STAAS: Advanced Sensors and Actuators for Agriculture and Knowledge in Engineering

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***Abstract*— The evolution of sensors and actuators for agriculture applications have been supporting the global production of food, fibers, and biomass energy. Nowadays, sensors and actuators are becoming more reliable, accurate, controllable, as well as customized, including opportunities to be affordable and compatible to Internet-of-Things and Artificial Intelligence operability. However, despite the advances that have already occurred, there still is a significant window of opportunities for research, development and innovation. Besides, for such developments, one may find unexplored solutions that can only be arrived upon collaborative research, adding expertise, and coming together in interdisciplinary approaches. This white paper is related to the special track in advanced sensors and actuators for agriculture and knowledge in engineering development.**

Keywords - ***sensors; actuators; computational intelligence; decision-making models; agricultural production; sustainability.***

I. Introduction

Sensor technology involves measuring, quantifying and transmitting signals used in decision support systems [1]. In sensor technology, several possibilities are created through the application of quantitative data obtained by sensors.

In modern automation systems sensors are present. They are devices that detect and respond to certain inputs from the environment. This input can be light, reflectance, heat, movement, humidity, pressure or other environmental phenomena associated with different forms of energies. Their outputs are signals that are converted into a human-readable display or transmitted electronically over a network for reading or further processing [2].

Although all sensors are transducers, not all transducers are sensors. A transducer is a device that converts one form of energy into another. So, when a device detects a physical quantity and converts it into an electrical signal, the entire unit is called a sensor [3].

In addition, the advent of internet of things (IoT) technologies has expanded the scale related to the use of sensors, as well as their potential and importance. In fact, where decision support devices and the Internet are connected, what is actually treated are the signals arising from sensors and data that help in qualifying the information that represents the state of things [4].

The use of knowledge and engineering have become more important for modern agriculture than ever before. Nowadays that the agricultural industry is facing huge challenges, from decreasing the productive costs of supplies, customization for the productive scale area, a shortage of labor, as well as changes in consumer preferences for transparency and sustainability.

In the last 20 years, agriculture technology has seen a huge growth in recognized scientific knowledge, technology 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.

Nowadays, the use of precision agriculture, which is a management strategy that utilizes a large number of sensors and information technology to optimize agriculture's productivity with sustainability, could help address the world population's demand for food, fibers and biomass energy.

Furthermore, regarding to sensors and actuators for agricultural decision making is also relevant to take into account a multidisciplinary context, which demands practically all kind of sensors and related signal processing concepts, actuators and its control process, modeling, simulation, emulation and enactment, signal and image processing, interoperability, internet of things (IoT), computational technologies, machine learning, deep learning, and Big data analysis, among others aspects.

This report is related to the special track carried out with the ALLSENSORS 2024, 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 it is presented a summary of the international contributions for the theme, 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 five scientific papers.

The first presentation will explain a study, based on the use of sensors for red and the near-infrared lights spectra, for the evaluation of the stress in a rainfed maize crop as a function of both Nitrogen dose and water availability. In fact, for validation, a truly crop dynamics stress was evaluated by the authors, i.e., using the normalized difference vegetation index weighting by the value of the near infrared reflectance for each specific region of the agricultural field. In fact, the signature related to plants led to a new sensor-based index to support decision making related to crop stress and its relation to productivity improvement, which is an original contribution. If an analysis shows a deficiency of Nitrogen, a manager can provide timely nutritional supplements, i.e., by aggregating values in sustainability of the crop area, avoiding overuse of fertilizers, decreasing the resulting toxicity in plants, as well as decreasing the costs [5].

The second presentation will discuss an earth-satellite monitoring system for storaged grains. In such a contribution the authors will discuss the availability of grain storage bins, and how the producers are taking care to sell their production, mainly that could not be properly stored. Some companies sell to farmers solutions like silo bags, or plastic bags, as a fast way to overcome this kind of problem. In fact, the authors will be presenting a new sensor-based project for monitoring post-harvest agricultural grains, and to detect potential risks [6].

The third presentation will explore digital imaging sensors, such as the Charge-Coupled Devices (CCD), and their use for large-scale agricultural pest control. Also, the authors will discuss challenges, especially due to the high dimensionality of the collected features for pattern recognition and classification. In fact, in the literature, it is possible to find various research on dimensionality reduction and algorithms, but the work will bring new insights, i.e., by presenting a study on the dimensionality reduction, to choose an optimal number of principal components for reducing feature dimensionality. In addition, the authors will show a true application to validate their method by using the Hu invariant moments and the principal components analysis with the dimensionality reduction for the classification of the Spodoptera frugiperda with a low error [7].

The fourth presentation will illustrate the use of affordable sensors to investigate aeration and resistance to plant root penetration for soil assessment. In such a way the authors will present a combination of three affordable sensors to perform the measurements of key factors in the relation soil-plant, in order to provide an effective solution to enhance agricultural productivity, food security, and supporting sustainable agriculture. The authors will show an innovative approach with accessible sensors to understand and monitor soil conditions, thus promoting more productive and sustainable issues. They also will demonstrate that the sensors are capable of accurately evaluating redox potential, oxygen diffusion rate, aeration, even in soil that is nearly saturated, and soil resistance to root penetration [8].

The fifth presentation will illustrate a real-time strategy for faults analyzing, when using flow and pressure sensors in a sprayer system. Additionally, a sensor-based method for reconfiguring the control loop using the fluidic resistance will be presented. Besides, the authors will demonstrate that a sensor-based method adds value and robustness to agricultural sprayers. In addition, a computational simulation of the control sensor-based model and real results will be compared to figure out a validation. In fact, the authors will show that the feasibility of changing sensors in agricultural sprayers during operation will improve the agricultural operation reliability [9].

III. CONCLUSIONS

This white paper summarizes the context and gives a preview on the presentations that will be carried out during the special track regarding advanced sensors and actuators in agriculture. Despite challenges related to the development and use of sensors and actuators in agriculture, nowadays one may observe the rising need of them, since they play an important role for decision making related to risk minimization and to the correct use of agricultural inputs.

Likewise, the scalability and practicality of using these devices and related signal processing architectures and embedded software will continue to increase, as will their importance to the agricultural industry. Nevertheless, not only the small-farmer but also the medium ones, and the large-scale farmers are still looking for innovations in sensors and actuators to support intelligence in decision making to increase production with sustainability, i.e., scientific research and development should be motivated and continually supported.

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