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IoT based System for Smart Agriculture

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Abstract – **Agriculture is the most traditional activity over time. Since the beginning of it, agriculture has suffered many changes to improve productivity and quality of crops. Some of the first significant improvements have been remarked when machines and new tools such as irrigation systems, harvest machines, farmland clearing machines were introduced in the primitive agriculture, where these activities were performed mainly by humans and animals. Over time, agriculture has been affected by weather disasters (such as storms or extreme temperatures) and by natural disasters (such as pests and plant diseases). Thus, the next step in the development of the agriculture domain was to propose the Internet of Things (IoT) solutions for monitoring of many parameters for better precision agriculture. Such a system would provide useful information on plant growth, crops' diseases, and soil properties that are a benefit for crops. This paper describes a possible solution for a more reliable IoT-based system using Libelium for Smart Agriculture to monitor the parameters that have a direct impact on crops. Moreover, the monitoring system aims to manage agricultural issues related to irrigations and analyses the effect of the measured parameters on agriculture, helping the farmers to have healthy crops.**

Keywords- Libelium; monitoring of crops; meteorological parameters; agriculture

I. INTRODUCTION

Smart Agriculture is a concept in which information and communication technology is implemented to manage all the activities and processes related to the agriculture domain. Internet of things has the capability to influence many of the areas of the world we live in such as advanced industries, smart cities and novel technologies in connected vehicles [1]. However, IoT could have an even more significant impact on the agriculture area. The designed solution described in this paper illustrates an IoT-based smart agriculture system built to perform crop fields monitorization based on multiple sensors (for temperature measurements, temperature of leaves and flower buds, level of oxygen in the soil, shortwave global radiation, UV global radiation, etc.) and to improve the irrigation system. One of the impacts that the system has is to enhance productivity while keeping the costs to a minimum.

The term of precision agriculture (PA) refers to any activity that makes farming practice more controlled and more accurate when it comes to raising livestock and growing crops [2]. Precision agriculture is formed with a set of technologies that combines sensors, information systems, and informed management to optimize production. It is based on observing, measuring and responding to inter and intra-field variability in crops [3]. The main goals of precision agriculture are [4]:

- Sensing and monitoring, meaning measurements of the performance of the farm processes. This can be done either manually by an observer or automated using sensors and satellites.
- Analysis and decision making, meaning the comparison of the measurements from the quantity, quality and lead time point of view.
- Intervention, which consists of improving farming performance.

Systems used for crop quality monitoring use renewable energy. There are two types of solar energy: passive and active. Passive solar energy involves taking advantage of the position, intensity, and duration of the Sun's rays, without any special technology besides the one needed to store the energy [5]. On the other hand, the active type of solar energy involves other mechanical and electrical technologies such as photovoltaic solar panels or thermal panels that have the function to capture the energy convert and store it for later use [5]. In the proposed system we used active solar energy; thus, the station has also a system which converts the energy and stores it in a battery to power it. In this way, we keep the cost to a

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minimum. The other primary functions of the system, used mainly to increase productivity, are assured by the use an increased number of specialized sensors. The presence of these sensors in such a large number allows the measurement of different parameters such as weather conditions, light and radiation levels, soil morphology, fertilizer presence, plant and fruit growth and development, and other environmental parameters necessary to improve production crop quality and to prevent harvest losses [6].

The rest of this paper is organized as follow: in Section II related studies for precision agriculture system are presented. Section III illustrates a thorough technical description of the architecture of the proposed system, including the hardware part and a summary of the monitored parameters. The experimental measurements are graphically outlined in Section IV. Section V consists in aspects related to conclusions and future work.

II. RELATED WORK

According to FAO (Food and Agriculture Organization of the United Nations), by 2050 worldwide food production should increase by 70% to feed 9.6 billion people. Thus, developing smart agriculture with IoT becomes a must. Besides, both weather and biological disasters produced a total damage of 36 billion dollars in a ten years period [7]. Various solutions that offer outstanding facilities and monitoring features on agriculture processes are available. However, the accuracy and the relevance of the measurements represent a big concern when it comes to making decisions based on the analysis performed on gathered data. Libelium and Beecham Research are improving knowledge on smart agriculture as a critical application in the IoT market, offering deep insight on how wireless sensor networks would have an impact in reducing crop losses and increasing production [8].

In [9] the authors proposed an IoT application that provides agricultural and crop information to farmers based on collected wireless sensor network data. This is used to adjust the proper amount of fertilizer within the recommended limit. In this way, the cost of excess fertilizer is eliminated, and the exact amount for the proper growth of the plants is applied, thus increasing productivity. An IoT application using WSNs (Wireless Sensor Network) and a monitoring interface, forming an alerting system for the control of water stress of plants is described in [10]. The goals are achieved by monitoring the variations of the soil conditions and whenever a certain threshold is reached, the system alerts via SMS the farmer. A complex application of IoT in precision irrigation is described in [11]. The primary purpose of the system is to build a platform based on IoT for the precision irrigation focusing on different challenges such as adaptability, deployment, and complexity using cameras, actuators for real-time management of irrigation system, ZigBee models. The fundamental idea is to optimize the water distribution and consumption based on collected data from all the aspects of the system. Thus, it guarantees the availability of water in some situations where the water supply is limited, preventing in the same time over-irrigation and under-irrigation.

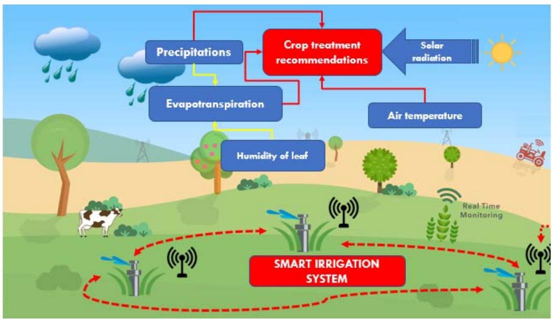
In [12] a solution for the existing automated systems in precision agriculture is developed. The proposed infrastructure uses AI (Artificial Intelligence) paradigms to optimize and improve the results. It can be installed on both current and new facilities. Two edge nodes and one fog node are proposed to control the irrigation process and climate. However, the AI services are implemented in fog node. The final goal is to optimize resources: water, energy, etc. without losing productivity.

The paper also presents the main IoT technologies applied in precision agriculture scenarios, a user-centered analysis and design of the architecture. Lee et al. proposed in [13] a monitoring system for crops that involves a method for decision making improvement by harvest statistics analysis and their correlation with the information regarding the monitored crop. The system consists in three components: crop monitoring subsystem (IoT Service), statistics prediction system and analysis system based on text mining technology. Intelkia has developed a Smart Garden solution based on Libelium Waspmote sensor platform to optimize the use of resources in a sustainable way and save costs to their customers. Smart Garden is a fully integrated solution that covers areas like water quality, air quality, soil quality, water flow measurement, controlling irrigation system and security [14].

III. TECHNICAL DESCRIPTION

An overview of the architecture of this system is presented, along with the hardware description of the component parts. The acquisition level is performed by devices that are part of Libelium platform. In Fig. 1 the architecture of the system used in irrigation process is illustrated.

Fig. 1. Proposed architecture



Libelium is a platform (hardware and software) used in IoT solutions systems and it is based on wireless sensor networks. Libelium can be used on some of the most common applications of Smart World: air pollution, forest fire detection, wine quality enhancing, sportsmen care, healthcare, smartphone detection, perimeter access control, water quality, smart parking, vehicle auto-diagnosis, smart lighting, intelligent shopping and smart agriculture. The area covering Libelium expertize involves new vineyard project developed with Libelium IoT platform on Agrotech, new weather station sensors for maximum accuracy, monitor “baby leaves” fourth-generation vegetables production for an efficient use of fertilizers and irrigation [15]. Libelium comes with a new version for smart agriculture, enhancing the accuracy for monitoring the crops. Smart Agriculture Xtreme device (Fig. 2) includes top performance sensors for the most demanding field applications such as vineyards, fruit orchards and greenhouse crops [16].

Fig. 2. Smart Agriculture Extreme [6]

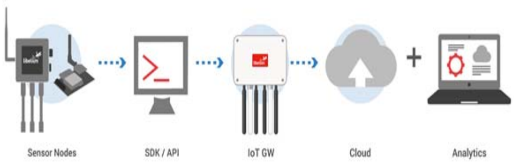
The new solution has 19 sensors provided by the most prestigious manufacturers such as Apogee, Decagon, Ecomatik and Gill Instruments [6]. Among the multitude of sensors used in smart agriculture, we list the main sensors required for precision agriculture [16]:

- Contactless sensor for measuring surface temperature.
- Sensor for temperature measurement of leaves and flower buds.
- Shortwave global radiation sensor.
- UV global radiation sensor.
- Temperature, humidity and pressure in air.

The values of the monitored parameters are sent to the Meshlium Xtreme Gateway and forward the data directly to Wi-Fi or 3G/GPRS protocols depending on the connectivity options available in the area.

Fig. 3 illustrates the prototype of the architecture integrated into the system for captured data visualization [17].

Fig. 3. Data visualization architecture [17]



IV. EXPERIMENTAL RESULTS

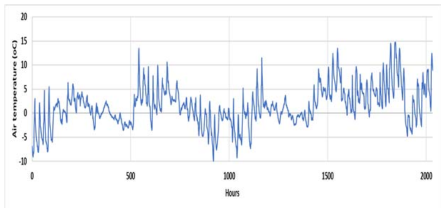
The analysis of the impact of meteorological parameters on agriculture was realized in a vineyard area (Fig. 4) using Libelium Smart Agriculture Extreme, from November 2018 until end of February 2019 for a period of almost 2000 hours. The data acquired from the agricultural sensors were centralized into a database and was used to highlight the impact of measured parameters on crops.

The variations of the registered parameters (illustrated in Fig.5-Fig.9) offer crucial information to the farmers, information related to the best period of time (in terms of air and soil temperature, leaf wetness, air and soil relative humidity and solar radiation) for them to start the cultivation process.

Fig. 4. Location of monitoring station

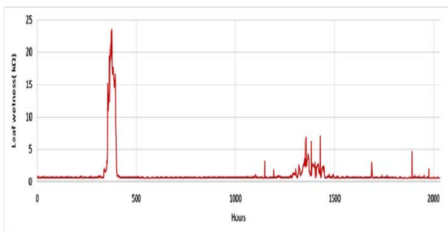
The variation of the measured parameters (temperature, leaf wetness, relative humidity of air and soil and solar radiation) are presented Fig. 5, Fig. 6, Fig. 7 and Fig. 8.

Fig. 5. Variation of air temperature



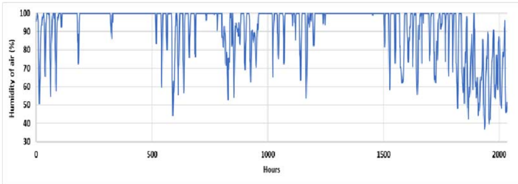
According to Fig. 5 the accuracy and precision of recorded data are very good considering that the December is the coldest month of the year (the temperature reaches minimum values around 1000 hours which correspond to day 42 of monitoring). In the same time, it can be observed that the air temperature is quite high for these periods.

Fig. 6. Variation of leaf wetness



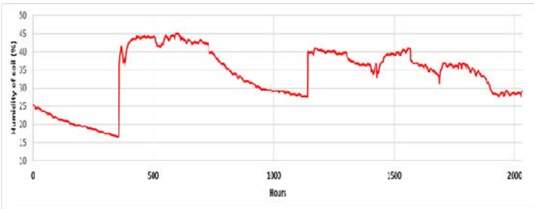
The leaf wetness was describing the amount of dew and rain on the leaves. According to Fig 6, the few peaks correspond to the time periods in which the atmosphere has been loaded with rainfall, the rest have been periods with reduced precipitation. Also, by correlating results from Fig. 5 with the results in Fig.6 it can be stated that the maximum values for leaf wetness are reached whenever the air temperature tend to 0°C (the water frozen limit).

Fig. 7. Variation of relative humidity of air



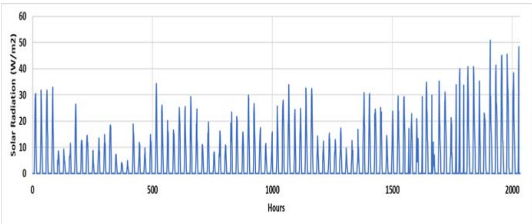
The analysis of the Fig.7 and Fig.8 show that during the entire monitored period (November 2018-February 2019), according to the measured values of air humidity and soil and leaf wetness, no rainfall was recorded.

Fig. 8. Variation of relative humidity of soil



The analysis of the Fig. 9 shows an increase in solar radiation values towards the end of winter, which greatly contributes to the development of vineyards.

Fig. 9. Variation of solar radiation



Solar radiation plays a vital role in providing light for seed germination, crop development, and influences the assimilation of nutrient distribution.

V. CONCLUSION

The main conclusion following the experiments outlines that the implemented field monitoring platform system Libelium based on IoT technologies can lead to good and accurate precision in monitoring, analysing, assessing and controlling agricultural fields. The platform system has performed automatic monitoring of the environmental temperature, humidity of air and soil, leaf wetness and solar radiation. These factors and field conditions are monitored continuously throughout seeding to harvesting. The existence of these data transmission systems highlights the knowledge of the soil-plant-atmosphere interactions needed to optimize agricultural production. The novelty of the system consists in use of solar energy that powers the entire system, along with dedicated sensors. As future work we envision testing the system for denial of service (DoS) attacks. We will focus on implementing DoS attacks to limit data transmission between Meshlium and the server, and as well, to prevent a legitimate user, a farmer, accessing their data from the server.

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REFERENCES

[1] C. Kamienski, et al., “Application Development for the Internet of Things: A Context-Aware Mixed Criticality Systems Development Platform,” Computer Communications, Vol. 104, May 2017, p. 1-16.

[2] Applications of IoT in Agriculture, https://www.iotforall.com/iot-applications-in-agriculture/, accesed on April 2019.

[3] European-Parliament Precision Agriculture: An Opportunity for EU Farmers—Potential Support with the CAP 2014-2020, http://www.europarl.europa.eu/RegData/etudes/note/join/2014/529049/IPOL-AGRI_NT%282014%29529049_EN.pdf, accesed on April 2019.

[4] Sjaak Wolfert, Lan Ge, Cor Verdouw, Marc-Jeroen Bogaardt, “Big Data in Smart Farming – A review”, Agricultural Systems,Elsevier, 2017.

[5] Renewable Energy Sources – A Brief Summary http://www.alternative-energy-tutorials.com/energy-articles/renewable-energy-sources-a-brief-summary.html, accesed on April 2019.

[6] Libelum’s new Smart Agriculture Extreme Sensor Node Provides Maximum Accuracy for Crop Monitoring, http://www.libelium.com/libeliums-new-smart-agriculture-xtreme-sensor-node-provides-maximum-accuracy-for-crop-monitoring/ ,accesed on April 2019.

[7] FAO, Disasters in agriculture, http://www.fao.org/news/story/es/item/1107192/icode/, accessed on April 2019.

[8] Developing Smart Agriculture with IoT Technologies, https://www.haptic.ro/developing-smart-agriculture-iot-technologies/, 2016, accesed on April 2019.

[9] Duan Yan-e, Design of Intelligent Agriculture Management Information System Based on IoT Fourth International Conference on Intelligent, Computation Technology and Automation 2011, Volume: 1 Pages: 1045 – 1049.

[10] F. Karim, F.Karimb, and A.Frihidab, “ Monitoring system using web of things in precision agriculture,” Procedia Computer Science 110, Tunis, Tunisia, 2017, pp. 402–409, 2017.

[11] I. Zyrianoff, A. Heideker, D. Silva, C. Kamienski, “Scalability of an Internet of Things Platform for Smart Water Management for Agriculture,” Proceedings of the 23rd Conference of Open Innovations Association FRUCT. FRUCT Oy, 2018, p. 58.

[12] F. J. Ferrández-Pastor, J. M. García-Chamizo, M. Nieto-Hidalgo, J. Mora-Martínez, “Precision Agriculture Design Method Using a Distributed Computing Architecture on Internet of Things Context” in Sensors, 18(6), 2018, p. 1731.

[13] M. Lee, J. Hwang, H. Yoe, „Agricultural Production System Based on IoT", 2013 IEEE 16th International Conference on Computational Science and Engineering, Sydney, NSW, pp. 833-837, 2013.

[14] http://www.libelium.com/libeliums-new-smart-agriculture-xtreme-sensor-node-provides-maximum-accuracy-for-crop-monitoring/ accessed at April, 2019.

[15] http://www.libelium.com/libeliumworld/agriculture/ accessed at April, 2019.

[16] Monitoring green areas in Spain to develop a Smart Garden system, http://www.libelium.com/monitoring-green-areas-in-spain-to-develop-a-smart-garden-system/ accessed at April, 2019.

[17] http://www.libelium.com/libelium-adds-interoperability-with-avevas-insight-powered-by-wonderware-online-cloud-platform-to-speed-up-industrial-iot-adoption/ accessed at April 2019.