AgrSensApps—Agricultural Sensors and Their Applications

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Abstract— **The use of sensor technology is a key factor that influences the field of agriculture. Sensors-based solutions provide detailed data on key food-production parameters, which are important for decision-making and risk management. Agricultural sensing applications demand the development of new smart devices that can improve precision agriculture for food safety and enhance productivity and sustainability. In addition, such sensor devices add reliability in the rational use of inputs, and improve the quality of life of people. Furthermore, they improve the control and efficiency of systems based on clean energy in the rural environment.**

Keywords-agricultural sensor; signal processing; food production; autonomous machinery; decision-making; clean energy.

I. INTRODUCTION

Sensors play an important role in agriculture. Measurement systems comprise sensors, transducers, and signal-processing devices [1]. A wide variety of such devices is now available for use. However, sensor development and applications has some challenges, and the subject is still open for research, development, and innovation.

In agriculture, there are challenges to be solved, for example, in relation to engineering systems and decision-making wherein it is still quite difficult to choose and integrate suitable sensors/transducers for applications related to water, soil, plants, and atmosphere to solve problems related to food, fibers, and energy production. In agriculture, the use of smart sensors would help in properly exploiting all available resources and applying agricultural inputs and products in a rational manner to achieve food security with sustainability [2].

There are requirements for sensors in fields of knowledge related to the measurements of physical, chemical, and biological variables to support decision-making processes based on advanced concepts such as agriculture 4.0, big data, internet of things (IoT), machine learning, deep learning, autonomous machinery, remote sensing, and advanced signal processing[3]). The main purpose of this track is the introduction of the concept: agricultural sensors and their applications. In such context, sensors are vital for productive agriculture.

II. MAIN SUBJECTS RELATED TO SENSORS IN AGRICULTURE

In addressing measurement problems in agriculture, it is often useful to have a conceptual model of the measurement process, i.e., a previous definition of the problem to be solved, that can help in selecting the sensors based on requirements, and circuitry for signal processing.

In such context, there are fundamental concepts to be observed for measurements of a physical variable of interest that is suitable for processing and recording. In general, to help in such tasks it is possible to consider the following sensors and systems, including, but not limited to

1. Resistive Sensors (millimetric, micrometric and nanometric scale);
2. Capacitive Sensors (millimetric, micrometric and nanometric scale);
3. Magnetic sensors (millimetric, micrometric and nanometric scale);
4. Sensors and their use in unmanned aerial or ground vehicles (UAVs and UGVs) for agricultural applications;
5. Sensors for autonomous machinery navigation in precision agriculture applications and environments;
6. Sensors for sprayers and agricultural inputs, such as chemical or biological products;
7. Sensors for quality evaluation of agricultural products for insitu analysis;
8. Sensors for post-production processes;
9. Sensors for image analysis in agricultural processes (optical cameras, Light Detection and Ranging (LIDAR), radar and micro-waves devices, embedded image sensors);
10. Wireless sensors and networks in agriculture.

In view of the wide variety of possible signal sources from agricultural sensors, it is necessary in addressing a required customized solution to observe the signal processing, signal-to-noise-ratio and signal statistics in space and time. Statistical signal modeling is used in such context based on the characteristics of a wide variety of signals in space and time. In this context, it is necessary to know about fundamental issues related to distributed signal processing and communication, including space-time sampling, signal inference and information flow requirements associated with each query. In addition, it is recommended to know the fundamentals of the interplay between information sensing, processing, communication and routing and the used hierarchical structure of sensors network and routing strategies.

III. SUMMARY OF CONTRIBUTIONS

The first presentation will explain a non-invasive sensor-based instrument for the determination of volumetric soil moisture, i.e., a microwave system based on transmittance of electromagnetic waves in the frequency range close to 5.0 GHz, which uses micro-strip patch antennas. In relation to the use of antennas, they can be used on both sides of a rhizobox, which allows non-invasive measurements of soil moisture in the box. The attenuation in dB is used to measure the effect of temperature, the different kinds of soil, sensitivity, reproducibility and the repeatability. Quantitative measurements on the effect of soil moisture in a rhizobox will also be presented. The microwave technique using microstrip patch antennas is a new and promising concept, having potential applications for rhizobox-based investigations of root performance.

The second presentation will discuss the usefulness of a soft-sensor, based on Principal Components Analysis (PCA), to infer the quality of application of pesticides for pest control in agriculture. This kind of sensor can use the operating conditions of agricultural sprayers as inputs and offers quality descriptors that serve as a base of information to estimate the level of quality that a pesticide application can meet at a certain time as output. Hence, the selection of historical data, as well as the exploration and filtering of data can be used. This presentation brings an opportunity to discuss new sensor devices for agriculture, based on the combination of sensor`s networks with computer models and machine learning structures. Such arrangement and initiative are useful for value aggregation to achieve better control in processes related to pesticide application and decision-making in agriculture.

The third presentation will demonstrate a new thermal detector based on the use of an inorganic crystal prepared with $PbZrO_3$/$PbTiO_3$ with 1% of La_2O_3. Such sensor can be useful in measuring the absorbed dosage using an electron beam typically used for the disinfection of food products. Smart ceramic sensors for absorbed dosage represent the next evolutionary and developmental step in engineering, such as is happening in applications related to agricultural automation, and robot control. For that presentation, a validation of the smart ceramic sensor will be presented, i.e., considering several exposure times from a linear electron accelerator source with selective voltage in the range of 200 kV to 10,000 kV. In fact, the calibration curve will report the relation of the absorbed dosage (kGy) versus the considered sensor´s amplified output voltage.

IV. CONCLUSION

This paper summarizes the context and gives a preview on the presentations that will be presented during the special research track regarding sensors and their application in agriculture. Sensors can be recognized as the central driving forces for quality and competitiveness in agriculture. Therefore, such track will allow discussions about innovation, not only for the Agriculture 4.0, but also for other challenges in automation and precision agriculture based on smart sensors for food production. Today, intelligent systems are widely used to control the agricultural inputs, such water, fertilizers, and pesticides, among others. The use of sensors is essential in helping scientists and producers understand plant behavior and increase consumer food security. Large-scale agriculture is still a challenge and to continue feeding people in the world, more sensors will have to be utilized and continually developed.

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