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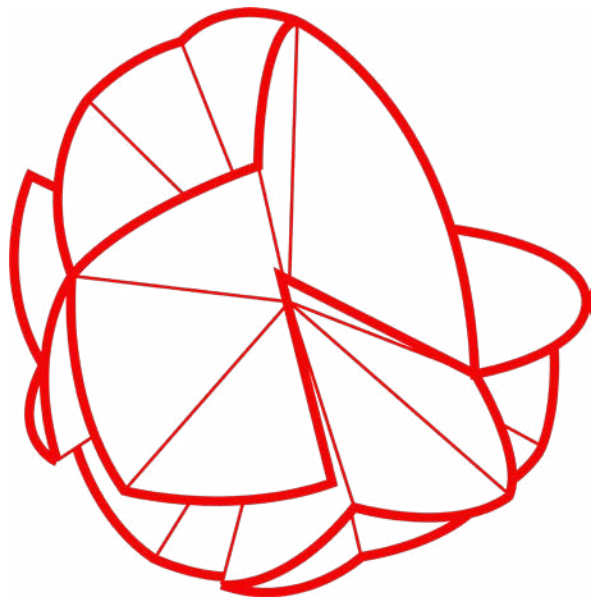
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Disrupting Geographies in the Design World

Proceedings of the 8th International
Forum of Design as a Process

Alma Mater Studiorum — Università di Bologna

Editors
(Eds.)
Erik Ciravegna
Elena Formia
Valentina Gianfrate
Andreas Sicklinger
Michele Zannoni





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Editor-in-chief
Flaviano Celaschi
Alma Mater Studiorum
— Università di Bologna

**Deputy Editor-in-chief
and Managing Editor**
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Alma Mater Studiorum
— Università di Bologna

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Elena Formia
Valentina Gianfrate
Andreas Sicklinger
Michele Zannoni
Alma Mater Studiorum
— Università di Bologna

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The Latin Network for the Development of Design Processes

The Latin Network for the Development of Design Processes is a group of researchers, academics, students and business professionals of Latin languages and cultures who study and operate in a particular field of design known as design processes. They meet in a Forum, conceived as an international specialised conference, to engage in lively discussions and debates about their studies and experiences.

The Network was founded in 2008 with the “Carta di Torino” manifesto. Since its very beginning, Professor Ph.D. Flaviano Celaschi has been leading a team that, over the years, guaranteed the cultural and scientific focus of the members of the Network, fostering inter-institutional cooperation. Since 2015, the Network has been hosted by the Alma Mater Studiorum – Università di Bologna, within the Advanced Design Unit (ADU) of the Department of Architecture, coordinated by Professor Ph.D. Elena Formia.



So far, the members organised eight Forums, covering the following thematic axes:

Design Cultures as Models of Biodiversity

1st Edition

Universidade do Vale do Rio dos Sinos, Porto Alegre, Brazil

June 24-26, 2009

Design, Art, Craft: Cross-fertilizations and Experiences

2nd Edition

Universidade de Aveiro, Aveiro, Portugal

October 28-30, 2010

Innovation in Design Education

3rd Edition

Politecnico di Torino, Torino, Italy

November 3-5, 2011

Diversity: Design/Humanities

4th Edition

Universidade do Estado de Minas Gerais

– UEMG, Belo Horizonte, Brazil

September 19-22, 2012

Advanced Design Cultures. The Shapes of the Future as the Front End of Design-Driven Innovation

5th Edition

Tecnológico de Monterrey, Campus Guadalajara, Mexico

September 18-20, 2014

Systems & Design. Beyond Processes and Thinking

6th Edition

Universitat Politècnica de València, València, Spain

June 22-24, 2016

Design & Territory: Emergencies and Conflicts

7th Edition

Universidad Nacional de Colombia, Sede Palmira, Colombia

June 23, 2020

Disrupting Geographies in the Design World

8th Edition

Alma Mater Studiorum — Università di Bologna, Bologna, Italy

June 20-22, 2022

For more information about the Editions and related publications, see: <https://www.forumdesignprocess.org/dgdw22/past-editions/>

8th Forum Main Partners

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The Advanced Design Unit is a community of professors, researchers and experts who deal with design cultures and their continuous innovation. It operates in the University of Bologna through teaching activities, research, and the third mission.

<https://site.unibo.it/advanceddesignunit/it>

Tecnológico de Monterrey (TEC)

Established in 1943, Tecnológico de Monterrey is a distinguished private nonprofit university dedicated to cultivating leaders with robust entrepreneurial acumen and a profound sense of humanity, making them globally competitive. With a presence in 26 cities across Mexico, the university boasts a student enrollment exceeding 65,000, encompassing both undergraduate and doctoral programs. Garnering recognition on the global stage, the QS World University Rankings (2021) position Tecnológico de Monterrey at an impressive 155th worldwide. Within its esteemed Escuela de Arquitectura, Arte y Diseño, the university nurtures talents in Architecture, Digital Art, Design, and Urbanism.

<https://tec.mx/es>

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The UC School of Design equips professionals to navigate intricate scenarios, addressing challenges stemming from the ever-evolving landscape of scientific and technological advancements and the socioeconomic and cultural intricacies of the contemporary world. Rooted in the ethical principles of the University, this educational endeavour places particular emphasis on fostering creative intelligence, nurturing critical thinking, and cultivating social sensitivity.

www.disenho.uc.cl

diid disegno industriale industrial design

diid is an open-access, peer-reviewed scientific design journal published three times a year. It was founded in 2002 to fill a gap concerning scientific journals in Italy related to industrial design and design studies. Over the last two decades, *diid* has investigated design disciplines and practices, recording their development thanks to the significant contribution of Italian and international scientific communities. The one inaugurated in 2021, with issue no. 73, is a new phase. The journal, while exploring advanced design cultures, delves into specific aspects such as anticipation, narratives of complex systems belonging to the evolving landscape of capitalism and relational dynamics, the front-end of innovation, the avant-garde of theoretical and applied design debates. The pivotal theme under the lens of analysis is transformation, aiming to comprehend its various impacts and meanings within the realms of innovation domains. With this approach, it aims at overpassing spatial, cultural, economic, and technological boundaries giving voice to design research coming from different areas.

<https://www.diid.it/diid/index.php/diid>

8th International Forum of Design as a Process

Disrupting Geographies in the Design World

Alma Mater Studiorum — Università di Bologna

Bologna, June 20-22, 2022



Responsible Innovation

Social Justice

Ecocentrism

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www.forumdesignprocess.org/dgdw22

How design is evolving to respond to the urgent needs facing our environment and society at large? How to understand and design the dynamic relations between artefacts, human beings and the ecosphere? How might design principles and practices adapt their approaches to attend to the diversity that characterised the world?

In an increasingly globalized world, new geographies in and of design offer the stage for negotiating ecosystem's complexity. Design is positioned as a key driver for improving the living standards of many, where human and environmental capitals are pivotal in local economies, and also for the connection to the rest of the world.

The 8th International Forum of Design as a Process (Bologna, June 20-22, 2022) featured speakers from the Global Design community, expanding the original vocation of the Latin Network for the Development of Design as a Process to include researchers and designers of the Mediterranean Area, Middle East, IOR (Indian Ocean Region), and Global South regions. The aim was sharing new perspectives on design futures with responsibility and justice, at the forefront of change, establishing strategic partnerships, and creating accessible knowledge.

The Forum, spanning three-days of meetings, reflection opportunities and networking activities, involved designers, scholars, young researchers, design entrepreneurs, opinion leaders, in an experimental format. Grounded in three pillars – seminars, workshops, and exhibitions –, the event aimed to attract audiences to Bologna, consolidating the potentials of the design world as hub for thought and creative production for present and future generations.

Speakers' contributions inspired the designers' community of practices, and resonated with students and the wide community, to connect design to all aspects of culture and life. This interdisciplinary approach explored the intersections of materiality and culture, post-coloniality, decoloniality, gender studies, and other areas of human thought and action which seek to analyze, question and challenge the disruptive geographies in the world, today.

Five tracks were proposed to address the different dimensions of design futures centered on responsibility and justice.

The submitted papers were reviewed, and a selection is published in this Digital Special Issue of *diid. disegno industriale – industrial design*. Each track begins with a red page containing the original text used in 2022 for the call for papers, also indicating the names of Chairs, Co-Chairs, and Track Editors. Following this, an introductory paper outlines the contents published in the form of research articles for each track.

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PASSO Project: Design of a Smart System Using Biofeedback to Train People with Parkinson's Disease

Silvia Imbesi

Università degli Studi di Ferrara
silvia.imbesi@unife.it
ORCID 0000-0002-8611-0045

Giuseppe Mincoelli

Università degli Studi di Ferrara
giuseppe.mincoelli@unife.it
ORCID 0000-0002-9336-8466

Abstract

This paper describes the design process of a smart system monitoring and training the gait and posture of people with Parkinson's disease. The project aimed to develop an innovative mHealth system and validate it in a laboratory context. The designed solution is supposed to help people in postponing the rise of the most impairing symptoms and prolong autonomy. The project was divided into three main design cycles regarding respectively the design and test of sensory signals, the smart wearable devices transmitting them, and the system interface.

The multidisciplinary team involved in the project followed a User-Centered methodology, involving users in the design process to improve the system's usability and accessibility.

The adopted methodological strategy led to satisfactory results and proved to be particularly suitable for multidisciplinary design processes involving both human and technological factors related to the development of smart systems targeted to niche users.

Keywords

User-centered design
Smart device
mHealth system
Sensory feedback

Introduction

The supplementing between digital technologies and wearable objects produces a new performance level for the human body, able to modify the relationship with the environment to improve the execution of daily life activities (Dall'Osso, 2021).

Wearable smart objects, intended as physical, visual, or virtual prostheses, are characterized by a consistent level of complexity demanding a multidisciplinary contribution from different sciences to develop efficient design research projects (Zannoni et al., 2021).

Thanks to the Internet of Things and Artificial Intelligence, it is now possible to design wearables supporting and empowering the human body to increase motor and cognitive abilities. Data detection, elaboration, and interpretation can suggest behaviors to improve performances and, in general, health and well-being (Tosi & Rinaldi, 2015).

Smart objects can detect the person's habits and autonomously adapt themselves to satisfy the personal needs of a disadvantaged category of users. This new scenario allows imagining possible solutions to sustain and prolong the autonomy of people with specific disturbances in the environments they are used to living in. People affected by motor impairments can take great advantage of emerging technologies correcting postural behaviors, by improving movements and postures and, consequently, decreasing their need for personal assistance for daily life tasks (Imbesi, Mincolelli et al., 2021).

This paper describes the design process for the development of a smart system monitoring and training the gait and posture of people with Parkinson's Disease (PD), aiming to postpone the rise of the most impairing symptoms and to prolong the person's autonomy. The project is related to a research agreement between the Department of Architecture of the Università di Ferrara and the Department of Electrical, Electronic, and Information Engineering of Bologna, both in Italy.

PD is classified as a degenerative neurologic disorder related to Dementia, resulting in several motor impairments related to the gait as akinesia (difficulty in starting the movement), bradykinesia (slow movements), rigidity, postural instabilities, tremors (rhythmic movements in a resting position), and events of freezing of gait (unexpected short immobility) (Reich & Savitt, 2019). Together with these limitations, there is an increase in the falling risk and a general decrease in the person's quality of life, starting to need personal assistance for activities of their daily routine.

Physical exercise and physiotherapy impact PD motor impairments by decelerating motor decline (Sweeney et al., 2019). Moreover, motor training effects can take advantage of increasing cognitive engagement thanks to the submission of cueing or biofeedback in PD (Davis, 2018). Cueing consists of temporal or spatial sensory stimuli that ameliorate and facilitate repetitive movements by providing an explicit motor target (Ayena et al., 2017).

Project PASSO

The PASSO (PArkinson Smart Sensory-cues for Older-users) project (“Cues”, 2021) aims to develop an innovative biofeedback system specifically designed to monitor and rehabilitate gait and postural impairments in people affected by PD, during specific training sessions in the domestic and ambulatory environment.

The system is targeted to PD subjects facing the initial and intermediate stages of the disease, dealing with some physical ailments affecting walking and motor skills, consequently creating an unfavorable effect on physical independence and well-being (Gibb & Lees, 1988; Kalia & Lang, 2015). It aims to support PD people in performing tasks and giving a most satisfying, efficient, and user-friendly experience.

The PASSO project involved a multidisciplinary team formed by researchers expert in design, biomedical engineering, Computer Science, and technology, following an iterative User Centered methodology. User-Centered Design (UCD) was considered an appropriate approach for this project that aims to improve the quality of life of self-sufficient older people with PD in safety, independence, and autonomy in domestic and ambulatory environments. Moreover, the UCD approach consented not to be focused only on primary users, but also to support the other users and stakeholders who could have a relationship with the developed system (Imbesi, Mincoletti, et al., 2021; Imbesi & Mincoletti, 2020; Mincoletti, 2008).

The first category of users considered in the project was persons with PD but also medical operators (neurology, physiatry, and physiotherapy) and technical operators (design, bioengineering, computer science, technology, informatics) were involved. The design process involved almost twenty users: the primary ones, identified as people affected by PD, were from 60 to 70 years old, facing the initial stages of the disease, and not presenting comorbidities.

The involvement of users in the design process wanted to improve the system’s usability, allowing people to take advantage of a satisfying experience that will help them to better deal with specific activities of their life (Imbesi & Scataglini, 2021).

The design process was split into three main parts, identified as a singular iterative cycle of the project. Specifically, the first cycle was about sensory stimulations and the system submitting them, the second design cycle regarded devices submitting sensory feedback, and the last aimed to develop the system’s interface for the users. Each design cycle was then separated into four interrelated phases: planning, analyzing, creating, and verifying (User-Centered Design Process Map, 2013).

Visual, acoustic, and haptic stimulations

The first design cycle analyzed which kinds of images, sounds, and vibrations more influence users’ spatiotemporal gait parameters, and which induce immediate reactions without stressing the person.

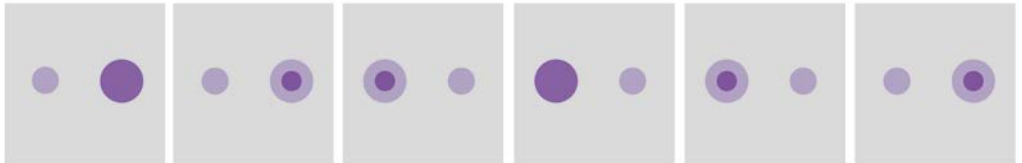
Designed cues typologies were related to different sensory channels: the visual stimulus was submitted to the user through Smart Glasses (SG), the acoustic stimulus was provided through

traditional wireless earphones and, finally, the haptic one was transmitted through the temples of SG.

The mHealth system submitting sensory cues was composed of inertial sensors positioned on the person's body, an Android Smartphone App using algorithms to compute posture and gait features, and an Android SG App generating visual and haptic biofeedback.

All designed cues did not represent or pronounce the suggested action but conversely tried to induce it with simple and intuitive communication, not requiring a cognitive or interpretative effort from the user Fig. 1.

Several mono-sensory and multi-sensory cues were tested to collect



information about users' physical and emotional responses. Users participated in a testing protocol, where they were asked to walk along a path while receiving sensory feedback and to adapt their gait to the suggested cadence.

Qualitative information was obtained from an individual interview and a short questionnaire submitted to users while testing the signals. The investigated aspects were perceived difficulty in following the signal and perceived invasiveness and annoyance. On the other side, quantitative information was collected by monitoring users' gait spatiotemporal parameters like the difference between the user's cadence and the target one, the number of steps to reach the target cadence, user's cadence variability, rhythmic asymmetry, etc. Fig. 2.

Fig. 1 PASSO, visual feedback prototype. The image represents the prototype of visual feedback projected on the SG lens. It is composed of six photograms simulating a symmetrical oscillation that, synchronized with the personal gait rhythm, should suggest a regular walk to the user. Credits: Silvia Imbesi.

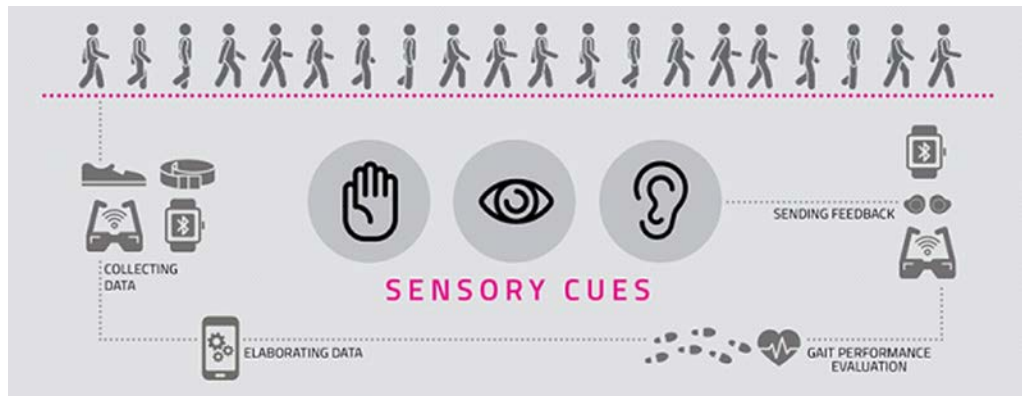


Fig. 2 PASSO, System layout. Simplified graphical representation of the system's strategies developed by PASSO to improve the gait of people with PD. Credits: Silvia Imbesi.

The second design cycle aimed to design a wearable device improving posture by transmitting haptic cues to the user practicing a training session: when the person assumes an unbalanced posture, the system detects it and submits in real-time a haptic signal in a specific part of the trunk depending on the person's postural instability.

Specifically, in this part of the project, it was investigated how many sensors and actuators should have this kind of device, and where should be positioned to influence postural issues like Pisa syndrome and forward lean of the trunk (Espay et al., 2016; Janca, 2002). The multidisciplinary team developed a mHealth system based on a wireless body sensor network enabling the real-time monitoring of trunk postural features.

After a deep analysis with the users, it was chosen to transmit the vibrating signal using as sensors and actuators smart-watches (SW) fastened to a wearable garment allowing specific configuration. Several layouts were evaluated, to understand which stimulus location could be perceived as more intense and ameliorate body posture, limiting the person's inclination on the frontal and mediolateral planes. Specifically, vibrations were located in different positions in the upper shoulders and blades area.

The finally chosen points of application on the chest or back are supposed to make the person straighten the trunk when hanging too far forward, as selected locations on the shoulders are supposed to bring the person to a correct posture when unbalanced to the side. Moreover, were tested different solutions for the vibrating signal, modulating its intensity, duration and rhythmic. Finally, it was chosen to apply a single, short, and intermittent vibration transmitted from the SW to the person's body Fig. 3.



In the developed mHealth system the SW acts as a remote control to set different modalities of use and start/stop, and as a sensor and actuator, returning the haptic stimulation in real-time. An Android app on a smartphone manages the system allowing one to set target postures.

The research team developed some prototypes to test the system in an ambulatory context, with the supervision and support of a medical operator. As in the previous cycle, a testing protocol allowed to collection quantitative and qualitative information about the postural improvement and the user's sensations about the wearable device.

Fig. 3
PASSO, wearing the device. The final prototype is a sort of postural band for the upper part of the body, allowing the positioning of the SW face in several configurations depending on personal preferences and medical needs. Credits: Silvia Imbesi.

App for the management of the system by different users

The third and last design cycle consisted of the design of the system interface following usability and accessibility requirements (Borsci & Federici, 2008). In this part of the project, two versions of the mobile application managing the system were developed, in different versions. The analyzing phase of this cycle suggested that it was necessary to personalize the app depending on the specific user. It was then decided to develop a version addressed to the patient with PD and another dedicated to the Medical Operator taking care of the patient's therapy.

People with PD are supposed to use the app when practicing a rehabilitation session by themselves in their environment. It is relevant for users to manage the system comfortably and to receive gratification as encouragement in the training (Kurniawan & Zaphiris, 2005; Nunes et al., 2016). Symptoms like hand motor impairments, difficulties in managing multitasking activities, and weakening of short-term memory, can create issues while using a mobile app (Espay et al., 2016; Montague et al., 2014; Trewin et al., 2013). Furthermore, typical interface gestures were analyzed to define the ones requiring lower motor and cognitive effort from the users (Nunes et al., 2016). To overcome possible limitations, the app version dedicated to patients presented a significant reduction of the system functions, keeping only fundamental ones for the training session management and the notification of the short report of a session.

Beyond aspects strictly related to real-time performance, a significant contribution to the personalization of the training and the monitoring of impairment evolution is given by performance monitoring (Mukhopadhyay, 2015). The collection of data regarding the person's walk, and their elaboration and comparison over time, allows for monitoring the person's capabilities and elaborating a tailored rehabilitation protocol (Espay et al., 2016).

Medical Operators should use the app during the patient's training in an ambulatory context. During the analyzing phase, they expressed the necessity of a simple interface without big amounts of data difficult to be interpreted, and a data visualization allowing a quick qualitative interpretation. In the developed prototype, Medical Operators can register the patients by creating personalized profiles, set thresholds (based on target trunk inclination angles) for the current training session, manage the current session, receive a report about every training session, access old reports and compare different sessions Fig. 4.



Fig. 4
PASSO, app screenshots. In the image are reported two screens of the system app in the medical operator's version. Precisely, the first image regards the patient's profile, and the second screen is the part where it is possible to set thresholds for the incoming training session. Credits: Silvia Imbesi.

Results

During the first cycle, it was conducted a deep analysis of cues' effects on the person's gait cadence. Among tested prototypes, the auditory and haptic cues reached a higher efficacy than the visual ones: while visual cues improve spatial gait parameters (e.g., stride length), auditory and somatosensory stimuli improve temporal gait features (e.g., cadence) (Imbesi, Corzani, et al., 2021). Auditory cues performing melodies with musical instruments were the most performing signal, influencing but not bothering the users.

The second cycle's output was the prototype of a wearable device using previously tested vibratory cues to maintain and correct the trunk posture during the gait. The innovative positioning of the vibrating stimulus on the upper part of the trunk was able to correct posture without needing an explanation of what to do when the biofeedback was submitted. This aspect seems to be very significant because it reduces the cognitive impact of the feedback on the person, lowering the mental effort requested for the posture-demanded correction.

The third and last cycle led to the design of a PD user and medical operator's interfaces of the system app. The testing phase confirmed that in health management, it is important to maintain, and if possible, to improve, motivation through accessibility and usability (Borsci & Federici, 2008). Moreover, even for people using an app for advanced professional tasks, it is fundamental to consider usability a priority. The design of a simple and intuitive data visualization and the choice of specific fonts, shapes, dimensions, and color palettes, guarantee the highest efficiency in completing tasks.

The tested protocols consisted in semi-structured interviews with users for qualitative information, and in a 30 meters straight walk wearing the smart garment, monitoring posture parameters and correcting unbalanced positions, for quantitative information.

During testing protocols with users with PD, the most important outcomes were related to the necessity of designed solutions to be tailored for the individuals both physically and technologically, and the possibility of being usable in daily life environments.

Even if there were some limitations concerning the ongoing pandemic and technical issues, obtained results confirmed the effectiveness of the developed smart system.

The applied methodology led to satisfactory results and proved to be particularly suitable for multidisciplinary design processes involving both human and technological factors, related to qualitative and quantitative evaluations, for the development of smart systems targeted to niche users (Imbesi, Corzani, et al., 2021).

Results obtained in the PASSO project are supposed to be used for people with PD in ambulatory contexts and outside specialized centers to rehabilitate postural and transient gait disturbances and provide training at home, respectively.

Conclusions

The PASSO project is developed with a comprehensive and cyclic approach, trying to develop UC methodological solutions in the complex field of smart devices for fragile people.

During the whole design process, three main categories of users were involved: Persons with PD, medical operators, and technical operators.

In three separate design cycles were designed sensory feedback, a wearable device transmitting them, and the system interface. Each design cycle comprised a verifying phase engaging users to perform a testing protocol for the validation of the prototype and confirm obtained results.

This design research project aims to impact the advancement of methodological guidelines for the design of UC solutions for older people affected by PD. This area is particularly challenging due to the need of integrating multidisciplinary teams and a heterogeneous body of knowledge. However, if validated on a larger sample, the proposed methodology might pave the way for a new generation of smart objects and medical devices.

In the long-term perspective, the main objective is to enrich the open system with other smart wearable devices, allowing the possibility of monitoring more parameters to optimize the training efficacy thanks to personalization.

Author roles acknowledgment

The current paper was conceived and written by Silvia Imbesi, and supervised by Giuseppe Mincoelli.

Silvia Imbesi

She works as a research fellow, contract professor, and freelance designer in the fields of Human Centered Design, User-Centered Design, and Inclusive Design. Her research interests are currently related to design methodologies for the development of smart devices using the Internet of Things for healthcare purposes.

Giuseppe Mincoelli

Architect and designer. Specialized in User-Centered and Inclusive Design, he conceived and realized hundreds of products for telecommunications, professional equipment, and renewable energy industry. Associate Professor of Design at the Department of Architecture of the University of Ferrara, publications and awards in Italy and abroad.

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