IoT based Electronic Irrigation and Soil Fertility Managing System

Mohammed Ateeq Alanezi

Computer Science and Engineering Department,
College of Computer Science and Enginering, University of Hafr al Batin

Abstract:
In areas where water is scarce, water management is critical. This has an impact on agriculture, as a significant amount of water is used for that purpose. Electronic measurement equipment are essential for regulating and storing soil data. As a result, research has been conducted to manage water usage in the irrigation process. Many equipment for managing soil fertility systems are extremely expensive, making this type of system unaffordable for small farmers. These soil fertility control systems are simple to implement because to recent improvements in IoT technology. The goal of this project is to develop a new methodology for smart irrigation systems. The parameters required to maintain water amount and quality, soil properties, and weather conditions are determined by this IoT-based Smart irrigation System. The system also assists in sending warning signals to the consumer when an error occurs in determining the percentage of moisture in the soil specified for the crop, as well as an alert message when the fertility of the soil changes, since many workers, particularly in big projects, find it extremely difficult to check the soil on a daily basis and operate agricultural devices such as sprinkler and soil fertilizing devices.
Keywords:
Smart Irrigation, Soil Fertility Management, Internet of Things (IoT), Irrigation, water resources,

1. Introduction

Farming is seen as a critical and essential industry for sustaining life, without which the life span would be impossible to complete. Farming is a vast field that necessitates expert assistance from other industries [1].Market has gradually played a significant role in the development of farming systems. In farming, the fundamental role of information systems is to properly gather and interpret data. These data were used in strategic decision to improve, expand, and maintain farming initiatives using the Internet of Things (IoT), which refers to the concept of things at the moment. Physical items that can be scanned, identified, located, and targeted by a data sensing unit and/or controlled by the Internet, irrespective of effective communication (RFID, wlans, public network, or any other means). [2]. Advanced smart cultivation strives to make cognitive use of water to meet a plant's irrigation needs and intelligent use of water to supply water to a plant at the right moment. [23-25].

In sustainable farming, soil quality and nutrition are regarded to be the foundation for agriculture [3]. This is due to a number of natural elements such as parental material, weather, geography, critters, and period, among others. All soil elements are equally significant and serve a similar role in soil development [4]. Farming enterprises have lately been confronted with a variety of issues, including the inability to control the freshwater extracted by turbines due to a lack of knowledge on the level of moisture content or dehydration, whereas water stress and disasters have exacerbated water loss [5]. Also, because each crop has its own moisture proportion and water level, over-irrigation affects soil oxygenation and root increased water assimilation. Digital farming allows for a great deal of versatility without the need for human involvement. [21]. Food shortages due to soil richness, which is assessed individually across a variety of project elements, increases the price, effort, and strenuous activity of farming activities [6]. Nitrates, fertilizers, magnesium nitrate, and salt are among the plant nutrients used in soil. The nutrient business is thought to be a potential source of natural radionuclides and toxic substances, which can be validated by using sensing devices and navigation system through an installed application to evaluate the degree of moisture content, alkalinity, and richness [7]. The major goal of this study is to create an IoT based electronic water harvesting system application.This system is a sensor-based device that measures and controls the humidity and nature of the soil. This makes use of computerized irrigation and soil measurement sensors to supply chemical fertilizer to the sand.The following aims are presented for this manuscript:

- To monitor and manage the work from distant location.
- Using an instrument, determine the degree of relative humidity and saltiness.
- To use the IoT based equipment to regulate the electronic irrigation operation.
- To investigate soil issues and restore fertility with plant nutrients.

An automated program is needed to manage farming, handle project drainage difficulties, and manage soil quality by providing fertilisers utilizing soil measuring sensing devices in

Manuscript received April 5, 2023
Manuscript revised April 20, 2023
https://doi.org/10.22937/IJCSNS.2023.23.4.19

order to achieve organizational objectives. The technology allows the user to specify soil and nutrients percentages for a grain crops. It also lets the customer to get information on current and prior soil ingredients, as well as humidity content measurements. It also allows the user to regulate the digital irrigation method and add chemical fertilizer like phosphorus and ammonia, as well as nitrogen and salt. When an issue in clay particles or hydration activities happens, the program also delivers an alarm message. The overall hydration in soil and soil alkalinity are measured using soil components and humidity measuring sensing equipment [8]. Through the soil hydration and ph data data from sensor device, the administrator saves all construction information such as moisture content and mineral component percentages, as well as the sensor device registration, in the platform. The gadget then communicates them to the platform, which subsequently communicates the user an alert signal to open the irrigation control devices. The user can also automate the application of chemical fertilizer to specific areas of the farmed area.

Physical components of a general smart irrigation system are shown in Figure 1. It consists of the various sensors and its actuators. The soil is dirrectly conected with a soil moisture measuring sensor along with the temperature and humidity sensor. Arduino boards were used to conect the soil moisture monitoring sensor along with the relay. The relay is further connected with a water pump. These devises were connected using various lines and wires with different colours. Usually the red is the power indicator and the blue is the digital output. The soil moisture measuring sensor is placed into soil in order to collect the degree of moisture, acidity and constituents of soil. This entire system sends alert message to the user automatically, when soil moisture or fertility is decreased.

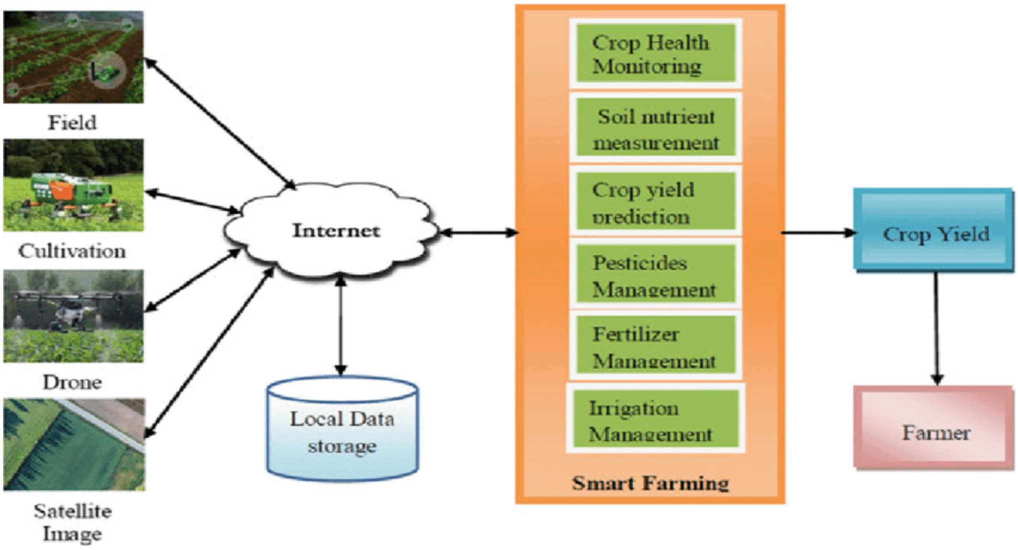


Figure 1 –Components of a general smart soil fertilitymanagement system [9]

The combination of IoT and sensor based systems acts as soil monitoring based farming systems. These systems should be considered trustworthy, quality controlled and certified to address liability concerns, by facilitating the transfer of knowledge and agricultural innovation on a person-to-person basis rather than focusing solely on passive information transfer. If those prerequisites are met, mobile technology will play a critical role in bridging the gap that currently exists in the soil fertility control system.

2. Literature Review

Intelligent farming solutions showcase innovative technology with the ability to regulate watering patterns in populated neighborhoods, lowering water use and contamination. Automated companies' products have introduced new functions to encourage the usage of these devices, such as combining local weather predictions in irrigation controllers or android interfaces, and early detection messages to aid in the process and minimize over cultivation. Few studies have been undertaken to address consumers' requirements regarding intelligent irrigation solutions. The IoT has had a massive effect on agriculture, and there are attempts to enhance efficiency in the use of numerous fertile land, particularly freshwater, using intelligent watering management and precision farming technologies. Intelligent irrigation systems are vital for gathering and processing weather parameters. The IoT includes the integration of intelligent automation with decreased monitoring across the entire food chain and crop yields, including indoor farming management and a variety of agricultural methods. In the context of a more modern farming, freshwater management is crucial, and the IoT may help significantly with more regulated use, as well as soil quality monitoring and fertilizer control. Supply of water will be among the most vital resources, and new technologies will be critical in ensuring its effective performance.

Farming cultivation uses around 85% of the freshwater available and may consume even more in the long term. As a result, a strategy for improved water use in farmland is required. A drip hydroponic system saves a lot of water compared to traditional irrigation. Furthermore, certain crops, such as rice, require varying water levels. In a hydroponic system, a smartphone takes pictures of the area, monitors its moisture content, and sends data to a microprocessor via the Gsm network on a regular basis. The microprocessor controls fertilization and sends information about the land's status to the owner's smartphone. The gadget is examined for farmlands for a period of 3 months. When compared to the standard irrigation methodologies, this approach conserve roughly 41.5 percent and 13% of the freshwater [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]. Suitable and effective farming methods arose as a result of a low supply of clean water, especially in nations with major sweet water shortages, necessitating the development of intelligent irrigation systems. Inefficient irrigation practices waste a lot of water. It is a repository driven strategy for dependable crop irrigation [13]. Plants' daily growing circumstances are governed by weather, humidity, and day durations, as well as the quantity of water available to them. This method not only preserves good quality water but also fosters conservation [25].

2.1. Smart farming system

The paucity of fresh storage tanks has become a significant impediment in modern farming, necessitating the development of an intelligent and smart underground agricultural system. In past few years, the optimal use of scarce sweet storage tanks has become a prominent concern. IoT-based water sources for flowerbeds and cattle ranches have recently been introduced as a solution to this issue, and while they appear to solve the type of issue, the emerging technological solutions are not intellectual or smarter to provide the large bandwidth of such advanced drip irrigation. It is not enough to just add sensors to an irrigation system. Intelligent strategies (such as AI, ANN, etc.) for better decision making, sensor systems (such as IoT, sensors, etc.), locating methodoloies (such as GPS, GIS, etc.), interaction and mobile (internet, cloud, web, etc.) innovations, software and smartphone apps (such as management information systems, etc.), and big data analytics channels (such as management information systems, etc.) are all needed. Figure 3 depicts the essential parts required for designing and developing a smart tunnel system of agriculture. The following are the important factors to consider while planning and implementing a drip irrigation, also known as intelligent tunnel farming, which emphasizes on the combination of the sensors and IoT based devices [14] as shown in figure 3.

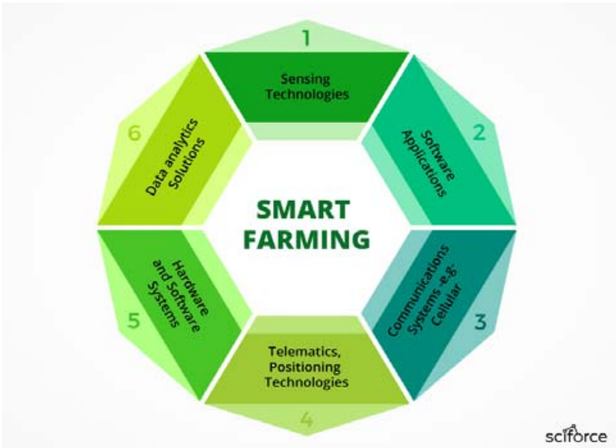


Figure 3 – Important components of a smart tunnel farming system [SCIFORCE]

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

Figure 4 – General overview of a Smart irrigation System

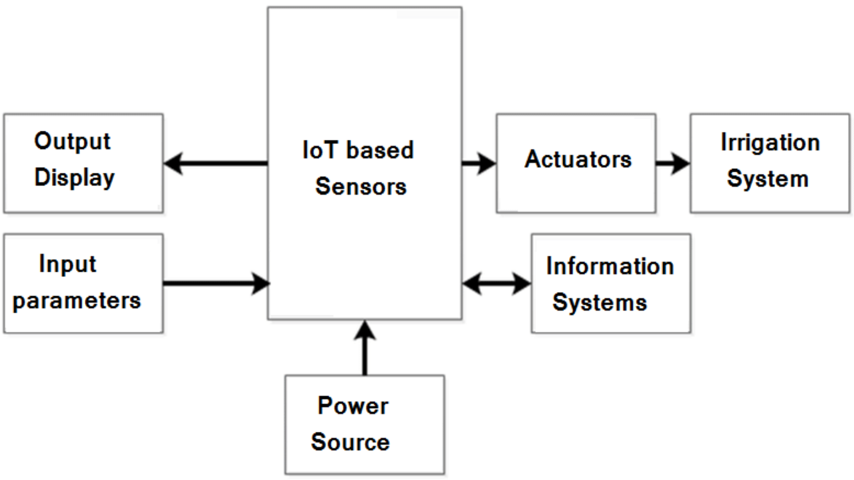
Water quality identifies water's chemical, physical, and biological constituents which has been widely investigated and documented on drinkable water [15]. The salt content of treated irrigation water may be greater than the municipal, drinking water resources. Water with reduced water content can also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

The Waterfall design method focuses the need of avoiding changes to qualifying requirements or high-level layouts early in the project development lifecycle without engaging in more extensive formulation and implementation operations [24]. The Waterfall methodology is likely to be undesirable if the criteria are not well comprehended or are projected to develop over the different stages of the project lifecycle [17]. Because each stage of level of production and the requirements are refined, iterations of previous and future stages are performed, though rarely with more remote and isolated processes. Because the necessary requirements appraisal is done at any level of the design phase, there is indeed a definite and limited changing standard to resort to in case of unforeseen design challenges [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 and continue to play a compelling role as decision support tools (DSTs). 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 System

In this study, various systems were proposed to operate the system remotely. This method comprises of various sensors, actuators, input and output displays, power source for the IoT based sensors, Informatio n systems, information sub system etc. This paper proposed a system based on the combination of IoT and waterfall model [19] where the IoT based sensors will work based on the classic model of software engineering that specifies some basic tasks to be performed sequentially as follow: Getting the inout from the soil. The soil is dirrectly conected with a soil moisture measuring sensor along with the temperature and humidity sensor. Arduino boards were usued to conect the soil moisture monitoring sensor along with the relay. The relay is further connected with a water pump. These devises were connected using various lines and wires with different colours. Usually the red is the power indicator and the blue is the digital output. The soil moisture measuring sensor is placed into soil in order to collect the degree of moisture, acidity and constituents of soil. This entire system sends alert message to the user automatically, when soil moisture or fertility is decreased. This paper aims mainly to propose a solution for managing and controlling agricultural projects using the combination of IoT and Information systems based technology. The proposed system also provides a project specific data interface, a system user input screen, an interface for addition of fertilizers in the soil, and alert message receiving interface in order to manage the electronic irrigation process [20]



4. Conclusion

A novel method based on the combination of IotT and Informatio n systems for Electronic Irrigation and Soil Fertility Managing System 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 methods such as IoT and information systems called as IoT based Remote Electronic Irrigation and Soil Fertility Managing System. The proposed architecture aims to manage the electronic irrigation process, by getting the input parameters, reading the moisture percentage and frttility comntents 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] W. Z. Taffese, E. Nigussie and J. Isoaho, "Internet of things based durability monitoring and assessment of reinforced concrete structures," Procedia Computer Science, vol. 155, no. 2019, pp. 672-679, 2019.

[2] S. R. Moosavi, E. Nigussie, M. Levorato, S. Virtanen and J. Isoaho, "Performance analysis of end-to-end security schemes in healthcare IoT," Procedia computer science , vol. 130, no. 2018, pp. 432-439, 2018.

[3] P. Fraga-Lamas, M. Celaya-Echarri, L. Azpilicueta, P. Lopez-Iturri, F. Falcone and T. M. Fernandez-Carames, "Design and Empirical Validation of a LoRaWAN IoT Smart Irrigation System," Proceedings, pp. 1-6, 2019.

[4] R. Nageswara Rao and B. Sridhar, "IoT based smart crop-field monitoring and automation irrigation system," in 2018 2nd International Conference on Inventive Systems and Control (ICISC), Coimbatore, 2018.

[5] A. Khanna and S. Kaur, "Evolution of Internet of Things (IoT) and its significant impact in the field of Precision Agriculture," Computers and electronics in agriculture, vol. 157, no. 2019, pp. 218-231, 2019.

[6] Mohapatra, A.G.; Keswani, B.; Lenka, S.K. Optimizing farm irrigation mechanism using feedforward neural network and structural similarity index. *Int. J. Comput. Appl.* **2017**, *7*, 135–141.

[7] Goldstein, A.; Fink, L.; Meitin, A.; Bohadana, S.; Lutenberg, O.; Ravid, G. Applying machine learning on the sensor data for irrigation recommendations: Revealing the agronomist's tacit knowledge. *Precis. Agric.* **2018**, *18*, 421–444.

[8] Jimenez, J.M.; Garcia, L.; Taha, M.; Parra, L.; Lloret, J.; Lorenz, P. Comprehensive Security Framework of an Intelligent Wastewater Purification System for Irrigation. In Proceedings of the Twelfth International Conference on Communication Theory, Reliability, and Quality of Service, Valencia, Spain, 24–28 March 2019

[9] Rajasekaran, T., Anandamurugan, S. (2019). Challenges and Applications of Wireless Sensor Networks in Smart Farming—A Survey. In: Peter, J., Alavi, A., Javadi, B. (eds) Advances in Big Data and Cloud Computing. Advances in Intelligent Systems and Computing, vol 750. Springer, Singapore. https://doi.org/10.1007/978-981-13-1882-5_30

[10] Sunmehra, D.; Kumar, B.H. WSN based Automatic Irrigation and Security System using Raspberry Pi Board. In Proceedings of the International Conference on Current Trends in Computer, Electrical, Electronics and Communication, Mysore, India, 8–9 September 2017.

[11] Barreto, L.; Amaral, A. Smart Farming: Cyber Security Challenges. In Proceedings of the International Conference on Intelligent Systems, Funchal, Madeira, 25–27 September 2018.

[12] Hassija, V.; Chamola, V.; Saxena, V.; Jain, D.; Goyal, P.; Sikdar, B. A survey on IoT security: Application areas, security threats, and solution architectures. *IEEE Access* **2019**, *7*, 82721–82743.

[13] A. G. Mohapatra and S. K. Lenka, "Neuro-fuzzy-based smart DSS for crop specific irrigation control and SMS notification generation for precision agriculture," International Journal of Convergence Computing, vol. 2, no. 1, pp. 3-22, 2016

[14] S. R. Kumbhar and A. P. Ghatule, "Microcontroller based controlled irrigation system for plantation," in International MultiConference of Engineers and Computer Scientists, Hong Kong, 2013.

[15] Giusti, E., Marsili-Libelli, S.: A fuzzy decision support system for irrigation and water conservation in agriculture. Environ. Model. Softw. **63**, 73–86 (2015)

[16] Nikolidakis, S.A., Kandris, D., Vergados, D.D., Douligeris, C.: Energy efficient automated control of irrigation in agriculture by using wireless sensor networks. Comput. Electron. Agric. **113**, 154–163 (2015)

[17] O'Grady, M.J., O'Hare, G.M.P.: Modeling the smart farm. Inf. Process. Agric. **4**, 179–187 (2017)

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

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

[21] Monica, M., Yeshika, B., Abhishek, G., Sanjay, H., & Dasiga, S. (2017). IoT based control and automation of smart irrigation system: An automated irrigation system using sensors, GSM, Bluetooth and cloud technology. In 2017 International Conference on recent innovations in signal processing and embedded systems (RISE) (pp. 601–607). Piscataway: IEEE.

[22] Khelifa, B., Amel, D., Amel, B., Mohamed, C., & Tarek, B. (2015). Smart irrigation using internet of things. In 2015 Fourth International Conference on future generation communication technology (FGCT) (pp. 1–6). Piscataway: IEEE.

[23] Kamienski, C., Soininen, J.-P., Taumberger, M., Fernandes, S., Toscano, A., Cinotti, T. S., Maia, R. F., & Neto, A. T. (2018). Swamp: An IoT-based smart water management platform for precision irrigation in agriculture. In 2018 Global Internet of Things Summit (GIoTS) (pp. 1–6). Piscataway: IEEE

[24] Haque, M. S. T., Rouf, K. A., Khan, Z. A., Emran, A., & Zishan, M. S. R. (2019). Design and implementation of an IoT based automated agricultural monitoring and control system, In 2019 International Conference on robotics, electrical and signal processing techniques (ICREST) (pp. 13–16). Piscataway: IEEE

[25] Chikankar, P. B., Mehetre, D., & Das, S. (2015). An automatic irrigation system using Zigbee in wireless sensor network. In 2015 International Conference on pervasive computing (ICPC), IEEE (pp. 1–5).