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Preface

On behalf of the Chairs of the Conference we welcome you to the 37th European Conference on Solid-State Transducers Eurosensors 2025 in Wrocław, Poland.

Eurosensors, a highly successful series of conferences, has become the leading European forum to cover the entire field of sensors, actuators, microsystems and nanosystems. Today, Eurosensors provides an excellent opportunity to bring together scientists and engineers from academia, research centres, national research institutes and companies, to present and discuss the latest results in these fields.

Eurosensors attracts hundreds of participants every year, mainly from Europe but also from other countries. As mentioned, Eurosensors asks for contributions describing the latest results on solid state-based sensors, actuators, micro and nanosystems as well as the emerging and related technologies, application areas and new sensors concepts involving quantum sensors and instruments for space exploration.

This year's conference program includes six plenary presentations, including those by the 2023 Nobel Prize winner, Prof. Anne L'Hullier (organized in collaboration with the cademia Europaea Wrocław Hub), nearly 100 oral presentations across three plenary sessions, two satellite events related to the implementation of European projects – AMUSENS and INTAKE, and over 140 poster presentations during two sessions at the end of the first two days of the conference.

The social events on Monday and Tuesday, located near Wrocław's cultural and entertainment center – the Market Square – will hopefully allow you to relax, engage in informal discussions, and network after a day of scientific discussions.

The abstract book of EUROSENSORS 2025 is published by AMA Association for Sensors and Measurement. All the abstracts receive individual DOI number. The authors are asked to submit their full-length paper to Journal of Sensors and Sensor Systems (JSSS). After peer reviewing process, the full-length papers are published in a EUROSENSORS 2025 special issue.

We want to thank you all for attending the Conference. It is the quality of your presentations and your passion to communicate with the others participants that really makes this conference success. We wish you a fruitful conference and a pleasant stay in Wrocław.

Prof. Rafał Walczak
Conference Chair

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Correlation of gaseous emissions with phenological phases in tomato crops

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Summary:
Currently, plant phenological phases are determined through models based on historical data series and advanced measurement tools such as satellite imaging, which are not always accurate. This study explores innovatively the relationship between Volatile Organic Compounds emitted by tomato plants and their phenological phases using machine learning algorithms. Supervised models, particularly k-NN, achieved an accuracy of 96.8% in identifying phases. These results highlight the potential of sensors and AI to accurately monitor crop development.

Keywords: Machine Learning, Phenological Phases, Precision agriculture, Volatile organic compounds, MOX gas sensors.

Introduction

Precision agriculture represents a strategic approach aimed at improving agricultural productivity while simultaneously reducing resource use and maintaining high-quality standards. At the same time, it serves as a fundamental tool for climate adaptation, addressing the growing environmental challenges faced by modern agricultural systems. Indeed, rising temperatures and prolonged periods of drought are causing serious issues, including shifts in crop phenological cycles, leading to a decline in both the quantity and quality of yields. The aim of this study is to identify a relationship between Volatile Organic Compounds (VOCs) secreted by tomato crop, and empirically derived agronomic parameters — in particular, the phenological phase (PPhases)— via supervised machine learning algorithms [1]. PPhases are currently complemented by more sophisticated estimates obtained through models based on historical data series and measurement tools such which are not always accurate. The Growing Degree Days (GDD) index, which measures the accumulation of heat useful for plant growth during the crop cycle, is used to mark the transition from one PPhase to another. Since each phenological stage requires a specific amount of thermal energy to be completed, knowing a plant's thermal requirements allows for reasonably accurate estimates of the duration of its developmental stages. PPhases represent the main stages of the crop's growth cycle, marking key moments in plant development. The PPhases are: (1) pre-emergence, (2) sowing/transplanting (3) fruit set – first truss (4) veraison – first truss (5) veraison – second truss, (6) ripening: 50% of berries fully colored and (7) ripening: 100% of berries fully colored.

Method

From 2020 to 2022, we carried out industrial tomato monitoring campaigns lasting three to four months (typically from early June to early September). As part of the project, a multifunctional station was installed in tomato crop field, equipped with: a relative humidity (RH%) and temperature sensor (Sensirion SHT11); a small camera with a removable infrared filter, used to monitor the plants' radiation absorption; four metal oxide (MOX)-based gas sensors to monitor plant gas emissions during their phenological development [3]. In particular, the sensors used were SnO_2/Au, SnO_2/Pt, SnO_2/Pd, WO_3; monitoring of VOCs emitted by plants is primarily aimed at assessing their health status, which can be affected by insects or diseases [4]. Classification may be defined as a supervised learning method in which machine learning (ML) algorithms are trained to assign

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labels to input data based on patterns learned from a labeled training dataset [1]. The main goal of these algorithms is generalizing from the training examples in order to enable the model to correctly predict the label of unseen data. In light of this, applying ML techniques to a wide range of sensor signals, makes it possible to train a model able to identify the phenological phase. In this work, a model capable of doing this type of classification was trained due to the vast amount of data acquired during the years.

Results

A signal was recorded approximately every 14 seconds during the data acquisition period. The datasets we obtained generally cover phenophases from 2 to 6, which have been assigned to classification labels ranging from 1 to 5.

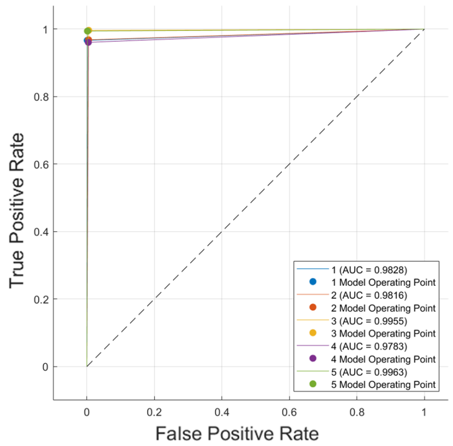

Fig. 1. ROC curves and AUC values for the k-NN algorithm (validation).

As an initial investigation, the 2020 dataset presented here was analyzed using several supervised machine learning methods, using a dataset split of 90% training and 10% testing, with 5-fold cross-validation. Even with relatively simple algorithms, the results proved to be promising. Among these, the k-nearest neighbors (k-NN) algorithm emerged as the best-performing method, achieving an accuracy of 96.8%, along with a high Receiver Operating Characteristic (ROC) curve score (Fig. 1), implying significant discriminatory power. The confusion matrix for this model is shown in Fig. 2. These promising results suggest that training the model on multi-year datasets at disposal could lead to a robust method for determining phenophases based on the signals acquired from an array of four chemoresistive gas sensors. A model of this kind could be integrated into decision support systems in agriculture, helping to improve the identification of phenophases and, consequently, to optimize agronomic strategies, making farming practices more efficient and sustainable.

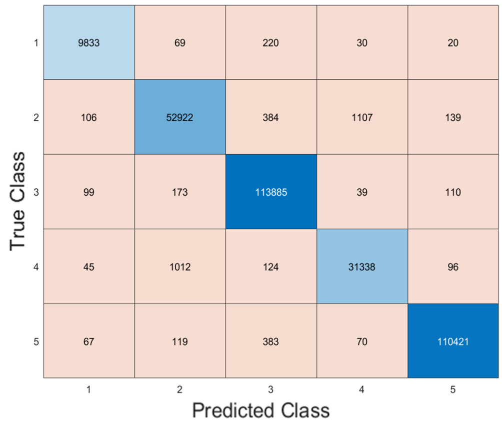

Fig. 2. Confusion matrix for the k-NN algorithm (validation).

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