Designing a Remote Electronic Irrigation and Soil Fertility Managing System Using Mobile and Soil Moisture Measuring Sensor

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Abstract

Electronic measuring devices have an important role in agricultural projects and in various fields. Electronic measuring devices play a vital role in controlling and saving soil information. They are designed to measure the temperature, acidity and moisture of the soil. In this paper, a new methodology to manage irrigation and soil fertility using an electronic system is proposed. This is designed to operate the electronic irrigation and adds inorganic fertilizers automatically. This paper also explains the concept of remote management and control of agricultural projects using electronic soil measurement devices. The proposed methodology is aimed at managing the electronic irrigation process, reading the moisture percentage, elements of soil and controlling the addition of inorganic fertilizers. The system also helps in sending alert messages to the user when an error occurs in measuring the percentage of soil moisture specified for crop and a warning message when change happens to the fertility of soil as many workers find difficulty in daily checking of soil and operating agricultural machines such as irrigation machine and soil fertilizing machine, especially in large projects.

Keywords:
Remote Electronic Irrigation, Soil Fertility Management, Mobile phone, Internet of Things (IoT), Smart irrigation.

1. Introduction

Agriculture is considered as the key and vital sector for human survival without which life cycle would not be possible. Agriculture has a wide field requiring specialized support from other sectors [1]. Recently, technology has played a great role in developing agricultural projects. The main objective of information technology in agriculture is to collect and process the data effectively. These dats were used in managerial decision making to enhance, diversify and to sustain the agricultural projects using the Internet of Things (IoT) that refers to the general idea of things. In particular, everyday things that can be read, recognized, localized, addressed through information sensor device and/or controlled by the Internet, regardless of communication means (whether through RFID, wireless LAN, wide area network, or whatever means else) [2]. The intelligent and smart irrigation aims at intelligent utilization of water to fulfill the watering needs of a particular plant and smart utilization of water to provide water to a plant in-time [23-25].

Soil structure and fertility are considered to be the basis for crop production in organic agriculture [3]. This is due to a variety of natural factors including Parent material, Climate, Topography, Organisms and Time etc. All the constituents of soil are equally important and play an equal role in the formation of soil [4]. Recently, agricultural projects are faced with different problems, namely, the method of agricultural irrigation process that includes the difficulty in controlling the water withdrawn by pumps due to lack of information about degree of soil moisture or dryness whereas excessive irrigation and floods have increased the water loss [5]. Also, over-irrigation reduces soil aeration, root absorption of water and nutrients, since each crop has specific characteristics regard to moisture percentage and water content. Electronic irrigation provides high flexibility without manhandle intervention [21].

Agricultural projects also encounter problems such as crop failure caused by soil fertility, which is measured manually across a number of project parts, increasing the cost, time and physical exertion [6]. Inorganic fertilizers are added to soil which includes phosphates, nitrates, aluminum nitrate and potassium. Fertilizer industry is considered to be a possible source of natural radionuclide and heavy metals, and this can be verified by conducting soil tests to measure the degree of soil moisture, acidity and

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fertility by using the technology of sensor devices and remote control through an electronic application that automatically pumps water and sprays chemical fertilizers with required quantity [7]. The main aim of this research is to design an application for electronic irrigation management system. The (AQUALIN) is a sensor based device used for measuring and controlling the soil moisture and fertility. This uses the electronic irrigation and adding inorganic fertilizers to soil by means of soil measurement devices (JHL9918). This paper is proposed to achieve the following objectives:

- To follow-up and control the project remotely.
- To read the degree of soil moisture and salinity using a device
- To control the electronic irrigation process using (AQUALIN) device.
- To explore soil problems and to treat fertility by adding inorganic fertilizers.

In order to achieve these objectives, an electronic application is required to manage agricultural projects, solve project irrigation problems and treat soil fertility by adding inorganic fertilizers using soil measurement sensor devices. The system allows user to enter specified percentage of soil moisture and fertility for an agricultural crop. It also allows the user to inquire current and previous soil constituents and moisture percentage measurement. It allows the user to control the electronic irrigation process and add inorganic fertilizers such as Phosphate and Nitrates, Ammonium nitrate and Potassium as well. The system also sends an alert message when an error occurs in soil constituents and moisture functions. The soil constituents and moisture measurement sensors devices measure the volumetric water content in soil and soil acidity [8]. The user saves all the project specific data such as soil moisture and inorganic elements percentage and the sensor device number in the system through the soil moisture and acidity data which is collected by the sensor device . The device then sends them to the system which in turn sends an alert message to the user in order to open the automatic irrigation devices. The user also controls the addition of inorganic fertilizers in the specified parts of the cultivated area automatically.

Physical components of the proposed system are shown in Figure (1). It consists of the sensor device (JHL9918). This device comprises of a sensor unit and a sensor device including the LM393 comparator, potentiometer, LED indicator - LED indicators of output and digital power. Usually the red is the power indicator and the blue is the digital output. The sensor device (JHL9918) is one of the test probes that are placed or inserted into soil to collect the degree of moisture, acidity and constituents of soil. Information is stored on the electronic application, the system sends alert message to the user when soil moisture or fertility decrease, and accordingly, the user operating the electronic irrigation system adds inorganic fertilizers using the (AQUALIN) device.

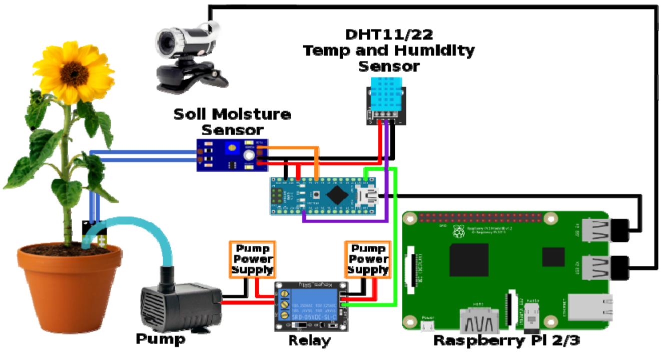


Figure 1 – Physical Components of the Smart System

Smartphones and smartphone apps repurposed to act as soil plant analyzers, digital agronomic advisories and fertilizer calculators must become better integrated into the farming systems. They should be considered trustworthy, quality controlled and certified to address liability concerns, and emphasize connectivity by facilitating transfer of knowledge and agricultural innovation on a person-to-person basis (facilitated by extension workers), rather than focusing solely on passive information transfer. If those conditions are met, mobile technologies will play an irreplaceable role in closing the gap present in this fertility management system.


Mobile AQUALIN JHL9918

Figure 2 – Sensor, its Automatic irrigation device and the Computer Connected to it

This paper discusses the proposal to develop and implement an electronic application for managing agricultural projects using a technology based on the soil sensor device (JHL9918) and the electronic irrigation device (AQUALIN). The user manages to accomplish this agricultural project using the sensor device that reads the degree of moisture, acidity and constituents of soil. This information helps the system user to control the agricultural irrigation process and to distribute inorganic fertilizers that soil needs as shown in Figure (2). This proposed approach can save time and effort spent in measuring soil in different areas, avoid wasting water, prevent reduction in yield or quality due to excessive nutrients [22] and maintain soil fertility. The paper is organized as follows: Section (2) reviews methodologies that focus on the different methods proposed by previous researchers. Section (3) describes the components of the system based on the technology of (AQUALIN) device and (JHL9918) sensor, and discusses the proposed methodology, its phases, modules, etc. Section (4) includes the results and discussion. Section (5) includes findings and recommendations.

2. Literature Review

Smart irrigation solutions portray new technologies, optimization potential to automate irrigation routines in residential areas, thereby reducing the water usage and pollution. The services provided by automation industries has initiated new functionalities in order to encourage the use of these systems, such as integrating local weather forecasts in irrigation water control systems or android controls, and early warning notifications that assist the process and prevent over irrigation. Very few researches have been conducted to tackle the priorities of homeowners for smart irrigation technologies [9].

The Internet of Things (IoT) and the Internet of Everything (IoE) have had great impact on the farms and are forms to improve the productivity in the use of several agricultural resources, namely the water, through approaches of smart irrigation and precision agriculture. The smart irrigation systems are important to collect and work environmental data. The IoT allows implementing automated operations with reduced supervision in the whole food chainand agricultural production, including in greenhouse agriculture control and in diverse farming systems. The water management is critical, where the IoT may contribute significantly for a more balanced use as well as in the soil health assessment and fertilization management, in a perspective of a more competitive agriculture. The potable water will be one of the scarcest resources and here the new technologies will be determinant for a more efficient management

Agricultural production requires about 85% of the groundwater and may require more in future. A system for efficient use of water in agriculture is therefore necessary. In comparison to conventional systems, a drip irrigation system eliminates a large amount of water use. And some crops need variable water volumes as they grow paddy, for example. In drip irrigation system, mobile phone records the picture of the field, measures its water content and periodically transfer data to a microcontroller via the GSM module. The microcontroller determines on the irrigation and transfers the land condition to the mobile phone of the owner. For a duration of 3-months period, the device is checked for paddy fields. The research procedure shows that it preserves about

41.5% and 13% of the water in comparison to the traditional irrigation methods and the traditional irrigation practices [10].

In framework of Mamdani control system is used to incorporate an open-layer fuzzy logical control system. The input feed in the dynamic logic monitoring system is modified from the humidity sensor, the temperature sensor and the field flux sensor. The outcome is the torch and water pump for this framework. This paper describes the membership mechanisms for fuzzy logic and rule-based structures for the controller [11]. Smart renewable energy (RES) irrigation systems have demonstrated major increases in agricultural productivity and farm sustainability. This paper demonstrate how sensors and environmental information is used with the help if internet of things to manage and track the control of a Solar powered smart irrigation system. To track and manage the device remotely, a web portal has also been designed [12]. Appropriate and productive irrigation methods evolved because of a limited amount of sweet water, particularly in countries significantly affected by lack of sweet water reserves, which meant an urgent need for smart irrigation system. Much water is lost because of inadequate irrigation techniques. an insightful method with a database for reliable plant irrigation [13]. The everyday growing conditions of plants are dependent on the temperature, moisture, and intervals of the day and the volume of water for a plant species governs. This strategy not only effectively saves sweet water, but also encourages smart energy usage [25].

2.1. Smart tunnel farming system

An intelligent and smart system for tunnel farming has become a need due to the scarcity of sweet water reservoirs is a main bottleneck in the modern agriculture. The efficient utilization of limited sweet water reservoirs has emerged as an eye catching challenge in recent years. To address this challenge, sensor-based irrigation systems for gardens and small-scale farms have been presented in the recent past [29] and they seemingly address this problem up to some extent, however the existing smart systems are not intelligent and smart enough to provide maximum throughput of such modern irrigation systems. Just adding sensors to an irrigation system is not sufficient. There is need of a few other important components such as intelligent techniques (such as machine learning, fuzzy logic, etc.) for improved decision making, sensing technologies (such as IoT, sensors, etc.), positioning technologies (such as GPS, GIS, etc.), communication and cellular (internet, cloud, web, etc.) technologies, software and mobile applications (such as decision support systems, etc.), and big data analytics platforms [30-32]. Figure 3 shows these important components required to design and develop a smart tunnel farming system. Main elements to plan and establish a smart irrigation system which is also called smart tunnel farming which focuses on integration of internet of things (IoT) [14] and involves:

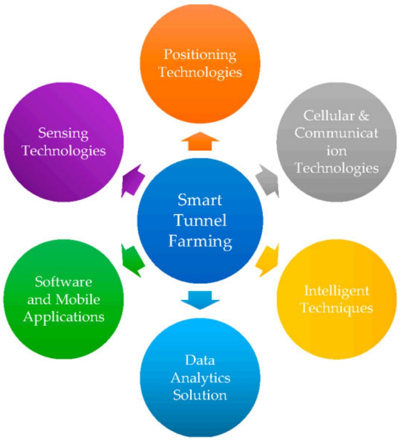


Figure 3 – Important components of a smart tunnel farming system

Following figure shows the generally recommended system for an integrated smart irrigation system [23].

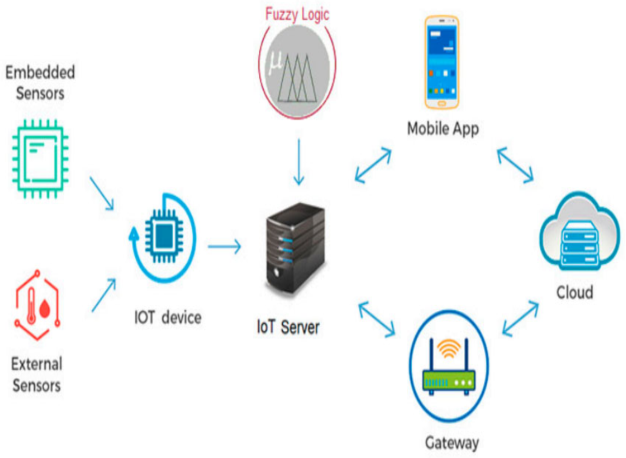


Figure 4 – General overview of a Smart irrigation System

Water quality identifies water's chemical, physical, and biological constituents which has been widely investigated and documented on drinkable water [15]. The salt content of treated irrigation water may be greater than the municipal, drinking water resources. Water with reduced water content can also limit pesticide effectiveness and change the natural soil fertility [16].

It is stressed that the Waterfall design approach is on preventing modification in criteria specifications or high-level layout quite prematurely in the development cycle of the project before investing in rather detailed design and execution activities [24]. So, if specifications are not well understood/defined or are expected to evolve in the duration of the project lifecycle, the Waterfall model is inclined to be unsatisfactory [17]. Since each production stage continues and the specifications are further analyzed, an iteration of the prior and subsequent phases are done although seldom with a more distant and isolated steps. There is a strong and narrow shifting reference to revert to in case of unexpected design problems, because at any stage in the development process the requisites review is regularly done. It is thus seen as a strength of such a step-down system of transition [18].

Mobile technologies offer a wide range of opportunities for potential ways to contribute to creation of such tools. Smartphones have been repurposed for use in farm management the moment they became affordable, and thus, available to the general public [26] and continue to play a compelling role as decision support tools (DSTs)[27,28]. This paper aims to review the increasing impact of mobile devices on agricultural decision making relating to sustainable use of MFs via phone based soil-plant testing, farm-level agronomic extension advisory, and assessment of economic viability of fertilizer application, whilst highlighting opportunities and challenges associated with these technologies.

3. Proposed Methodology

In this study, various systems have are proposed to use applications with devices remotely. This paper proposed a system based on the waterfall model, the classic model of software engineering that specifies some basic tasks to be performed sequentially as follow: requirements definition, architectural design, detailed design, implementation [19]. This paper aims mainly to propose a solution for managing and controlling agricultural projects using remote sensing technology. The proposed system also provides a project specific data interface, a system user control screen, an interface for addition of soil inorganic fertilizers, and alert message receiving interface in order to manage the electronic irrigation process [20]. A programmer designs, implements and tests all system components to apply the proposed methodology. a system using the (AQUALIN) device and sensor ((JHL9918) is required to be developed.

3.1 Use Case

Figure (6) shows a use case diagram of the proposed system. In Figure (6), the system administrator is the first actor to have the access authority to the entire system for controlling the project management (project inquiry - inorganic fertilizers addition - electronic irrigation - agricultural projects follow-up). The second actor is the sensor device (soil moisture and elements display- fertilizers percentage display).

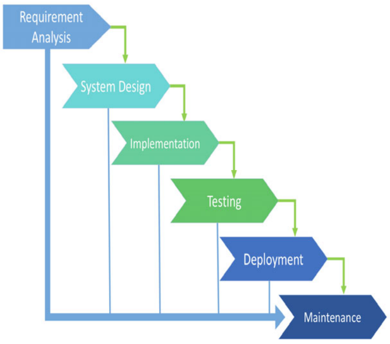


Figure 5 – Schematic Representation of an Incremental Model

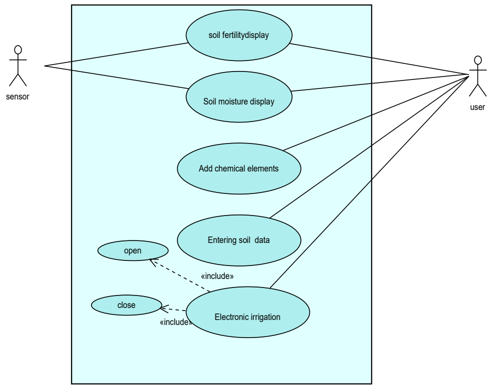
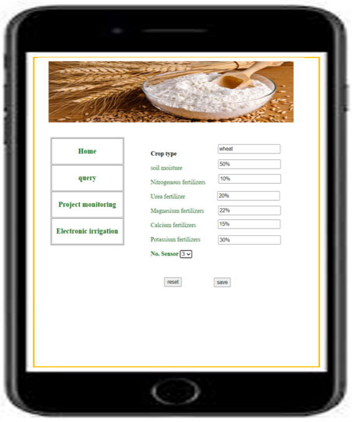


Figure 6 – Use Case Diagram for the Proposed System

Figure (6) shows a screen saving crop soil moisture data, degree of inorganic soil constituent measurement, and sensor device number.



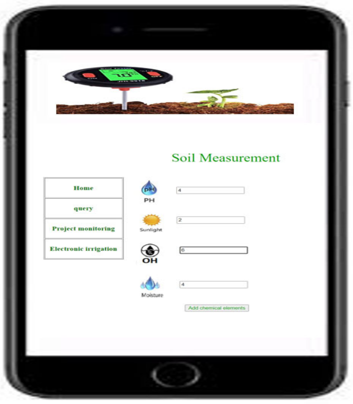
Crop type wheat
soil moisture 50%
Nitrogenous fertilizers 10%
Urea fertilizer 20%
Magnesium fertilizers 22%
Calcium fertilizers 15%
Potassium fertilizers 30%
No. Sensor 3

Figure 7 – A Main Soil Constituent Data Saving Interface

Nitrogenous fertilizers 1.1
Urea fertilizer 2.2
Magnesium fertilizers 3.1
Potassium fertilizers 4
Calcium fertilizers 2.00

Figure 8 – Application Interface for Adding Inorganic Fertilizers

Figure (8) shows how the user controls the addition of inorganic fertilizers to soil after receiving alert message from the system.



PH 4
Sunlight 2
OH 6
Moisture 4

Figure 9 – A Main Measuring Soil Moisture and Type Interface

Figure (9) shows a screen readings of the soil, the measurement of which is performed by sensor device pointing out the soil moisture, temperature degree and the soil type (alkaline/acidic). The screen also includes a button , from where the user enters a screen to add nonorganic fertilizers.

The degree of soil moisture for device 2 is less than 50 %

Figure 10 – Receiving Alert Message Interface

Figure (10) shows the user receiving alert message about low soil moisture percentage, and points out the sensor device number. The screen contains the button (open tap) through which water can be opened automatically.

4. Conclusion

A novel method for Remote Electronic Irrigation and Soil Fertility Managing System Using Mobile based and Soil Moisture Measuring Sensor is proposed in this paper.The proposed methodology enables communications between users and the irrigation service providers thus enabling the remote based electronic irrigation technique. This paper proposes a combination of sensors such as AQUALIN and JHL9918 based system called as Remote Electronic Irrigation and Soil Fertility Managing System. The proposed architecture aims to manage the electronic irrigation process, reading the moisture percentage and elements of soil, and controlling the addition of inorganic fertilizers. The system also helps in sending alert message to the user when an error occurs in measuring the percentage of soil moisture specified for crop. A warning message is also sent when change happens in soil fertility.

5. References

[1] D. Rapong'o, "The Role Of Information Technology In Agriculture," 17 October 2017. [Online]. Available: https://www.linkedin.com/pulse/role-information-technology-agriculture-dennis-rapong-o. [Accessed 2020].

[2] S. M. P. C. S. Keyur K Patel, "Internet of Things-IOT: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges," International Journal of Engineering Science and Computing, vol. 6, no. 5, 2016.

[3] N. A. a. L. C. Christopher Johns (Research Manager, "Soil Structure and the Physical Fertility of Soil," 17 December 2015. [Online]. Available: https://www.futuredirections.org.au/publication/soil-structure-and-the-physical-fertility-of-soil/. [Accessed 2020].

[4] L. Matchavariani, "Soil-Forming Factors," in The Soils of Georgia, Springer, Cham, 2019, pp. 19-50.

[5] H. I. Mohamed, "Egypt'S Water Resources Management Under Pressure Of Development," in First Eng. Conference for young, 2007.

[6] D. Neina, "The Role of Soil pH in Plant Nutrition and Soil Remediation," Applied and Environmental Soil Science, vol. 2019, p. 9, 3 November 2019.

[7] S. Savcı, "Investigation of Effect of Chemical Fertilizers on Environment," in International Conference on Environmental Science and Development, Hong Kong, 2012.

[8] A. J. E, "Soil Moisture," NASA, 15 June 2015. [Online].

[9] H. K. Xumin Zhang, "Investigating Homeowners' Preferences for Smart Irrigation Technology Features," Water, vol. 11, no. 10, 25 September 2019.

[10] B. J.-S. S.R.BarkunanV, Smart sensor for automatic drip irrigation system for paddy cultivation, vol. 73, January 2019, pp. 180-193.

[11] M. A. J. M. Z. A. R. a. M. H. J. T. A. Izzuddin, "Smart Irrigation Using Fuzzy Logic Method," ARPN Journal of Engineering and Applied Sciences, vol. 13, no. 2, January 2018.

[12] S. M. R. M. R. D. E. K. Favour Adenugba, "Smart irrigation system for environmental sustainability in Africa: An Internet of Everything (IoE) approach," Mathematical Biosciences and Engineering (MBE), vol. 16, no. 5, pp. 5491-5503, 13 June 2019.

[13] I. S. B. M. A. N. B. R. M. Safdar Munir, "Design and Implementation of an IoT System for Smart Energy Consumption and Smart Irrigation in Tunnel Farming," Energies, vol. 11, p. 18, 6 December 2018.

[14] A. H. M. A. B. M. I. Muhammad Khaorshed Alam, "Smart Tunnel Farming Model: An Inculcation of Cloud Computing with Cortex for Reliable Agricultural Production," International Journal of Sensor Networks and Data Communications, vol. 7, no. 4, January 2018.

[15] R. M. M. Walker, "A web site for interpreting drinking water quality analyses," February 2003.

[16] S. A. W. N. M. Dara M. Park, "Assessing Irrigation Water Quality for pH, Salts, & Alkalinity," Journal of Extension (JOE), vol. 52, no. 6, December 2014.

[17] M. Ganis, "Agile Methods: Fact or Fiction," International Business Machines, vol. 12, 2010.

[18] C. W. D. B. Kai Petersen, "The Waterfall Model in Large-Scale Development," in International Conference on Product-Focused Software Process Improvement, 2009.

[19] S. K. Pushkar Dubey, "Software Development Life Cycle

(Sdlc) Analytical Comparison And Survey On Traditional And Agile Methodology," Abhinav National Monthly Refereed Journal Of Research In Science & Technology, vol. 2, 6 August 2013.

[20] A. O. O. G. A. Olugbenga Ogidan, "Smart Irrigation System: A Water Management Procedure," Agricultural Sciences, vol. 10, no. 1, pp. 25-31, January 2019.

[21] A. L. T. A. F. Mutiu A. Adegboye, "Automatic Fertilized-Irrigation Control And Management System," Science & Technology Libraries, vol. 2, no. 2, October 2017.

[22] D. W. R.S. Ayers, Water quality for agriculture, vol. 29, 1994.

[23] M. S. M. M. A. N. M. S. M. M. imran Sarwar Bajwa, "Design and Implementation of an IoT System for Smart Energy Consumption and Smart Irrigation in Tunnel Farming," Energies, vol. 11, p. 3427, December 2018.

[24] S. M. J. F. Eric Conrad, Eleventh Hour CISSP, 2 ed., 2014, p. 216

[25] D. Podar, "Plant Growth and Cultivation," Methods in molecul biology, pp. 23-45, January 2013.

[26] Duncombe, R. Mobile Phones for Agricultural and Ru Development: A Literature Review and Suggestions for Futu Research. Eur J Dev Res, 28, 213–235 (2016).

[27] Suporn Pongnumkul, Pimwadee Chaovalit, Navapo Surasvadi,"Applications of Smartphone-Based Sensors in Agriculture: A Systematic Review of Research", Journal of Sensors, vol. 2015, Article ID 195308, 18 pages, 2015.

[28] Inwood, S.E.E. and Dale, V.H., State of apps targeting management for sustainability of agricultural landscapes. A review. Agronomy for sustainable development, 39(1), p.8, 2019.

[29] Gnauer, C., Pichler, H., Tauber, M. et al. Towards a secure and self-adapting smart indoor farming framework. Elektrotech. Inftech, 136, 341–344 (2019).

[30] Qualls, R.J.; Scott, J.M.; DeOreo, W.B. Soil moisture sensors for urban landscape irrigation: Effectiveness and reliability. J. Am. Water Res. Assoc. 2001, 37, 547–559.

[31] Vasanth, A.; Grabow, G.L.; Bowman, D.; Huffman, R.L.; Miller, G.L. Evaluation of evapotranspirationbased and soilmoisture-based irrigation control in turf. Biol. Agric. Eng. 2008, doi:10.1061/40976(316)117.

[32] Rawal, S. IOT based Smart Irrigation System. Int. J. Comput. Appl. 2017, 159, doi: 10.5120/ijca2017913001.

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