

Smart Irrigation System Techniques using Artificial Intelligence and IoT

Angelin Blessy J^{1*}, Anveesh kumar²

School of Computing Science and Engineering, Galgotias University, Greater Noida, India.

Abstract— The smart irrigation system is the combination of software, hardware, and firmware with the help of various computational techniques such as IoT, artificial intelligence, and Machine learning. It is important and needed to society because of the effective production of yields and effective usage of resources. Effective techniques are needed to optimize the water, monitor the moisture, and increase the yields. This article presents different recent techniques related to the smart irrigation systems in agriculture using IoT and artificial intelligence system. The various components, Modern irrigation system, various comparison parameters, and its requirements are presented in this article. Finally, presented various issues, challenges, and future direction of the research in the smart irrigation system.

Keywords— Smart irrigation system – Artificial Intelligence – IoT- Challenges – Future Direction of Irrigation system.

I. INTRODUCTION

In smart agriculture effective utilization of resources is important and needed for irrigations. As per the world bank data around 70% of freshwater needed for agriculture in the future [1]. So, agriculture water optimization and effective usage of water is an important one to consider the research using different techniques. Currently, the smart system is an effective concept to utilize the resources in a different field and especially in agriculture smart system plays an important role in different areas such as irrigation system, decision making, disease prediction, control system, and energy efficiency, etc. The smart system is the combination of sensing, control, activate, analyze and make decisions based on the various automation operations [2]. The automation operations based on the various emerging techniques, networking capabilities, sensing, and intelligence computations. So, with the help of a smart system, effectively usage the water and increase the yields. The advanced technologies-based agriculture and smart irrigations decrease freshwater usage. The smart system with IoT and machine learning concepts produce the centralized storage, processing, and analyzing the data from different ubiquitous sensors with the decision process[3]. Using this process, the artificial way of distributing resources or water in the agriculture process is called an irrigation system. Mainly this irrigation system used in fewer rainfall areas to maintain the soil moisture and temperature. Another main important usage of artificial irrigation system helps to stop the unwanted plant growth or weeds in the agriculture field. The irrigation system has two types such as conventional irrigation system and Modern irrigation system. The conventional irrigation system uses

watering buckets, cans, and canals. The main methods of conventional methods are basin, furrow irrigations, strip irrigations, and basin irrigation and it is not applied knowledge. The expenditure of the conventional irrigation system is very high. The expanded conventional irrigation system with the help of modern technologies is called the modern irrigation system. The modern irrigation system has three types such as sprinkler irrigation system, pot irrigation system and drip irrigation system, etc. [4]. The modern irrigation system also classified into different other usage also. As per weather evapotranspiration controller-based, it is classified into the signal-based controller, Historic controller, and On-site weather measurement controller's irrigation system, etc. As per the soil moisture sensor controller, it is classified into Suspended cycle irrigation systems and water on-demand irrigation. Those are some of the main classifications based on the usage of components and properties. The various controlling and sensing of modern smart irrigation technology shown in figure 1.

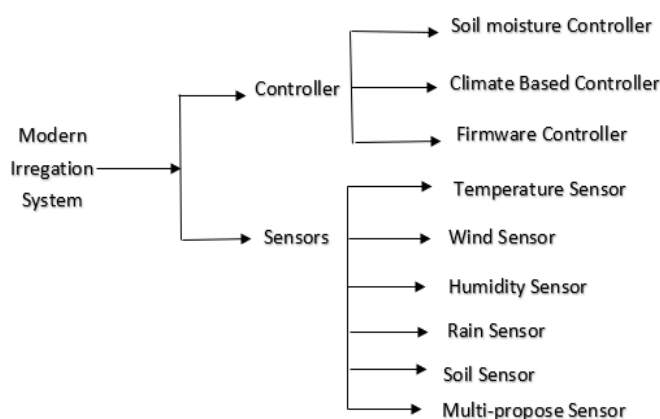


Figure 1: Various controller and sensors in Smart irrigation system

The main outcome of the modern smart irrigation system is reducing the water usage, money and increase the yields. The automated smart irrigation system used different recent technologies such as artificial intelligence and machine learning [5], big data [7], IoT [9], wireless sensor network [6], and cloud computing [8] etc. The main components of smart irrigation systems are computation techniques, sensors, automatic controllers, satellite data, flow meters and valves, WSN and battery, etc. The general representation of the modern irrigation system shown in figure 2. The modern irrigation system having different steps such as i. Real-time

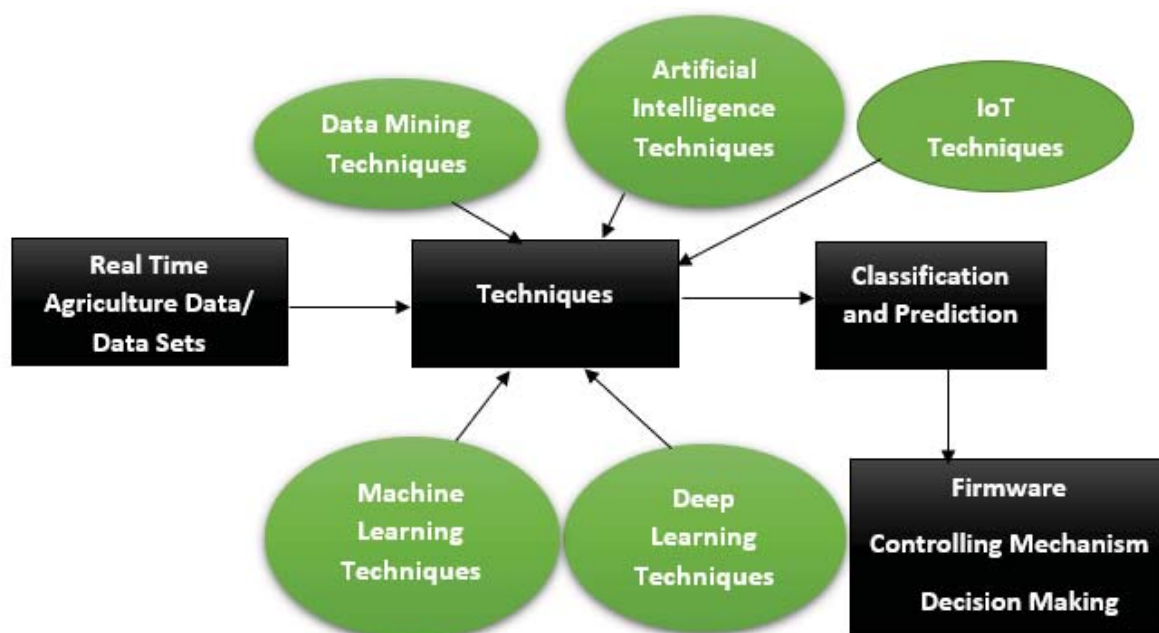


Figure 2: Modern irrigation system

data collection ii. Applying techniques iii. Classification and prediction iv. Controlling and decision making.

The organization of the paper is consisting of section 2 having various comparison parameters, section 3 has various smart irrigation techniques using artificial intelligence and IoT, section 4 having issues, challenges, and future direction, and finally the conclusion.

II. VARIOUS PARAMETERS OF SMART IRRIGATION

Various parameters are used to measure the effectiveness of the smart irrigation system. The smart irrigation system consists of soil management and water management. Soil management having different parameters such as soil moisture, soil temperature, conditions of soil and dryness of the soil, etc. The water management having different parameters such as dew point temperature, Evapotranspiration, air temperature, wind temperature, and humidity. Apart from those parameters the accuracy of prediction, rate of data transfer, effective usage is the other parameters to consider in the smart irrigation model. The trending formula for measuring soil management and water management are as follows [10].

Gravimetric contents of soil = $\frac{\text{Volume of soil moisture} - \text{Volume of oven-dried soil}}{\text{Volume of oven-dried soil-dried soil}}$

Volumetric contents of soil water = $\frac{\text{Volume of Water}}{\text{Volume of Soil}}$

Moisture of the Soil = $\frac{\text{weight of the moisture of the soil} - \text{Weight of the dried Soil}}{\text{weight of the dried Soil}}$

Beyond these, different formula and equations are used for getting aggregate, mean, and prediction of present and future values.

III. VARIOUS SMART IRRIGATION TECHNIQUES

Various techniques and methods are used to manage smart irrigation. The recent smart irrigation techniques based on IoT, Artificial Intelligence, Deep Learning, and machine learning. With the help of these techniques can manage the weather, soil management, water management, and multi-parameters. This section gives a brief summary of information about various prediction and management techniques of irrigation systems. The authors of [11] proposed IoT based sprinkling irrigation system. In this system solar panel is connected to the water tank and which is incorporated with a level indicator. The authors of [12] proposed a statistical analysis method for managing water using temperature, moisture, and PH. This application is used in a small farm and small size land. The authors of [13] proposed an automated model to manage water irrigation with the help of IoT components. Using this system, water is pooled to the soil but different parameters are considered for water management. The authors of [14] proposed an IoT based autonomous system to manage irrigation system using different components such as Raspberry pi 3, WIFI node, and microcontroller. If water shortage raised, immediately supplied to the ground. The authors of [15] proposed an IoT model for monitoring soil moisture using losant platform. The authors of [16] proposed a model for a low-cost smart irrigation system using MQTT protocol to transfer predicted data using sensors. Depending on the soil moisture, the node MCU-12E controller controls the water pump action. The authors of [17] proposed a model

for monitor and analyzing the crop environment using IoT. Using this model efficiently solves the problems of the former and save power, money, and time. The authors of [18] proposed an M2M deployment model to control irrigation. The M2M manages irrigation sprinklers. The temperature, humidity, and other information are extracted from the soils. The metrological parameters also used to decide the irrigation sprinklers. The authors of [19] automated irrigation system based on soil management. Based on the soil water requirements, the microcontroller pump the water. The authors of [20] proposed an automated fertigation system using IoT. In this system SQLite database used to display the GUI interface. The microcontroller, interface, control, and communication system used to manage the automated fertigation.

Table 1: Components and Advantages of various methods

| References | Components | Advantages |
|----------------------------|--|---|
| [11] Johar R. et al., | Solar system and IoT | Water consumption and electricity reduced. |
| [12] Gupta A. et al., | ATMega 8 microcontroller and Sensors | Water management and power managed |
| [13] Gulati A et al., | Es-8266 WIFI module chip used to manage water. | Water is managed using IoT |
| [14] Imteaj A et al., | Automated irrigation system using Raspberry P1. [Microcontroller, WIFI module, GSM, and rely board] | Water shortage is noticed and supplied immediately. |
| [15] Kodali R.K. et al., | Soil moisture calculated using ESP-8266 microcontroller, and moisture sensor. | Real time soil moisture calculated using small circuit. |
| [16] Kodali R.K. et al., | Water managed using soil sensor, ESP-8266, node MCU-12 E, and MQTT for data transfer. | Measure the soil moisture and to the pumping of water. |
| [17] Wasson T. et al., | Monitor and analysis crop environment using RFID technology and sensors. | Saved the power, time and money. |
| [18] Reche A. et al., | The M2M deployment model used to control and uses metrological parameters and characteristics are used to manage the soil. | Manage the irrigation of sprinklers. |
| [19.] Padalalu P . et al., | Monitor the soil water level based on microcontroller (Atmega 328) and | Based on the recombination, water is supplied. |

| | | |
|--------------------------------|---|--|
| | Naive bayes algorithm used to decision making. | |
| [20] Abidin S et al., | Microprocessor, Web-GUI and control communication system managed automated fertigation. | Monitor and manages the farms using Mobile applications. |
| [21] Krishna K.L. et al., | Raspberry Pi 2 and intelligence robot used to monitor the soil and other parameters. | Monitor the irrigation environment fields and various parameters are observed |
| [24] Guruprasadh, J.P. et al., | ZigBee Modules used to monitor the soil issues. | The soil deficiency alert transferred to the farmer. |
| [25] Raut R. et al., | ARM7 LPC2138 processor, 1185 SunRom color sensor, UART, and Solenoid Valves. | checked the amount of the three major macronutrients, nitrogen (N), phosphorus (P), and potassium (K), in the soil. |
| [27] J. Gutiérrez. et al., | Wireless sensor unit, wireless information unit, and web application are used to smart irrigation system. | Automated system was developed for water optimization. |
| [28] Köksal, Ö. et al., | Advanced Message Queuing Protocol, Data Distribution Service, and Constrained Application Protocol used for farm management information system. | Using this method data acquisition and processing, monitoring, planning, decision making, documenting, and managing the farm operations. |
| [29] Cambra Baseca C. et al., | The IoT based application used to manage and monitor the real time events in the fertirrigation system. | Various events such as wind flow, irrigation events, pressure levels are monitored and decision performed. |
| [30] Amarendra Goap . et al., | Using IoT and machine learning soil temperature, soil moisture, air temperature, Ultraviolet (UV) light radiation, and relative humidity are monitored. | Intelligence system used to perform the smart decision making. |
| [31] Khoa TA et al., | IoT and multi-sensor system | Using this system managed the water. |

The authors of [21] proposed an application for implementing a mobile boat robot for sensing soil moisture and other various parameters of the environment. The authors of [22] proposed an IoT and wireless sensor network application to improve the efficiency of irrigation. In this method, the software and hardware used to expand the operation using Zigbee node, sensor, and green land. The authors of [23] proposed a model for automatic irrigation and soil PH using a sensor and microcontroller. The authors of [24] proposed a system for an intelligent sensor network for sensing soil moisture and finding nutrients deficiency of soil. using this method deficiency alerts are sent to farmers. The authors [24] proposed a system using IoT, checked the nitrogen, phosphor, and potassium. using these parameters saved money, time, and power. The authors of [26] proposed a model for data acquisition and task management for the decision making of the smart farmer. using this method, task management, planning, and environmental factors are measured. The authors of [27] proposed a model for optimizing water using various components such as wireless sensor unit, wireless information unit, and web application. The authors of [28] presented various protocols and hardware unit to manage the farm. The authors of [29,30] proposed a model for managing farms and a smart decision system for water management. The authors [30] proposed open source technologies for smart irrigation using machine learning. In this method, various irrigation events are monitored.

IV. CHALLENGES AND FUTURE DIRECTION OF RESEARCH

A. Challenges

Smart irrigation system facing different issues and challenges in different situations such as building the smart system, communication of data transformation, integration of the hardware, decision making, and data analysis etc. In this section presented various challenges in different situations are as follows.

- i. The integration of sensors is very challenging task because the different sensors are used for different purpose. For example, in the figure 1 mentioned the different sensor for different purpose. The integration of data from the collected nodes is difficult task.
- ii. An IoT based smart system having different layers to data observation, transformation, and integration of the hardware and software. The integration of layers facing problems in cost and implementation.
- iii. Improve the smart irrigation automation system in the following way such as irrigation time, wastage of water, prediction of moisture level in the soil, and the finding the requirements of water and nutrients of soil.
- iv. The IoT based irrigation system needed smart automated microcontroller, so smart irrigation effective infrastructure, automated switches, automated pump are need for better automations.
- v. Multi- events such as climate parameters (Soil parameters, moisture, humidity, rain fall timing and

future time fall prediction) are important to consider in implementation of smart irrigations.

- vi. The role of LED indication, smart mobile based indication and connectivity to consider in implementation.
- vii. The decision making based on the past data and future data prediction is important to consider in implementation.

Those are the some of the general challenges are faced in the implementation of smart irrigation system. The main research gap of various existing works is shown below.

- i. The authors of [11-20] presented optimization methods in either managing soil moisture or water.
- ii. For Water optimization, multi-nodes are not introduced in the various existing methods [31].

B. Future direction of Research

The current research in smart irrigation system needed further improvement because new automatic decision-making systems are introduced using IoT, Big Data, artificial intelligence and machine learning etc.

- i. Future Data Prediction: In smart irrigation, future data prediction is an important task. But the most of the previous works summarized in the survey work [32] not present future data management in smart irrigation system.
- ii. Infrastructure and integration of weather prediction in smart irrigation not presented and implemented.
- iii. Past, present and future data analysis and predictions in the smart irrigation using IoT, Big data and artificial intelligence techniques are help to take decision making.
- iv. Need to improve the Sustainable smart irrigation Systems.
- v. Frequency and new form of the Data Acquisition.
- vi. The common architecture for designs and implementation for IoT Irrigation Systems for different crops are needed.
- vii. Best Recommunication system using machine learning and deep learning methods.

V. CONCLUSION

The smart irrigation system is an important research area because future of the world facing different short coming in water and energy. In the world, 70% of fresh water is consumed for agriculture. So, water optimization, reducing energy, saving money and increase the yields is an important task in smart irrigation system. In this article presented various components of smart irrigation, functions of each layers in smart irrigation and modern irrigation system is presented. In the section 3 presented various techniques and summarized for further research. The end of the section various challenges and future direction of the research are presented.

REFERENCES

- [1] <https://www.worldbank.org/en/topic/water-in-agriculture>
- [2] Akhras, G. "Smart Materials and Smart Systems for the Future", *Canadian Military Journal*, 08/2000.
- [3] Gubbi, J., Buyya, R., Marusic, S., Palaniswami, M., 2013. Internet of things (IoT): a vision, architectural elements, and future directions. *Futur. Gener. Comput. Syst.* 29,1645–1660.
- [4] Janani M and Jebakumar R. A Study on Smart Irrigation Using Machine Learning. *Cell Cellular Lif Sci J* 2019, 4(2): 000141.
- [5] Liakos KG, Busato P, Moshou D, Pearson S, Bochtis D (2018) Machine Learning in Agriculture: A Review. *Sensors (Basel)* 18(8): 2674.
- [6] Viani F, Bertolli MG, Salucci M, Polo A (2017) Low-Cost Wireless Monitoring and Decision Support for Water Saving in Agriculture. *IEEE Sensors Journal*.
- [7] Nick Piette (2018) How Big Data is Growing Agriculture.
- [8] Radadiya BL, Thakkar RG, Thumar VM, Chaudhari BD (2016) Cloud computing and agriculture, *International Journal of Agriculture Sciences* 8(22): 1429-1431.
- [9] Gupta A, Krishna V, Gupta S, Aggarwal J (2016) Android based Solar Powered Automatic Irrigation System. *Indian Journal of Science and Technology* 9(47).
- [10] <https://eos.com/blog/soil-moisture-control-is-an-essential-farming-constituent/>.
- [11] Johar, R.; Bensenouci, A.; Benesouci, M. IoT based Smart Sprinkling System. In Proceedings of the 15th Learning and Technology Conference, Jeddah, Saudi Arabia, 25–26 February 2018.
- [12] Gupta, A.; Krishna, V.; Gupta, S.; Aggarwal, J. Android based solar powered automatic irrigation system. *Indian J. Sci. Technol.* 2016, 9, 1–5.
- [13] Gulati, A.; Thakur, S. Smart Irrigation using Internet of Things. In Proceedings of the 8th International Conference on Cloud Computing, Data Science & Engineering (Confluence), Noida, India, 11–12 January 2018.
- [14] Imteaj, A.; Rahman, T.; Hossain, M.K.; Zaman, S. IoT based Autonomous Percipient Irrigation System using Raspberry Pi. In Proceedings of the 19th International Conference on Computer and Information Technology (ICCIT), Dhaka, Bangladesh, 18–20 December 2016.
- [15] Kodali, R.K.; Sahu, A. An IoT based Soil Moisture Monitoring on Losant Platform. In Proceedings of the 2nd International Conference on Contemporary Computing and Informatics (IC3I), Noida, India, 14–17 December 2016.
- [16] Kodali, R.K.; Sarjerao, B.S. A Low Cost Smart Irrigation System using MQTT Protocol, In Proceedings of the 2017 IEEE Region 10 Symposium (TENSYP), Cochin, India, 14–16 July 2017.
- [17] Wasson, T.; Choudhury, T.; Sharma, S.; Kumar, P. Integration of RFID and Sensor in Agriculture Using IoT. In Proceedings of the International Conference on Smart Technologies For Smart Nation, Bangalore, India, 17–19 August 2017.
- [18] Reche, A.; Sendra, S.; Díaz, J.R.; Lloret, J. A Smart M2M Deployment to Control the Agriculture Irrigation. In Proceedings of the ADHOC-NOW 2014: International Conference on Ad-Hoc Networks and Wireless, Benidorm, Spain, 22–27 June 2014.
- [19] Padalalu, P.; Mahajan, S.; Dabir, K.; Mitkar, S.; Javale, D. Smart Water Dripping System for Agriculture/Farming. In Proceedings of the 2nd International Conference for Convergence in Technology (I2CT), Mumbai, India, 7–9 April 2017.
- [20] Abidin, S.A.H.Z.; Inrahim, S.N. Web-based Monitoring of an Automated Fertigation System: An IoT Application. In Proceedings of the IEEE 12th Malaysia International Conference on Communications, Kuching, Malaysia, 23–25 November.
- [21] Krishna, K.L.; Silver, O.; Malende, W.F.; Amuradha, K. Internet of Things Application for Implementation of Smart Agriculture System. In Proceedings of the 2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), Palladam, India, 10–11 February 2017.
- [22] Qi, D.; Li, G.; Dai, X. Design of Urban Greening Intelligent Monitoring System based on Internet of Things Technology. In Proceedings of the 2017 9th International Conference on Intelligent Human-Machine Systems and Cybernetics (IHMSC), Hangzhou, China, 26–27 August 2017.
- [23] Kumawat, S.; Bhamare, M.; Nagare, A.; Kapadnis, A. Sensor based automatic irrigation system and soil pH detection using image processing. *Int. Res. J. Eng. Technol.* 2017, 4, 3673–3675.
- [24] Guruprasadh, J.P.; Harshananda, A.; Keerthana, I.K.; Krishnan, K.Y.; Rangarajan, M.; Sathyadevan, S. Intelligent Soil Quality Monitoring System for Judicious Irrigation. In Proceedings of the 2017 International Conference on Advances in Computing, Communications and Informatics (ICACCI), Udupi, India, 13–16 September 2017.
- [25] Raut, R.; Varma, H.; Mulla, C.; Pawar, V.R. Soil monitoring, fertigation, and irrigation system using IoT for agricultural application. *Intell. Commun. Comput. Technol. Lect. Notes Netw. Syst.* 2017, 19, 67–73.
- [26] Suakatnto, S.; Engel, V.J.L.; Hutagalung, M.; Angela, D. Sensor Networks Data Acquisition and Task Management for Decision Support of Smart Farming. In Proceedings of the 2016 International Conference on Information Technology Systems and Innovation (ICITSI), Bandung, Bali, 24–27 October 2016.
- [27] J. Gutiérrez, J. F. Villa-Medina, A. Nieto-Garibay and M. Á. PortaGándara, "Automated Irrigation System Using a Wireless Sensor Network and GPRS Module," in *IEEE Transactions on Instrumentation and Measurement*, vol. 63, no. 1, pp. 166-176, Jan. 2014.
- [28] Köksal, Ö., Tekinerdoğan, B. Architecture design approach for IoT-based farm management information systems. *Precision Agric* 20, 926–958 (2019). <https://doi.org/10.1007/s11119-018-09624-8>.
- [29] Cambra Baseca C, Sendra S, Lloret J, Tomas J. A Smart Decision System for Digital Farming. *Agronomy*. 2019; 9(5):216. <https://doi.org/10.3390/agronomy9050216>
- [30] Amarendra Goap, Deepak Sharma, A.K. Shukla, C. Rama Krishna, An IoT based smart irrigation management system using Machine learning and open source technologies, *Computers and Electronics in Agriculture*, Volume 155, 2018, Pages 41-49.
- [31] Khoa TA, Man MM, Nguyen T-Y, Nguyen V, Nam NH. Smart Agriculture Using IoT Multi-Sensors: A Novel Watering Management System. *Journal of Sensor and Actuator Networks*. 2019; 8(3):45. <https://doi.org/10.3390/jsan8030045>.
- [32] García L, Parra L, Jimenez JM, Lloret J, Lorenz P. IoT-Based Smart Irrigation Systems: An Overview on the Recent Trends on Sensors and IoT Systems for Irrigation in Precision Agriculture. *Sensors*. 2020; 20(4):1042. <https://doi.org/10.3390/s20041042>