Precision Irrigation Model For Agriculture Using Intelligent Iot

R.Thiagarajan[1], N.Sripriya [2]

[1]Professor, Department of Information Technology, Prathyusha Engineering College,
Email: rthiyagarajantpt@gmail.com
[2]Assistant Professor, Department of CSE Prathyusha Engineering College,
Email: narasimhan.sripriya@gmail.com

Received: 07.04.2024 Revised : 14.05.2024 Accepted: 22.05.2024

ABSTRACT
The critical importance of water management arises from its scarcity, affecting not only domestic and industrial sectors but also agriculture, which demands a significant proportion of new water for irrigation purposes. Various methods of irrigation have been recognized, including flood, spray, and drip irrigation. The planning of irrigation requires careful consideration of several agricultural factors, such as temperature, humidity, and soil moisture, which are commonly observed.Sensor data will trigger the irrigation system to start watering the agricultural land. The collected data and images are sent to IoT platform like Blynk, and the IoT application acts as the intermediary between the host and the devices. It manages connections and authorizations between smartphones and microcontroller, while also continuously monitoring the board to collect data at regular intervals. The sensor information was collected by Arduino UNO, and the acquired data was presented in a Graphical User Interface (GUI) to provide agricultural field data.The suggested approach for determining irrigation needs for each crop is by utilizing machine learning. The system is highly recommended, and the proposed system aims to achieve several primary objectives. The first objective is to develop a soil condition monitoring system that comprises a sensor array and a wireless communication module for transmitting soil conditions from weather stations. Secondly, the use of low-cost IoT allows for the monitoring of weather conditions through weather stations, while soil conditions are gathered through various soil sensor nodes. Thirdly, the system focuses on identifying the most effective ML technique for forecasting irrigation needs, even in unpredictable climatic conditions. Finally, the IoT is utilized to remotely monitor and store soil and weather data from weather stations with optimal computational cost.

Keywords: low-cost, IoT, temperature, humidity, soil moisture.

INTRODUCTION

In certain regions of the world, agriculture may account for as much as 70 percent of total freshwater use [1]. This underscores the need of effective water management in ensuring that people everywhere have access to sufficient and healthy food and water. Irrigation methods and crop-growth methods used in the field play crucial roles in this process. Water stress, which may be induced by under-irrigation, can lead to a loss of yield, hence farmers often spray more water than is strictly required to prevent this. However, this leads to not just productivity issues but also water and energy waste. Precision irrigation, on the other hand, has the potential to make more effective use of water, avoiding both under- and over-watering of a plant's roots and leaves. Smart water management for precision irrigation in farming is crucial for increasing agricultural yields while decreasing costs and helping the environment in the long run. Population growth has created an urgent need for more food to be produced [5], and as a consequence, agriculture now consumes over 85 percent of the world's freshwater.

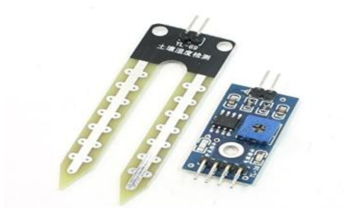

Fig. 1 Moisture Sensor

The conventional method of managing irrigation is plagued with issues, such as wasteful water usage and low productivity. Furthermore, the availability of rainfall necessary to provide water for plants is regularly impacted by the dynamics of climate change and global warming [2,3]. The reason for this is that global warming is raising the average temperature of the Earth. Similarly, plant species have different water requirements and go through different physiological processes depending on the time of year and other environmental factors like the weather. When compared to an open field farm [4], where it is more difficult to regulate environmental variables, the greenhouse environment is easier to control. Adaptive management of the ever-changing environmental conditions requires the use of precision irrigation systems. The Internet of Things [2] seems like the obvious choice for uses like smart water management, even if the integration of the numerous technologies required to make it work seamlessly in practice is not yet complete.

The emergence of the Internet of Things may be attributed to a confluence of events. These include high-performance computing resources in commodity platforms, computational intelligence algorithms, and the availability of cloud data centers for storage and processing. Other factors include management frameworks for dealing with unstructured data from social networks. Reasons for this trend include the widespread availability of low-cost devices, the development of efficient wireless technologies, and the advent of cloud data centers for data storage and processing. There are now a number of challenges that prevent the widespread use of IoT technology for precision irrigation. To begin, the development of software for Internet of Things-based smart applications like agricultural irrigation is not yet fully automated [3]. Second, the deployment of pilot applications for smart water management is hampered by the absence of advanced IoT software platforms, which would allow for the automation of a portion of the process and the integration of multiple technologies. These technologies include IoT, big data analytics, cloud computing, and fog computing. Thirdly, appropriate information models and standards are required for the integration of current and different sensors.

Several IoT and ML-based irrigation systems have been developed for this objective of monitoring and regulating irrigation systems. Each sprinkler in a newly developed sprinkler irrigation system is equipped with sensors and an energy module. Another program uses an online connection and a moisture sensor to keep track of soil moisture [8], while a third uses environmental factors like temperature and humidity to calculate when plants need watering and uses machine learning to analyze the resulting data [6]. Although ground water is the fundamental engine of societal and economic progress, a large portion of this resource is used for agricultural reasons. Over the last two decades, artificial intelligence (AI) and machine learning (ML) have expanded their reach into a wide variety of industries, including agriculture. ML has been used to make predictions about the flow of rivers and the quality of water [9]. Effective water management is crucial because of the scarcity of the resource. Since agriculture also uses a significant portion of the fresh water supply for irrigation, this has consequences for that industry as well. In addition to flood irrigation, which is the most widespread kind of irrigation in India, other types of irrigation including as drip irrigation, spray irrigation, and nebulizer irrigation have been identified. The soil's temperature, humidity, and moisture content are among the most crucial agricultural parameters to consider while making irrigation plans. Most of the existing irrigation management systems use on open-source platforms, with Arduino often serving as the principal board [10].

BACKGROUND STUDY

In recent years, there has been much discussion regarding the possible uses for integrating IoT with cloud computing and big data analytics. Europe is very curious in the challenges and persuasive impacts of IoT in large-scale pilot programs for smart agriculture. The agrifood areas of dairy, fruit, arable crops, and the meat and vegetable supply chain are addressed by Brewster et al. [12], along with large-scale pilots for the Internet of Things in agriculture, as well as technologies and solutions that may be available in these areas. Machine learning, a subfield of AI, allows computers to acquire new capabilities without being explicitly programmed to do so [16].

Intelligent machine learning methods have developed as a beneficial intelligence-based decision-making tool for the sustainable and rational use of freshwater resources within the framework of sustainable accuracy irrigation management. Until recently, farmers depended only on their gut feelings to choose whether or not to irrigate, but advances in machine learning have made it feasible to factor in predictions of weather and soil conditions. The ability to anticipate water needs, yield, and soil moisture content improves management [18]. Irrigation plans rely heavily on predictions. The goal of machine learning, a subfield of artificial intelligence, is to give machines the ability to learn and do activities that humans would normally handle [19]. It is capable of solving issues involving intricate irrigation systems by factoring in non-linear, time-dependent factors [21]. Algorithms based on machine learning may be used for gathering new information in the form of general decision rules that can be used to irrigation operations that make efficient use of natural resources like water. Machine learning methods including reinforcement learning, supervised learning, unsupervised learning, and federated learning have been more popular in precision irrigation management for solving complicated issues like classification and prediction [20].

Machine learning makes use of pre-written code to draw conclusions from data. In the same way that humans learn through experience and trial, machine learning algorithms do the same. The building blocks of a machine learning system are as follows [11]: raw data, data preparation, ML algorithms, generalization, and decision making. One of the most important applications of machine learning is data mining. In [13], the authors discuss many important supervised learning algorithms in ML, such as the decision tree, neural networks, and instance-based learning. Machine learning allows for far quicker decision making than humans are capable of. The essay covers a wide range of pedagogical methods, from role playing to analog learning to discovery learning. Banking, telecommunications, marketing, and network research are just few of the many [17] applications of ML. Machine learning is a branch of AI that gives computers the ability to learn new skills via practice and trial-and-error. ML provides an answer in accordance with a fixed set of rules, as opposed to the likelihood-based statistical method. Knowledge is acquired by machine learning systems via the study of previously processed data. Learning machine techniques may be roughly classified into three broad categories: supervised, unsupervised, and reinforcement. Classification and regression are examples of supervised learning, whereas clustering and anomaly detection are examples of unsupervised learning [15].

METHODOLOGY

A supervised learning model known as linear regression consists of dependent (target) variables that are predicted from a collection of independent (predictor) variables. These variables give a prediction of output in accordance with the variables that were input. Linear regression and logistic regression are the two types of regression algorithms that are used the most to assist choices on irrigation. The multilinear regression model is another form of linear regression that consists of an equation for prediction and estimate of the difference between the fitted value and the reference value. This equation is indicated by the number 1, and it is shown below.

$$\hat{y} = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_n x_{in}$$

In recent years, there has been much discussion regarding the possible uses for integrating IoT with cloud computing and big data analytics. Europe is very curious in the challenges and persuasive impacts of IoT in large-scale pilot programs for smart agriculture. The agrifood areas of dairy, fruit, arable crops, and the meat and vegetable supply chain are addressed by Brewster et al. [12], along with large-scale pilots for the Internet of Things in agriculture, as well as technologies and solutions that may be available in these areas. Machine learning, a subfield of AI, allows computers to acquire new capabilities without being explicitly programmed to do so [16].

Intelligent machine learning methods have developed as a beneficial intelligence-based decision-making tool for the sustainable and rational use of freshwater resources within the framework of sustainable accuracy irrigation management. Until recently, farmers depended only on their gut feelings to choose whether or not to irrigate, but advances in machine learning have made it feasible to factor in predictions of weather and soil conditions. The ability to anticipate water needs, yield, and soil moisture content improves management [18]. Irrigation plans rely heavily on predictions. The goal of machine learning, a subfield of artificial intelligence, is to give machines the ability to learn and do activities that humans would normally handle [19]. It is capable of solving issues involving intricate irrigation systems by factoring in non-linear, time-dependent factors [21]. Algorithms based on machine learning may be used for gathering new information in the form of general decision rules that can be used to irrigation operations that make efficient use of natural resources like water. Machine learning methods including reinforcement learning, supervised learning, unsupervised learning, and federated learning have been more popular in precision irrigation management for solving complicated issues like classification and prediction [20].

Machine learning makes use of pre-written code to draw conclusions from data. In the same way that humans learn through experience and trial, machine learning algorithms do the same. The building blocks of a machine learning system are as follows [11]: raw data, data preparation, ML algorithms, generalization, and decision making. One of the most important applications of machine learning is data mining. In [13], the authors discuss many important supervised learning algorithms in ML, such as the decision tree, neural networks, and instance-based learning. Machine learning allows for far quicker decision making than humans are capable of. The essay covers a wide range of pedagogical methods, from role playing to analog learning to discovery learning. Banking, telecommunications, marketing, and network research are just few of the many [17] applications of ML. Machine learning (ML) is a branch of AI that gives computers the ability to learn new skills via practice and trial-and-error. ML provides an answer in accordance with a fixed set of rules, as opposed to the likelihood-based statistical method. Knowledge is acquired by machine learning systems via the study of previously processed data. Learning machine (ML) techniques may be roughly classified into three broad categories: supervised, unsupervised, and reinforcement. Classification and regression are examples of supervised learning, whereas clustering and anomaly detection are examples of unsupervised learning [15].

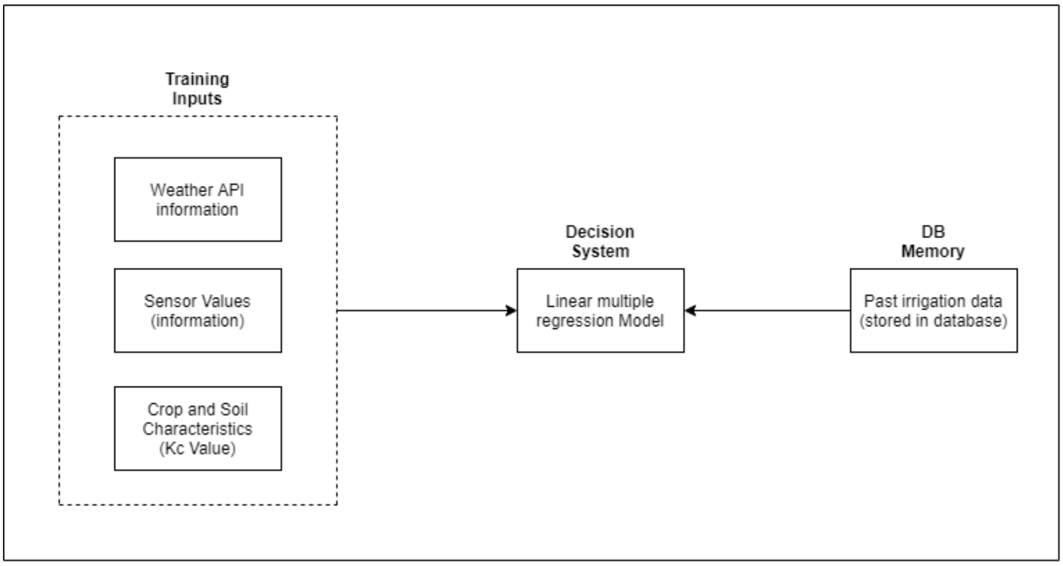

Fig.2 Methodology of proposed system

IMPLEMENTATION RESULTS

There are 500 records in the dataset, with 100 entries for each soil and weather parameter (100 rows and 5 columns). The five columns of data represent different aspects of soil and meteorological conditions: air temperature, humidity, wind speed, volumetric moisture content, and soil temperature. A new sixth column, "Decision," is added to the database to indicate whether or not rice and wheat should be irrigated given the current soil and weather circumstances. Environmental and meteorological data from the farm, including ETo, rainfall, air temperature, and humidity, are collected through sensors used for irrigation control. These records are uploaded to a cloud server database after passing via the gateway.

```
from pyfirmata import Arduino,util
import time


def smart_irrigation(moisture,key):
    board = Arduino('COM4')
    iterator = util.Iterator(board)
    iterator.start()
    board.digital[4].write(0)
    value = board.get_pin('a:0:i')
    print("Machine Started")

    while key == 1 :
        time.sleep(1.0)
        print(value.read())
        if(value.read()<moisture):
            print("Moisture")
            board.digital[4].write(0)
        else:
            print("NO Moisture")
            board.digital[4].write(1)
```

Fig. 3 Irrigation module

Farmers may utilize the patterns of soil, plant, and weather data that are provided to remotely regulate water valves, fans, and other controls through apps by using the data that is shown. These controls are modifiable according to the patterns in the data. There have been a number of various ways in which people have rethought the concept of using mobile technology to aid with agricultural tasks. Top-down services provide a method of material distribution in which the aims of a designer serve as the main determinant of what is given. Top-down services are provided by companies like Amazon and Google. Customers have the option to subscribe to many kinds of services in order to get agricultural tips and seasonal reminders. One such service is SMS push-alerts, which is an example of this kind of service. These programs have the advantage of giving farmers with access to the most current agricultural research and introducing new themes; nevertheless, they do not have the flexibility to address challenges that are special to the circumstances of each individual farmer. Before the advent of information technology, farmers were required to physically examine their plants while they were working on their fields and to determine the amount of moisture present in the soil. This was carried out at the same time as an ongoing survey of the surrounding air temperature.

Table 1: Weather conditions (https://www.worldweatheronline.com)

	Time	Friday	Saturday	Sunday
Temperature	3:00 AM	12°C	12°C	11°C
	12:01 PM	21°C	22°C	22°C
Humidity	3:00 AM	50%	44%	33%
	12:01 PM	26%	22%	20%
Wind speed	3:00 AM	4 kmph	9 kmph	8 kmph
	12:01 PM	10 kmph	8 kmph	9 kmph

The Internet of Things has made it possible for data to be gathered from a variety of sensors, such as the moisture content of the soil, soil and air temperature, humidity, and plant factors such as the vegetation index, and then examined remotely. This was made possible as a result of recent developments in the field of wireless sensor networks. It is possible to assemble all of this data by using a gateway, and then store it on cloud databases thereafter. Because of the cloud platforms and databases that are already accessible, an integrated machine learning model has the ability to learn and relearn new information. This makes it possible for the model to discover patterns and linkages between the observed data that were previously concealed. In ecologically responsible precision irrigation management, the processing and display of sensor data are particularly significant components. MATLAB is providing this as an extra open-source data visualization tool, and it has been shown already. It has been put to use in the field of irrigation management for prototype applications. The cultivation of date palms and cucumbers has benefited from its use in the management of irrigation systems.

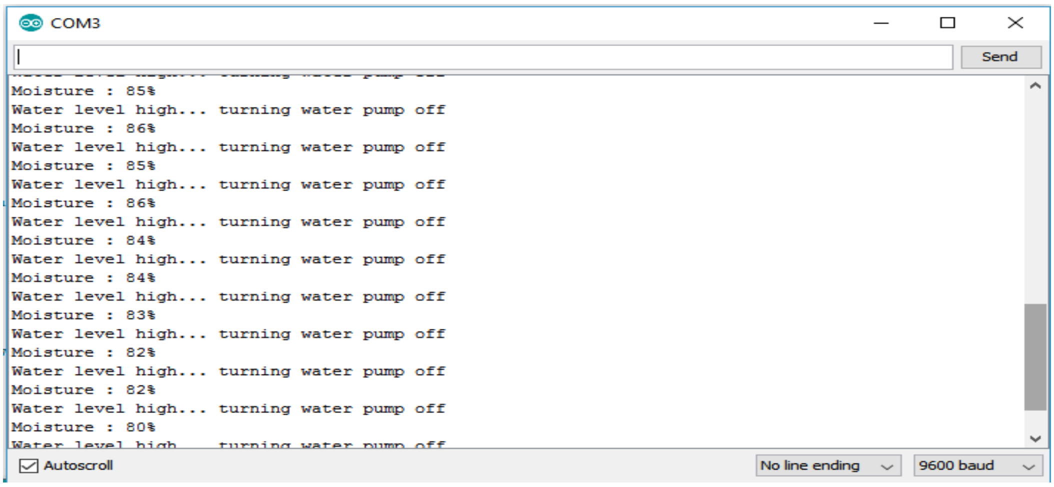

Fig. 4 Irrigation and moisture notifications

Table 2. Accuracy predictions of proposed model compared with existing models

Algorithm	Accuracy
LR	82.5
SVM	62.8
KNN	84.24
DT	85.6
NB	84.9
LDA	92

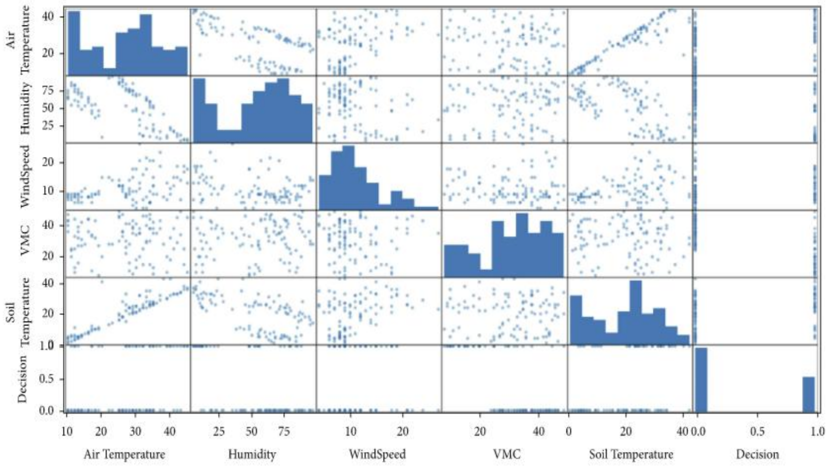

Fig 5. Variant plot for proposed weather and soil conditions

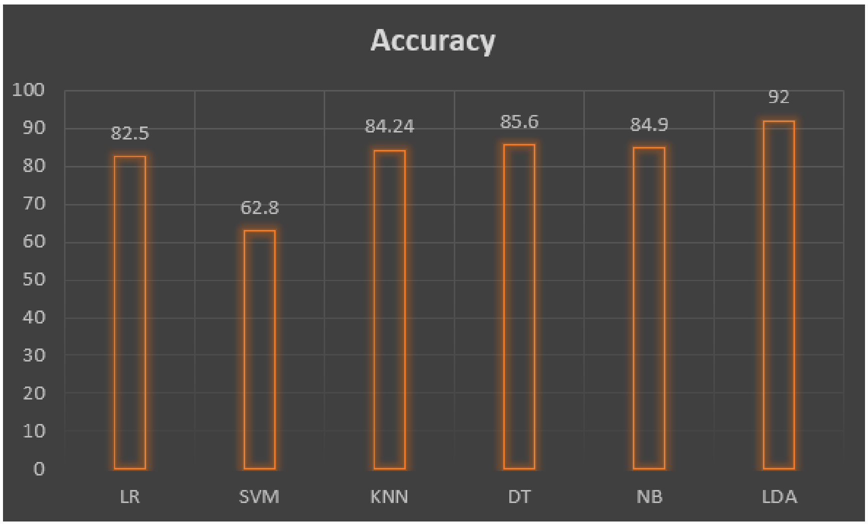

Fig 6. Visualization of performance metric comparison

CONCLUSION

Incorporating cutting-edge technology like as machine learning, the internet of things, the web, and the mobile framework has been an essential component in the successful implementation of sustainable precision irrigation. According to the findings of this study, adopting sustainable precision irrigation management may be one way to assist in the process of achieving food security and preventing water shortages. There are many different models for irrigation, but they all ignore either essential technical or agricultural elements. Within the scope of this research, we propose a decision-support system for irrigation that is high-tech, knowledge-based, and long-range scalable. The configuration that was presented makes an attempt to overcome the issues that are present in the currently available automated irrigation systems while maintaining a low cost. For the purpose of designing the recommended irrigation system, we monitor both the weather and the soil. Because the soil sensor nodes use a scalable, long-range communication technology that consumes a minimal amount of power, systems are now able to monitor larger regions with a higher degree of accuracy. The Internet of Things cloud eliminates the need for the local storage and display of data pertaining to the climate and the soil. A ML technique that is informed by past information is used throughout the decision-making process for irrigation. The accuracy of six different machine learning (ML) systems, both linear and nonlinear, is calculated using the observed information in order to estimate irrigation needs. It was discovered that the LDA approach had the maximum efficiency, coming in at 92%. Once the machine learning algorithm that produces the best results has been selected, a number of different soil and weather variables are analyzed in order to ensure that the best judgments are made. Before determining whether or not to irrigate, the intelligent irrigation decision support system is able to do an accurate assessment of the agricultural soil as well as the climatic circumstances. This is made possible by the Internet of Things.

REFERENCES

[1] Talaviya, T.; Shah, D.; Patel, N.; Yagnik, H.; Shah, M. Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides. Artif. Intell. Agric. 2020, 4, 58–73.

[2] Afzaal, H.; Farooque, A.A.; Abbas, F.; Acharya, B.; Esau, T. Precision irrigation strategies for sustainable water budgeting of potato crop in Prince Edward Island. Sustainability 2020, 12, 2419.

[3] Pereira, R.M.S.; Lopes, S.; Caldeira, A.; Fonte, V. Optimized planning of different crops in a field using optimal control in Portugal. Sustainability 2018, 10, 4648.

[4] Zinkernagel, J.; Maestre-Valero, J.F.; Seresti, S.Y.; Intrigliolo, D.S. New technologies and practical approaches to improve irrigation management of open field vegetable crops. Agric. Water Manag. 2020, 242, 106404.

[5] Benyezza, H.; Bouhedda, M.; Djellout, K.; Saidi, A. Smart irrigation system based Thingspeak and Arduino. In Proceedings of the 2018 IEEE International Conference on Applied Smart Systems(ICASS2018), Medea, Algeria, 24–25 November 2018; pp. 1–4.

[6] Devanand Kumar, G.; Vidheya Raju, B.; Nandan, D. A review on the smart irrigation system. J. Comput. Theor. Nanosci. 2020, 17, 4239–4243.

[7] Bigah, Y.; Rousseau, A.N.; Gumiere, S.J. Development of a steady-state model to predict daily water table depth and root zone soil matric potential of a cranberry field with a subirrigation system. Agric. Water Manag. 2019, 213, 1016–1027.

[8] Gu, Z.; Qi, Z.; Burghate, R.; Yuan, S.; Jiao, X.; Xu, J. Irrigation scheduling approaches and applications: A review. J. Irrig. Drain. Eng. 2020, 146, 04020007.

[9] Togneri, R.; Kamienski, C.; Dantas, R.; Prati, R.; Toscano, A.; Soininen, J.-P.; Cinotti, T.S. Advancing IoT-based smart irrigation. IEEE Internet Things Mag. 2020, 2, 20–25.

[10] Cáceres, G.; Millán, P.; Pereira, M.; Lozano, D. Smart farm irrigation: Model predictive control for economic optimal irrigation in agriculture. Agronomy 2021, 11, 1810.

[11] García, I.F.; Lecina, S.; Ruiz-Sánchez, M.C.; Vera, J.; Conejero, W.; Conesa, M.R.; Domínguez, A.; Pardo, J.J.; Léllis, B.C.; Montesinos, P. Trends and challenges in irrigation scheduling in the semi-arid area of Spain. Water 2020, 12, 785.

[12] Osroosh, Y. Internet of Plants and Plant-Based Irrigation Scheduling. Available online: https://www.duruntashlab.com/post/internet-of-plants-and-plant-based-irrigation-scheduling

[13] Kumar, A.; Surendra, A.; Mohan, H.; Valliappan, K.M.; Kirthika, N. Internet of things based smart irrigation using regression algorithm. In Proceedings of the 2017 International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT) Internet, Kerala, India, 6–7 July 2017; pp. 1652–1657.

[14] Choudhary, S.; Gaurav, V.; Singh, A.; Agarwal, S. Autonomous crop irrigation system using artificial intelligence. Int. J. Eng. Adv. Technol. 2019, 8, 46–51.

[15] González Perea, R.; Camacho Poyato, E.; Montesinos, P.; Rodríguez Díaz, J.A. Prediction of irrigation event occurrence at farm level using optimal decision trees. Comput. Electron. Agric. 2019, 157, 173–180.

[16] Christias, P.; Daliakopoulos, I.N.; Manios, T.; Mocanu, M. Comparison of three computational approaches for tree crop irrigation decision support. Mathematics 2020, 8, 717.

[17] Weller, D.L.; Love, T.M.T.; Wiedmann, M. Interpretability versus accuracy: A comparison of machine learning models built using different algorithms, performance measures, and features to predict E. coli levels in agricultural water. Front. Artif. Intell. 2021, 4, 628441.

[18] Blasi, A.H.; Abbadi, M.A.; Al-Huweimel, R. Machine learning approach for an automatic irrigation system in southern Jordan valley. Eng. Technol. Appl. Sci. Res. 2021, 11, 6609–6613.

[19] Yazici, M.; Basurra, S.; Gaber, M. Edge machine learning: Enabling smart internet of things applications. Big Data Cogn. Comput. 2018, 2, 26.

[20] Vij, A.; Vijendra, S.; Jain, A.; Bajaj, S.; Bassi, A.; Sharma, A. IoT and machine learning approaches for automation of farm irrigation system. Procedia Comput. Sci. 2020, 167, 1250–1257.
[21] C. G. Murthy and T. Chaspari, "Machine learning-based irrigation control optimization," in Proceedings of the 6th ACM International Conference on Systems for Energy-Efficient Buildings, Cities, and Transportation, Association for Computing Machinery, New York, November 2019.
[22] A. Goap, D. Sharma, A. K. Shukla, and C. Rama Krishna, "An IoT based smart irrigation management system using Machine learning and open source technologies," Computers and Electronics in Agriculture, vol. 155, pp. 41–49, 2018.
[23] A. Goldstein, L. Fink, A. Meitin, S. O. Bohadana, and G. Ravid, "Applying machine learning on sensor data for irrigation recommendations: revealing the agronomist's tacit knowledge," Precision Agriculture, vol. 19, no. 3, pp. 421–444, 2018.
[24] S. R. Barkunan, V. Bhanumathi, and J. Sethuram, "Smart sensor for automatic drip irrigation system for paddy cultivation," Computers & Electrical Engineering, vol. 73, pp. 180–193, 2019.
[25] M. N. Rajkumar, S. Abinaya, and V. V. Kumar, "Intelligent irrigation system — an IOT based approach," in Proceedings of the 2017 International Conference on Innovations in Green Energy and Healthcare Technologies (IGEHT), IEEE, Coimbatore, India, March 2017.
[26] D. Mishra, A. Khan, R. Tiwari, and S. Upadhay, "Automated irrigation system-IoT based approach," in Proceedings of the 2018 3rd International Conference On Internet of Things: Smart Innovation and Usages (IoT-SIU), IEEE, Bhimtal, India, Feb. 2018.
[27] P. Rajalakshmi and S. Devi Mahalakshmi, "IOT based crop-field monitoring and irrigation automation," in Proceedings of the 2016 10th International Conference on Intelligent Systems and Control (ISCO), IEEE, Coimbatore, India, Jan. 2016.
[28] S. Rawal, "IOT based smart irrigation system," International Journal of Computer Application, vol. 159, no. 8, pp. 7–11, 2017.
[29] Y. Shekhar, E. Dagur, S. Mishra, and S. Sankaranarayanan, "Intelligent IoT based automated irrigation system," International Journal of Applied Engineering Research, vol. 12, no. 18, pp. 7306–7320, 2017.
[30] S. Talari, M. Shafie-khah, P. Siano, V. Loia, A. Tommasetti, and J. Catalão, "A review of smart cities based on the internet of things concept," Energies, vol. 10, no. 4, p. 421, 2017.
[31] B. Hammi, R. Khatoun, S. A. Zeadally, and L. Khoukhi, "IoT technologiesfor smart cities," IET Networks, vol. 7, no. 1, pp. 1–13, 2018.
[32] X. Feng, F. Yan, and X. Liu, "Study of wireless communication technologies on internet of things for precision agriculture," Wireless Personal Communications, vol. 108, no. 3, pp. 1785–1802, 2019.
[33] J. L. Hatfield and J. H. Prueger, "Temperature extremes: effect on plant growth and development," Weather and Climate Extremes, vol. 10, pp. 4–10, 2015.