STSA: Sensors, Actuators, and Metering for Agriculture and Knowledge in Engineering

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***Abstract*— Sensors and actuators are important components of modern agriculture. They play a vital role in farming technologies. Sensors gather data about various aspects of the farm, such as soil conditions, crop health, and weather, while actuators are devices that respond to this data, automating processes like fertilization, irrigation, pest control, crop management, and other applications. The evolution of sensors and actuators for agricultural applications has been supporting the global production of food, fibers, and biomass energy. Nowadays, sensors and actuators are becoming more reliable, accurate, and controllable, as well as customized, including opportunities to be affordable and compatible with Internet-of-Things and Artificial Intelligence operability. However, despite the advances that have already occurred, there still is a challenge for research, development, and innovation. Besides, for such developments, one may find unexplored solutions that can only be arrived at through collaborative research, adding expertise, and coming together in interdisciplinary approaches. This white paper is related to the special track in advanced sensors and actuators, as well as metering processes for agriculture and knowledge in engineering development.**

Keywords: sensors; image processing; actuators; modeling; interoperability; IoT; bigdata; agricultural production; smart agriculture; sustainability.

I. INTRODUCTION

The world is currently experiencing a transition from the fourth to the fifth wave (Industry 5.0). It is related to knowledge, sustainability, and innovation. In fact, it has been promoting a positive impact on society, despite also bringing great challenges. Such a context is also occurring for food, fiber, and energy production from agricultural processes [1][2].

Additionally, this new wave is anchored by advanced knowledge and technologies, human centrality, sustainability, and resilience, thus understood as a bioeconomy that integrates ecology, industry, and economy to generate high value-added products and services.

In the core of such a movement, one may find the evolution of sensors, actuators, and metering procedures, including better connections between the analogical world and the digital one [3].

Likewise, in agriculture there are demands for sensors, which includes research, development, and customization for different applications.

Nowadays sensors, actuators, and metering are becoming more reliable, accurate, and controllable, as well as smart-customized, including opportunities to be affordable and compatible with Internet-of-Things (IoT) and Artificial Intelligence (AI) operability [4].

Furthermore, for such developments, one may find unexplored solutions that can only be arrived at through collaborative research, adding expertise, and coming together in interdisciplinary approaches. In the last 20 years, agricultural technology has seen a huge growth in recognized scientific knowledge, technological innovations, and investments not only for indoor vertical farming but also regarding automation and robotics, livestock technology, modern greenhouse practices, precision agriculture, artificial intelligence, and blockchain.

This report is related to the special track carried out with the ALLSENSORS 2025, the ninth international conference on advances in sensors, actuators, metering, and sensing, organized by the International Academy, Research, and Industry Association (IARIA).

After this introduction, in section II, a summary of the international contributions for the theme is followed by section III with the conclusions and future opportunities.

II. SUMMARY OF CONTRIBUTIONS

The agenda prepared for the track session is considering the presentation and discussion of seven scientific papers.

The first presentation will explain a study related to the dead zone time reduction effect of actuators based on the use of sensors in agricultural sprayers and a strategy with an S-shaped function gain for management of a Generalized Predictive Control (GPC). In fact, for validation, the authors have shown an evaluation in terms of performance considering not only the GPC but also the fuzzy-based GPC and a sigmoid-based GPC controller for the flow rate regulation in agricultural sprayers. The incorporation of the sigmoid function enabled the inclusion of bounds for the GPC parameters, i.e., bringing better stability and optimal system response to noise and disturbances [5].

The second presentation will discuss an evaluation of an IoT system, which is used with sensors for weed family recognition in groundnut crops. Such a paper also will be discussing the importance of sensors for data collection from the physical agricultural world, which is also a key part of the Internet of Things (IoT) ecosystem. The authors have shown that IoT has enabled monitoring and automation in agriculture, supporting the implementation of precision agriculture applications. Besides, a study related to the effectiveness of these systems will be presented [6].

The third presentation will explore the use of a radar to evaluate the sensitivity of an electronic nose sensor in the soybean's water stress detection [7]. Water stress significantly limits soybean (*Glycine max* L.) productivity worldwide. In fact, early water stress detection is crucial for implementing timely irrigation strategies. In this context, the use of electronic noses (e-noses) allows a non-invasive approach for monitoring plants, i.e., helping health and productivity. In such a paper, the authors will present a complete study using radar chart areas as a novel method to evaluate the sensitivity in detecting water stress in soybeans. Likewise, providing a comprehensive metric for sensor sensitivity and effectiveness enhancement for agricultural applications.

The fourth presentation will illustrate an applicability assessment of a thermoformed piezoelectret accelerometer and its use in agricultural robotics systems. Such a paper shows topics related to the advances of robotic systems in precision agriculture and the demands for robust, cost-effective, and customized inertial sensors capable of operating in diverse agricultural machinery. The authors evaluate the applicability of a custom-developed accelerometer for use in agricultural robotics. Their sensor is based on a composed thermo-formed piezoelectret, a 30 g seismic mass, and a polyurethane foam support. Also, the validation of such a sensor and its performance as an accelerometer will be presented, i.e., over a frequency range of 50 Hz to 3.2 kHz. Also, by comparing its response with vibration frequency bands reported in the literature for Unmanned Aerial Vehicles (UAV), gear-driven implements, robotic arms, and harvesters, the sensor has presented an excellent and suitable response [8].

The fifth presentation will illustrate a prototype for a grain storage monitoring sensor-based system, useful for a real-world setting. [9]. In such a paper, the authors present a further step in the sequence of their previous studies and developments of an instrumentation for monitoring grains in silo bags. In such a context, it will be discussing an advanced monitoring system that includes the developed ecosystem, i.e., including sensors, electronics, communication protocols, a low Earth orbit satellite, and a central data storage unit for data analysis.

The sixth presentation will be related to a sensors-platform for evaluation of atmospheric carbon sequestration's potential by maize crops. Its content will discuss an innovative sensor-based method for the evaluation of CO_2 sequestration potential from the atmosphere by agricultural crop environments. The authors have used a multispectral camera embedded in a UAV to calculate different vegetation indexes and also a wireless sensor network to get spatial information from sunlight intensity, air temperature, and soil moisture. This study has led to new insights into the management of crop fields for food and energy production. It is also bringing together information related to the carbon sequestration potential, which can allow opportunities not only for the use of sensors and related techniques in soil science but also for value aggregation for the agricultural process and environmental care [10].

The seventh paper will present a proposal for a system to estimate the best time to see yellow leaves using iot devices for tourists. It uses image classification and deep learning (ResNeXt). Besides, such a method proposal detects the rate of yellowing and falling leaves from ginkgo images [11].

CONCLUSIONS

This white paper summarizes the context and gives a preview of the presentations that will be carried out during the special track regarding sensors, actuators, and metering for agriculture and knowledge in engineering. Despite challenges related to the development and use of sensors and actuators in agriculture, nowadays one may observe the rising need for them, since they play an important role in decision-making related to risk minimization and to the correct use of agricultural inputs. Likewise, the scalability and practicality of using these devices will continue to increase, as well as their importance to the agricultural industry.

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