of rationality and science. They thought to have taken the high road of history and that the time of uncertainty was over to make room for an era of infinite progress, power and truth (Latour, 2017).

Objectivity, effectiveness and profit were the three graces that accompanied this supposed infallible modernisation that perceived other cultures as collectives to be indoctrinated into "true" science, and nature as a resource to be manipulated (Latour, 2007a, b). However, according to the French philosopher, it is precisely those other cultures and nature that are undermining the project of modernity and forcing us now to think beyond it (Latour, 2012). Indeed, scientificity, which was supposed to be objective and non-politicised, has created an extremely unequal world populated by collectives protesting against the modern mindset. Moreover, nature, which was intended by the moderns as the inert background of our actions, has in the era of the current climate crisis shown its essence as an active and susceptible force. Therefore, it is necessary to think of an overcoming of modernity: science and politics are not two pure domains that sometimes come into contact, but categories through which ex post we analyse objects that have a hybrid essence. Latour's intention is to shed light on the production of the hybrid objects that modernity hid in order to expose them to democratic debate and control (Latour, 2012). Technological artefacts and scientific discoveries must also be discussed in relation to their social implications, and political decisions must take into account the mass of natural objects and the scientific practices they involve.

Latour's position undermines the idea of modernity that we have seen underpins the smart city discourse and thus one of the two pillars on which an AI urbanism for sustainability would be erected. In fact, in the corporate version of the smart city paradigm - which is very influential in policy making - technology is often seen precisely as a rational and progressive way of solving cities' problems and not as one of the politically connoted components that contribute to changes in the urban fabric (Söderström et al., 2014; Greenfield, 2013). Modernisation as well as sustainability if understood in continuity with it are models of development that conceal the complexity of power relations between the actors involved. Models in which the production of hybrids remains in the shadow.

As mentioned in the preceding chapter, which addressed the issue of bias from an ethical standpoint within certain urban AIs, it is evident that biases are intrinsic to the development and implementation of urban AI. The imperative action to be undertaken, therefore, does not pertain to the pursuit of a utopian, unbiased artificial decision, but rather to the elucidation and exposition of these biases, along with their democratic evaluation. In accordance with Latour's perspective, it is imperative to elucidate what, within a contemporary conceptualisation of urban AI, would remain implicit and obscured. Specifically, this pertains to the interweaving of ethical decisions and technological instrumentalities that collectively form the fundamental substance and functionality of this system. Rather than conceptualising urban AI as the favoured offspring of a progressive and rationalist vision of modernity, and consequently as a bearer of rationality and order, it is imperative to emphasise its socio-technical composition and subject it to democratic evaluation through a concept of control that does not aspire to produce a perfectly rational artefact, but rather to establish the conditions for democratic access to its functioning. As we will demonstrate at the end of this section, following Latour (2007b), we are compelled to recognize that between modernisation and sustainability there is a contradiction.

3.2. «Go tell your masters that scientists are on the warpath»: a new role for science

Latour shows us how there is a strong link between modernity and science. However, the science of the moderns has certain characteristics: the Galilean idea of understanding objects from their primary qualities (physical and measurable) paves the way for an unprecedented ability to calculate reality (Husserl, 1970; Latour, 2012; 2017). All the qualities that are not mathematically expressible are relegated to the role of secondary qualities and ousted from the backbone of reality (Latour, 2017). From this new quantitative ontology, the new science of the moderns unleashes a renewed capacity to investigate and mobilise nature, which, according to the French philosopher, becomes one of the cornerstones of the moderns' alleged invincibility (Latour, 2012). The scientific and industrial revolutions, colonialist expansion and the doctrine of globalisation are just a few examples of the power of the moderns. This quantitative-mathematical turn gives concreteness to Francis Bacon's utopia that we have seen as the foundation of the smart city paradigm: all the problems can be analysed and solved scientifically as long as they can be interpreted quantitatively and then calculated. What I called technosolutionism (Sætra, 2023a) has its origin in such explosion of scientific power at the dawn of modernity.

In the smart city, the datafication of the city is nothing more than a new stage in this process of creating a quantitative and calculable ontology (Söderström et al., 2014): information becomes the new primary

quality, as I have argued in the chapter two with regards to cybernetics. As demonstrated, this awareness is founded on the notion that the concept of information can be potentially applied to all domains, as it is not contingent on the material composition of the domain in which it is implemented. Hans Jonas (1999) had previously discerned this all-encompassing essence of the concept of information, emphasising the potential of cybernetics to evolve into a comprehensive theory of reality. In the domain of architecture , Ciribini (1971) has demonstrated an understanding of this philosophical aspect, centring his endeavours on cultivating technical intellectuals who can facilitate the advancement of culture in this novel phase of technological evolution.

In smart urbanism , science is conceived as a mechanism for solving the problems of society and the environment. Science is the safe, objective rail, the principle of order capable of ensuring a rational process. According to Latour, the role of science must change in the Anthropocene. Science must no longer be an impartial arbiter but a stakeholder; ecological science must realise that it is facing enemies and has therefore entered the realm of politics (Latour, 2017). The sciences that are showing us the effects and causes of climate change cannot play the role to which science was relegated in the moderns' paradigm: a safe, objective, pure place untouched by essential conflicts, an impartial arbiter (Latour & Schultz, 2023).

A science that is truly useful to the community must avoid the risk of depoliticization, which does not mean being corrupted by a political power, but rather asserting the demands and values generated by its knowledge together with the communities that share them and consider them vital (Latour, 2017; Turnhout et al., 2020). Scientists must move away from the role of arbiters and become producers of situated useful knowledge; they must be able to be in the community by also taking responsibility for the political consequences of their research (Turnhout et al., 2013). As posited by Forester (1989), in the domain of urban planning, the practice of acting as informed technocrats or neutral mediators poses a significant risk, precisely because it obscures the political dimensions of the decision-making process, thereby placing those lacking access to this information at a disadvantage. In the preceding chapter, I introduced the concept of design justice, which conceptualises the technical legitimacy of design solutions in terms of their adherence to and maximisation of the decision-making capacity of the communities affected by these choices. There is no inherent contradiction between efficiency and politicization; on the contrary, genuine efficiency can only be achieved by incorporating the values and needs articulated by these communities.

There are two main reasons why the change advocated by Latour is necessary in the era of AI urbanism. First because science has already entered the political realm in AI urbanism: the techno-solutionist perspective, in fact, by not questioning any of the political and economic causes of the current ecological crisis takes a political stance, namely the defence of the status quo. This version of AI urbanism is as technologically disruptive as it is politically conservative.

The second reason concerns the rhetoric that informs smart and eco urbanism as precursors of AI urbanism. In both cases, science is seen as something external to society: on the smart side as a principle of order that technologically regulates urban chaos (Cugurullo, 2021), and on the eco side as a principle of natural order capable of bringing harmony in the relationship between society and nature (Endlicher, 2007). If Latour's reflection on science shows the inadequacy of the smart-city paradigm in the Anthropocene, we still need to understand how the eco paradigm is also unsuitable for these tumultuous times of radical artificial intelligences.

3.3. Characterising Gaia: an ecology beyond the concept of nature

In Latour's perspective, in the Anthropocene it is no longer possible to conceptualise nature in Galilean terms. Galileo's nature, in fact, had a movement but no behaviour, it had laws but no agency (Latour, 2017). It was not understood as a living organism, but a set of quantities governed by rules. The climate crisis and the extreme events that bear witness to it force us to realise that nature is an active, limited, sensitive, delicate and wrathful open system (Latour, 2017). The first trait of Gaia (the name of this new conceptualization of nature) is precisely this recapturing of an out-of-control subjectivity. If a mute, passive, quantitative nature is the perfect resource for the moderns' system of production, Latour's Gaia is not.

This is why, according to the French philosopher, an ecological perspective must necessarily step outside the sole focus on production, development and growth. An economy based solely on the mobilisation of resources for production needs to be replaced by one founded on the mobilisation of resources for the maintenance of the habitability of this fragile open system (Latour & Schultz, 2023). This first characteristic of Gaia already allows us to realise that any perspective of urban ecology that does not question the development model that has characterised modern urbanisation is out of sync in the context of Gaia. It is not a matter of managing the negative externalities of the system, perhaps with the new technological tools offered by AI, but of changing the structure of the system itself. Alternatively, we could think of a Buckminster-Fuller's spaceship-earth (2008) model in which the whole of humani-

ty must take care of nature as a global totality, as a complex system that can be managed cybernetically, rationally and without conflict.

From an urban perspective, this is also the idea of an urban ecology that believes it is possible to harmonise nature and society through science. However, Gaia is not a stable global system with an unambiguous purpose, and it is not a cybernetic machine whose parts can be harmonized. If this were the case – that is, if Gaia were a hierarchical and ordered system – the techno-solutionist dream of an artificial management of this mega-machine would be rational. However, this perspective starts from the false assumption of understanding nature metaphorically as a machine which for Latour (2017) is a terribly modern mistake. Latour considers Gaia as an active system in which each organism from its own perspective flexes its environment. This is far from a first-order cybernetic system in which all agencies are coordinated by the environment (ivi). The always provisional states of order that emerge from the interactions between organisms are not the result of a mechanism but of processes of interplay that are always in motion.

From a philosophical point of view, Latour explains this dynamic through a Kantian conceptualization: the ontology of Gaia is one in which all agents, human and non-human, are considered primarily as ends and not as means (Latour, 2007b). Thus, both human and non-human agents are not parts of a machine that finds its higher purpose in the stability of the system, but free agents capable of modifying their own environment. Gaia is not a cybernetic mega-machine but a teeming plane of force vectors that influence each other, creating occasional balances and imbalances. This is why a proper urban political ecology is incompatible with a first order cybernetic perspective that claims to harmonise, through the powers of AI, the relationship between the natural and the artificial in the city (Ratti & Belleri, 2020).

As mentioned in the introduction, Latour's perspective not only reformulates the concepts of modernity, science and nature – crucial for the relationship between AI urbanism and sustainability – but also gives the concept of design a decisive importance. Design represents one of the possible active components of Latour's reflection, which does not merely reformulate tradition but suggests new methods of action. Latour conceptualises design as the fundamental way in which humans shape the objects and envelopes that enable them to live (Latour, 2008). The range of this term is very broad. One can look at the design of individual objects as well as houses, cities or entire regions in which various actors must be assembled in a specific way.

In the age of AI and climate change, design is necessary precisely because there is a need to challenge the way we act in the world. Indeed, design for Latour is a way of acting that has gone through the re-vision of modernity, science and nature that has been the topic of this section. Design, according to the French philosopher, has ceased to be an idea connected only to the aesthetics of an object. (Latour, 2008). A term such as urban design shows how this concept is used to indicate a reconfiguration of extremely complex objects. However, design has certain characteristics that make it compatible with the questioning of modernity, science and nature that we have been following, and make it a good candidate for thinking about a new relationship between AI and the city, oriented towards sustainability. Design is for Latour opposed to modernisation because it treats the objects it modifies not as matters of fact but as matters of concern. We should then understand why it is necessary to conceive urban AI for sustainability as matters of concern and then try to apply the rules indicated by Latour to its design.

4. A design theory for a sustainable urban AI

4.1. Beyond matters of fact

«We cannot characterize political ecology by way of a crisis of nature, but by way of a crisis of objectivity» (Latour, 2004 p. 19). The joint crisis of modernity, science and nature leads Latour to assert that the first real step towards a real political ecology is to change the way we conceptualise objects in order to then be able to act on them in terms of design. Latour defines matters of fact as the modern way of conceiving of objects, and it is interesting to note how the characteristics of this perspective illuminate many of the problems we are facing in AI urbanism [Figure 11]. As has been stated on multiple occasions, this shift in perspective is consistent with a distinct conception of control within the domain of AI urbanism. This conception encompasses not only the control of AI over the city, but also the reverse, namely the control of the city over AI. Upon enumerating the characteristics of the non-modern manner in which objects are conceptualised, this relationship will become more evident.

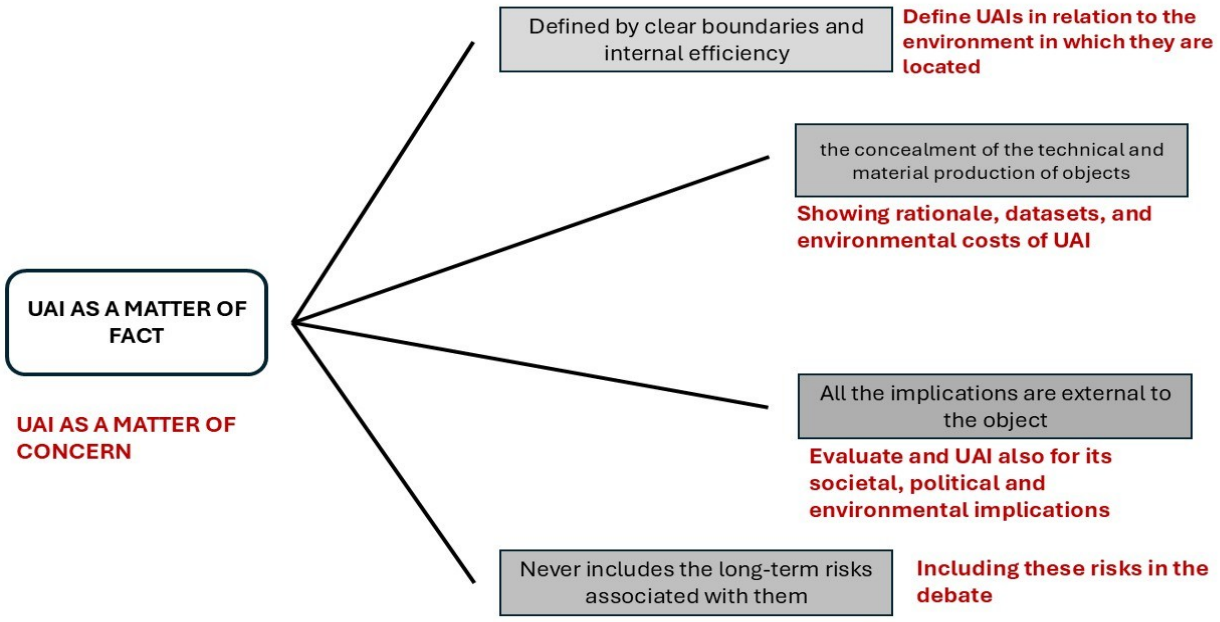

Figure 11 (Author's original) The diagram illustrates the possibilities of a different design of urban AIs with reference to a design culture that understands them as a matter of concern or a matter of fact. This distinction by Latour highlights the alternative possibilities capable of promoting a sustainable design of AIs through the four changes illustrated.

First of all, matters of facts are objects defined with clear boundaries and which are considered for their internal efficiency (Latour, 2004). It is easy to recall how efficiency is at the heart of the technosolutionistic rhetoric on the urban application of AI and how this object is evaluated in itself as a bearer of order regardless of context. Traffic (Caprotti & Liu, 2022), policing (Tulumello & Iapaolo, 2021), urban infrastructure (Cugurullo et al., 2024), housing (Rosen et al., 2021), urban management and design (Son et al., 2023): all these domains are supposed to be made more efficient through AI because this is an object bearer of order and rationalisation.

However, such conception problematically understands AI as a mere instrumental technology to be applied to various fields. Not as a technology capable of completely redefining the fields into which it is grafted, by changing their logic (Coeckelbergh, 2022). Moreover, through this feature, AI is conceptualised as a technology separate from society. Especially AI companies and a relevant portion of the research in computer science and engineering promotes a vision in line with the idea of science that we criticised in the previous section.

The second characteristic concerns the concealment of the technical and material production mechanisms of objects (Latour, 2004). In the AI context, this characteristic develops in two senses. Firstly, the great advances in AI in recent years are based on the large amount of data that our society makes available on which machine learning systems can be trained (Lee, 2018; Floridi, 2022). However, the quali-

ty and quantity of data that literally informs the ability of these systems to act can contain biases, errors, inaccuracies that affect the very functioning of these tools (Floridi, 2022). Moreover, as already mentioned, all steps in the production of AI have considerable environmental costs. Like many digital technologies, the material trail connected to these tools is extremely articulated and starts from the extraction of rare materials to then arrive at their application through the assembly of components, the structuring of subsystems and the programming of platforms (Sætra, 2023b). Indeed, AI specifically adds material costs in terms of emissions and water consumption, which are also linked to the training phase and management of data centres (Van Wynsberghe, 2021; Coeckelbergh, 2021; Brevini, 2021; 2023).In the urban context this hiding of the logical and material production processes of urban AI is certainly an obstacle to a just and sustainable use of these tools.

The third characteristic concerns the fact that the implications of these objects are always seen as external to the objects themselves, as if belonging to different universes. In the case of urban AI, this approach is particularly evident when considering the social, ethical, and environmental implications that accompany the use of these tools. These implications are very often addressed in diverse fields such as sociology, ethics, urban planning, environmental sciences, not affecting the conceptual and technical composition of these systems.

Finally, according to Latour (2004), the consideration of objects as matters of fact never includes the long-term risks associated with them. These risks are interpreted as historical contingencies that may occur but are not included in the initial definition of the object. Two examples are extremely interesting in the field of urban AI. Firstly, AI is becoming decisive as an infrastructure in our societies both on its own and as a mechanism for enhancing and supporting existing infrastructures (mobility, waste and electricity management systems, for example). The current rush to artificially upgrade our infrastructures conceals the medium- to long-term risk of getting locked into the compulsory use of AIs which, as we have seen, come with considerable environmental costs (Robbins & van Wynsberghe, 2022). Making AI fundamental for infrastructure, without taking its costs into account, risks leading us into an unsustainable future (ivi). Finally, the increasing autonomy of urban AI is leading and may lead in the long run to questioning the very concept of the city as something created by humans for humans (Cugurullo, 2021). Indeed, while AI is profoundly changing the ways in which cities are planned and managed (Batty, 2023; Son et al., 2023), even the very composition of the citizenry is affected by these logics: in experimental settings such as the Neom project in Saudi Arabia a robot may even become a full citizen (NEOM: Made to Change, n.d.). These poorly considered risks could lead to significant changes in what we mean by city, thereby challenging its very definition.

It is possible, at this juncture, to comprehend the reasons behind the notion that this distinct manner of conceptualising objects in the context of urban AI has the potential to promote a varied conception of control, predicated upon reverse enveloping. Adhering to this ontology, the conception of urban AI as a autonomous entity becomes invalid, as it is inextricably linked to the city in which it is implemented. The purported autonomy of urban AI is rendered moot by the fact that the ramifications generated by this process are intrinsic to its very definition. Moreover, the production of its hardware and software is predominantly contingent on material and immaterial resources that bind this technology to a specific geographical location. Reverse enveloping is possible because it has always been a part of how urban AI works. It's just a matter (a difficult one) of making it more democratic by showing what it means and how it's made. Instead of just looking for efficiency, it should be about finding ways to meet the needs of different communities. This would give the city real power over something that is urban in every sense.

4.2. Towards a non-modern theory of design

As I have illustrated by analysing the literature on smart and eco-cities, the simple application of technology to increase the efficiency of our cities does not seem to be enough in the Anthropocene (Cugurullo, 2021). Some systemic changes are needed in the way the habitability of our cities is thought about (Elmqvist et al., 2019); a new design theory seems necessary to try to assemble technology and urban space together with the goal of sustainability (Yigitcanlar, 2018). Through Latour's thinking, I have highlighted the need to change the way in which AI is interpreted by abandoning the moderns' concepts of science and nature and going beyond the perspective of matters of fact.

According to the French philosopher, the concept of design has five specific principles concerning a new theory of action that can be useful, in the context of this chapter, to conceptualise the relationship between urban AI and sustainability [Figure 12].

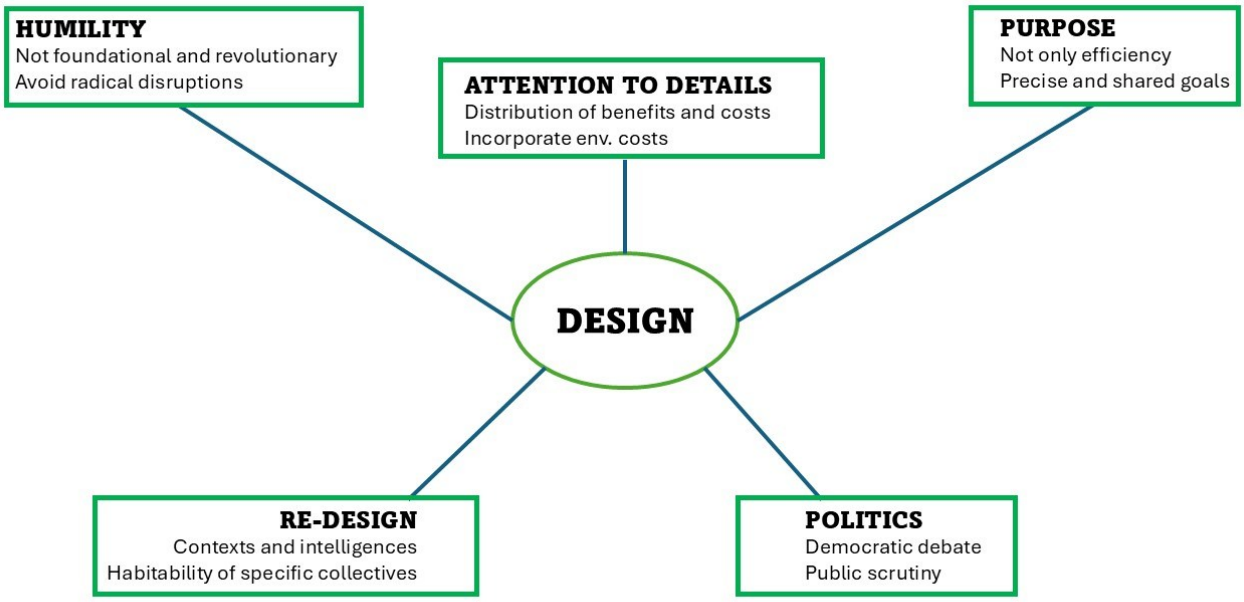

Figure 12 (Author's original and based on Latour 2008). The diagram illustrates the characteristics of a theory of design capable of overcoming the problems of modernity according to Bruno Latour. Each principle (humility, Attention to details, Purpose, Re-Design and Politics) is associated with two characteristics that clarify its potential for application.

The first two principles visibly contrast with contemporary trends in AI urbanism. The first relates to humility, that is the willingness not to be always foundational and revolutionary (Latour, 2008). The design of urban AI does not have to follow the path of radical disruption, which is evident for instance in AI urbanism projects such as the linear city The Line in the Neom project in Saudi Arabia, which aims to be «a revolution in urban living». The very slogan of the Neom project is «made to change» (NEOM: Made to Change, n.d.; THE LINE: a revolution in urban living n.d.) to signify a radical break with the past all within that concept of modernity that Latour intends to overcome and that in contemporary urbanism we can define as the idea that technology will produce an autonomous solution to urban problems. The great power of AI and the great fragility of Gaia would suggest, instead, an experimentalism of a different kind (Bulkeley, 2021). A diffuse and small-scale experimentalism that could test the actual functioning of urban AIs in the ecosystems in which it fits. This approach would avoid the already highlighted risk of being trapped in environmentally expensive and socially damaging infrastructures (Robbins & Van Wynsberghe, 2022). In this light, the attention to limits highlighted both in the history of urban ecology (Endlicher, 2007) and in Latour's reflection (Latour & Schultz, 2023) is extremely relevant. Being revolutionary and foundational might have been a reasonable approach in the face of Galileo's inert nature capable of absorbing every shock, but it appears to be a suicidal strategy in the magmatic context of Gaia.

The second characteristic is closely linked to the first one and involves attention to detail. The idea is to have an almost craftsman-like attention to detail in design and not to proceed without considering the implications of actions or thinking that these will only be addressed at a later stage (Latour, 2008). In the design of sustainable urban AIs, therefore, it is key to first understand and publicise the impact of these technologies on the various collectives that populate the city, namely how the placement of robots, AVs or software agents can have costs that are distributed differently in the urban space (between centres and suburbs, between different ethnic communities, between different social classes, between people of different ethical orientations, between different ecosystems) (Bulkeley, 2021). Furthermore, a sustainable and detail-oriented urban AI cannot fail to incorporate within itself an indication of the environmental cost (materials, energy, emissions) associated with its assembly, training and deployment to enable citizens and policy makers to make an informed assessment of its use (Van Wynsberghe, 2021).

The third characteristic concerns the focus on purpose (Latour, 2008). A sustainable urban AI must move away from the logic of efficiency as a fundamental purpose (Hodson & Marvin, 2010; Ahvenniemi et al., 2017; Yigitcanlar, 2018; Mora et al., 2021). In fact, efficiency is what we might contradictorily define as an instrumental purpose: something is efficient with respect to a purpose and not in itself, and we must always ask ourselves whose benefit a technology is efficient for. A sustainable urban AI must emerge from the goals discussed by the collectives that populate the city and arise from that dialogue between science and community that we examined in the previous section (Latour, 2017; Turnhout et al., 2020). Scientific reflection and technological solutions must arise from the concrete interests and needs of communities, overcoming a modern conception of science. As demonstrated in the preceding chapter, the urbanisation of AI could be predicated on the principles of justice and disorder, with the design process being informed by the specific needs of the community and their interrelationships.

The fourth characteristic concerns the fact that design is always re-design (Latour, 2008). That is, the design of urban AI is always situated in a context of humans and non-humans with specific needs. The critical literature on AI urbanism has already highlighted how the application of urban AI takes little account of contexts (Bratton, 2021) and how it is often believed that AIs should be the main intelligences in the cities of the future (Lynch & Del Casino, 2020), that is, the ones capable of coordinating the others. It has also been pointed out in the first chapter of this dissertation this mindset contradicts any claim to sustainability. Sustainable urban AIs must first and foremost be put at the service of preserving the habitability conditions of the various collectives by dialoguing with the natural ecosystems

that are the foundation of urban life. They must also fit into the relationships between intelligences (human and non-human) in order to foster cooperative cohabitation while respecting specific differences. Situating urban AI in Gaia means putting it at the service of habitability and differences and not of efficiency and homologation.

The last characteristic concerns the importance of politics, the idea that one should always discuss whether design is right or wrong, suitable or unsuitable for a certain context. Following Latour: «no designer will be allowed to hide behind the old protection of matters of fact. No designer will be able to claim: "I am just stating what exists", or "I am simply drawing the consequences of the laws of nature", or "I am simply reading the bottom line"» (Latour, 2008). Designing a sustainable urban AI therefore means abandoning the problematic concept of progress that animated moderns in thinking both AI (Coeckelbergh, 2022) and urban AI (Cugurullo, 2021). This design culture must not only ask how AI can change the city but also how the urban ontology – made of differences, clashes, cooperations and balances – can change the very logic of AI.

The suggestion that can be made to design sustainable urban AI through Latour is to start seeing it as a matter of concern. With this term, the French philosopher designates the new type of objects that we have to deal with in this time marked by a global climate crisis. These new objects have no clear boundaries but must be defined in relation to the environment in which they are located; their material, scientific and technological production has to be made visible; they must be not independent of their implications and impacts but determined by them and must by definition acknowledge the possible long-term risks associated with their use (Latour, 2004).

According to Latour, as this chapter demonstrates, in order to establish a true political ecology, it is necessary to question the concepts of modernity, science and nature that have accompanied us so far and to change our way of understanding objects - from matters of fact to matters of concern - and to change them through a new design theory. I believe that sustainable urban AI design needs this reflection to break out of the impasse created by the juxtaposition of smart and eco urbanism. In an urban reality in crisis that needs to be redesigned, an urban planning that merely repeats the paradigms of the past seems to be ineffective and, worst, harmful. The era of AI and the Anthropocene demands a radical reflection on the way we inhabit the world, and Bruno Latour's philosophy certainly points a way forward in this regard.

5. AI Urbanism as a matter of concern

Research question chapter 4: *What are the limitations of the current relationship between urban AI and environmental sustainability? what principles can be used to change this relationship?*

The first part of the research question that guided this chapter, which can now be answered. The foundations of this connection – namely the juxtaposition of smart and eco urbanism – have been questioned by reporting empirical evidence and theoretical aporias that illustrate a situation that is far from being frictionless. In terms of empirical issues, the environmental costs and material impacts of assembling, training and using AI have been highlighted. In line with the material interpretation of digital technology presented in Chapter 1, it has been shown that the idea of a twin digital and green transition is anything but a foregone conclusion. In fact, digital technology and AI in particular imply a new materialisation of the world, involving the use of rare materials and an increase in harmful emissions. Rather than seeing technology and sustainability as twins, it is therefore necessary to weigh up the choices in a rigorous cost-benefit analysis.

In terms of theoretical aporias the concepts of modernity, science and nature emerged as the focal points of these difficulties and, through the philosophy of Bruno Latour, a reconceptualization of these terms was undertaken. By critically examining these three concepts, it has been possible to systematise some important aspects of the debate on the sustainability of urban AI. Namely, the modern soul of the design culture that inspires AI urbanism (Cugurullo, 2021; Duarte & Álvarez, 2019), the need to consider science and technology as internal dimensions of social and urban dynamics rather than as prescriptive and rational principles (Karvonen et al., 2021; Mora et al., 2021; Turnhout et al., 2013), and the idea of considering nature not as a compact whole that acts as a backdrop to human action, but as an active and multiple terrain with which to dialogue (Elmqvist et al., 2021; Pickett et al., 2016; Wu, 2014).

Such a conceptual operation was undertaken not only to systematise certain concepts present in the critical literature on AI urbanism, but above all to highlight how these elements are clues that should lead to a structural rethinking of modern Western design culture, rather than secondary implications of the application of a specific AI technology. Finally, in the last section, these reflections resulted in an application of Latour's design philosophy to the relationship between urban AI and sustainability, highlighting the advantages that the principles described by the French philosopher can bring to this specific field.

Regarding to the second part of the research question of this chapter (*what principles can be used to change this relationship?*). The shift from matter of fact to matter of concern has proven to be a powerful conceptual device for promoting a more relational vision of urban AI: (1) the urgency of seeing urban AI as an element of further complexity in the urban system, rather than a way of ordering it (Bratton, 2021; Lynch & Del Casino, 2020); (2) the need to make explicit the environmental costs of the production, development and application of this technology (Brevini, 2021; Van Wynsberghe, 2021); (3) the importance of considering social, ethical and environmental implications and impacts in the very definition of a given technological object (Coeckelbergh, 2021; Crawford, 2021); (4) the risk of being too dependent on AI for the functioning of the city (Robbins & Van Wynsberghe, 2022) and that of profound changes in what we mean by the urban and by citizenship (Cugurullo, 2021). This change of perspective breaks down the boundaries between AI and the urban context and promotes an integrated vision of both. As shown in the previous chapters, this permeability of boundaries certainly allows AI to modify some urban dynamics, but it can also allow these dynamics to modify this disruptive technology. It is this process of reverse enveloping that is at the heart of this dissertation, and which in this chapter seeks to connect urban AI and environmental sustainability. As in the previous chapter, this is a direct and design-based reverse enveloping, meaning that it is based on the ability of different urban actors to take actions that can make urban AI more sustainable. This chapter also proposes a framework that can influence the design culture of urban AI towards environmental sustainability.

In this case, the framework is based on Latour's design theory and consists of 5 principles that are applied in the sense of environmental sustainability of urban AI: 1) Humility, abandoning the need to always be disruptive and revolutionary in design. In fact, disruption implies a profound and often traumatic upheaval of the reality to which it is applied, and this can rarely be reconciled with the idea of sustainability; 2) Attention to detail, or rather serious consideration of the implications. In the context of sustainable urban AI, this refers both to taking into account the environmental costs of the technology and to paying attention to the extent to which different communities are affected by technological innovation in terms of ecosystem impacts; 3) Purpose, or moving beyond the idea of efficiency to specific, shared, and measurable goals in terms of sustainability; 4) Re-design as attention to the context in which urban AI is to be deployed. These contexts are often already characterised by ecosystems of intelligences and relationships that are useful from a sustainability point of view, and understanding how to integrate technological agency implies a study of these states of affairs; 5) Politics as the imposition of a public, open and informed debate on all choices.

The decision to use Latour's philosophy as a logical scheme to bring together the existing criticisms and future perspectives on the relationship between urban AI and sustainability is motivated by two elements. Firstly, the concepts of modernity, science and nature – which constitute the main theoretical reasons for the friction between smart and eco urbanism – are at the centre of Latour's reflection, and he has proposed an original and radical shift in their meaning. Secondly, unlike many other philosophers, Latour has identified design as a necessary mode of action in the Anthropocene. This makes his work useful for interdisciplinary studies and activities that have this practice at their core.

This chapter primarily has sought to demonstrate the need for a relationship between philosophy and urban studies with regard to the topics addressed. For if it is true that philosophy risks becoming an empty exercise in style if it abstracts too much from concrete problems, it is equally true that the weight of philosophical concepts underlying urban planning is decisive for its concrete applications. With regard to the theme examined, the distinction between theory and practice has appeared in its abstractness. Indeed, the problematic relationship between AI urbanism and sustainability has led to a rethinking of the fundamental philosophical categories of modernity, showing how this is relevant to concrete urban planning practices. The present analysis has not dealt with single design practices or specific case studies, but has aimed to impact the debate regarding the principles and values that should inform them in the future. The arguments produced are intended to have an impact on design culture, which needs to be radically rethought to address the challenges raised by technological progress and climate change. Far from wanting to produce strange hybrids such as philosopher-designers, the aim here is to stimulate a necessary transdisciplinary discussion, leading to collaborations whereby the philosophy of the city and urban theory can aid architects, urban planners and policy makers in the design of sustainable urban AIs. Following Latour for one last time, we can state that in these dangerous but interesting times the limits of disciplinary fields must be treated with agility, producing assemblages of intelligences and competences capable of questioning the new ways of living that Gaia requires.

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Chapter 5

Urban Digital Twin. A tool for the future of urban planning

1.A tale of smartness, AI, twins, and brains

Through which processes is the BDT project attempting to carry out a reverse enveloping of its urban digital twin?

This is the research question that guides this chapter. However, before answering it directly, in the first part of this chapter, an in-depth study was carried out on the urban digital twin (UDT) as a tool for AI urbanism.

Urban Digital Twins (UDT) represent one of the most recent trends in the relationship between digital technology and the city. This concept has an articulated origin (Grieves, 2023). Following Michael Batty (2018) one can state that «In strict terms, a digital twin is a mirror image of a physical process that is articulated alongside the process in question, usually matching exactly the operation of the physical process which takes place in real time» (p. 817). Clearly, it is technically possible to shape digital twins of objects, buildings, industries, and a vast array of physical processes. Starting from 2018 the concept of DT gain momentum also in the urban domain as an innovation in the vast and articulated debate on smart cities (Ferré-Bigorra et al., 2022).

According to the literature, most of the UDT currently under development regards urban physical systems such as infrastructures, while the research is struggling to involve the social component of the city in this process of digital modelling (Batty, 2018; Weil et al., 2023; Nochta et al., 2021). As Batty (2018) notes the core idea of an Urban Digital Twin (UDT) is to design a model of a given urban system that is capable to interact in a bidirectional way with the real world: by gaining information form the real system and suggesting solutions for its management. Moreover, it is relevant to notice that an UDT is not a single and simple object, though is more an articulated assemblage of different kind of technologies from sensors, to computing tools, storage, visualization systems aimed to produce a digital model of something (Weil et al., 2023; Ferré-Bigorra et al., 2022). This model can be implemented to analyse, manage and adapt a vast array of physical infrastructures and flows such as roads, energy consumption and production, traffic flows, grids etc.

In order to grasp the key characteristics and the rationale of an UDT is useful to follow two different strategies. First, it is worthy to explore the two recognized conceptual sources of UDT, namely product

life cycle management and the history of urban modelling. The analysis of some fundamental concepts proposed by these two literatures can bring to light some conceptual trends that are relevant for the definition of this complex object. Then, I will situate the UDT in the literature on smart and AI urbanism to contextualize this model in the current debate on digital urbanism especially comparing it to the city brain. This defining process through time and space – conceptual sources and other instances of the relationship between digital technology and the city – will ensure some coordinates for an actual definition of these tool. This definition process is a prerequisite for the analysis of the Bologna Digital Twin (BDT) case, which will be discussed in the second part of this chapter. In fact, it is essential to examine in depth the nature and characteristics of the UDT in order to understand the nascent project in Bologna as clearly as possible.

1.1 A clash of conceptual sources

As has been highlighted in various occasions in this dissertation, in order to understand a phenomenon, it is worthy to lookback at its conceptual sources. Indeed, in the first chapter, an examination was conducted of modern urban planning, cybernetics and the smart city, to highlight some of the challenges of AI urbanism; in the second, the cybernetic theme was explored through the history of urban modelling and architectural technology; and in the fourth, a proposal was put forward to frame the relationship between AI and sustainability through an analysis of the smart and eco city paradigms. Conceptual sources are responsible for certain tendencies that come into play when it comes to the definition and essence of complex objects. Thus, it is remarkable to notice that several scholars have highlighted a double conceptual source when it comes to UDT (Weil et al., 2023; Ferré-Bigorra et al., 2022; Nochta et al., 2021). On the one hand, the concept of DT that emerged in the field of product life cycle management at the beginning of the millennium (Grieves, 2023); on the other hand, the history of urban modelling which traces back to the 1950s (Batty, 1994). If one has the goal to really grasp the essence of UDT this ambiguity must be faced. As summarised in Figure 13, from these two conceptual sources it is possible to identify some salient features and a common approach to the issue of urban digital twins, which will be explored in the next two sections dedicated to product life cycle management and urban modelling respectively.

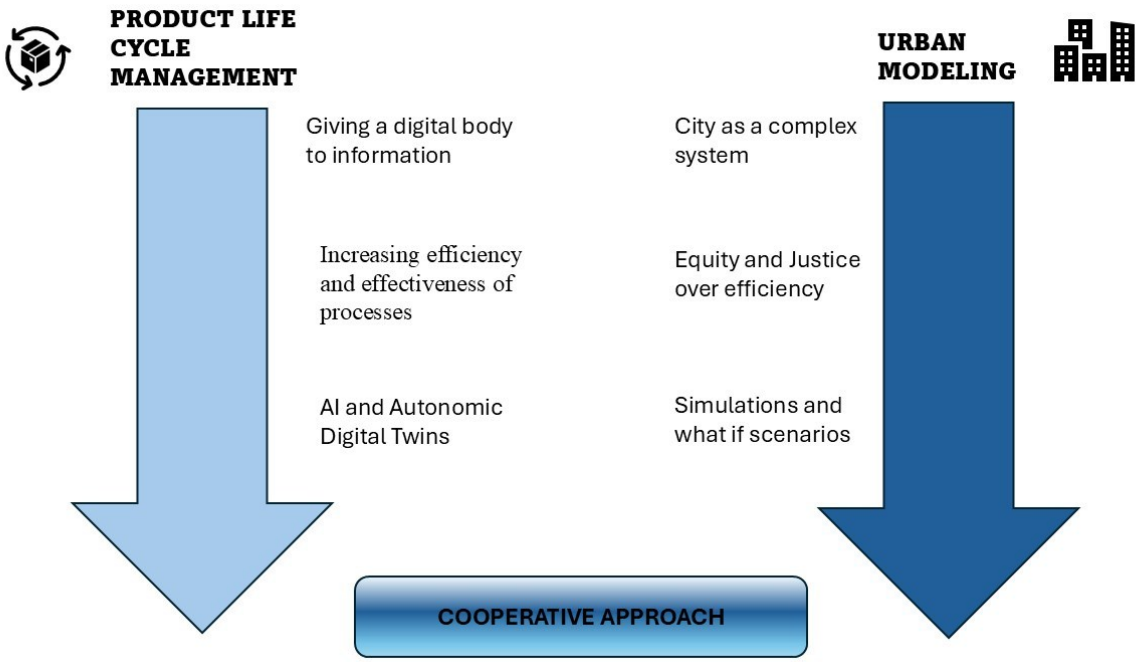

Figure 13 (Author's original) The figure illustrates the main characteristics that the urban digital twin has inherited from its two different conceptual sources in terms of epistemology, goals and AI implementation. Furthermore, the collaborative approach is indicated as a feature of both product life-cycle management and urban modelling.

1.2. Digital Twins in manufacturing

Michael W. Grieves, who is considered the inventor of Digital Twin (DT) in the field of product life cycle management, states that he started to think about the possibility to representing physical things in a digital space since the 70s (Grieves, 2023). The core idea was giving to information a digital body, to make it visible and interactable as an object, namely a digital one. Following this path, the access and use of information could have been more direct and fruitful by substituting the media of numbers and equation, with a more visual and intuitive one. As in the case of the Italian research group in architectural technology analysed in chapter 2, Grieves had also understood, as early as the 70s, that information would be the fundamental concept to investigate in order to innovate industrial and creative processes.

However, the high computational cost of a digital representation of an object has held back its development. At first, a DT is a digital object generated from data about a real object and capable of returning information about that object. According to Grieves (2023), this defined idea was there already at the beginning of millennium. However, it gains momentum only after 2010 due to hight requirements in terms of computation, storage, and bandwidth. In addition, Grieves (2023) claims that the metaphor

of the twin has to be taken into account only for two specific characteristics, namely duality and strong similarity. A DT needs a corresponding object in the real world, and it has to be as similar as possible to this object. After 2010, the concept of DT has literally exploded, going far beyond the field of manufacturing and becoming a buzzword in several domains (Crespi et., 2023). In the current technological context, it is technically possible to generate a DT of any physical object. However, even in this widespread diffusion, it is necessary to remember that the concept originated in the field of product life cycle management. Indeed, this origin matters when it comes to the aims of a DT.

According to Grieves (2023), a DT is pivotal in increasing efficiency and effectiveness of production and management. Efficiency means that the information provided by a DT can reduce the waste of resources of a given process. The more information is available, the less energy is wasted. Instead, effectiveness regards the prevision about the result of a process. As an example, a simulation could suggest that a given effort will be ineffective. In this case, the gain is to avoid the actual effort by replacing it via a digital simulation. Although we do spend energy to produce information, the trade-off is going to be often positive, especially because it is possible perform different (in types) and multiple (in time) tasks with the same amount of information. Already at this stage one can notice that previsions are key for DT, and as I will show AI is paramount to improve these characteristics.

Minerva et Al (2023) in their work on Digital Twins and AI in manufacturing point out four types of DTs, namely passive, predictive, reactive and autonomic [Figure 14]. The adoption of AI rises from passive to autonomic, while the involvement of humans experiences a downward trend. A passive DT represents an object under static conditions; a predictive one can foster with precision future states of the object; a reactive DT is able to adapt to changes, taking corrective actions and require the intervention of an operator; finally an autonomic DT is «capable of fully understanding the current situation and its future evolutions and to autonomously prepare and execute plans to reach their goals within a changing environment without any human intervention» (Minerva et al., 2023, p. 303).

It is not by chance that in this case we find the highest grade of AI involvement. In fact, it is possible to incorporate AI in all these DTs, although this relationship is only in full display in the autonomic version. In addition, it is relevant that autonomic DT is recommended when one has to build a Twin in a domain characterized by an hight degree of complexity and uncertainty (Minerva et al., 2023). That is the case of cities which are full of complexity and uncertainty due to the multiplicity of actors and systems that constitute the flash and bones of the urban fabric.

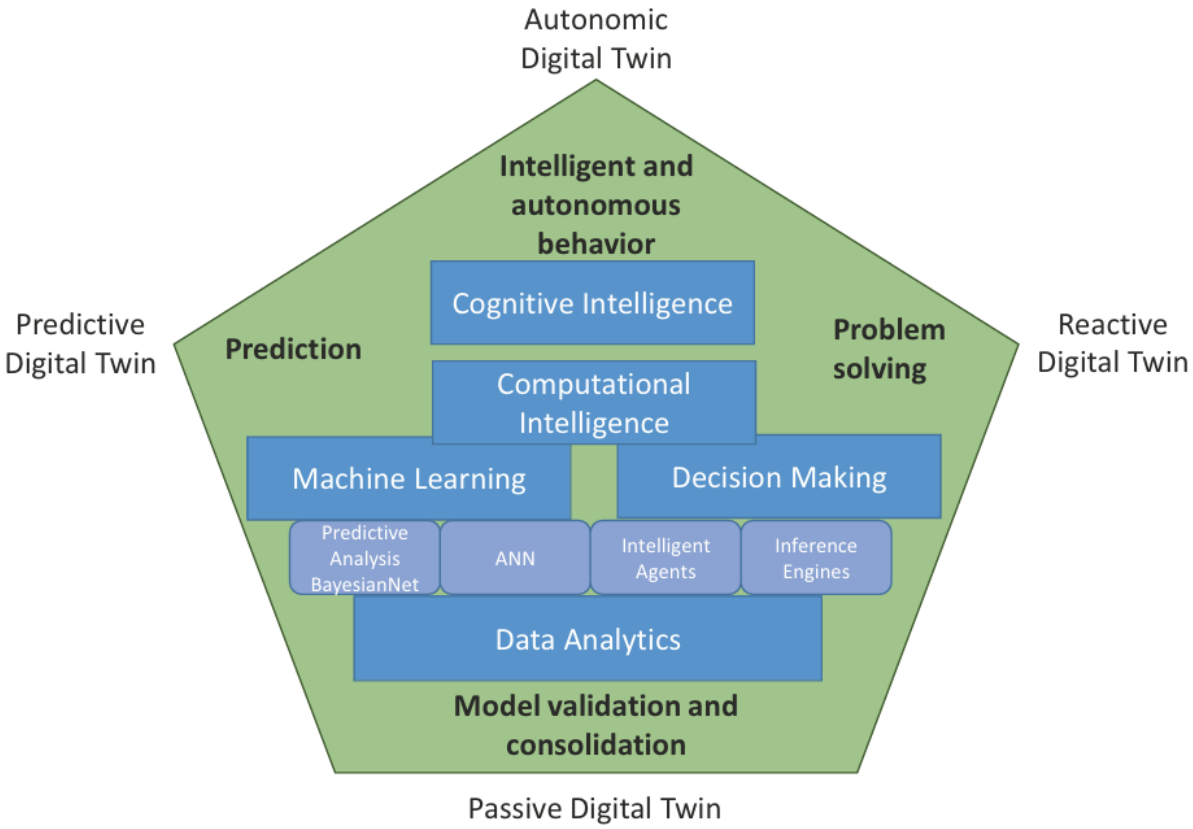

Figure 14 (Source Minerva et al., 2023) The different types of DTs in product life cycle management and the various degrees of artificial intelligence use.

Thus, considering this conceptual source one can state that the relationship between DT and AI is destined to growth in the urban context. Indeed, the urban fabric is certainly characterized by an high degree of complexity, and the idea of implementing reactive or autonomic digital twins will be very seductive for urban policy makers. As mentioned several times in this thesis, the history of technologically driven urbanism, from its earliest origins has been focused on efficiency, acquisition of a new level of knowledge and a rationalisation of decision-making. Therefore, it is not surprising that the characteristics of DT can meet the ambitions of those who have a vision of the city strongly influenced by this history.

In summary, DTs are aimed to give a digital and interactable body to information in order to reducing inefficiencies and promote effectiveness in the manufacturing process. Moreover, it is possible to incorporate AI in the design of DT at different stages and for different purposes. This approach is espe-

cially needed for predictive, reactive and autonomic DTs to promote respectively predictions, problem-solving and autonomous behaviours.

1.3. Urban Modelling

As it has been anticipated, Urban Digital Twins have also another conceptual source namely, the history of urban modelling (Batty, 1994; Batty, 2024) that I have already analysed in chapter two. It is relevant to notice that from this standpoint the city is interpreted as a complex system that are unintelligible only from the properties of its components, and in which non-linear and network interactions are pivotal in shaping its new and relevant characteristics (Caldarelli et al., 2023).

This approach is the output of a long series of development in the field of urban modelling. In a nutshell, this discipline has experienced a paradigm change in the 70s: from large scale models, characterized by a mechanical approach and scientific positivism to a humbler practice characterized by complexity science and uncertainty (Batty, 1994). Indeed, the idea of the city as a machine in search for equilibrium has been replaced by the metaphor of the organism as a system physiologically unbalanced (Bertuglia & Vaio, 2011). This shift has been also characterized by the passage from the goal of efficiency to the burst in of equity, justice and fairness as new values. If it rational to think mainly about efficiency in the context of a mechanical city, the actual urban fabric is made of value issues that cannot be addressed only with that criterion. In the chapter dedicated to ethics I showed how urban ontology does not allow for a purely functionalist conception of the city. In fact, starting from Lefebvre the city is interpreted as a field of forces, even contradictory ones, that pursue different interests with different intensities. In the contemporary debate in urban ethics, the idea of pluriversal urbanism (Moreno-Tabarez et al. 2023) highlights exactly this intuition, and criticises an urban ethos founded only on rationalisation of aims and efficiency.

Already here, one can notice a distance from the path that we have followed in the previous conceptual source. First, the city is not a simple artifact or a machine. Therefore, the reflections performed in the field of manufacturing have a limited relevance in the urban domain. By the same token, efficiency can be the rationale of a DT in manufacturing, but not for a UDT. Indeed, already 50 years ago urban modelling have performed an overcoming of this criterion as a silver bullet in the urban context.

Moreover, not only the idea of a complete digital twin of a city is an absurd (Batty, 2018), but also the idea to go for large scale models has been proved ineffective when it comes to urban modelling (Batty, 1994). First of all, because cities are complex systems made of different agents with different perceptions and views of the urban experience. A single, objective DT therefore runs the epistemological risk

of underestimating this plural essence of the city and, as a result, being a reduced and limited representation of the urban (Caldarelli et al., 2023). What is more, also in the current technological context integrated by AI the dream of completeness is picked by several issues: measurements limits such as sample bias, computational limits and mathematical constraint like undecidability and incompleteness, common issues of data analytics involving overfitting or ambiguities, and limits of AI using black box algorithms (Caldarelli et al., 2023).

Despite these issues, the idea of UDT gain some momentum in urban planning as a new and promising tool (Myers et al., 2023). Indeed, urban policymakers are extremely interested in models that can capture the changing shape of the city suggesting insights and solutions to a vast array of urban issues, from energy consumption to traffic flows (Myers et al., 2023; Raes et al., 2021; Arcaute et al., 2021). As an example, this approach is considered pivotal with regards to sustainability issues (Caprari et al., 2022). Indeed, the chapter on sustainable urban AI demonstrated that the idea of coupling sustainability goals with the power of AI, green and blue, is particularly vogue nowadays.

However, from the perspective of social and the complexity sciences, this efficiency-based approach is subject to strong criticism. Firstly, due to the suggestion that cities are mechanical systems that can be evaluated in terms of efficiency (Arcaute et al., 2021). Secondly, because the focus of UDT projects is very often on the production of digital twins of physical components of the city, with very little emphasis on the human and social components (Caldarelli et al., 2023; Weil et al., 2023). Subsequently, this situation generates a remarkable paradox where cities, as systems created by humans and for humans, are represented and evaluated with little regard to this essential actor (Arcaute et al., 2021). By the same token, with few exceptions, participation has been relegated to an afterthought within ongoing UDT projects (Weil et al., 2023).

Building on these considerations, it is possible to grasp that these difficulties are deeply linked to the duality of the conceptual sources that informs UDT. Indeed, issues such as the different perspectives that shape the urban experience, the social and political component of the city, and participation are substantially alien to the epistemology of product life cycle management from which the concept of DT is derived. In that case is perfectly rational to centre the action of DTs on efficiency, and to respond to an increase in complexity with more technology and AI. However, the city and an industrial product are not the same thing at all. The latter has a complexity and an essence that resists technological solutionism, as we have shown in the chapters of this thesis. The dream of controlling the city via technology continues to prove ephemeral. The real question remains how to integrate technology into the urban

logic and not using it to solve the city. Indeed, building on the previous chapters, the modern dream of building a perfectly rational machine capable of controlling urban dynamics is destined to remain just that. As mentioned in the introduction, Batty (2024) has neatly outlined the paradox associated with this idea of technological control: the technological tools that are introduced into the urban fabric to control it increase its complexity and open up new challenges that had not previously been considered. I have emphasised the development of this dynamic both in terms of urban ethics, where the insertion of artificial agency raises new challenges, and in terms of environmental sustainability, where the relationship with AI forces us to rethink some of the fundamental categories of modernity.

In many ways, therefore, it is crucial to overcome the manufacturing origins of the DT concept if we are to apply it properly to the urban environment. The Gemini Principles (Bolton et al., 2018; Figure 15) represent an influential attempt to adapting the concept of DT to the build environment through the individuation of nine principles divided in three areas: 1) Purpose expressed as public good, value creation, and insights; 2) Trust intended as security, openness, and quality; 3) Function as federation, curation and evolution. Although chapter 3 demonstrated that in AI ethics principialism struggles to grasp the actual urban dynamics, these precepts are important to frame the discourse on UDT differently. Indeed, especially the public good and openness are principles that can steer the UDT projects toward the needs of citizens addressing the urban degree of complexity. In addition, the specific reflection on the purpose must suggest the overcoming of the simple efficiency as a goal. Moreover, this change in perspective can help this discipline to overcome the dream of a complete UDT toward a humbler and purpose-driven approach, in which the quality of data (Caldarelli et Al 2023) and the adherence to some concrete needs should be the paramount criterions (Wan et al., 2019). Following this path, Noctha et al (2021) state that the situated knowledge of communities has to play a role in the design of UDTs, also mirroring the different perspective expressed in a given context by different actors. In accordance with chapter 3 a focus on situated knowledge is essential to overcome ethical regulation based solely on abstract principles. Both the design justice and design disorder perspectives focus on this aspect, forcing the planner to enter into a dialogue with the needs of the communities. Urban knowledge cannot be reduced to technologically analysed information, but must take into account the ethical, social and ecological relationships that characterise the fabric of cities. Overall, all these aspects are aimed to urbanize the concept of DT, trying to implement some of the insights taken from urban studies into the flash and bones of these new tool.

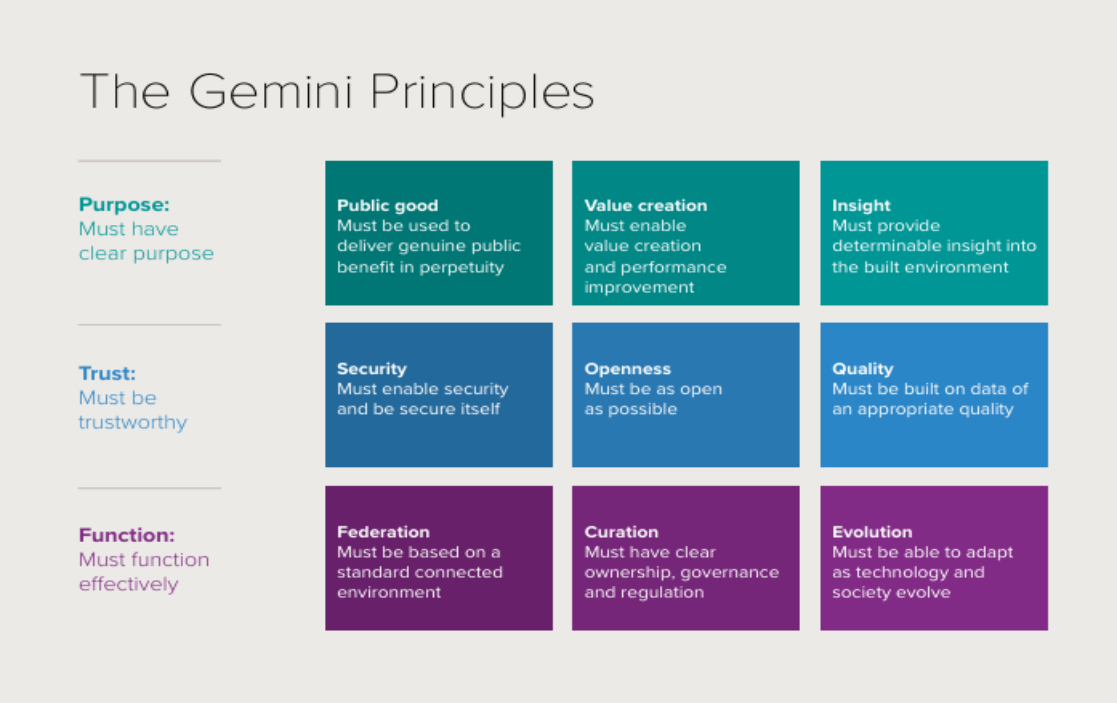

Figure 15 (Source Bolton et al. 2018) The Gemini Principles.

Notwithstanding, there is a key aspect that is mentioned in both the conceptual sources of UDT that could be pivotal to steer the UDT in a more urban and participatory domain. Grieves (2023), the father of DT concept, highlights several times that that the role of this new technology is aside the human/user creativity. Even when AI is strongly involved in the process, IDT (Intelligent Digital Twin) has to act as a real time reviewer providing information to the user/ designer (Ivi). Minerva et Al (2023) describe an autonomic DT capable of autonomous behaviour, although they neatly state that the role of the twin is to help the human user to act in a more creative and effective way. Thus, in the field of product life cycle management, the relationship between humans and DTs is substantially cooperative. The digital model is shaped to help the human user is some specific tasks by accomplishing routine tasks, providing reviews and operating simulations.

This cooperative trend is even more marked in the tradition of urban modelling. Indeed, according to Batty (2012) the models based on the concept of complexity has to inform via simulation and what if scenario, rather than predict. From a similar perspective, Caldarelli et al., (2023), state that simulations have to enhance knowledge and capacity of the human actors involved in the urban dynamics. Finally, in the view of Arcaute et al (2021) the UDT has to clarify the effects of a given public policy, and empower citizens and stakeholders facilitating a participatory dialogue. Indeed, the role of a model is to inform, increase knowledge and empower human actors.

Although the two sources focus on different characteristics, they share the attention to knowledge and the cooperative nature of the relationship between technology and humans. In manufacturing, the idea is to deploy DTs and AI to support the decision making of designers. In this case, the human and creative side of the equation is embodied by designers as situated subjects responsible for the actual creation of objects. When it comes to urban modelling, one might ask: who are the designers? In the case of UDT, who represents the human and creative side of the equation? I will answer these questions by analysing a case study. First, however, it is necessary to take another step in defining the urban digital twin by situating it in the context of the current landscape of technologically driven urbanism.

1.4. Between Smart and AI urbanism

Smart and AI urbanism are two influential urban paradigms in the contemporary debate on technology-driven urbanism. In the first chapter of this thesis, I considered smartness as a conceptual source of AI urbanism, suggesting that scholars and various urban stakeholders need to look back at the smart city debate in order to avoid some pitfalls in shaping the future of AI urbanism. Moreover, in the chapter on sustainable smart urbanism was mentioned as one of the two paradigms used to establish the idea of sustainable AI urbanism. Thus, there is a strong continuity between these two discourses.

However, Cugurullo et al (2023) have pointed out nine specific differences between these two urban paradigms, and in the chapter on Ethics of urban AI I have implemented some of these features to identify specific ethical issues that emerge with the increasing use of AI. Certainly, the recent explosion in the availability and effectiveness of AI is accelerating the transition between these two paradigms by redefining certain features of the relationship between digital technology and urbanism. Thus, it is relevant to situate the UDT into this debate. UDT can be considered as a tool, as an objective output of the relationship between digital technology and the city. As a tool, UDT can be situated both in smart or AI urbanism discourse. Indeed, it is relevant to note that AI is not a necessary condition for the design of the digital twin. In fact, there are also other ways of processing information and data, such as numerical simulations and logical operations (Ferré-Bigorra et al., 2022). Nevertheless, the development and the hype of machine learning solutions are driving a more concrete coupling between UDT and ML, and this new wave of urban modelling is driven by the new opportunities opened by big data and ML (Raes et al., 2021). Hence, exploring the link between UDT and AI will be crucial for studying the future of technologically driven urbanism. As mentioned earlier in this study, Cugurullo et al. (2023) identified

nine specific differences between smart and AI urbanism regarding technology, action, space, agency, culture, personality, governance, time and materiality [Figure 16].

	Smart Urbanism	AI Urbanism
Technology	IoT	AIoT
Action	Count	Account
Space	Confined spaces	Open spaces
Agency	Automation	Autonomy
Culture	Niche	Pop
Personality	Impersonal	Characterful
Governance	Tool	Stakeholder
Time	Present	Future
Materiality	Soft	Concrete

Figure 16 (Source Cugurullo et al. 2023) The Nine difference between smart and AI Urbanism.

Three of these are crucial in comparing the use of UDT in smart and AI urbanism: action, time and agency. With regards to action the difference highlighted by Cugurullo et al. (2023) lies between count and account. In the smart city paradigm, the focus in on the capture and record of urban data. The idea is to accumulate data in order to have a detailed picture of a certain urban issue. A well-known example regards urban dashboards, or control rooms that can provide a report of the different flows of data that are involved in the urban dynamics (Coletta & Kitchin, 2017). In this case an UDT can be implemented as a visual (2D or 3D) representation of these data and to monitor the development of different urban issues such as traffic flow, energy production or the crowding of certain places. In these cases, a UDT can count the data and translate it into a visual representation. However, in AI urbanism the idea is to identify some regularities and correlations in order to bring light on the causes of some urban phenomena (account). The aim is to analyse the data to obtain some significant correlations and to act in order to mitigate, reinforce or stop a specific urban trend. For example, consider the difference between counting the number of cars in a particular traffic jam and suggesting a different structure of traffic flows to avoid that particular jam in the future. In this second case the computational power of AI is pivotal and therefore it should be implemented in the UDT.

Another difference regards time. In the smart city paradigm, all the attention is on the real-time dimension (Kitchin, 2014). The idea is to reach an immediate grasp on the present in order to change and adapt solutions. Also in this case one can use an UDT to obtain a dynamic picture of the present state of a urban phenomenon. When it comes to AI, foresight comes into play and then the focus shift on the future (Cugurullo et Al. 2023). Two of the main goals of UDT are deeply related with future as a temporal dimension. Indeed, building models to forecast some kinds of events is a key challenge for the twin. As an example, one can think about future trends in the impact of climate change in cities (Weil et al., 2023;), or predictions about some infrastructural criticalities based on historical data (Whyte et al., 2019). Moreover, another key task for UDT regards helping urban decision-making via simulations and the previsions of alternative futures based on some urban planning decisions: the closure of a road, the construction of a park, or the deployment of a new line of public transport. In all these cases, one can notice that the focus in on future.

Thus, it can be said that while it is possible to design and use a UDT as a tool in the context of smart urbanism, the rise of AI and the idea of discovering relevant correlations and predicting events pushes this tool into the realm of AI urbanism. Overall, it is possible to frame this passage in the difference between automation and autonomy (Cugurullo, 2021; Cugurullo et al., 2023). Automation regards the mechanical repetition of a set of programmed actions. In that case the machine has no autonomy in the decision since its logical steps are disposed by a human programmer. Here, there is no surprise in the machine's behaviour, and humans can easily understand the decisional process that is on-going. On the contrary, AI is an autonomous technology that produces some results that are not known before the process. Moreover, the reasons for these responses are often unclear, and AI can act in this way without human control; it therefore has a significant degree of autonomy. In the first case, a UDT is a prescriptive machine programmed to take specific actions, while in the second case, this tool is used to discover new patterns or predict scenarios that go beyond the current status quo.

1.5. Models and brains

To investigate further the link between UDT and AI urbanism, it is also instructive to compare the former with a city brain. Indeed, a city brain is a tool shaped in the context of AI urbanism and it is basically a software agent that can accumulate and analyse a huge amount of urban data from different sources in order to anticipate and solve a vast array of urban issues (Cugurullo & Xu 2024; Capriotti & Liu 2020; Zhang at al., 2019).

From this standpoint the similarity is clear: one can see both City brain and UDT as platforms capable of accumulating and analysing urban data from different sources to shape simulations and solutions. What is more, in both cases building a digital representation is pivotal. In the case of UDT it is the core activity, while with regards to city brain it is a relevant part of the task (Zhang at al., 2019). Moreover, when it comes to applications one can notice that traffic flows, infrastructural management and environment related measurements are remarkably present in both cases (Capriotti & Liu 2020; Weil et al., 2023).

Apparently, the only strong difference is technological, and regards the role of AI. Indeed, as has been highlighted it is possible to conceive a digital twin without AI. On the contrary, a city brain is a direct manifestation of AI urbanism, and AI is an essential part of its definition: «City Brain is a new infrastructure built on massive data, which utilises AI to solve urban governance and development issues that cannot be solved by the human brain» (Zhang at al., 2019). Apart from the predominance of the AI the prosecution of this definition could also be applied to the UDT: « It is a program that offers a comprehensive suite of acquisition, integration, and analysis of big and heterogeneous data generated by a diversity of sources in urban spaces through video and image recognition, data mining and machine learning technology. With this, city council and urban planners will be able to make better decisions for the community» (Ivi). Thus, one can state that while UDT are currently still between smart and AI urbanism, city brains are definitively a matter of urban AI. This in between essence of UDT is relevant also with regards to another difference.

In fact, in the context of the general similarity, it is possible to notice something that may herald a major difference, not in technology, but in the socio-technical context. Zhang et al. (2019) have stressed a lot the idea of the City brain as a more then human machine. Indeed, in Asia, especially in China and Malaysia, City Brains are shaped and proposed via a precise narrative: the idea is that for the current complexity of the urban systems humans are not enough, so we have to rely on those artificial brains in order to perform effective actions in the urban fabric. In this contexts city brains are conceived as entities gifted (coded) with superpowers. The relationship between humans and city brain is a competitive one, and clearly, humans are on the weaker and less performative side of it.

This perspective is also evident in the technologically mediated anticipatory governance that is embedded in city brains deployment (Cugurullo & Xu, 2024). In this logic the human component in the urban decision-making process is less and less relevant due to the forecasting power of the brains and to its capacity to act autonomously. Here, the technological superpowers of city brains ended to be the real

protagonist of this new urban science, despite the obscureness and unintelligibility of AI decision making. In the case of city brains, the technocentric approach is aimed to put the humans and the citizens in a less relevant spot when it comes to decision making, leaving room for an AI driven urban science.

As has been considered with regards to the conceptual sources, the situation in the case of UDT is different. Indeed, along with increasing efficiency and sustainability, participation and explicability are often mentioned as specific goals (Bolton et al., 2018). Moreover, the relationship between twins and humans is essentially cooperative. Although UDT are aimed to improve our urban decision-making, the explicit aim is not to take humans apart from the process. On the contrary, the idea is to get more information to take better decision. One can argue that this difference is rooted in the dissimilarity between the twin and brain metaphors. Indeed, a twin is something that is similar to another entity, while the brain is the centre of the decision-making of a given system. On the one hand, the brain metaphor implies an active approach in which this organ has to guide and steer the process. On the other hand, the twin metaphor suggests a more passive standpoint, in which someone can study the twin system with the aim of acting on the actual entity in a more informed way.

Notwithstanding, the risk of a technological solutionism embodied by the city brain is always present in both development and deployment of UDT. Indeed, one can consider the vast array of criticism focused on the lack of social, participatory and non-physical dimensions of the city (Raes et al., 2022; Nochta et al., 2021). The seductiveness of reducing urban complexity and manage it via technology is constantly latent danger in the development of these tools. As highlighted several times in this research, this appeal comes from different moments in the history of technology-driven urbanism. This means it has a lot of influence today in the context of AI urbanism.

This perspective is well represented by Kitchin and Dawkins (2024) in an article on digital twins and deep maps. According to the authors, while the digital twin understands the city as a system of systems (in a quantitative way), the deep maps conceive the urban as an array of communities (in a qualitative way). The former is basically a peopleless, functional and univocal representation of the city, the latter is a people-centric, and multilayered tool attentive to the immaterial knowledge (experiences, stories, traditions) that animate the urban fabric (Kitchin & Dawkins, 2024). In this case, UDTs are characterised as purely quantitative tools aimed at reducing the human component of the city. They are therefore perfectly in line with the history of the technosolutionist approach to the urban fabric. However, as has been considered, the idea of considering the human component of the city is a need also in the literature on UDT (Nochta et al., 2021).

In the current situation, it seems that the essence of UDTs is at stake between the technological seductiveness of city brains and the critical perspective represented by deep maps [Figure 17]. On the one hand, UDT is a technological tool, and a quantitative approach is needed in order to shape simulations and scenarios. On the other hand, there is no necessary contradiction between quantity and quality, and it is possible to feed an UDT with qualitative data attentive to the communities. Only the actual shaping of a UDT can decide the place of a specific tool in a spectrum that goes from city brains to deep map. A UDT is not exactly a city brain or a deep map. Thus, its essence remains poised between a pole characterised by technocentrism, foresight and autonomy, and another driven by participation, knowledge and cooperation.

As I have argued in the chapter on Urban AI ethics it should be pivotal, in the context of AI urbanism, to understand how the city can influence and steer the technology. A reverse enveloping in which the urban is capable to hack AI in order to promote participatory and democratic values. In the case of UDT it will be pivotal to maintain knowledge as the main goal of this tool. Indeed, the idea of producing knowledge is propaedeutic to a cooperative relationship between the city and the twin. However, this knowledge cannot be confused with information. In fact, the latter concerns the technological capacity to produce and analyse data on urban dynamics, while the former involves listening, understanding and elaborating the various instances of values that inhabit the urban fabric. As shown in the previous chapters, the former tends to generate a flat urban ontology, univocal and analysable in terms of efficiency, while the latter forces us to deal with the unpredictability and contradictions generated by the differences in values and power present in the city. Cities are already populated by intelligences, and they are knowledge producer. In such context the inclusion of UDT can lead to an increasing of knowledge via an active cooperation between natural and artificial agencies. On the contrary, it can be dangerous to conceive a UDT as a tool that is capable to give solutions via previsions. That is the city brain approach and in that case one can notice a downward trend in the actual capacity of the urban to produce complex knowledge. Indeed, the previsions are entrusted to the machine, while the other urban intelligence (human and non-human) must follow this opaque and technocentric rationale.

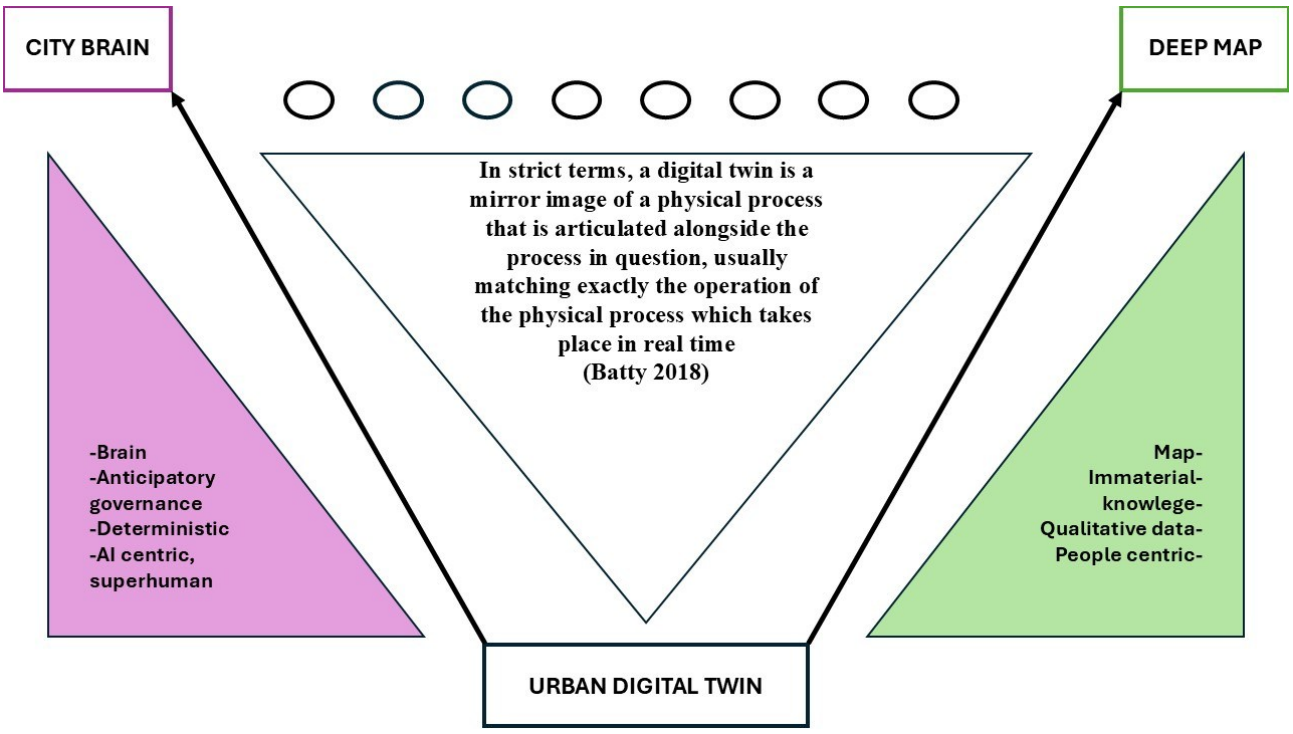

Figure 17 (Author's original) The diagram shows the alternative possibilities of the Urban Digital Twin. On the one hand, the City Brain model characterised by anticipatory governance, determinism and an AI centric approach and, on the other hand, the Deep Map model marked by an attention on immaterial knowledge, qualitative data and a people centric approach. The actual design of a UDT can fall between these two extremes and be defined by a particular combination of their characteristics. Design culture and design choices will be crucial in guiding the development of this tool in one direction or another in the near future.

To sum up, this chapter has defined some of the key characteristics of the concept of UDT via two different strategies regarding time and space. On the one hand, a temporal axis, an inquiry on two conceptual sources of this concept, namely product life-cycle management and urban modelling. This has highlighted not only some differences (the role of efficiency, the relationship between complexity and technology) between these two sources, but also a similarity in the framing of a cooperative relationship between technology and humans. On the other hand, a special axis, through which UDT has been contextualized in the transition between smart and AI urbanism. In this case UDT has been situated in both these urban paradigms by suggesting that the rising use of AI will push this tool more and more in the realm of AI urbanism. In this realm it has been showed that UDT owns a magmatic essence and that it could be shaped in the direction of a city brain or a deep map. Regarding to this alternative, as I will illustrate in the case study, the governance of a UDT project is of paramount importance. Cities have many opportunities to influence AI in the sense of reverse enveloping. Certainly, the structuring of competent, solid and participatory governance can be an important key in this sense. Indeed, through governance mechanisms a city can influence both the design and the deployment of an urban digital

twin. At the very end is the quality of the governance that can decide the place of a given UDT projects in the spectrum between city brains and deep maps.

2.Bologna Digital Twin

2.1. An unorthodox approach

The definition of the urban digital twin (UDT) is articulated in a multiplicity of conceptual sources and complexified by the contemporary geography of the relationship between digital technology and the city. The use of AI in the construction and deployment of digital twins is increasing, and this raises new questions about the relationship between AI and cities. Moreover, this tool lies between the perspectives of city brains and deep maps. Hence, an empirical investigation of a case study can help to clarify the picture.

Ferré-Bigorra et al (2022) mapped 22 published studies on the development of UDT, of which only 9 do not focus on a specific infrastructure but on the city as a whole. These cities are Athens (Raes etal., 2021), Pilsen (Raes et al., 2021), Luleå (Simonsson et al., 2021), Herrenberg (Dembski et al., 2020), Vienna (Lehner, H., & Dorffner, L. (2020), Zurich (Schrotter, & Hürzeler 2020), New York (US), London (Whyte et al., 2019), Helsinki (Ruohomäki et al. 2018), Pisa (Bacco et al., 2017). As can easily be seen, the vast majority of cities are located in Europe and it is therefore reasonable to define the UDT tool as being mainly located in this geographical area. Furthermore, Ferré-Bigorra et al. (2022) categorise these projects according to the actors who will have to use the UDT once it is developed (citizens, asset owners, asset managers and researchers). None of these projects are designed to be used by all these actors simultaneously and almost all of them focus on the physical 3D representation of the city in order to visualise the *ville* (the physical component of the city) in a more holistic and manipulable way. Citizen participation is often mentioned as an element to be considered, but almost never as a central element, except in the case of Herremberg (Dembski et al., 2020).

As I will explain in the rest of this chapter, the Bologna Digital Twin (BDT) project stands out as original for several reasons. First, it is the only project that explicitly and structurally distances itself from some typical characteristics of the smart city paradigm, such as the involvement of private technology companies and the technocratic approach. The political mandate of the project explicitly aims to build an alternative tool and narrative to the smart city as it has been developed so far. Furthermore, participation and the civic aspect are not an aspect of the project, but its centre. The focus on the 3D model and the physical component of the city is much less pronounced than in other cases. In fact, the attention seems to be focused on modelling the social component of the city and promoting civic use of the platform (Luca et al., 2024). Furthermore, compared to the other cases mentioned, BDT is the only one

that is designed to be used by both citizens and researchers (as well as the public administration). This element derives from a concept of urban knowledge that is at the centre of the project. Finally, the BDT project also seems to be the most politically situated (along with the project developed in collaboration with Barcelona) in a neo-municipalist perspective of radical opposition to the neo-liberal version of the relationship between technology and the city, based on the strong presence of private companies and the concept of efficiency as the ultimate goal.

Bologna is a medium-sized city and the capital of the Emilia Romagna region. The city's government has historically been characterised by a left-wing policy based on the values of civic participation and social protection (Giovanardi & Silvagni, 2021This approach is situated in a regional context that, through the cooperative logic, has been an international model of fruitful combination of industrial productivity and labour rights (Zamagni, 2006). Bologna is also home to the University of Bologna, the oldest university in the Western world, and the city has always been characterized by a lively student and academic atmosphere, often intertwined with important political demands in Italian history. In addition, the Emilia Romagna Region launched the Data Valley Plan in 2015 and then the Data Valley Commons in 2020, with the aim of making this territory a national and European pole of excellence in the field of digital technology, in data production and collection, in computing capacity. Digital technology will be a subject of academic and industrial research and a transversal element of the vertical policies that will define the future of the territory (Regione Emilia Romagna).

These roots are relevant when it comes to The Bologna Digital Twin (BDT) project which represent a pivotal part of the mandate of the administration that took office in 2021 under Mayor Matteo Lepore. This project has attracted international attention for its highly progressive approach, which aims to present itself as an alternative model to the neoliberal approach to the relationship between digital technology and the city (Garrido, 2023; 2024). According to the roadmap proposed by the municipality, the aim is to obtain a functioning UDT after a three-year experimental phase in 2023-2026.

One can immediately enumerate two key challenges in this plan: a) The intention to build a UDT without the involvement of a private technology company during experimental phase. This idea responds to a challenge that the development of AI urbanism has inherited smart cities, pointed out in Chapter 1. Indeed, the presence of private technology companies has highlighted some negative aspects of the development of smart cities, starting with the privatisation of public assets and the lack of transparency and accessibility of the data collected. b) Including social aspects in the project with a strong focus on participation and ethics. This issue is crucial in the transition from digital twin to urban digital twin.

Indeed, urban complexity requires an approach that goes beyond simple efficiency and the physical representation of objects. In this chapter, GEMINI principles has been presented as an example of this necessary change of perspective. These elements are certainly original in an international context that is more focused on digital models of physical component of the city. These characteristics resonate with the idea of a reverse enveloping described in this dissertation. Indeed, on the one hand AI has been modifying the shape cities, on the other hand cities must pursue the goal of steering the design and the implementation of Urban AI.

Bologna is a remarkable example of this idea of a city that aims to dictate the tempo of its own technological development. Governance and participation are the two pivotal concept to characterize this attempt. The first regards the shaping of a governance that is able to deliver a UDT without a private tech company. The second is referred to the idea of including the social aspects of the city in the very structure of the twin, and to make this tool usable by citizens and communities.

As the first year of the project is ended (the research that is the subject of this thesis was interrupted on 14 April 2025, the date of submission of the dissertation), the focus of this chapter is on the composition of the governance and the theoretical framework that gives political direction to the construction of this tool. It will certainly be necessary and worthwhile to follow the project over the next few years and to measure the real results of a plan that has been described as ambitious in its radicalism.

Based on these initial considerations, the BDT project does not represent a standard and widespread model for the application of the urban digital twin. In fact, as this chapter will show, this project aims to structurally change certain dynamics that characterise the relationship between technology and the city. However, this extreme case is useful to measure the real capacity of strong governance to direct the structure, use and objectives of this new technological tool in the era of AI urbanism. According to Flyvbjerg (2006), looking at an extreme case study is more informative, especially when looking at a case from a specific perspective. For example, in the case of Bologna, to understand whether a certain governance structure may or may not be useful in pursuing the goal of using the digital twin tool in a democratic and citizen-oriented way. Thus, the aim of this chapter is not to illustrate a standard implementation case, but to assess the feasibility of a project with specific characteristics that aims to change the *status quo*. In addition, Chapter 3 proposed a constructivist approach to technology analysis, and the BDT case made it possible to follow a UDT project from its beginning, focusing attention on the principles underlying the process.

The methodology of this study involves literature review about UDTs, desk-based analysis on Bologna DT project, participant observation, and qualitative interviews. The literature review regards both papers aimed to conceptualize UDTs and case studies papers. The desk-based analysis covers both the in-depth study of official documents on the project issued by the Municipality of Bologna the other actors involved in governance (University of Bologna, Fondazione Bruno Kessler, CINECA and Fondazione per l'innovazione urbana) and papers focused on the relationship between technology and the city and on civic participation in Bologna. The participant observation regards the attendance in workshop and public initiatives (in the first year) on this project promoted by the municipality of Bologna an other stakeholders involved in the governance. Finally, this work is based on 11 in-depth qualitative interviews.[6] I interviewed two times a hight profile representative of each entity involved in the governance (5) of the project and the councillor with responsibility for urban planning, strategic projects, digital twin, science, research and knowledge. The first five interviews with the actors involved in the governance were in depth and conducted between 12 December 2024 and 7 March 2024, with 8 open-ended questions. Only one of these questions, concerning a general evaluation of the project in the contemporary panorama of the relationship between technology and the city, was common, while the others were conceived and written according to the specific characteristics of each actor. Each interview lasted about an hour, and thanks to the interviewees' key role in the project, it was possible to get a broad picture of each stakeholder's involvement in governance. The second round of interviews took place between 12 September and 19 March 2025. In this case, each interviewee answered 4 open-ended questions about BDT in about 35 minutes. Instead, the interview with the councillor, which was the same duration as the others, was published in an Italian journal on June 12, 2023 and consisted of six questions regarding the relationship between technology and the city of Bologna, with particular reference to the BDT project.

Firstly, the political context in which the Bologna Digital Twin project is embedded will be described. In fact, this project is part of the mandate plan «Bologna City of Knowledge», which represents the

[6] The 10 interviews with key figures from the five actors involved in governance (Bologna Municipality, University of Bologna, Fondazione Bruno Kessler, CINECA, Fondazione per l'innovazione urbana) were not conducted in the form of multiple-choice questionnaires. They were semi-structured interviews designed to obtain qualitative data on the project. In accordance with the agreements made with the interviewees, their names will not be revealed, except to say that they are leading figures in their respective realities related to the BDT project. Furthermore, again in agreement with the interviewees, the interviews will not be used verbatim and in their entirety. Some key sentences are included, but in general the interviews have been used to better understand the BDT project, and the information gathered informs the overall argument of the chapter. On the other hand, the interview with Councilor Laudani was previously published in an Italian journal and is therefore fully accessible and included in the bibliography (Palmini & Bottos, 2023).

broad strategy of the administration. This overall framework in which the project is embedded will be presented based on the official documents issued by the municipality and the interview with the responsible councillor. Secondly, the governance structure of the Bologna Digital Twin (BDT) project will be outlined on the basis of official documents and interviews. The main characteristics of each actor will be defined, and some of the main objectives of the three-year experimental phase set by the city will be highlighted. Finally, some salient features of the project will be analysed through the lens of neo-municipalism to understand how this project aims to change the profile of the relationship between digital technology and the city.

2.2. Bologna City of Knowledge

«Bologna City of Knowledge» is the title of the «great mandate strategy» (Comune di Bologna 2023) designed by Bologna municipality to shape the future of the city. Formally, the strategy is grounded in three pillars: 1) Science, research, and advanced training; 2) innovation, and impact for economic development, hight quality of work and international attractiveness; 3) widespread knowledge and culture (Ivi). However, these pillars could seem abstract without a proper understanding of the urban political background in which they are situated. Because of this reason, in 2023 I have interviewed Raffaele Laudani councillor with responsibility for urban planning, strategic projects, digital twin, science, research and knowledge (Palmini & Bottos, 2023).

Firstly, it is relevant that the mayor has chosen Laudani in this role. Indeed, he is not a technician, not an architect or an urban planner. Laudani is full professor of history of political thought at the University of Bologna, a humanist with a vast expertise in political theory. In the interview he immediately pointed out the centrality of cities in contemporary political landscape. According to the councillor, we are in front of a paradox when it comes to the role of the urban areas: on the one hand, cities are affected by international (financial and technological) flows that seem to far exceed the possibilities for action of local authorities; on the other hand, urban spaces are the places where the consequences of these flows become tangible for citizens, and the sites in which these trends can be reoriented towards urban needs.

It is not by chance that Laudani mentioned the work of the sociologist Joan Subirats as a key reference. According to Monterde and Subirats (2023), cities have a pivotal role in the actual deployment of the digital revolution. Indeed, a hight percentage of the social interactions that feeds a vast array of digital platform are performed in urban areas. In addition, cities are at the forefront of the combinations be-

tween the extractive processes of platform capitalism (Snricek, 2017) and the democratic needs of the citizens. According to Subirats (2011), cities have to find new ways to promote democratic values in the context of the digital society, this is a paramount battle, and the future of the relationship between technology and democracy is at stake.

Laudani explicitly shares this city-centric approach. In the interview the councillor interpreted this complex issue through Herbert Marcuse' Philosophy of technology, one of the first research topic investigated by Laudani as a young scholar:

«According to Marcuse, technique concerns the tools made available by society on the basis of technical-scientific development at a specific historical moment; technology, on the other hand, is the way in which these tools are organised. The technology presupposes a perspective of meaning» (Palmini & Bottos, 2023).

In Bologna this perspective of meaning is embodied in the concept of knowledge as the context that must steer technological innovation towards democratic and urban needs. Indeed, the city of knowledge is not the same as the city of science/technology. Urban knowledge is not just the information that is technologically collected and analysed in urban contexts. Knowledge is intended as something that is produced by a vast array of urban intelligences. With the term Knowledge one has to intend not only specialized and scientific knowledge, but also situated knowledge expressed by individuals, communities and associations. This kind of Knowledge is something intrinsically urban, a collective production of the fabric that can act as a vector of force in order to mould technological innovation. This idea of knowledge is compatible with the urban ontology I described in Chapter 3. In fact, the city is to be understood as a field of forces characterised by vectors of different intensity and direction that promote a variety of purposes with different intensity and resources. Urban knowledge is therefore represented by the relationships established in this complex vectorial geometry, which prevents the city from having a single interpretation.

This idea of fostering the production of urban knowledge is in line with the goal that complexity-oriented urban modelling theorists give to UDT (Batty, 2012; Aracaute et al., 2021; Caldarelli et al., 2023). In fact these scholars consider this tool as an enabler of urban knowledge production that can foster it through the production of models, simulations and analyses. This approach is certainly a distant from the City Brain approach (Zhang et al., 2019; Cugurullo & Xu, 2024), in which technology is seen as merely surpassing human-produced urban knowledge.

In order to turn science and technology into knowledge Bologna municipality propose the idea of the city as a platform (Comune di Bologna). The correlation between cities and platform is well-known (Barns 2019), and it is typically referred to the role of digital platform in shaping the new dynamics of

urban areas. As an example, one can consider the urban impact of digital platforms such as Uber or Air BnB (Södeström & Mermet, 2020) in which the intersection between the smart city paradigm and platform capitalism taking shape (Caprotti et al., 2022). However, the connection between platforms and cities can also indicate the idea of government as a platform in which digital tools are used and shaped to open new mode of participatory and interactive relationship between citizens and governs (Barns, 2018; Pope, 2019).

According to Bologna municipality «In order to live up to our time, urban spaces must be organized more and more as urban platforms that connect, enable and promote the various scientific, technological, economic, cultural and social actors operating on their territory» (Bologna Municipality, p. 4). Thus, the idea is to become an urban platform to avoid being defined by the many private platforms operating in the city. According to Laudani, just as capitalist platforms are driven by private algorithms to maximise profit, urban platforms must be guided by public algorithms to direct their operations. These public algorithms consist of the political projects that must guide technological development; in the case of Bologna, the City of Knowledge project represents this algorithm. Going back to Marcuse, it is possible to state that the most advanced technological innovations, that are expression of international production and flows, must be situated in a specific urban culture capable of steering these forces into the needs of communities.

This ambition shapes the BDT project that is situated in the city of knowledge mandate [Figure 18]. The plan is divided in two parts, the Lane of Knowledge and Knowledge Policies. The first is an urban regeneration project of the Northwest quadrant of the city aimed to connect and reshape the five innovation districts of the city: district of Wellness and Industry 4.0, of Social and Cultural innovation, of democratic memory and critical culture, science and technical culture, of digital transition and global challenges. The Knowledge policies constitute the immaterial side of the mandate, aimed to promote actions and administrative framework to identify strategic issues, invest resources, stimulate connections and promote critical culture and science education. «Among the most important projects of Knowledge Policies – with an investment of between 7 and 10 million euros – Bologna is a candidate to design the first digital twin of the Italian city, a pilot project expandable to regional level and replicable also in other local contexts of the country» (Comune di Bologna, p. 38).

The fact that the project is situated in an overall and detailed plan is promising in order to avoid considering the BDT as a spot project separated from the actual future development of the city. However, conceiving it as a part of the immaterial section of the mandate hides a danger. Indeed, as I have

demonstrated in this dissertation considering digital technology as an immaterial one is largely superficial. In Chapter I the idea of enveloping was pointed out (Floridi, 2014) to show that AI has a functional need to reorganise its environment. This characteristic is even more evident in urban AI, as various examples of experimental urban planning demonstrate. Furthermore, Chapter 4 highlighted how the entire life cycle of AI has highly relevant material implications in terms of environmental sustainability (Pitron 2022; van Wynsberghe et al., 2022; Brevini, 2023). Indeed, in order to pursue sustainable goals via AI one needs to be aware of the environmental costs related to the building, training and maintenance of this technology.

Urban digital twins are not an exception, as every other urban AI they represent an environmental cost in terms of rare materials, emissions, water, energy and space consumption. Certainly BDT can be useful in terms of reducing emissions and energy transition (Longo et al., 2024), however it will be pivotal to monitor the real trade-off of this project with regards to environmental sustainability focusing the attention of the data on environmental costs of every step in the shaping of this urban AI.

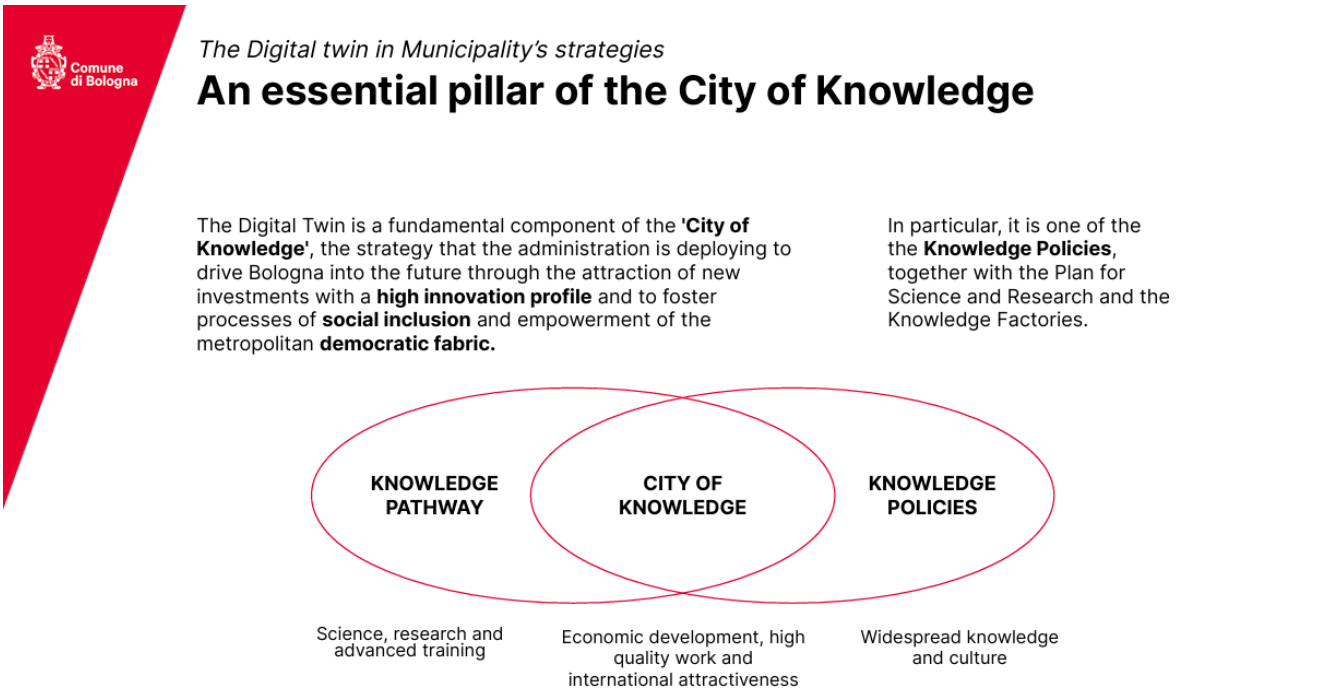

Figure 18 (Source: Comune di Bologna 2023) This image shows Bologna's Masterplan, Bologna City of Knowledge. This strategy is the result of the interaction between the Knowledge pathway and the knowledge policies, and the Bologna Digital Twin project is a pivotal component of the knowledge policies.

2.3. The shape of the Twin (5 actors x 3 years)

Bologna Municipality provides a working definition of the Twin: « A City Digital Twin is a full digital model of the city, which continually adapts based on the collected online data and information, supports decision making through analysis and forecasting and is capable of co-evolving with its physical counterpart» (Comune di Bologna 2023). This definition is unpacked in the description of the different actions that the Twin has to perform: analysing data to facilitate the comprehension of the urban system, anticipating urban changes and risks and assessing it, monitoring and optimising the effects of specific policies, supporting decision making, and involving citizens in design activities and behavioural changes (Comune di Bologna 2023).

Moreover, values dimension, research and innovation approach, and civic value are pointed out as the pillars of the originality of the project (Comune di Bologna 2023). The first regards the attention on ethics, digital rights, transparency, fairness and data protection, the second involves the idea of both academic and industrial research as a goal for the twin, and the third refers to a pact between the stakeholder on sharing data and values. Looking at these characteristics, it is already possible to observe that the focus of BDT is strongly on social, ethical and participatory aspects, which often play a secondary role in urban digital twin projects (Luca et al., 2024; Ferré-Bigorra et al., 2022; Nothca et al., 2021). Furthermore, the idea of contributing to the acquisition of knowledge resonate with contemporary critiques of the idea of UDT, which point out how this tool should provide knowledge to enrich the urban policy debate, rather than trying to solve it from a technocentric point of view (Caldarelli et al., 2023).

In order to steer the project towards this vision, it was decided to form a governance of five actors who will have to contribute their expertise in order to realise a functioning UDT within the three years of the experimental phase 2024-2026 [Figure 19]. Four of these five actors are based in or near Bologna, while one is based in Trentino Alto Adige, another Italian region. The peculiarity of this governance lies in the challenge of developing this tool without recourse to collaboration with a private technology company. This is an extremely rare approach, aimed at building a solid foundation over these three years to ensure that the flesh and bones of the BDT are designed to pursue the democratic goals I have already partially described.



Figure 19 (Source: Comune di Bologna 2023). The actors involved in the Bologna Digital Twin project and their respective operational roles.

The Municipality of Bologna is in charge of the project and it has the strategic management. Municipality's perspective has been already illustrated commenting the ideas of the councillor Laudani. The vision is to apply the idea of the city of knowledge and four other actors have been involved for this purpose.

Firstly, University of Bologna (UniBo) which holds the scientific management. As has emerged in the interview, UniBo has to ensure a multidisciplinary approach to the project with a particular attention to the social, ethical, environmental and economic implications of the Twin. With regards to this issue, already in the first year there are 9 departments involved, and the number will growth. This effort is aimed not only to face the various implications of the digital twin, but also to traces the future direction of research in the field. UniBo imagens a win-win scenario regarding the Bologna digital twin project: «The project is also strategic because it gives us the opportunity to have a concrete case study and steer actual project decisions, it is an opportunity for growth and experimentation in the field» (UniBo Interviews). On the one hand, the University can offer its vast array of competences to the project including the Alma AI centre (https://centri.unibo.it/alma-ai/it), an interdisciplinary research centre focused on artificial intelligence. On the other hand, BDT can serve as a promising case study to develop new research paths in the near future. As an example, the representative from UniBo cited the field of Open

Science and Citizen science that represent a paramount goal for the university and can be explored in the context of BDT project (https://www.unibo.it/it/ricerca/open-science). The relationship between scientific expertise and citizenship has emerged several times in this thesis. In Chapter 3, the design justice paradigm highlighted the need to ground design choices in participatory and genuine listening to the needs of communities affected by the functioning of technological objects. In Chapter 4, drawing on Latour's critique of the scientific perspective, I emphasised how those with technical expertise should not act as impartial arbiters but as producers of situated knowledge useful to citizens. The BDT project seems to take up this challenge, and it will certainly be very interesting to see how this process takes shape in Bologna.

CINECA is the technical manager of the project. It is a non-profit consortium which involves a vast array of universities and research centres in Italy and operates under the Italian Ministry of Universities and Research (MUR). CINECA is located in Casalecchio di Reno a small town near Bologna, and it has already collaborated with the Municipality of Bologna and University of Bologna. CINECA is responsible for the technological requirements of the Twin. In the interviews the representative stated that the core business of CINECA in this project is to provide the hardware structure and the computational power that it will be necessary in the next three years in terms of cloud and HPC (Hight performance computing) infrastructures. CINECA can provide a high-profile technological infrastructure, namely the supercomputer Leonardo. Leonardo has been installed in the 2022, and it is part of the EURO HPC project aimed to establish a world class supercomputing ecosystem in Europe, and it is one of the most powerful supercomputers in the world (CINECAa)It has been developed with three goal that are perfectly in line with the spirit of Bologna digital twin project: sustain the computing capability of European research; help to ensure EU sovereignty on key technologies; tackle relevant societal challenges (CINECAb). Thus, the empowerment of knowledge, the political mandate, and the attention to the societal aspects that characterize the BDT project are embodied in the computing capability of Leonardo: « It is important to say that Leonardo has already been paid for by the European Community and the Italian Ministry, so it is a tool that is being made available for these three issues. We are not here to do business, we are here to help the actors that are interest in this perspective, [...] In terms of sovereignty, an Italian supercomputer clearly allows us not to use private platforms» (CINECA interviews). Moreover, according to CINECA the specific architecture of Leonardo was designed for AI development and to ensure short computation times (CINECAa). Ultimately, as I was told in the interview, this project represents a new challenge for CINECA. In fact, the consortium has already been involved in digital twin projects, but only at the industrial scale and not at the urban one. This challenge is particularly rel-

evant. Indeed, DT developed in the context of product lifecycle management has very different characteristics from urban models developed in the context of urban planning, due to the difference in the object to which they are addressed. It will therefore be both conceptually and technologically interesting to see how CINECA will manage this transition from a model in which it is easier to interpret the technological tool as a simple enhancer of production processes, to a more complex urban scenario.

Knowledge sharing and participation are demanded to Fondazione per l'innovazione urbana (FIU). FIU was founded in 2018 by Bologna Municipality and University of Bologna following the legacy of Urban centre Committee Bologna and its 15 years of experience in the field of urban communication and civic participation (FIU 2020). FIU is a multidisciplinary research, development, co-production, and communication centre that aims to promote an inclusive and sustainable urban development in the city (FIUa). As it emerged in the interview, FIU has the goal of organizing the participatory tools that will inform the logic of the BDT, by using also the data already produced in the vast array of activities developed in these years, whit regards to participatory budgeting, urban mobility, urban sustainability and urban labs (FIUb). FIU has to ensure a relevant amount of data about the human and social component of the city that has to feed the Twin. Moreover, it must also help the development of tools for an interaction between the twin and citizens, in terms of data visualization, use, and comprehension. However, according to FIU: « The difficulty we have begun to encounter concerns the risk of perceiving this technology as a technology of control and dehumanisation of choices » (FIU intervies). Thus, with regards to participation it will be pivotal to build some trust around this new tool.

Finally, Fondazione Bruno Kessler (FBK) is multidisciplinary research centred based in Trento a city in the Nord of Italy approximately 200km away from Bologna. FBK in the last years has been involved in several smart city project in Italy and its mandate 2024-2027 is focused on measurable impacts of AI in various domains such as health, industry and society (FBK 2024) Thus, both FBK's traditional expertise and the present mandate are perfectly in line with BDT project. As the interviews revealed, FBK has long experience in designing technology projects and in monitoring medium and long-term impacts.

These skills are very relevant to FBK's role in governance, namely that of a project manager who has the responsibility to monitor the various phases of the project (FBK 2023). FBK consider the project as a pivotal one, given the challenge of integrating social data into a technological system such as the digital twin, increasing its complexity. The interview revealed that this interest is grounded in original request of Bologna Municipality: «Many cities with which we are in contact are in fact asking for a solu-

tion that is not yet there. Bologna in this case is an exception, it does not ask for a solution but proposes to be a laboratory» (FBK interviews).

These five actors will manage the three years experimental phase in which the municipality aims to shape an actual urban digital twin capable of delivering some impactful output for the city, especially with regards to three use cases: urban mobility, energy consumption, and climate change impacts [Figure 20].

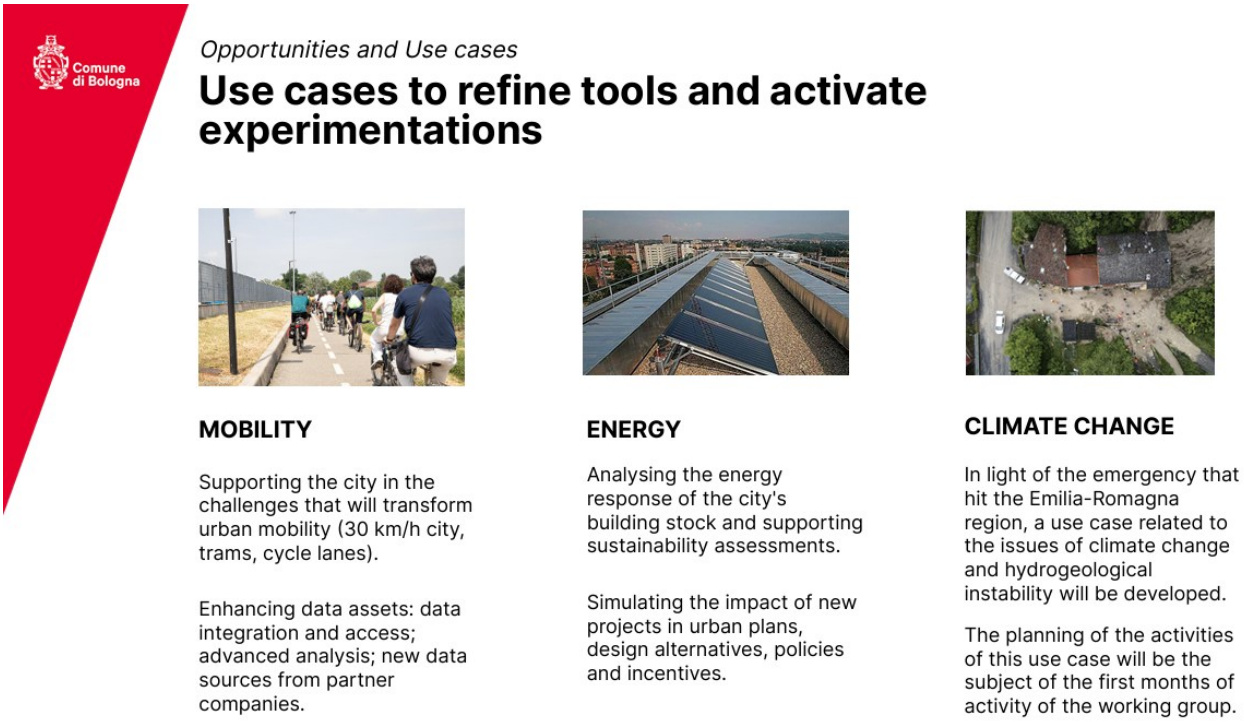

Figure 20 (Source Bologna 2023) The three initial use cases of BDT

These three aspects are already well-known in both smart city and AI urbanism debates (Bratton, 2021), and the idea to use UDT to augment the efficiency of traffic and energy flows is already established (Weil et al., 2023). Thus, in these three use cases it is difficult to see the social turn that the project aims to impose in the practice of UDT. Social issues and correlated data are not necessary to make these domains more efficient. Thus, there is a risk to under valuate these aspects that are explicitly described as a relevant part of the originality of the project.

However, the project is just in the first of three years of experimental phase, and the municipality states that:

The first year we will have simple use cases. For example, the issue of mobility, from the second year onwards we would like to try to do more cross-sectoral activities that can hold more data together to support decisions and not one-dimensional simulations. In the second year we already want to have different scenario building. In the third year we would like to have the social and economic dimension integrated in the twin (Bologna Municipality Interviews).

Thus, it will be key to monitor this aspect in the next two years of the project. Indeed, while the idea of guiding the construction of this urban AI through the composition of a strong governance seems already clear and promising, the possibility of innovating the concept of UDT through the implementation of the social component remains more abstract at this stage of the project.

By looking at the project the idea is to shape a fully deployed, cross sectorial, economically sustainable, and ethically viable UDT in three years. As stated by EURO Cities (Garrido 2023) this plan is ambitious, and all the interviews have illustrated that the stakeholders are aware of that. This level of complexity is likely to result in a longer and more arduous process than other UDT projects. Everyone who was interviewed stated that there is an intense desire on the part of the stakeholders to continue with the project. However, a longer timeline could increase pressure on the project and thus change its structure a certain amount. It will be interesting to monitor this in the future.

Thus, one must consider the BDT as a structural project, with the aim of modifying the way in which urban decision are taken in Bologna. All the stakeholders are aware that after the three years there will probably be a need of a partnership with a private technology company. However, the idea is to build solid ground in these three years to have a real negotiation after altering the classical power balance between municipality and tech companies.

2.4. Toward a platform neo-municipalism in Bologna

The reference to municipalism is explicit both in the BDT project and in the interview with Councillor Laudani. Indeed, the urban dimension is considered as a privileged place to challenge certain contemporary political and economic trends, and the idea of an alliance between cities capable of influencing state and European governance is prominent. Therefore, considering this project through the lens of municipalism can allow us to assess its characteristics in depth and critically. However, it is essential to describe the peculiar municipalism that is taking form in Bologna.

Municipalism has a long and articulated history. It can be traced back to the time when the Greek poleis were the main centres of political power in the West. Without doubt, cities and alliances between cities played a decisive role in the political morphology of Europe before the rise of the nation-states in the

modern era. The most striking example regards undoubtedly Italian Renaissance, in which a series of independent cities gave rise to one of the most dynamic and creative moments in Western history, shaping some of the ideas that would later guide modernity. According to Thompson (2021), since the nineteenth century, municipalism has undergone a change of perspective, from a strong social reformism and experimentalism (Dogliani, 2002) to a perspective centred on the common good and the avoidance of urban conflict in favour of liveability. In the last 50 years, this tendency has merged with neo-liberal policies, giving rise to a technical and post-political municipalism, which has seen its latest revival in the labels of smart, sustainable and resilient city (Saunier, 2002; Clarke, 2012).

The neo-municipalist approach has emerged exactly in contrast with a neoliberal version of the urban fabric. If one has to indicate a significant date the year 2017 could be a good choice, because of the Fearless City initiative launched by Barcelona Municipality. Indeed, this event was capable of gathering more than 700 participants from all over the world, and it was anticipated by and academic workshop entitled "What about New Municipalism? Austerity, Globalization and Democracy" and hosted by Laura Roth and Joan Subirats (Russell, 2019).

Thus, it is in this year that one can point out the birth of a new kind of municipalism, namely neo municipalism. The BDT project is deeply linked to this perspective. Indeed, Subirats is an explicit reference in Laudani's urban perspective, while Barcelona is the main partner of BDT project via a signed collaboration of three year involving the municipalities, CINECA, and Barcelona Supercomputig Centre. Indeed, in 2022 Barcellona and Bologna signed a collaboration aimed «to position themselves as benchmarks in the field of urban digital governance and promote the development of a European digital infrastructure for urban policies through the promotion of a European network of cities with digital twins » (Barcelona Digital City, 2022). Thus, both theoretically and geographically Bologna is deeply involved in this framework.

Neo-municipalism is a reaction to austerity, neoliberal globalization and the erosion of urban democracy (Russell, 2019; Thompson 2021). The core idea is to place the city at the forefront of a radical shift in political discourse, implementing it both as an entry point for larger social changes, and as a site for shaping experiments of a different and prefigurative politics (Russell 2019). Thus, the logic is to consider the urban as a trigger and as a model for a radical political change. Subsequently, the neo-municipalist agenda aims to invert some key neoliberal urban trends such as the privatization of a vast array of public assets and services, and the establishment of a permanent competition between cities

(Thompson, 2021). On the contrary, neo municipalism propose a (re)municipalization of public assets (Becker et al., 2015), and cooperation between cities (Barcelona en Comu et al 2016).

These two characteristics have been described as essential to BDT project. On the one hand, the idea of shaping a UDT without the initial involvement of a private company is aimed exactly to back out of the risk of privatization; on the other hand, the collaboration with Barcellona is described by Laudani and Bologna Municipality as a strategic partnership aimed to share not only data and practices, but also political and strategic perspectives. Those kinds of alliances that are pivotal for the municipality overcoming the competitive approach suggested by urban neoliberalism.

In order to characterize even better this framework Thompson (2021) has listed three types of neo municipalism: platform, autonomist, and managed. Due to the centrality of digital technology and the idea of the city as a platform, the BDT project can certainly be interpreted as a platform municipalism. Moreover, the autonomist perspective is characterised by degrowth perspective, and anarchist themes, which are largely marginal in Bologna. On the contrary, managed municipalism is too much top-down and technocentric to be useful in this context. In addition, one of the most relevant models of platform municipalism regards again Barcelona, and its transition from a neoliberal smart city to a rebel city (Charnock and Ribera-Fumaz, 2019; Lynch, 2020). Thus, for conceptual sources and urban alliances it is rational to consider BDT as a form of platform municipalism.

Indeed, as I already argued, Bologna municipality intends the city as a platform capable of enabling civic participation and empowering urban knowledge production. BDT aims to be a radical institutional change in decision making processes and with regards to the connection between citizens and the city. This vision is a shaped against the neoliberal conception of the city via designing a digital infrastructure capable of enabling different practices in terms of sharing, participation, and political activism.

Following Milburn and Russell (2018), one can characterize Bologna platform neo municipalism as an institutional one, since the idea is to digitally hybridize the municipal institution in order to produce changes in the future development of the city. The aim is to build a UDT through governance that extends the powers of the municipality in terms of both computational power and digital and organisational skills. This is a form of neo-municipalism in which the institution acquires the capacity to direct technological development through the structuring of governance. This is certainly a way in which the city can transform AI and technological development. An institutional method that does not seek to regulate a tool that has already been developed, but to build a new tool that can respond to the needs of the community. This admittedly more costly approach in terms of capacity and resources resonates with

the constructivist perspective I have outlined in my understanding of the ethics of urban AI. This is certainly a remarkable case in which reverse enveloping aims to ensure control, understood as the explicit and public, democratic disclosure of the design and construction of an urban UDT. In fact, through governance, the municipality aims to build a UDT that is understood as an integral part of the urban fabric and not as an autonomous entity designed to regulate it. Control has to be ensured through full traceability of funding sources, data collection and analysis methods. It is indeed possible to interpret this tool as a matter of concern in Latour's terminology, that is, as an object whose definition escapes the limits of its physical-technical composition. In fact, in the idea of the project proposed by the Municipality of Bologna, the political orientation, the ideas of the citizens, the different levels of ethical frameworks should become fundamental cogs in a machine aimed precisely at producing models to face the medium- and long-term challenges that the city will have to face in the near future.

To sum up, it is possible to characterize bologna's municipalism approach as platform, institutional, and constructivist. In fact, digital technology has a central place in the project, the goal is to radically reform the institution of municipality, and the ambition is to build the digital twin tool autonomously.

2.5. Power balance, knowledge, ethics and participation

As has been highlighted in the documents shared by Bologna municipality, and in all the interviews conducted, a pivotal aspect of this ambitious plan is to avoid the involvement of a tech company in the experimental phase to steer morphology of the twin toward urban and public needs. In the smart city debate the imbalance of power between tech companies and municipality is well-known in terms of digital skills, data availability and computational power. A vast array of scholars pointed out idea that in many cities the march toward smartness regards a privatization of key digital infrastructure and a subsequent erosion of a democratic control (Greenfield 2013; Shelton et al. 2015).

Considering that often municipalities suffer of both digital skills and computational power scarcity, the plan described in Bologna can be perceived as ambitious or even bold. Nevertheless, BDT project owns some characteristics that can lead to success. First, all the stakeholders understand that after the experimental phase of three years it will be necessary to involve a tech company to maintain the economic and technological sustainability of the twin. Thus, the perspective in not naïve or utopistic: although in the long run a partnership with a private company will be needed, the real issue regards the kind of partnership. In the words of the municipality «we want to talk with CEOs, not with commercials» (Bologna Municipality Interviews).

The rationale is developing solid socio-technical foundations during the experimental phase to be able to negotiate with more power with tech companies in the long run. As pointed out in the interview with Fondazione Bruno Kessler:

> In order to have a chance to negotiate, we need to have a common vision and then results. You can negotiate in two ways: either the private company is looking to sell you something, or they see an investment opportunity. We want to get to the second option and then we need a vision, results and penetration of the outcomes in the area (FBK interview).

Thus, the three-year experimental phase of the project has been designed to force the second type of relationship in a situation where some key points on ethics, participation and strategy have already been consolidated.

In addition, the involvement of CINECA, UniBo and FBK in the governance have been essential to make this ambition real. Indeed, the first guarantees free access to advanced computational power and infrastructures capable of producing a twin that respects the current state of the art in the field; the second makes it possible to mobilise a quantity of interdisciplinary research on the project that is unattainable for almost all Italian cities; finally, FBK guarantees consolidated expertise on urban digitalization, that is out of reach for the vast majority of municipalities. Computational power, research capacity, and digital skills, traditionally the most insidious difficulties for a municipality, have been turned into strengths through governance design. In this way, the ambitious political mandate deployed by the municipality relies on key actors involved in governance who share the overall rationale of the project and are real powerhouses in their fields.

This kind of governance shaping process can be considered as a promising way to overcome, in the AI urbanism context, some of the difficulties that have characterized smart urbanism in terms of power balance between public and private actors. However, this does not appear to be an easy path to follow. In fact, technology companies are usually attracted to urban investment in order to make an immediate profit by selling an asset or to access the vast amount of data that cities generate in order to secure a competitive advantage. The first motive is explicitly rejected in this project, which is looking for an investment partner, not a tool seller. Moreover, if the experimental phase were to produce the desired results, the second objective would also be compromised by the strong focus on ethics, participation and privacy. Thus, this audacious but challenging attempt to restructure the relationship between cities and technology companies will certainly be something to evaluate at the end of the three years. The real challenge will be an understanding of what kind of medium-term investment a company can have in a project like this.

As pointed out by Ferré-Bigorra et al. (2022), although AI is not technically required to produce DTs, this technology is rapidly taking over the field. When it comes to producing twins of complex objects, capable of monitoring them and responding efficiently, AI is certainly becoming key. In BDT project it is neatly stated that AI will play a central role and its developing is considered a key challenge for the entire projects. In the first chapter of this dissertation, following Coeckelbergh (2022), I reported a serious political risk related to the deployment of this technology, namely the idea of considering AI decision making as objective and rational glossing over the partiality of this artificial decision-making depending on the quantity and quality of data, bias and programming logic. This perspective has been also relevant also in urban studies. Indeed, in the smart city debate, argued Söderström at al. (2014) argued that behind the idea of more rational decisions guaranteed by data and algorithms, there were in fact specific interests, often linked to technology companies. As AI becomes more widespread in cities, it is difficult to believe that the use of this technology will be immune to this already feared risk.

This tendency is reinforced by long-standing trends such as technosolutionism (Saetra, 2023), in which problems and thus solutions are always approached from a strictly technological point of view, or by new trends such as transurbanism (Cugurullo, 2021), in which the development of the complex system that is the city is considered to be essentially technological. As an example, one can observe this kind of logic at play in the deployment of City Brains. Indeed, in that case the idea is to technologically obtain superhuman power in order to face the urban challenges of the future (Zhang et al. 2019; Cugurullo, Xu; 2024)

This seductiveness of an autonomous and objective decision-making is at play also in the field of urban digital twins. As it has been showed, better decision-making, optimization, and anticipation of risks and opportunities are all goals of the BDT (Comune di Bologna). Even at the conferences dedicated to the theme of urban digital twins in Emilia Romagna, many urban policy makers emphasised the need to adopt technology in order to make more rational and informed decisions and to overcome widespread prejudices among the leadership and the population. These are powerful concepts situated in a crisis of western democracy, that is often described in the public discourse as inefficient and slow. Following a technocentric approach one could consider fixing this ineffectiveness via AI, with the obvious result of eroding the democracy itself (Coeckelbergh, 2020).

Also in this case, the interviews have been pivotal to give concreteness to some statements present in the documents of the project regarding the role of the twin in the future of Bologna's policy making. From councillor Laudani's standpoint is clear that technological development has to be affected and

oriented by a specific political and social context. It is rational talk about to an actual improvement in the quality of decision making only due to an effective coupling between technology and contexts. By the same token, according to Bologna municipality:

> We must not fall into a kind of artificial decision-making; the choices will remain political and in the hands of the human being. The Twin will provide scenarios from which to decide based on a political project. The choice will remain political we do not see the Twin as overcoming politics or ethics (Bologna Municipality Interviews).

To integrate this approach, it is relevant to mention FIU's perspective on this topic: «Surely the aim is to have data available. Data that has a clear genesis and that can provide a rational basis for discussing and measuring the impact of interventions» (FIU Interview). This idea is well defined by FBK: «The twin should not tell the politician the right thing to do, but should say 'if you do this, x and y may happen', or 'if you do this, and these are the short-term effects, but consider that there may be long-term effects', or 'if you do this, you enter a chaotic regime and the results are not obvious'» (FBK interviews).

Thus, all the actors involved in the governance are aware that data, simulations, scenarios must be interpreted as tools available to citizens and policy makers to develop an informed debate on urban policies. These digital outputs can be key in conducting data-based claims, or to discuss about planning changes being supported by simulations and scenarios. In a nutshell, the idea is to inform the debate via AI and not to solve it. Here, one can see the concept of knowledge displayed, not as something that is artificially achieved, but as a craftsman-like work involving technology and the city.

This approach to the AI of the twin is particularly evident with regard to ethics and participation. Firstly, both data ethics and AI ethics are considered in the project. In both cases it is possible to notice an approach that is far from the simple principialism that I have criticized in the chapter on ethics of Urban AI. On the contrary, the idea is to follow a constructive approach by enumerating and facing all the ethical issues involved in the shaping of an AI systems, starting from data and algorithms to the implications (Prem, 2023). As it has been illustrated, an urban AI is a complex object made up of different processes, and for each of them it is possible to identify ethical issues (Popelka et al., 2023).

This standpoint was described in a clear way in the interviews with the representative of University of Bologna. According to the University, it would be unwise to start working on ethical issues after the twin has been built. In fact, biases can arise even before the model is built, in the selection and structuring of data sets, in the modelling and algorithm writing phase, and in the interpretation of the results. This perspective «increases the complexity and may slow things down, but we feel that if you don't do that, there's little point in acting» (UniBO Interviews). This approach is expanded by the University

itself by the vast array of multidisciplinary research that has been deployed to chart the various epistemological, social, political, economic, and environmental implications of the project. Thus, not only the project is in line with the state of art in terms of AI ethics, but it also expands the research in a multidisciplinary manner by charting the possible future implication connected to the BDT.

Participation is key in all the documents and expositions of BDT project. Fondazione per l'innovazione urbana (FIU) is in charge to promote the relationship between citizens and this new tool. FIU was founded in 2018 by Bologna Municipality and University of Bologna exactly to respond to a growing demand of public participation in urban decisions (FIU 2020). In the next years FIU has developed a vast array of participatory project in order to fix the gap between municipality and citizens with regards to participatory budgeting, neighbourhoods labs, youth participation, neighbourhood centres, participatory evaluation of mobility and urban sustainability projects (https://www.fondazioneinnovazioneurbana.it/progetti). When it comes to BDT, one can divide the participation tasks in three areas: 1) contributing to shape a public understanding of the project itself and of its potentialities; 2) feeding the twin with the data collected from these vast arrays of participatory processes; 3) promoting a public use of the BDT in terms of accessibility and usability of data, models and simulations.

Starting in 2021, FIU organised a series of conferences to disseminate the project, involving governance actors and to explain the overall importance of this initiative (https://www.fondazioneinnovazioneurbana.it/progetto/gemellodigitale). This process aims to address an issue pointed out by Bologna municipality in the interview. Indeed, Bologna has a strong history of civic participation and activism well rooted in the Emilia Romagna tradition. However, this deep awareness and participation is scarcely oriented to digital rights and social and environmental implication of technology. According to the municipality in Bologna it is relatively easy to build participation on a project of urban renewal, but this dynamic is more difficult when it comes to something seemingly abstract as an Urban Digital Twin. FIU and the municipality aim to promote a STEM activism as a next step in the urban participatory history in Bologna.

Participation, whether physical or digital, is not built from scratch. Bologna certainly has a long tradition of attention to participatory processes, dating back to the middle of the last century (Giovanardi & Silvagni, 2021). However, since the 1990s, even this city has been involved in processes of urban governance that are inspired by a neo-liberal perspective (Ivi). This political orientation has provoked reac-

tions from the social fabric that have been intercepted by the municipality, for example in 2014 or in 2018 with the establishment of the Fonfazione per l'innovazione urbana (FIU).

On the one hand, these acts are undoubtedly attempts to develop methods of citizen participation in urban decision-making, but on the other they have also been criticised as a means of containing and neutralising dissent within institutionalised channels (Zinzani & Proto 2023; Bianchi, 2018). It is inevitable to consider the FIU, founded by the municipality and the University of Bologna and headed by the current councillor Laudani as its first president, as an entity extremely close to the institutions and functional to the BDT project. From a critical point of view, there is certainly a risk of limiting the participation to subjects already active and in line with the institutionalised perspective. This could be interpreted as a reduction in the complexity of the urban ontology outlined in this thesis. In fact, the challenge of urbanising AI lies in taking into account the greatest possible number of urban vectors of power that can direct and ensure forms of control over the technological artefact. To achieve this, genuine participation is required, seeking dialogue with all the relevant entities from urban communities.

However, the strong centrality of the participation theme in the project and the presence of the FIU may also represent an opportunity for the various communities to make their voices heard in a public arena and to try to influence the development of the project. The documents on the BDT project and the interviews collected show a clear desire not to make the twin a tool for overcoming and neutralising the political debate. On the contrary, all the actors are aware of this risk and are developing a methodology to avoid it. Once again, as in the relationship between cities and tech industries, this is about managing a power relationship. In this respect, too, it will be necessary in the future to monitor how the technological object of the digital twin is shaped by the different forces and made available to the different ideas of the city that are simultaneously present in the urban space.

The second challenge regards the inclusion of participatory data into the very logic of the twin. As stated by the Bologna municipality in the interview this is a semi-uncharted territory due to the fact that the majority of the UDTs are focused on the *ville* the physical component of the city rather than on the *cité* that regards the ways in which people inhabit the city. This operation is scheduled for the second year and remains one of the most difficult challenges if the project both form a philosophical and technological perspective. Indeed, the first issue is to understand how to use this type of data, for what purpose and in what domain. It is then necessary to integrate this data into the model building process, merging it with different data in order to obtain a cross-sectoral model.

Finally, the third issue regards the public use of the twin in order to establish it as a tool to provide information for a data-based urban debate on policies and urban decisions. The starting point is the participation practices developed by FIU and the challenge is how to integrate the digital twin as a new medium to enrich them. In order to promote this approach, the FIU's knowledge needs to be coupled with CINECA's expertise in data visualization, and with UniBO projects on Open and citizen's science (UNIBOb). These are the pillars that should serve as a starting point for this ambitious task.

2.6. An ambitious project

Research question chapter 5: *Through which processes is the BDT project attempting to carry out a reverse enveloping of its urban digital twin?*

The BDT represents an attempt of a direct reverse enveloping in which, through a project led by the municipality itself, the city of Bologna is trying to decisively influence the development of a UDT. This idea of influencing the development of the technology has three basic elements: 1) to actually develop a technology and not just regulate an already existing tool; 2) to structure a governance capable of managing this process and compensating for the typical shortcomings of municipalities; 3) to include social aspects and urban participation in the project, directing the urban digital twin tool towards a more civic declination. All these elements point to the need for modification of aspects of the technocentric culture of urban design that have been analysed in the course of this thesis: the imbalance of power between the public and private sectors in urban technological innovation, the lack of objectives that are concrete and in line with the needs of the community, and the lack of focus on the social component of the urban fabric. The first two elements are already sufficiently visible in the project in the first year, demonstrating great commitment and the identification of creative and potentially profitable solutions. The third aspect is very clear in its intentions, but still undefined in its methods and specific objectives. These three aspects have been analysed in depth through the lens of the platform of neo-municipalism, both in terms of the political content of the project and in relation to the urban alliances that characterise it, especially in the case of Barcelona. In order to delineate the specificities of the Bologna case: 1) the ambition to build a UDT without recourse to a technology company in the first three years, in order to have more power in a future negotiation; 2) the centrality of knowledge in the relationship between an AI-equipped urban digital twin and urban policy; 3) a conscious and clear approach to ethical and participatory standards.

Strengths and potential difficulties have been highlighted for each of these three aspects. Indeed, the structuring of governance is certainly a strength for a project that wants to emancipate itself, at least initially, from private investors, but it remains to be defined what kind of relationship such a project will be able to establish with a technology company in the future. Certainly, the idea of placing knowledge at the centre of the project could lead to a new capacity of the city to think and design itself, but it will be necessary to conceive this knowledge in the plural in order to dispel the suspicion of a relationship between knowledge and control. Finally, the goal of building a civic digital twin, fed by social data and able to be used by communities, is a highly original and desirable statement within the urban digital twin debate. However, the ways and means of this civic twin need to be designed, certainly starting from a reactive context such as that of Bologna. In general, if Bologna's plan is to urbanise its digital twin through strong governance and participatory mechanisms, the former is much more structured in the latter. This is also explicitly programmed in the three-year plan drawn up by the municipality, where the mechanisms of participation and inclusion of data on social aspects are foreseen in the second and third years. Thus, at the end of the first year, it is possible to state that the structuring of the governance is certainly achieved in accordance with the principles of the project and its ambitions. This step is a necessary but not a sufficient condition for achieving the ambitious goals set by the project.

The BDT project has the explicit aim of proposing a new model for the relationship between technology and the city and has so far taken important and original steps towards making other cities imagine a different future on these issues. It is difficult to say whether the project will be able to represent a model for other cities, given the many peculiarities that characterise the Bologna context. What is certain, however, is that even at this initial stage, the project can be an inspiration for other urban realities to rethink the relationship between technology and the city in the era of AI urbanism.

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Conclusion

1.AI, City and Interdisciplinarity

AI is transforming the city primarily through a new wave of materiality made up of agent objects that are populating the contemporary urban experience. Digital technology in the AI era is far from being light and immaterial, with robots, drones, autonomous vehicles, digital twins and city brains already reshaping the face and texture of contemporary urban space. This new materiality is already opening the field to a whole new set of empirical investigations into the city, aimed at mapping the interactions between these new agents and the more traditional urban human and non-human agents (2024; Sumartojo, 2024; While et al. 2021; Jackman & Brickell, 2022; Dooling & McGuirk, 2020). The cartography of these human-machine and non-human-machine interactions will certainly be a defining feature of the near future of urban studies.

Furthermore, this thesis has shown how the advent of Urban AI is also changing the way the city is interpreted, planned and managed. Indeed, the current technological context is bringing to light a new version of the idea of the science of the city that animated the birth of modern urbanism. A science based on an unprecedented capacity to accumulate data on urban phenomena and on the computational capabilities of reasoning and forecasting provided by AI (Batty 2024). This new artificial mode of interpreting the city invests urban theory by radically changing it (Cugurullo & Xu 2024; Son et al., 2023). Thus, philosophically it can be stated that AI urbanism is producing a radical change by altering both the ontology and the epistemology of the city. That is, by changing both the physical configuration and interpretations classically associated with the urban context.

Each chapter of this research has explored a specific issue related to AI urbanism, namely the on-going relationship between AI and the city. A connection that, in the light of what has been written, can be described as biunivocal (Cugurullo et al., 2024). In fact, the emergence of AI is certainly having a remarkable impact on the structure of cities, but at the same time the urban space is proving to be an active context capable of influencing this new technology.

Indeed, the city is not a blank waiting to be filled and transformed by this new technology. The urban fabric is an active and articulated milieu, made up of tradition, intelligence, innovation and constant interactions that keep it constantly vital (Mattern, 2021; Lynch & Del Casino, 2020). Therefore, the idea that AI can enter this context and remain unaffected by it is a mistake. In the first place, urban AI is nourished by urban data, and so its own technological composition is constantly being grafted with

logics and relationships that come from the city; already at this first level, the urban context inexorably alters the logic of this technology, providing it with the data that underpin its great problem-solving capacity. AI is becoming increasingly urban in its very material composition.

Furthermore, this thesis has highlighted how different urban actors can deliberately attempt to influence the AI. In this dissertation, I referred to this phenomenon as direct reverse enveloping, or the ability of various urban actors to directly influence the design and implementation of urban AI. The central role assigned to design, especially in chapters 3 and 4, regards precisely the ability that different urban actors possess to shape the composition and application of an urban AI. In the case study of Bologna Digital Twin project, the municipality is trying to modify the traditional logic of interaction between digital technology and the city, which has dominated the smart city paradigm, by structuring governance capable of steering the design and use of a powerful urban AI as an urban digital twin. This example highlights the fact that cities, with their institutions and citizens, have the potential to play an active role in the context of AI urbanism, seeking to locate technological innovation, often produced in distant places, within a specific urban reality. The city, as Bologna's Councillor stated, is certainly the place where technological and financial flows have their most concrete impact, but for this very reason it is also the place where they can be modified by the presence of intelligences, skills, desires and needs that animate the urban fabric.

Moreover, as most of the chapters in this research have demonstrated, the city has another way of influencing the urban application of digital technology. I referred to this phenomenon as indirect reverse enveloping, that is the way in which the history of reflection on the city can be the place to identify concepts capable of being critically inserted into the contemporary debate on AI urbanism. Indeed, many concepts from the history of urban theory have proved useful in highlighting the limitations and possibilities of AI urbanism. For example, retrospective on the origins of the science of the city in modern urbanism proved useful in Chapter 1 in highlighting the risks of an overly quantitative interpretation of the city. Similarly, the relationship between urban technology and the private sector that has shaped the smart city paradigm is key to shining a spotlight on the imbalance between public and private investment in the age of AI. Furthermore, the recent history of urban ethics in chapter 3 provided a conceptual framework for understanding the relationship between AI and the power dynamics driving the development of urban AI. Finally, in chapter 4 the analysis of the history of the smart and eco-urbanism paradigms revealed the need for deeper reflection aimed at promoting sustainable AI urbanism.

These examples suggest an active role for urban history in modifying and directing the present and future trajectories of AI urbanism. The city has been a privileged object of interdisciplinary theorization in Western modernity, producing a body of knowledge and ideas that must be understood as living tools capable of influencing technological innovation. One of the results of this dissertation is to bring some of these concepts back to the centre of the debate, demonstrating that urban culture is a field of research that is anything but secondary, even in the field of urban innovation.

This attempt to reactivate the conceptual history of the city in order to influence the future development of AI urbanism also involves an interdisciplinary method. In the introduction interdisciplinarity has been considered pivotal in this research by looking at the very definition of urban AI. The research work strengthened this argument by applying this method to the various issues addressed (technology, ethics and sustainability). Indeed, chapters 2, 3 and 4 illustrated how an interdisciplinary method is essential both to fully understand the implications and thus to attempt to modify or influence the design culture that animates AI urbanism.

An interdisciplinary standpoint is paramount to critically reflect on the design culture of AI urbanism, and to move from a perspective of mere technological application to one focused on changing urban conditions in a new technological context. Indeed, a risk inherent in AI urbanism, and related to the dizzying pace of technological innovation, is that of applying as much technology as possible simply because it is technically feasible. Without asking ourselves how this technological innovation is changing the face of our urban experience. A design culture confined to the acritical application of an even powerful technological innovation would fail in its fundamental role as an integrated gaze on urban reality. A gaze that must be capable of understanding technological innovation by relating it to the current state of our cities and their specificities always thinking in terms of urban innovation and social and environmental changes.

In order to modify the technocentric paradigm, it has been necessary to deconstruct some of the assumptions that underpin it and replace them with other perspectives. First, the nature of urban AI, its ontology. In Chapter 4, Latour's distinction between matter of fact and matter of concern is a clear example of this shift (Latour 2004). It is necessary to abandon a vision of urban AI that focuses exclusively on its technological and internal efficacy. The definition of this emerging technology must include social and environmental implications, such as the environmental costs of AI production and the possible consequences of its use in the medium and long term. This change of perspective must also lead to a different approach to the issue of control indicated by Winner (1977) as a key concept of modern

technology. Indeed, urban AI has traditionally been considered as a means of rationalizing an urban reality considered as a chaotic context. This perspective has deep roots in the history of urban planning and modern technology. However, it implies a passive notion of the city. In Chapter 3, I showed how it is instead possible for the city to exercise greater control over urban AI. For example, this can be done by highlighting and democratically discussing the goals and value choices that are embedded in each individual urban AI, and also by subjecting the design and deployment of these systems to a combination of the principles of justice and disorder. Different combinations of these two principles can help to promote the adaptation of different urban AI to urban situations that are not necessarily identical and comparable.

The relationship between control and urban AI should therefore be considered not only in terms of how the city is controlled by technology, but also by defining ways in which the city can exercise varying degrees of control over AI. This control can be exercised directly by influencing the design of urban AI through frameworks, or indirectly by introducing concepts into the design culture of AI urbanism that can make this technological innovation more urban. This research characterizes this different relationship between city and AI as reverse enveloping, and all chapters of this thesis have contributed to clarifying this concept.

2. Five answers for a work in progress

In the introduction to this dissertation, five research questions were identified, one for each chapter. It is now possible to provide answers that can both illustrate the findings of this research and point to future developments.

1. The first question: *which concepts taken from the cultural sources of AI urbanism can be useful to actualize an indirect reverse envelopment of urban AI?* This question referred to chapter one, which identified modern urbanism, cybernetics and smart cities as key conceptual sources for AI urbanism. With regard to the first source, the focus was on the idea of the science of the city, which is flourishing in modern urbanism due to a new scientific approach to the city. However, it was pointed out that this approach was also characterised by a qualitative component (novels and written reports) that provided information that topography and statistics could not. This consideration was implemented to examine the role of the qualitative approach in the science of the city in the age of AI, which is dominated by the combination of data availability and computational power. A role that should not and cannot be limited to the implications of urban AI and

therefore played after its design. The qualitative approach of philosophy, sociology and citizen science must be integrated into the production and design of these new urban agents.
The exploration of the second source has revealed how the dream of an autonomous city, able to regulate itself and be managed almost without human intervention, stems from a distinctly cybernetic approach. However, this perspective runs the risk of understanding the city as a set of repetitive, routine behaviours, obscuring the contingent aspects that contribute to defining the urban fabric and the conflicts of urban politics that gradually define its goals. An overtly cybernetic approach – especially when inspired by first-order cybernetics – risks misunderstanding the nature of the city while ignoring the biases that AI decision-making mechanisms have already revealed. This analysis also served as an introduction to a more detailed consideration of the cybernetic paradigm, which is discussed in Chapter 2.

Finally, the smart city is certainly the nearest source of AI urbanism. The smart city paradigm, born to increase urban efficiency in a politically neutral way, has led to a strong imbalance of power between private companies and municipalities with regard to technological infrastructures, which also favours the progressive privatisation of vital urban infrastructures. This tendency, which has hindered the progressive functioning of smart urban development, is also a risk in the context of AI urbanism, as the development of this technology remains in the hands of a small number of actors, often private. This situation of high dependence on the private sector, and thus the risk of privatisation of public assets, must be taken into account in the context of AI urbanism.

Thus, the first chapter outlined some basic concepts of indirect reverse enveloping that can be applied to AI through the study of urban history and culture. In fact, the qualitative integration of the quantitative dimension, the rejection of autonomous technology as the primary urban actor, and the focus on the balance of public and private power are elements that returned repeatedly and in various guises, and that were useful in the subsequent development of the thesis. These three aspects of design culture represent three crucial fronts motivating the research and development of design solutions in the era of AI urbanism.

2. The second question: *what issues from the relationship between cybernetics, architecture and urbanism can guide the reverse envelopment of urban AI?* The answer to this question emerged from the analysis of two historical moments in which a truly interdisciplinary effort developed between cybernetics, urban studies and architecture. On the one hand, the history of urban mod-

elling in the US and UK in the second half of the last century; on the other, debate on architectural technology in Italy in the 1970s and 1980s. Both of these studies were based on a quantitative approach to the city, but they generated insights that can be used in the context of an indirect reverse enveloping of AI urbanism. The first survey highlighted two important concepts, transparency and clarity of purpose. The first relates to the transparency of technological models and the ability of different urban stakeholders to understand how they work. In the 1970s, this feature seemed scarce in urban models, but the issue is even more pressing today, given the black box nature of AI systems. A commitment to transparency is crucial to ensure public and democratic control over tools that have extremely serious implications for everyday urban life. As discussed also in Chapters 3 and 4, transparency is a crucial element of the control that cities need to exercise over urban AI. The second point concerns the abandonment of a totalising perspective of technology in the study of the city, namely the claim that it is possible to address every urban problem through a technological model. This ambition is particularly evident in city brains and urban digital twins, as highlighted in Chapter 5. Focusing on specific problems and then developing dedicated technology is certainly a way out of technological determinism and towards a greater focus on urban innovation and not just technological innovation.

The second study pointed to the non-contradictory relationship between automation and ethics. Indeed, through a critical consideration of cybernetics, it has been shown that an increasing degree of automation of decisions should not be accompanied by a reduction in the role of ethics, but rather by a redefinition of the role of ethics that focuses on the fundamental questions of the project and its relationship to the context. This new role, explored in Chapter 3, opens up a new possibility for the relationship between technical and humanistic knowledge. This theme is also taken up by the Italian research group mentioned in this chapter, which proposed the training of technical intellectuals precisely in order to reduce the gap between humanistic and technical culture. Thus, issues of transparency, project-based approach, and ethics have emerged as central to the indirect reverse enveloping of urban AI promoted by the cybernetic conceptual source.

3. The third question: *through which ideas is it possible to make ethical reflection on urban AI more concrete and direct its reverse enveloping in this direction?* The analysis of AI ethics and urban ethics has revealed deep affinities in their historical development and interesting possibilities for interaction, with the aim of investigating the power relations that define the design and use of Urban AI. Based on this affinity, the research indicated the need to move beyond a prin-

ciple-based ethical approach in favour of a more constructivist perspective aimed at defining and addressing ethical issues in all steps of the construction implementation of an Urban AI. This shift in perspective identified design as the site of interaction between these two ethical perspectives, and thus design culture as the target to be modified for ethical outcomes. Thus, design was identified as the domain through which it is possible to directly reverse enveloping AI by grafting urban logic onto it. Two principles have been highlighted to promote a direct reverse enveloping of urban AI from an ethical perspective: justice and disorder. The first relates to the need to anchor urban AI design firmly in the needs of the communities affected by this technology. This would help to ensure that the impact of urban AI is measured not in terms of overall urban efficiency, but in terms of its ability to address the specific problems of the community in which it is deployed. The second concerns the possibility of using urban AI to connect the ethical visions and diverse lifestyles that underpin the complexity of life in our cities. A non-deterministic and open-ended design could certainly confirm urban AI as a tool for connecting differences. These two principles are not considered as absolutes, but as points of reference to find the right balance in any project of urban AI that wants to respect the city as an ethically characterised context.

4. The fourth question: *what are the limitations of the current relationship between urban AI and environmental sustainability? What principles can be used to change this relationship*? In this case, the interdisciplinary approach highlighted the impossibility of founding this connection on the juxtaposition of smart and eco-urbanism. This impossibility is primarily characterised by empirical factors, such as the increasing environmental costs of digital technology and especially AI, which make it problematic to conceive an ecological and digital transition together in an acritical way. Furthermore, the analysis of the history of smart and eco-urbanism has revealed a fundamental conceptual incompatibility on crucial design culture issues such as modernity, science and nature. This situation led to a necessity for a different conceptualization of these three ideas through the lens of Bruno Latour's philosophy. This research has demonstrated the need for a profound shift in the way Urban AI is intended in order to implement it as a driver for future sustainability.

   This chapter proposes a framework to actively engage in reverse-enveloping of the relation between AI and cities in terms of environmental sustainability. This framework is based on Latour's deign theory and addresses 5 aspects: 1) Humility: it is not always necessary to be dis-

ruptive in the design of Urban Ais. A disruptive approach very often implies a great impact on the urban ecosystem and the need for huge amounts of materials and energy. Moreover, completely redefining a space does not automatically help to improve the ecosystem of intelligences that inhabit it. 2) Attention to details: Calculating and disclosing the environmental costs of producing and deploying an urban AI, and highlighting the possible impact on the ecosystem, may seem like a detail, but these are often the aspects that allow for a truly rational calculation of the environmental impact of a technological solution. 3) Purpose: it is extremely challenging to calculate the environmental sustainability of a city as a whole. Focusing on a specific part of the city and a specific problem to be solved helps to better define and make measurable the potential impact of an urban AI. 4) Re-Design: any change is made within an existing context. This principle suggests that the ecological relationships that already exist in the area should be employed, and that the agency of urban AI should be incorporated into them. Often, existing relationships can provide a pathway for concrete innovation. 5) Politics: this idea cuts across the others and highlights the political nature of design decisions. This nature implies the need for clarity of purpose and means, which can encourage democratic debate about AI-enabled ways of modifying urban spaces.

5. The fifth question: *through which processes is the Bologna Digital Twin (BDT) project attempting to carry out a reverse enveloping of its urban digital twin?* This answer concerns an ongoing attempt to reverse-envelope a specific urban AI, namely an urban digital twin (UDT). The first part of this chapter aims to define and UDT through a survey of its conceptual sources and its relation to two urban paradigms (smart and AI urbanism) and two comparable tools (City Brain and Deep Map). The analysis of the conceptual sources – product life-cycle management and urban modelling – revealed some differences but also a significant underlying affinity concerning an essentially collaborative relationship between the digital twin and the human operator who uses it, even when this technological tool is enhanced with AI. In the field of AI urbanism, this tool is still located between the City Brain model (technocentric and top-down) and the Deep Map model (person-centric and bottom-up). This still undefined essence can be defined as much by a precise design culture capable of promoting a collaborative dynamic between human agents and this urban AI, as by the structuring of a governance of urban innovation aimed at democratising its development.

The analysis of the BDT project was incorporated here. In fact, the exclusion of private companies, the focus on urban knowledge, participation and ethics were interpreted as elements characterising a possible reverse enveloping of the UDT. Through the analysis of the governance of this project, a number of fundamental characteristics necessary for the design of a UDT were highlighted: accessible computing power, high level specialised research capabilities, field experience in the relationship between digital technology and the city, a long tradition of civic participation, and a political leadership aware of the state of the art in the field and with a specific project as its goal. Therefore, the structuring of a governance capable of satisfying these crucial aspects is considered as an example of direct reverse enveloping of a UDT in the era of AI urbanism.

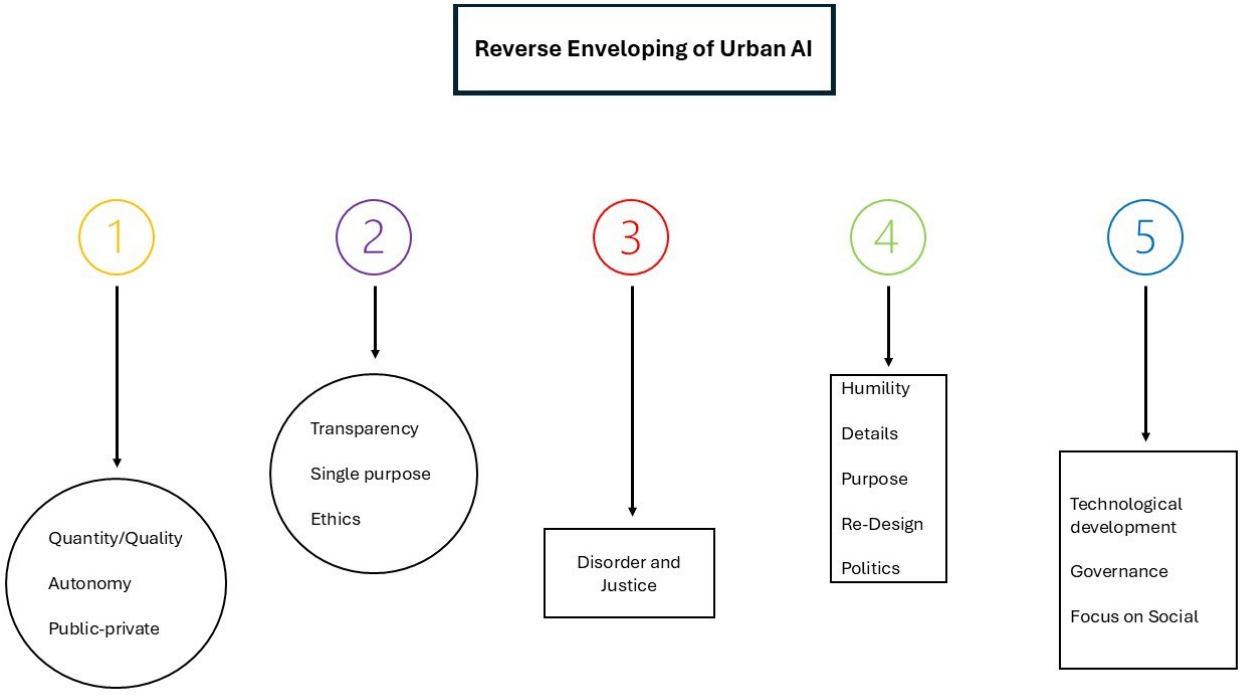

Figure 11. (Original by the author). This diagram summarizes the key terms highlighted in the thesis that can guide a reverse enveloping of the city on AI, divided into chapters. The terms included in the circles concern an indirect reverse enveloping. A process to be carried out through a reactivation of the history of reflection on the city as a basin in which to identify concepts capable of guiding action. The terms in the rectangles, on the other hand, concern frameworks and concepts that can be used as direct guides for the design of urban AIs. In the case of chapters 3 and 4, they have been identified through interdisciplinary work aimed at modifying the current design culture of AI urbanism. In the case of Chapter 5, the concepts are derived from the analysis of the case study.

The relationship between AI and cities is often examined in terms of how the former affects the latter. As this dissertation has shown, this approach is certainly necessary, but it is also possible to think about this relationship in the other way around. That is, by considering how cities can influence this new disruptive technology. The answers provided in each chapter are possible paths for this process [Figure 21]. Some of them, such as those highlighted in chapters 1 and 2, involve an indirect reverse enveloping in which some concepts from the cultural history of the city can be critically reactivated in the era of AI urbanism. In other cases, as in chapters 3 and 4, frameworks have been proposed that can guide direct reverse enveloping processes by different urban actors. Finally, chapter 5 presents a contemporary and still evolving case where a municipality is trying to urbanise AI by structuring a strong governance with objectives oriented towards public value and social sustainability.

The conclusions of the five chapters that constitute this research can be understood as a starting point for the development of theories and practices based on the ways in which reverse enveloping has been described in this work. In fact, the concepts and frameworks highlighted in the 5 chapters can serve as a basis for further theoretical reflection or practical applications in the context of AI urbanism. These have been obtained through a purposeful conceptual analysis involving different literatures on key topics (technology, ethics and sustainability) that have emerged in the recent debate on AI urbanism. The Bologna case study, with the limitations that will be mentioned later, also contributed to the identification of a possible practical direction for the reverse enveloping of urban AI.

However, the idea of working on the design culture was partly motivated by the desire to respect the dimension of effective design in its independence. The approach of this thesis was not empirical and project-oriented, but more theoretical and aimed at providing conceptual tools that can be useful for planners, policy makers and different urban actors to address the emerging relationship between AI and urban planning with greater awareness. The interdisciplinary approach was dictated by the fact that the relationship between urban studies and philosophy of technology is implicit in the very definition of urban AI, but also by the fact that the city is the subject of study in many disciplines and therefore a vertical approach alone would end up being reductive. The overall aim of this research effort is to scientifically ground, on the broadest possible literature, the premises for a different relationship between AI and the city. A relationship in which technology is deployed within the contextual dynamics of the city, rather than as an extraneous force capable of solving them. Chapter 3 showed that urban problems are Wicked problems that cannot be solved as technical problems. They are constantly changing and not decidable in a binary way. The five responses in the chapters provide a basis for continuing to think

about these problems by orienting the always partial solutions towards goals that are compatible with contemporary urban challenges.

3.Future research and limitations

As with all research on contemporary and still evolving topics, this thesis comes to conclusions (reported in points 1-5) on the issues addressed, but also opens up future paths necessary to integrate the framework, and to respond to the changes that AI urbanism and its implications will generate in the coming years. Two general issues addressed in this thesis will certainly be at the centre of the debate in the coming years, especially in the European context, namely the relationship between Urban AI and ethics and between Urban AI and sustainability.

With regard to the first aspect, it is clear that the regulation and ethical use of AI is at the heart of the European Union's technology policy – one can refers to the Ethics guidelines for Trustworthy AI of 2019 (European Commission, 2019), Ethics By Design and Ethics of Use Approaches for Artificial Intelligence of 2021 (European Commission, 2021) and finally the AI Act of 2024 (EP, 2024). These and other documents demonstrate the European Union's focus on the relationship between ethics and technology. In terms of the material development of AI (pure technological innovation) the European Union lags far behind potential competitors such as the US and China, but in recent years the EU has carved out a role for itself as a global leader in the regulation of this technology. This trend, which is certainly problematic from an industrial point of view, suggests that the ethical issue will be at the centre of reflection in the coming years. This, considering the growing use of urban AI one can foresee a surging interest in an urban version of the AI ethics debate. A promising nexus between AI ethics and urban ethics has already been developed in this thesis, but further development remains a pivotal task for future research.

Moreover, the relationship between sustainability and digital technology is certainly also at the centre of European politics at least from 2021 onwards. The idea of a twin transition, digital and ecological at the same time, has been explored as a direction of development for the European Union in the coming decades. Cities are certainly at the forefront of this endeavour one only needs to recall the 2021 Green City Accord and the EU's Climate Neutral and Smart City Mission, which commits to creating 100 smart and climate-neutral cities by 2030. The idea of massively deploying urban AI to pursue this strategy is already a reality. Thus, it seems clear that the relationship between urban sustainability and AI is likely to be at the centre of the debate in the coming years. However, as this thesis has argued, to really

pursue this path a deep reconsideration of some of the fundamental categories of development that we have drawn from modernity is needed.

These two debates – on ethics and sustainability – become part of the research on the different tools resulting from the actual deployment of AI Urbanism. The urban digital twin (UDT), to which chapter 5 of this thesis is entirely dedicated, is particularly interesting for two reasons: 1) It aims at an overall management of the city. In other words, it does not focus on a single aspect but proposes itself as a new way of managing decision-making in urban planning and management; UDT is a cross-sectoral tool and therefore aims at a general reorganisation of the science of the city. 2) It follows that through this tool it will be possible to plan, monitor and manage other incarnations of AI urbanism, such as robots, AVs or specific software agents. The UDT is thus at a higher level of abstraction that will allow it both to have the whole city as its object and to manage other technologies.

In the European context, UDT is already a recognised tool, and its development is the focus of several projects that have already been launched. Examples include the LEAD (LEAD) and DUET (DUET) projects, funded by the Horizon 2020 plan, which focus respectively on DTs of urban logistics and DTs of entire urban areas. Moreover, EUROCITIES in 2024 (Garrido 2024) has identified UDTs as a key resource for the EU's urban future and, through the VCITIES project funded by the Next Generation EU plan, promises to work on this tool in the near future to promote a digital transition characterised by people-centric approach and sustainability (Garrido, 2024). Finally, as I have outlined in this thesis, the Bologna Digital Twin project also stands as an innovative model in Europe for a UDT focused on citizen science and participation. It will therefore be crucial to deepen this issue in the future, as it is certainly the most ambitious tool that AI urbanism is producing in the European context.

Ultimately, as I argued in chapter 5, and as is clear from the characteristics of the European projects just mentioned, this instrument can be interpreted as a European version of the Asian City Brain, with which it shares the ambition of targeting entire urban areas, but from which it seems to distance itself in terms of fundamental values and objectives. The study of this tool could therefore also be used to measure the extent to which geographical, cultural and political aspects can alter technological development in the era of AI urbanism.

As explained in each chapter, this thesis is not intended to be a definitive or complete work on the subject of AI Urbanism. Firstly, because the subject is still in its formative phase and the transition from the Smart City paradigm to AI Urbanism is not yet fully defined. In the three years of work that have gone into this thesis, the topic has undergone a dramatic evolution, emerging as an argument of scien-

tific (in various disciplinary fields) and public discussion. The phenomenon of AI urbanism is undoubtedly in an expansive and initial phase of its existence and will most presumably undergo major innovations in the coming years, both in terms of theoretical frameworks and practical applications. Suffice it to note that my own doctoral project was originally intended to focus on the Smart City paradigm, but this perspective has found its natural evolution in the present dissertation due to the development of technological and urban innovations over the last three years.

As a result, some of the analysis in this thesis will undoubtedly be outdated and require supplementation in the years to come. However, I believe that the ideas proposed in these pages will still be useful in the future for at least two reasons: 1) Because they capture some of the issues related to the emergence of AI urbanism. Issues that will certainly evolve in the future, but which have been described here in the auroral moment of this paradigm and will therefore be of value to future research as a benchmark. 2) In particular, chapters 1, 2, 3, 4 deal with theoretical issues with a twofold aim: on the one hand, to root AI urbanism in conceptual sources that can clarify its current form and future course, and on the other hand, to initiate an analysis of issues that seems extremely promising for future development. The focus on conceptual sources regards an historical approach that can certainly be criticised or supplemented but should not be overly influenced by future developments of the paradigm. As far as the thematic reflections on ethics and sustainability are concerned, these two themes already mentioned seem to be on the rise, especially on the European scene, so it seems unlikely at the moment that the reflections contained in this thesis will be useless in the coming years.

Chapter 5, in particular the section dedicated to the Bologna Digital Twin project, deserves a separate consideration. Here it has been decided to focus on the initial stages of the project, in order to highlight some of its specific characteristics, which could be modified in the future. The project is still in an experimental phase and there will certainly be another two years of development. It will be in my interest to continue and complete my research on this interesting case study. In this sense, it will be particularly interesting to understand the extent to which the project outcome will remain faithful to the initial formulations and to investigate the reasons for possible variations and changes both in the political and governance approach and in the technological dimension. In addition, the project launched in Bologna aims to develop the UDT in collaboration with the municipality of Barcelona. At the moment, the actual structure of this collaboration does not seem to be defined in detail. Certainly, in the future it will be important to deepen the link between these two cities in order to design another version of urban digital twins.

A final limitation concerns the interdisciplinary perspective that is crucial to this work. In these three years of work, I have been able to engage in a continuous dialogue with philosophers of technology, architects, urban geographers and software engineers, but this text certainly remains an early career stage work. I sincerely hope to expand the network that has supported it in order to enhance and improve the interdisciplinary approach outlined. AI urbanism is an emerging topic that lends itself very well to being studied from this perspective, and much has already been done in these early years of reflection. Certainly, this interdisciplinary maturity is destined to grow, and I hope that some sections of this dissertation can contribute to this process.

For the series of reasons outlined in this thesis, AI urbanism will be key topic of discussion in the near future for urban studies and, more specifically, for the relationship between digital technology and the city. The pace of technological innovation suggests that the coming years will be crucial in defining the relationship between AI and the city. This research has defined some of the problems and challenges that have already emerged in the still largely unexplored territory of AI urbanism. This process of conceptual clarification has been carried out by means of an interdisciplinary method that has proven its usefulness and is characterising an increasingly important part of the research on the subject. The main objective of this work has been to contribute to broadening the scope of this research and, despite the limitations mentioned, I believe that many of the themes touched upon in this work can be developed in the near future.

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