A Coast Effective IoT Based Intelligent Irrigation System Using ML algorithm.

Anagha C S and DR. Pranav Mothabhau Pawar

Department of Computer Science,
Birla Institute of Technology and Science, Pilani,
Dubai International Academic City,
Dubai, United Arab Emirates

ABSTRACT

Agriculture contributes to the growth of human civilization. Adequate amount of irrigation needed for healthy crops and to increase productivity. While water scarcity is a major problem the world faces, Agriculture consumes a major portion of fresh water. lot of studies have conducted in automating irrigation without wastage of water. Now machine learning algorithms are also using for automated irrigation systems. This incorporates intelligence to the automated irrigation systems. With the emergence of "M2M (Machine to Machine)" communication technology, devices can communicate each other, data can be sent to cloud or data can be send to server using Internet system. Thus, human intervention for irrigating the plant can reduce to a great extent. Using the Internet of Things (IoT) and ML technologies, Automated water irrigation systems have made for the optimum utilisation of water and thus by reducing the wastage of water. The changing weather conditions also to be monitored since, they contribute to the healthy growth of the plants. We can develop an automated water irrigation System, which uses sensors to collect temperature, water moisture of the soil, humidity and online weather forecast data and uses ML algorithm to automate irrigation. Here we can impart intelligence with the help of ML algorithms to take decision on irrigation.

Key Words: IOT, ML algorithm, Sensors, Irrigation

INTRODUCTION

Agriculture and human civilization have a very tight bond. Cultivation of crops are mandatory for food production, growth of countries economy, to enrich the beauty of the land, etc. Plants contribute to natural air purification. Most of the Countries tries to protect and enhance their green land. But the problem arises with watering them properly and Survival of the changing weather conditions. If plants are not irrigated properly, they cannot survive. While water scarcity is a problem that the world faces, a major portion of fresh water consumed by agriculture. If water wastage can be controlled in agriculture, we can save a great percentage of fresh water. Maintenance of soil moisture is important for the uninterrupted growth of the plant. There are different methods used for irrigation like Sprinkler, drip irrigation etc. The water should be given so that the plant gets adequate amount of water for the uninterrupted growth and productivity of the crop. While maintaining soil moisture, moisture level also should be considered. It should not be over watered or should not be under watered. Soil moisture is also depending on type of the soil, Humidity, rain, temperature etc. In traditional irrigation systems human assess whether the moisture is enough and take decision to irrigate the plant. But we are trying to reduce human intervention in watering and monitoring by automated system. Human labour can be reduced by establishing an automated intelligent irrigation system. The amount of water adequate for the plant can be determined by using a smart irrigation system and thus can reduce the wastage of water as well. For this we can seek

the help of modern technologies like sensors, Internet of Thing (IoT), Machine Learning algorithms. These technologies can contribute for the automation and monitoring of crops without the help of a farmer.

With the high usage of computers and smart devices there exists systems for effective monitoring of corps. There have been conducted studies on crop decease detection and management. When human started to use modern machineries in agriculture and farming his labour reduced a lot. Even though watering and care at the accurate time is a must in caring plants. Watering plants is a time-consuming process. If it could be automated with intelligence, then farmers can utilise their time for other farming activities. Traditional irrigation system does not have intelligence. Which will cause wastage of water or some time the plant may not get adequate amount of water. Smart irrigation system can make decisions on its own when to water and the amount of water required to water the crop. This system can reduce the over watering and under watering problems and thus reduces the plant decease, root rot problems plant drying problems.

Drip irrigation is a water-saving system that slowly spray water into the soil or plant root. This system can reduce the spread and diseases of plants. Drip irrigation is suitable all type of soil. The problem with system is maintenance of the pipe from clogging. But that is not required in short intervals. With the developments in Sensors, IoT (Internet of Things) and ML (Machine Learning) it is possible to innovate a system which can automate and impart intelligence to the irrigation in agriculture. Sensor can utilise to check water moisture in the soil, temperature, humidity etc. Water moisture in soil depend on temperature, humidity, and weather conditions. This data can be used to prevent water wastage by calculating the optimum requirement of water. M2M allows devices to communicate each other without human intervention. IoT comprises of web-enabled smart devices. IoT uses embedded systems, such as processors, sensors, and communication hardware, to collect, send and act on data they acquire from their environments. IoT devices can send the sensor data to other edge device or to a gateway. ML programs concerns with how to automatically improve a model with experience, ML algorithms can learn from data and can use those data to make predictions.

LITERATURE SURVEY

So far, many works have been conducted on Automatic irrigation systems. Different methodologies used in different works. Summary of selected works are as follows.

In paper [1] they to collect soil moisture of the plot. They are Collecting temperature data and predict weather to forecast the irrigation plan for the upcoming week. Here they construct a weekly irrigation plan for plots. In this paper they collect soil moisture of the plot, collects temperature data and predict weather, forecast the irrigation plan for the upcoming week, Construct a weekly irrigation plan for plots using ML algorithms, Predict the required irrigation quantities for each plot thus get succeed in reducing work load of agronomists. They used Regression and classification models. Linear regression model was not giving much success rate for the prediction compared with the agronomist's prediction. But the regression tree model, called gradient boosted regression trees (GBRT) resulted 93% accuracy and boosted trees classifiers (BTC) resulted 95% accuracy. GBRT is considered as one of the most effective and popular models for prediction which gives particularly good accuracy. They required fewer transformations to capture non-linear relations among variables. But are GBRT-based regression trees being more difficult to interpret, being a collection of many regression trees. The models included fifty decision trees. So, they are more difficult to interpret.

The paper [2] discusses about the traditional irrigation systems, ICT based agricultural monitoring, the scope of machine learning in Agriculture and IoT based irrigation systems. In traditional irrigation systems the use of fuzzy logic contributes to decision making. ICT based systems make use of sensors to give information about the field to the farmers. These systems made suggestions and alarms to farmers devices. Using intelligent method, they are trying to irrigate by taking data such as soil moisture and temperature to predict the soil type and turn on the water accordingly. The details of soil conditions and Amount of water irrigated are saved to the cloud and can be assessed by the farmer using his mobile phone. The system uses Arduino as microcontroller and Raspberry Pi3 as processing unit. This system can make intelligence about when to water, rather than watering periodically without using any intelligence. The KNN algorithm used for this study will give high accuracy with less dimensional data. In this project only 2 dimensioned are needed KNN can produce great results in a less time to make decisions.

Another study [3] uses a microcontroller ATMEGA328P on Arduino platform is as control unit. They implemented a system which uses GSM-GPRS SIM900A modem and a web page is created to check for the farmer about the sprinkler status. The GSM modem is used to transfer data obtained from sensors to internet. They tire to avoid over watering and under watering using less human intervention in watering the plant. For this purpose, the experiment setup collects soil moisture. And uses THINGSPEAK open data platform and API to analyse the data and act accordingly with sensor results automatically. Thus, the sprinkler can on and off until desired moisture is obtained. Farmers can check the status and control the water by switching on or off using IoT based system. In this work No ML algorithm applied to incorporate intelligence to the system.

The paper [4] talk about irrigation system using ML algorithm implementation. They more parameters like consider soil moisture, soil temperature, air temperature, Ultraviolet (UV) light radiation, and relative humidity of the crop field. The algorithm considers sensed data and the weather forecast parameters for the near future for impart intelligence to the system. The study found that precipitation and evaporation are major things which contribute to the soil moisture, thermal imaging, Crop Water Stress Index (CWSI), direct soil water measurements, etc.The paper point outs the importance of weather forecasting in irrigation systems. I just creating a system with soil moisture data, there are chances of rain after the watering and thus wastage of water. So they Implemented a system which applies machine learning algorithm on sensor data collected from the field and weather forecast data collected from internet. Prediction of future Soil Moisture Differences (SMD) is done using trained SVR model and the output value of SMD is given as input for k-means clustering to improve the prediction result of soil moisture difference. Soil moisture difference is taken as centroid value of k-means. The result from K-means clustering is used to make the irrigation decision. A real time monitor is implemented for the irrigation management. The system will start and stop irrigation automatically by considering threshold values for starting and stopping. An interface to manage the water pump manually as well as automatically has been provided. The system uses a hybrid algorithm combining Support Vector Regression (SVR) followed by k-means clustering. The SVM will give high accuracy but will not work with large number of datasets. This can be resolved by using K-means clustering which works with large number of datasets. The algorithm can give a good accuracy of 96%.

Another work [5] discusses about the problems faced by chestnut trees in the summer. These trees need optimum irrigation for the fruit productivity. They found the relation between soil, tree and water. They found that the photosynthetic productivity of chestnut trees is depend on the soil moisture. Soil moisture also decides by the nature of the soil, since as per soils nature the water retention rate also changes. The data set used for study are sensor data of soil moisture

of both irrigated and non-irrigated trees, climate conditions, tree leaf and stem moisture data of both irrigated and non-irrigated trees. The regression model uses for the Photosynthetic rate and midday stem water relationship.

The article [6] presents a prototype for automated, IoT and ML based irrigation system using sensor data. The irrigation is done by collecting sensor data such as moisture, temperature, age of the plant, type of the plant, soil etc. of the plant. The sensor values catch by a gateway and send the data to a Raspberry pi. control unit. KNN (K- Nearest Neighbor) machine learning algorithm run in Raspberry pi. To analyse the information, send from the sensor for taking decision on switch on and off the pump. The analysed information send to cloud server and farmers can access them through their mobile handset. The cloud server stores trained data as well. Instead of scheduling the irrigation periodically the system will predict the soil condition for watering based on sensed and trained data and applying ML algorithm. They selected water scheduling parameters are temperature, soil CO2 and humidity sensor value. They used the theta dataset to implement Multifractal Downscaling Model algorithm. This gives a novel approach by resolving heterogeneity in soil moisture.

The paper [7] tries to protect agriculture in urban areas by introducing an automated irrigation system. This algorithm uses rainfall prediction algorithm to predict crops suitable for specific area. They discuss about the wastage of water and power due to the lack of an automated irrigation system. They try to introduce Romyan's method to determine when to switch on irrigation and thus reducing the electricity and water usage. The paper gives a brief description about different type of soils and how they differ in retaining moisture. They use linear regression model to predict rainfall using parameters Mean Temperature(C), Max Temperature (C), Min Temperature(C), Mean Humidity (C), sea Level pressure (hPa) and Wind speed (km/h). Moving average mechanism applied on entire dataset to calculate data points. The methodology used are Time-series Analysis, Artificial Neural Network, Multi Linear Regression. Romyan's algorithm implemented and predict the water requirement. Rainfall prediction gives almost high accurate results. Results shows prediction of moisture requirement for different corps. The methodology seams to be more complex.

Traditional farming results reduced crop production.[8] Water scarcities need to be reduced. Farming consumes 70% of fresh water. The drop irrigation system can reduce a huge amount of water. If intelligence can apply the power and water can be saved. low-cost intelligent system for smart irrigation farming can be developed using IoT and neural networks. The IoT can be used to inform user about the current crop situation. Using MQTT broker data can monitor remotely. MQTT provides fast and light weight message transfer. To make decision for future irrigation schedule using ML algorithms. soil surface evaporation, transpiration from the plant leaves, stems, flowers, etc. Will affect water requirement. Water requirement may vary according to type of plants. The experiment took user data as input for the purpose of estimation of required amount of water. Planting area can divide into zones according to type of crop or moisture. the moisture sensor placed in places where average moisture is present. If different mode of irrigation can impart it will help while random weather changes occur. This drip irrigation system can save up to 67% of water by imparting NN method.

This study [9] make use of IoMT and ML algorithms to construct a smart irrigation system. This system can reduce water wastage with the intelligence applied to the system. This is an automatic irrigation without the human intervention which uses digital image processing and IoMT techniques. The system consists of a set of hardware units along with software programs. Arduino MEGA 2560 is a microcontroller board to link sensor data. ESP8266 chip used to collect information from microcontroller to the server. Soil moisture sensor, humidity and temperature sensors are used to collect environmental data. A light sensor used to link with

temperature sensor data to decide the water requirement during situations such as low light and moderate heat. An ultrasonic sensor used to alert the farmer about remaining water in the water source, thus, to avoid hazard. To avoid water wastage during rainy season, a rain drop sensor added to the system. A relay used to switch on an off the water pump. WEKA (Waikato Environment for Knowledge Analysis) is used for classification. WEKA contains the implementations of various data mining methods of various domains such as classifiers, clustering algorithms, feature selection algorithms, association rules discovery methods, and visualization methods Data set for training set is the data obtained from the sensors. IP cameras has been used to capture images of soil crack and yellowing of leaves to add decision of watering along with other sensor data. ML algorithms used along with digital image processing for this. The Classification Algorithm used are SVM, Convolutional Neural Networks and Random Forest. In Which Neural Network Could give precision 0.96. SVM is giving 0.95. Recall for Neural Network was .80 and SVM is slight difference but also gives recall near to .80. By considering High accuracy Neural Network is best. But if consider training time SVM is the best.

The work [10] talks about site specific farming. This method continuously monitors farm specific soil or plant to enhance the agriculture process. The work integrates IoT, Sensors, Data Analytics and Web interface. Hydroponics farm integrated with sensors to monitor the parameters have used as hardware. Software includes cloud server, analysis of data and ML predictions. Sensors and actuators are installed to monitor and control the parameters of the farm. The sensor values gathered to build the Bayesian Network, to classify and predicts the optimum value in each actuator and autonomously control the hydroponics farm. The model achieves an accuracy of 84.40% and f1-score 84.50%. Accuracy response of sensor data is calculating in this work. Think speak IoT platform used for the dashboard. The Automated system found more productive than manual system as per this study. The problem with this kind of system is high cost. And BN does not Give results as SVM.

This research [11] develop an automated irrigation system which monitor past weather conditions and soil moisture and current weather conditions. The system can reduce human intervention in agriculture by imparting proper irrigation method using ML algorithm. Along with weather data, data from Temperature sensor, Soil moisture sensor, and Light intensity sensor used to make decision with ID3 machine Learning algorithm. ID3 algorithm is resilient to outliers and missing values, they require less cleaning of data than other algorithms. But the performance on external data is not satisfactory.

This work [12] consists of five stages Data acquisition model, online weather data. collection, soil prediction model, real-time monitoring using web interface and IoT based motor controller. Sensors placed at different divisions of the field to cover over all field. Using python code fetches data every 10 minutes. ESP32 node publishes Soil moisture, Humidity, temperature, UV radiation Data collected using specific sensors and Raspberry pi node collect data using MQTT cloud service. sensor data along with weather data of the farm location used to calculate evapotranspiration rate using Penman-Monteith model which contribute to water consumption rate. Which is stored in server. Bagging ensemble learning model applied to predict Soil moisture Using sensor data, whether data and evapotranspiration rate. The idea of Bagging ensemble model is, different samples (with replacement) fit on several models of the dataset. Then, these models are added using their average, weighted average or a voting system. A web inter face used to set the required water threshold value by the user and to monitor real time data. Python code used to start and stop relay switch of the water pump automatically. Ensemble algorithm used for training and testing. Initially, bagging algorithm applied to get the difference between the actual and the predicted soil moisture then compared the predicted

value using SVR and bagging methods. The results show R-square value for Bagging model is highest and MSE of the Bagging model is less while R- square value of SVR is less compared with bagging model and MSE of the SVR model is high.

The problems faced in agriculture sector in Jordan valley [13] because of extreme weather conditions and lack of water resources is solved using artificial intelligence by providing irrigation water to the highest extent possible. Sensor data used to construct the smart irrigation system using traditional drip irrigation system with a pipe control mechanism and ML algorithm for automation. Selected data (Soil Humidity, Soil Type, Soil Salinity, and Temperature) from the data set collected from Directorate of Agriculture of the Southern Jordan Valley analysed using python programming. Data pre-processed from numerical to categorical data to apply DT algorithm. After Training and testing, the data from sensors used to determine the irrigation needs. Humidity level and temperature also determines whether to stop or start irrigation. With the simple DT algorithm, a high accuracy (97.86%) achieved in this work.

The problems faced by Indian agriculture can be solve by automatic and smart irrigation systems.[14] The work done to solve the water wastage in Indian agriculture and to avoid unplanned usage of water causes decrease in ground level water. Since 70% Indian economy depends on Agriculture there is a need to increase the productivity from agriculture, but water usage must be optimum. The objective was to conserve energy and water resources, develop a system which can control manually and automatically, and detect the field water level. This system uses data from the sensors and weather forecast data from the internet. Sensor data gather and sent to base station via Gateway. This data can visualize and analysed using server-side software. ML algorithm applied on the dataset to automate the irrigation. Program is done on microcontroller and actuators are controlled according to the decision. Photovoltaic panels used to power the whole system. The Author claims system could meet their objective with high accuracy. But the results are not shown in this paper.

Due to the scarcity of water the farmers go for groundwater to supply water which will result again in ground level water reduction. [15] Unavailability of human labour for agriculture in cities point out the requirement for an automated system. They made an automated system using sensor collected temperature, moisture, and humidity data. System uses a DC operated fan to manage the temperature. Arduino gets the sensor data and makes the decision to switch on or switch off the motor. To get the time RTC timer circuit connected with Arduino. The data uploads to a platform using XBee for the real time monitoring of the data. This system is a low-cost irrigation management. The draw back with this system is Lack of use of ML algorithm to impart intelligence.

REFERENCES

1. Goldstein, A., Fink, L., Meitin, A. *et al*. Applying machine learning on sensor data for irrigation recommendations: revealing the agronomist's tacit knowledge. *Precision Agric* **19,** 421–444 (2018). https://doi.org/10.1007/s11119-017-9527-4
2. Intelligent IoT Based Automated Irrigation System
3. IOT based Smart Irrigation System
4. 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,ISSN 0168-1699,https://doi.org/10.1016/j.compag.2018.09.040. (https://www.sciencedirect.com/science/article/pii/S0168169918306987)

5. Margarida Mota, Tiago Marques, Teresa Pinto, Fernando Raimundo, António Borges, João Caço, José Gomes-Laranjo, Relating plant and soil water content to encourage smart watering in chestnut trees, Agricultural Water Management, Volume 203, 2018, Pages 30-36, ISSN 0378-3774, https://doi.org/10.1016/j.agwat.2018.02.002. (https://www.sciencedirect.com/science/article/pii/S037837741830088X)
6. Yashika Mahajan, Mrunalini Pachpande, Ruchita Sonje, Swati Yelapure and Manisha Navale 2018. "Effective use of water in irrigation system using machine learning", International Journal of Current Research 10, (01), 63873-63875.
7. R. Kondaveti, A. Reddy and S. Palabtla, "Smart Irrigation System Using Machine Learning and IOT," 2019 International Conference on Vision Towards Emerging Trends in Communication and Networking (ViTECoN), Vellore, India, 2019, pp. 1-11, doi: 10.1109/ViTECoN.2019.8899433.
8. Neha K. Nawandar, Vishal R. Satpute, IoT based low cost and intelligent module for smart irrigation system, Computers and Electronics in Agriculture, Volume 162, 2019, Pages 979-990, ISSN 0168-1699, https://doi.org/10.1016/j.compag.2019.05.027. (https://www.sciencedirect.com/science/article/pii/S0168169918318076)
9. AlZu'bi, S., Hawashin, B., Mujahed, M. *et al.* An efficient employment of internet of multimedia things in smart and future agriculture. *Multimed Tools Appl* **78,** 29581–29605 (2019). https://doi.org/10.1007/s11042-019-7367-0
10. Melchizedek I. Alipio, Allen Earl M. Dela Cruz, Jess David A. Doria, Rowena Maria S. Fruto, On the design of Nutrient Film Technique hydroponics farm for smart agriculture, Engineering in Agriculture, Environment and Food,Volume 12, Issue 3, 2019, Pages 315-324, ISSN 1881-8366, https://doi.org/10.1016/j.eaef.2019.02.008. (https://www.sciencedirect.com/science/article/pii/S1881836617303294)
11. Volume 8, No.2, March - April 2019 International Journal of Information Systems and Computer Sciences Available Online at http://warse.org/IJISCS/static/pdf/file/ijiscs02822019.pdf https://doi.org/10.30534/ijiscs/2019/02822019 Automated Irrigation System Based On Machine Learning Concept Ebin P.M1, Kavitha Nair R2, Jimsha K Mathew3
12. IoT Framework for Smart Irrigation using Machine Learning. Technique Ramya, S., Swetha, A.M. and Manivannan Doraipandian
13. Blasi, A. H., Abbadi, M. A., & Al-Huweimel, R. (2021). Machine Learning Approach for an Automatic Irrigation System in Southern Jordan Valley. *Engineering, Technology & Applied Science Research*, *11*(1), 6609-6613.
14. Velmurugan, S., 2020. An IOT based Smart Irrigation System using Soil Moisture and Weather Prediction. International Journal of Engineering Research & Technology (IJERT)ISSN: 2278-0181 Published by, www.ijert.org ECLECTIC - 2020 Conference Proceedings
15. International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429 Volume 9 Issue III Mar 2021- Available at www.ijraset.com ©IJRASET: All Rights are Reserved 196 IoT based Greenhouse Irrigation System.

A Coast Effective IoT Based Intelligent Irrigation System Using ML algorithm. Literature survey.

NO	Reference	Objective	Problem Statement	Methodology	Dataset	Algorithm	Advantage	Disadvantage	Performance measure value
1	Goldstein, A., Fink, L., Meitin, A. *et al.* Applying machine learning on sensor data for irrigation recommendations: revealing the agronomist's tacit knowledge. *Precision Agric* **19,** 421–444 (2018). https://doi.org/10.1007/s11119-017-9527-4	1.Collect soil moisture of the plot. 2.Collect temperature data and predict weather to forecast the irrigation plan for the upcoming week. 3.Construct a weekly irrigation plan for plots using ML algorithms. 4. Predict the required irrigation quantities. 5. Reduce the workload of agronomist.	1.With the common approach - Penman–Monteith Equation, it is not possible to plan a plot wise irrigation system using plot specific data. 2. Automated System for irrigation was not existed. 3. This system uses a weekly irrigation plan	The models were trained with eight different sets of features to enhance the decision-making process of the agronomist. The dataset First Classifies using Gradient boosted regression trees followed by Linear regression. Another BTC classifier also used on the data set.	1.Soil moisture data collected from uMANAG2. 2.Soil moisture collected from different plots using sensors. 3. meteorological data collected for temperature, humidity and solar radiation collected from station of 1 to 2km distance	1.Regression models: regression tree model, called gradient boosted regression trees (93%) and Linear regression. 2.Classification models: boosted trees classifiers (BTC) (95%).	GBRT is considered as one of the most effective and popular models for prediction. Provides Very good accuracy. Required fewer transformations to capture non-linear relations among variables.	GBRT-based regression trees are more difficult to interpret, being a collection of many regression trees. The models included fifty decision trees. So, they are more difficult to interpret.	gradient boosted regression trees (93%) and Linear regression. boosted trees classifiers (BTC) (95%).
2	Intelligent IoT Based Automated Irrigation System	1.Collect Soil moisture and Temperature data using Sensors. 2.Use ML algorithm to analyse the collected data and to predict the irrigation of the soil. 3. Develop IOT based automatic water irrigation System	1. Traditional Automated and semi-automated irrigation Systems do not employ even water irrigation. 2. Traditional Systems required human intervention. 3. Apply ML algorithms to incorporate intelligence to the automated system by analysing the data based on experience.	Using intelligent method, they are trying to irrigate by taking data such as soil moisture and temperature to predict the soil type and turn on the water accordingly. The details of soil conditions and Amount of water irrigated are saved to the cloud and can be assessed by the farmer using his mobile phone. The system uses Arduino as microcontroller and Raspberry Pi3 as processing unit.	Soil moisture and temperature data collected using sensors.	1.classification using KNN-(K-nearest neighbour) algorithm used to predict the soil type.	No training is required since it is a lazy learner. Gives high accuracy with small dimensions. Much faster in predictions.	Will not be effective with high dimensional data. Need feature scaling for correct predictions. Noise and outliers need to be removed manually	High Performance

			4.The atmospheric conditions of the plants vary from place to place.						
3	Srishti Rawal. IOT based Smart Irrigation System. *International Journal of Computer Applications* 159(8):7-11, February 2017.	1.Avoid Over watering and Under watering. 2.Avoid Human intervention in watering the plant. 3.Collect soil moisture. 4.Find a System which allows farmers to check the status on the water is on or off using IOT based system	1. Wastage of water is a problem with normal watering system. 2. Agriculture sector needs high human labour. 3. Stop and start irrigation through smart devices when needed according to the collected data.	ATMEGA328P on Arduino platform is used as control unit. They implemented a system which uses GSM-GPRS SIM900A modem and a web page is created to check for the farmer about the sprinkler status. The GSM modem is used to transfer data obtained from sensors to internet. The THINGSPEAK open data platform and API to analyse the data and act accordingly with sensor results automatically.	1. Soil moisture data collected using Sensor.	Soil moisture level cheeked to control the water pump.	Automated system can developed.	No ML algorithm applied to incorporate intelligence to the system.	NIL
4	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,ISSN 0168-1699, https://doi.org/10.1016/j.compag.2018.09.040.	1. Develop an automatic IOT based intelligent irrigation system. 2. The system must prevent wastage of water. 3. Develop a System which utilises both sensor data and online weather forecasting data.	1.World faces water scarcity problem. Major potion of water used by the agriculture. 2.Unavailability of cost-effective intelligent water irrigation system. 3.Most of the available irrigation system do not consider whether forecasting and thus causes wastage of water.	combination of supervised and un-supervised machine learning techniques. Dataset collected from the field had given as input to train SVR model. The output of the SVR model used as input to the K-means clustering to improve accuracy and decrease the error rate. Output from k-means is used to manage the water pump controller for effective irrigation.	1.sensor data (soil moisture, air tem-perature, air relative humidity, soil temperature, and radiation) collected from the field. 2.weather forecast data collected from internet.	1.Support Vector Regression (SVR) followed by k-means clustering (96%)	SVM can be used with higher dimensional data, with high accuracy. K-means is unsupervised learning method, which work well with large number of dataset.	SVM will not work well with large number of dataset. If target Classes overlap, SVM may not perform well. So the classes must be clearly separated for using SVM.	96%

	(https://www.sciencedirect.com/science/article/pii/S0168169918306987)								
5	Margarida Mota, Tiago Marques, Teresa Pinto, Fernando Raimundo, António Borges, João Caço, José Gomes-Laranjo, Relating plant and soil water content to encourage smart watering in chestnut trees, Agricultural Water Management, Volume 203, 2018, Pages 30-36, ISSN 0378-3774, https://doi.org/10.1016/j.agwat.2018.02.002. (https://www.sciencedirect.com/science/article/pii/S037837741830088X)	1. Study the need for a smart irrigation system for chestnut trees. 2. Find out the factors which need to be consider for an automatic irrigation system. 3. Find out the relationship between photosynthesis rate and soil moisture for irrigated and non-irrigated trees using ML algorithm	1.Chessnut tree cannot survive summer. 2.They need to assure good photosynthetic productivity and water moisture at mid-day. 3.Type of soil need to be considered along with the moisture.	The regression model applies on the collected data for calculation of Photosynthetic rate and midday stem water relationship.	1.Sensor data of soil moisture of both irrigated and non-irrigated trees 2.climate conditions, 3. three leaf and stem moisture data of both irrigated and non-irrigated trees	linear regression Polynomial Regression	Linear Regression is Simple and easy to implement. Less complex, if dependent and independent variables are known.	Boundaries are linear and outliers may affect the results. Overfitting problem	Got Results. Correct value not given Linear Reggression R^2=.3104 Polynomial Regression R^2 = 0.43
6	Yashika Mahajan, Mrunalini Pachpande, Ruchita Sonje, Swati Yelapure and Manisha	1.Find out an automatic irrigation System. 2. The System must use IOT and Wireless sensors.	1. Find out a novel approach for irrigation System. 2. How to manage irrigation without a farmer.	Multifractal Downscaling Model	1.Sensor data of soil moisture, Field parameters. 2.Theta dataset	Clustering	Resolves heterogeneity in soil moisture.	Effect of irrigation attenuate by downscaling model	

	Navale 2018. "Effective use of water in irrigation system using machine learning", International Journal of Current Research 10, (01), 63873-63875.	3. Use ML algorithm to determine the needed water amount.	3. How to Find out the amount of water needed for watering.						
7	R. Kondaveti, A. Reddy and S. Palabtla, "Smart Irrigation System Using Machine Learning and IOT," 2019 International Conference on Vision Towards Emerging Trends in Communication and Networking (ViTECoN), Vellore, India, 2019, pp. 1-11, doi: 10.1109/ViTECoN.2019.8899433.	1. Develop an automatic irrigation System. 2. Use of rainfall prediction algorithm to predict crops suitable for specific area. 3.Introduce Romyan's method to determine when to switch on irrigation and thus reducing the electricity and water usage.	1.In rural areas water and electricity distribution is unequal. They need to be saved. 2.Farmers face difficulty in predicting rain fall, and changing climates which leads to unsuitable selection of corps for the season. 3. Lack of rainfall prediction-based Algorithm in automated water irrigation system.	Time-series Analysis Artificial Neural Network. Multi Linear Regression	1.Soil moisture sensor data. 2.Humidity sensor data.	Romyan's algorithm	Using Romyan's algorithm helps to predict the water requirement. Rainfall prediction gives almost high accurate results. Results shows prediction of moisture requirement for different corps.	Methodology seams to be little complex.	Rain prediction results are Similar With Actual results
8	Neha K. Nawandar, Vishal R. Satpute, IoT based low cost and intelligent module for smart irrigation	1.Develop a low-cost intelligent system for smart irrigation farming. 2.Make use of IOT in smart irrigation system to inform user about the current crop situation.	1.Traditional farming results reduced crop production. 2. Water scarcity need to be reduced. Farming consumes 70% of fresh water.	Neural Network Model	1.Soil moisture data 2.humidity 3.Temperature data	Unified sensor pole: To forecast and predict water requirement using Neural Networks.	Perform well in predicting required water and thus optimum utilisation of water	Complex algorithm	Mean square error =.0037699 at epoch=85

	system, Computers and Electronics in Agriculture, Volume 162, 2019, Pages 979-990, ISSN 0168-1699, https://doi.org/10.1016/j.compag.2019.05.027. (https://www.sciencedirect.com/science/article/pii/S0168169918308076)	3. Make decision for future irrigation schedule using ML algorithms	3. Cost effective IOT based system needed.			Bayesian regularization algorithm used for training			
9	AlZu'bi, S., Hawashin, B., Mujahed, M. *et al.* An efficient employment of internet of multimedia things in smart and future agriculture. *Multimed Tools Appl* **78,** 29581–29605 (2019). https://doi.org/10.1007/s11042-019-7367-0	1.Use wireless sensors IOT and IoMT techniques for smart irrigation system. 2.Use image processing in smart irrigation system. 3. use ML algorithms to make sure optimum irrigation.	1. Water wastage is a problem in agriculture with the traditional irrigation systems. 2.If farmers are not experts, they cannot make decisions on when to water and how much to water to the crops. 3. Traditional irrigation methods require human intervention.	use multimedia sensors in the field for optimized irrigation process. An ultrasonic sensor used to alert the farmer about remaining water in the water source. To avoid water wastage during rainy season, a rain drop sensor added to the system. IP cameras has been used to capture images of soil crack and yellowing of leaves to add decision of watering along with other sensor data. ML algorithms used along with digital image processing for this.	1.Soil moisture data. 2.Humidity and Temperature data. 3.IP camera data of images of leaves and Soil cracks.	1.SVM(95%) 2.Neural Networks(96%) 3.Random Forest(83%)	Best results with Neural Networks. SVM comes near to it with less Training time comparing to NN. Random Forest is the fastest Algorithm in predicting results.	Neural Network take worst training time. Convolutional neural network would require lengthy training time due to its complex architecture. Random Forecast classification results are not satisfactory.	SVM(95%) 2.Neural Networks(96%) 3.Random Forest(83%)
10	Melchizedek I. Alipio, Allen Earl M. Dela Cruz, Jess David A. Doria, Rowena Maria S. Fruto, On the design of Nutrient Film Technique	1. develop a hydroponics farm which monitored by sensors. 2. make an automated system using Bayesian networks on the gathered data.	1.Ther is no system exists which integrates Hydroponics and ML. 2.Most of the previous work does not tests the performance of their system.	Sensors and actuators are installed to monitor and control the parameters of the farm. The sensor values gathered to build the Bayesian Network, to classify and predicts the optimum value in each actuator and autonomously control the hydroponics farm.	Sensor data of light intensity, pH, electrical conductivity, water temperature, and relative humidity.	Bayesian Algorithm(84.53%)	BNs are better suited to capture the complexity of the underlying decision-making process, taking into account the many	Not Cost effective.	84.53%

	hydroponics farm for smart agriculture, Engineering in Agriculture, Environment and Food, Volume 12, Issue 3, 2019, Pages 315-324, ISSN 1881-8366, https://doi.org/10.1016/j.eaef.2019.02.008. (https://www.sciencedirect.com/science/article/pii/S1881836617303294)	3. use a web interface via a cloud platform for the remote access, monitor and control of the farm.	3.Need of a system which control the farm environmental parameters using data analytics.				inter-dependencies among the variables. Moreover, it provides a global view of the variables' associations compared with decision tree type of classification learning		
11	Volume 8, No.2, March - April 2019 International Journal of Information Systems and Computer Sciences Available Online at http://warse.org/IJISCS/static/pdf/file/ijiscs02822019.pdf https://doi.org/10.30534/ijiscs/2019/02822019 Automated Irrigation System Based On Machine	1.Develop an automated irrigation system. 2. An irrigation system which monitor past weather conditions and soil moisture and current weather conditions. 3.Reduce human intervention in agriculture by imparting proper irrigation method using ML algorithm.	1. Water resource is not using effectively and causes wastage of water in agriculture sector. 2.Need for an automated water utilising irrigation system. 3.Current irrigation causes over flooding and causes for nutrient loss from the soil.	Dataset used to make decision using ID3 ML algorithm. According to the decision the motor pump automatically stars and stop the irrigation.	1.Data from Temperature sensor, Soil moisture sensor, and Light intensity sensor. 2.Past weather data and current weather data	ID3 algorithm.	As decision trees are resilient to outliers and missing values, they require less cleaning of data than other algorithms.	The performance on external data is not satisfactory. Overfitting problem.	Getting Results with high accuracy

	Learning Concept Ebin P.M1, Kavitha Nair R2, Jimsha K Mathew3								
12	IoT Framework for Smart Irrigation using Machine Learning Technique Ramya, S., Swetha, A.M. and Manivannan Doraipandian	1.Develop a smart irrigation system utilizing IOT and ML algorithm. 2. Predict irrigation Requirement of the field using Environmental parameters and weather forecasting. 3.Provide a low-cost prototype model utilising advanced technologies.	1. Traditional methods does not incorporate intelligence. 2.Traditional methods causes wastage of water. 3. cost effective irrigation system is needed while utilizing advanced technologies.	Agricultural field data collected using sensor. ML algorithm used to train the data to predict the soil moisture and nutrients. Checking weather condition and information from ML algorithm used to predict the water required for production and take decision to switch on the motor pump.	1.Soil moisture, Humidity, temperature, UV radiation Data collected using specific sensors. 2. Weather data	Ensemble algorithm used for training and testing. Initially, bagging algorithm applied to get the difference between the actual and the predicted soil moisture then compared the predicted value using SVR and bagging methods.	R-square value for Bagging model is highest MSE of the Bagging model is less	R- square value of SVR is less compared with bagging model. MSE of the SVR model is high.	Matrix index giving 0.98
13	Blasi, A. H., Abbadi, M. A., & Al-Huweimel, R. (2021). Machine Learning Approach for an Automatic Irrigation System in Southern Jordan Valley. *Engineering, Technology & Applied Science*	1.prevent plants from drying and improve plant quality. 2. make use of artificial intelligence to provide irrigation water to the highest extent possible. 3.construct a smart irrigation system to control the irrigation. mechanism using sensor data.	1.Lack of water source in Jordan valley. 2.Agriculture sector consumes most quantity of water. 3. Agriculture affected by extreme weather conditions.	Selected data analysed using python programming. Data pre-processed from numerical to categorical data to apply DT algorithm. After Training and testing, the data from sensors used to determine the irrigation needs. Humidity level and temperature also determines whether to stop or start irrigation.	1.Sensor data of soil moisture, temperature. 2. Directorate of Agriculture of the Southern Jordan Valley. 3.data about the weather from Taqs Al-Arab website and the Department of Meteorology	decision tree (DT) algorithm (97.86%)	Simple to implement. Understandable. easy to implement. give a high accurate result.	Work only with categorical data type.	decision tree (DT) algorithm (97.86%)

	Research, *11*(1) , 6609-6613.				4.Selected data (Soil Humidity, Soil Type, Soil Salinity, and Temperature)				
14	Velmurugan, S., 2020. An IOT based Smart Irrigation System using Soil Moisture and Weather Prediction. International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Published by, www.ijert.org ECLECTIC - 2020 Conference Proceedings	1.conserve energy and water resources. 2. develop a system which can control manually and Automatically. 3. detect the field water level.	1.Reduce the water wastage in Indian agriculture. 2.Need to increase the productivity from agriculture since 70% Indian economy depends on Agriculture. 3.Unplanned usage of water causes decrease in ground level water.	Sensor data gather and sent to base station via Gateway. This data can visualized and analysed using server side software. ML algorithm applied on the dataset to automate the irrigation. Program is done on microcontroller and actuators are controlled according to the decision. Photovoltaic panels used to power the whole system.	1.Soilmoisture and temperature data from the sensors. 2.Weather forecast data from the internet.	1.Energy saving Algorithm. 2.Tree based ML protocol	Tree based algorithms are easy to implement and will produce more accuracy	Categorical data type transformation needed. The paper does not discuss about the accuracy and error rate.	98% accuracy MSE = 0.023
15	International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429 Volume 9 Issue III Mar 2021- Available at	1.Develop an automated irrigation system. 2. A system which does not need human intervention. 3. develop an IOT based Irrigation system.	1.The farmers go for groundwater to supply water which will result in water scarcity. 2. Unavailability of human labour for agriculture in cities point out the requirement for an automated system. 3. Adequate amount of water need to be determined for optimum utilization of water	Using a DC operated fan to manage the temperature. Arduino gets the sensor data and makes the decision to switch on or switch off the motor. To get the time RTC timer circuit connected with Aurdino. The data uploads to a platform using XBee for the real time monitoring of the data.	1. sensor data of soil moisture, temperature, humidity	Algorithm checks for sensor data and take decision according to some previously set threshold conditions	Automated system for irrigation without human intervention developed.	Does not use ML techniques. No reforecasting techniques. Or future water requirement prediction.	NIL

	www.ijraset.com ©IJRASET: All Rights are Reserved 196 IoT based Greenhouse Irrigation System								
*	My work	1.Make an IoT based smart automatic irrigation system with intelligence. 2.Make system which can irrigate without human intervention. 3.Make use ML algorithm to impart intelligence to the system.	1. Current system needs manual monitoring for the irrigation. 2.Manual irrigation system will waste water and power and it is time consuming. 3.Corrent system will not check adequate amount of water needed. It will damage the plant.						