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A Fresh Perspective on Deploying IoT-Enabled Agricultural Monitoring Systems

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Abstract: Nowadays, in the era of technology, the rural areas are undergoing major changes by incorporating various present-day, high-tech tools which are used to raise yields and to conserve natural resources as well as to implement sustainable ways of farming. Precision agriculture as it is called, sometimes smart agriculture, uses modern technologies to act as sensors, manage and monitor different systems, and even automate some vital farm tasks. The adoption of the Internet of Things into agricultural business, as well as which sometimes is referred to as Intelligent Agriculture, brings about a new step and a fundamental leap that creates the intersection between technology and business. This proposition will use the IOT devices and sensors, which connect the entire environment together to enable the farmers to use the new methods that were not there a long time ago. Major examples of them include weather monitoring, water irrigation, and rainfall detection that are critical for growing crops and raising tropicality rural communities. The smart implementation of IoT in agriculture especially in regions including climate variations, water supply, and rainfall detection is a natural progress in the agricultural sector. This technological offer generates live data and cognitive insights that in turn allow farmers to make smart and well-informed decisions that spark the transformation of the agriculture sector into holistically, more efficient and profitable venture. These developments are completely overhauling the way farmer's farm; therefore there is a high output, reduced wastage and an environmental footprint that is diminishing.

Keywords: Agriculture analysis, Internet of things, IoT sensors, Machine Learning.

I. Introduction

In terms of India's employment, the agriculture is one of most crucial factors for it channels a huge share of the population. Sensing devices, GPS solutions, healthcare tools and other technological advancements into the agriculture sector is emerging with the support of Internet of Things (IoT) which is making farmer's lives easier, challenging the present production chain and helping drive new economics. The approach of "smart farming" seeks to achieve higher yields both in quantity as well as quality of the farm outputs. Now the farmers can utilize technology in their industry such as Global Positioning System, soil sensing, data, and the Internet of Things. Smart agriculture research should come up with the blueprint of farms' management information system which acts as a fundamental basis for the optimum crop production support system. Smart farming shares the issues relating to population growth, climate change, and labor, giving each of the elements of farming management such as sowing and irrigation, health, and harvesting a technology boost. Traditionally, Internet of Things has always been a great factor in the modern world by giving geographic areas around the globe the platform to produce services like intelligent living, health services and smart automation. In addition, one is strategically determined to fit in different business sectors such as manufacturing, transportation, agriculture, and corporate management. At IoT arena, smart agriculture is subjected to set up system that may be among other things be used to automation of irrigation system and monitoring field via sensors that may measure light degree, humidity, temperature, soil moisture etc. IoT (Internet of Things) can be defined as a form of agriculture which uses the technology of sensors, cameras and similar tools that transform each single activity performed by a farmer into the digital data. If this innovative approach aims to evolve and expand, it will be the one that features the comprehensive diminution of the negative impacts that conventional agriculture has on the environment.

IoT devices such as sensors, light, and meters are used by smart cities that are IoT hip hive and collected information for extraction. The deployment of IoT based new endeavors is definitely will highlight the aforementioned challenges, making the rancher oversee the qualifications and expansion of ranch produce. IoT is an innovation that uses a phone as a hub in mobile sensor networks which dispatches the status of the sensor repeatedly. The Web of Things associates open things not only forms different location but even the distance is not the problem anymore. The Internet of Things (IoT) allows data from sensors to be collected within a range and shuffles it interactively to the web for data exchanging. The gadget's rank can as well circulate. Agriculture looking for the way of implementing it, the IoT is at the advantage of: It expands operation efficiency, reduces resource loss, increases crop quality and overall increases crop productivity in the long run. Farmers could certainly produce more, reduce their footprints, and control their sustainability standards. Apart from IoT innovation encouraging predictive analysis and enabling farmers to anticipate problems and implement solutions, it, also limits the risk of diseases and pests by introducing preventive measures.

II. Literature Survey

The paper by Pankaj Kumar *et al.*, developed a model to assist in agricultural irrigation management by predicting soil moisture content, irrigation intervals, and water distribution for cultivable land using a Long Short-Term Memory (LSTM) recurrent neural network (RNN) model. The architecture of this suggested model allows it to be adjusted to various climates and geographical areas. It does, however, entail the difficulty of setting up and maintaining an Internet of Things system as well as dependable power sources for the actuator, anchor, and sensor nodes. The requirement for a stable power source could potentially impact the functionality of the Internet of Things-enabled system.

A. D. Boursianis *et al.,* the paper presents the future of technology like IoT and RF energy harvesting with the presentation of agricultural techniques based on precision agriculture, the platform of IoT called AREThOU5A offers an innovative solution for the intelligent irrigation systems that is environmentally friendly and profitable for farming. A significant disadvantage of the integration of the harvesting of the energy via the RF emission into the block of IoT modules Rectennas as the components which transform electromagnetic radiation into direct current cannot work with the same efficiency in hostile environments. The reduction in efficiency may lead to the non-capturing of the sufficient amount of energy as it was expected, which will decrease the general system's efficiency.

Antonino Pagano *et al.*, provide a LoRa technology integration into irrigation applications as a tool to optimize processes, to cut waste and to increase yields. It provides scalability, interoperability, extensibility, and energy efficiency addresses open issues in agriculture through the use of Machine Learning for control automation features and the creation of an autonomous energy source. The author admitted that the emphasis of monitoring tree conditions, micro-climate environment and plant biological/physiological conditions is required for proper agricultural activities performance. even though this, The LoRa integration to smart agriculture creates several issues that will require consideration for a smooth run of the system such as intermittent latency on the downlink channel, power management, device diversity, interoperability, data management, and expandability or scaling.

Abdulaziz *et al.*, found a SWAP, which is information sharing tool that the irrigation management system for smart cities uses. This communication protocol utilizes LoRa and UDP stack for the creation of the Wi-Fi network mesh. It enables interoperability of the LoRa and Wi-Fi devices according to the smart irrigation system requirements for urban gardens in the smart cities and then assesses the ease of use of the most affordable devices to outperform them. On the contrary, such a decrease in physical area determines the limited ability to transmit data. This system is designed to be energy efficient and this allows it to have a prolonged range and as a result, a small data transfer speed too. This characteristic may pose challenges for applications necessitating real-time or high-frequency data updates.

A. Keyurbhai *et al.,* recommended an alternative approach for optimizing resource usage in smart agriculture systems through incorporating IoT technology. It deals with farm resource scarcity through using an intelligent framework that IoT sensors are the pillars of farming to do activities like irrigation, fertigation, pest detection, and pesticide spraying. The sensors, actuators are gathering real-time data and synthetically computerized decisions so the farmers maximize the crop yield and minimize the resources. The proposed architecture consists of three layers: encapsulating the three components: hardware layer, framework layer, and application layer to meet the user's visualization, analysis, and management needs. Data comes into conclusion that smart irrigation module is better than others in conservation of resources and in agricultural yield production. The main aim of the framework is to increase agriculture productivity, as well as make the system as efficient as it is possible through IoT technology. Nevertheless, it only provides an optimization algorithm than does not detail the exact algorithm used. This demonstrates that a certain part of the given data can be considered as lacking.

Venkanna *et al.,* make a smart agriculture device that is an IoAT (internet of agro-things) savvy creation. sCrop tackles three crucial challenges: curing of diseases automatically using data, selection of crops based on data and irrigation management being optimized. This capability is the essence of disease prediction. sCrop employs an image camera as well as deep learning to scan crop photos and detect diseases at their seedlings' stage, which consequently reduce crop losses thrashing to harvesting time. Also, sCrop is equipped with different kinds of sensors to gather the environmental data (temperature, humidity, soil moisture) that is real-time. Such data from the model will be used to recommend a suitable crop to pick thus enhance informed decision-making, and consequently, boost productivity. However, sCrop's usefulness in actual agricultural contexts will need to be reinforced by tackling issues like rainfall forecast and data considerations.

Rayner Alfred *et al.,* put forward an idea that an analysis of data generated from IoT sensors will help to improve the different technologies in rice cultivation. Sensing data includes soil pH, temperature, humidity, and other nutrients' status. The technique of machine learning algorithms may advance the judgement of irrigation, forecast yields, identify and resist diseases and pests early, as well as estimating quality of rice grains. It indicates that big data and machine learning are tools for agricultural revolution oriented on increased return on investment in rice production, its greater productivity, efficiency, sustainability, and reducing the cost of production. Nonetheless, data necessary for machine learning and, in particular, deep learning methods have to be very large volumes (with appropriate labels) in order to train high-performance models.

Sanku Kumar Roy *et al.,* introduce the system allows for minimization of water waste in agriculture by providing real-time sensor data, such as moisture of soil, enabling an understanding of the level of crop requirements. AgriSens is a data-driven fortune in irrigation with chances to be less invariant of water waste in crop yields, with 10.21% improvement compared to the conventional approach. This system features an interface designed for easy use, displaying the farmers with field dataset and control over irrigation distribution via remote technology. Besides the mentioned benefits both devices have on their network lifetime with 2,5 times longer lifespan and the reported reliability after overused network was at 94%. The data generated by the designed AgriSens system ascertains it as a prospective aid in water management of precision agriculture. However, the current system depends on a preset algorithm for scheduling irrigation, which may not fully take into account the weather's dynamic influence on crop water requirements.

Faruk Bin *et al.*, suggest a concept of an automation controller by means of implementation of sensors (soil moisture) as a collecting effective environmental data. With the help of the data, the main processing unit interprets the information and irrigation is controlled using pre-fixed programming. Besides, the implementation of an IoT architecture may carry on monitoring, assimilation, and data-based decision-making that may result to more efficient irrigation and water conservation in agriculture. However, the absence of weather prediction data might render it less adaptable to abrupt weather changes.

R. Khan *et al.,* propose a Smart DSS equipped with sensors, for water scheduling in orange irrigations systems. The system using wirelessly integrated sensor networks and sensing technology is designed to measure the parameters like soil moisture, leaf wetness, temperature and humidity in the orchard. DSS helps make a decision about the watering schedule based on data received applying solely to water management efficiency. The main parts of the system are a refinement section for data accuracy, modified Longest Common Subsequence for on time differentiation and an augmented RTS/CTS transaction in order to handle collisions in the system. The superiority of the proposed method is highlighted through the experimental outcomes and simulated data. The proposed scheme achieves a higher performance in outlier detection, packet delivery, and decision accuracy than the existing methods. Among our findings, Smart Sensing-Enabled DSS is seen as a practical implementation in helping for the attainment of water use and irrigation management in agriculture. On the one hand, the system should be characterized by its flexibility in using it for various agricultural applications, when on the other hand, it should be easily adjusted to others as well.

III. Related Gap Findings

IoT on farm is about smart system development on weather monitoring and water irrigation for farm practice improvement. This decision support system utilizes IoT devices (e.g., sensors and actuators) that for collecting real-time information such as weather conditions and soil moisture. A weather that is precise is achieved by analyzing the data to produce weather forecasts that are accurate and the determination of the suitable time for irrigation of the crops and the amount to be used.

It is a sustainable approach to the future, water management and resource conservation for farming if weather forecasting using the irrigation process is integrated. Nonetheless, related gap areas include the development of higher accuracy in weather forecasting, the better coordination of IoT devices with used farming equipment, and the addressing of the cyber security issues that companion IoT data collection and transmission. Besides, there could also be obstacles in extending the system large livestock farms and production available for smaller farms grounded.

IV. Problem Identified

The current farming system does not have the best efficiency and accuracy to control diseases and pests. Normally, a traditional farmer is going to do all of the above-mentioned activities such as weather forecasting, and water irrigation management by using manual observation and undemanding processing. Unlike wise, these approaches have a risk of mistakes and incompetencies that causes incomplete crop yield and high waste of resources.

Moreover, climate change and agro-meteorological conditions which becomes unpredictable adds menace to farmers; therefore, it is paramount for farmers to scrap the old method and adopt the latest monitoring technologies. The most effective solution for these issues is the automated monitoring system with integration with the sensors of IoT (Internet of Things) that generate real-time data of weather conditions, soil humidity and crop health. The combination of weather forecasting with water irrigation management into one platform allows for farmers to make the decision they think is right at the right time and therefore, they can increase the productivity of the farming operation.

V. Architecture of the Proposed Work

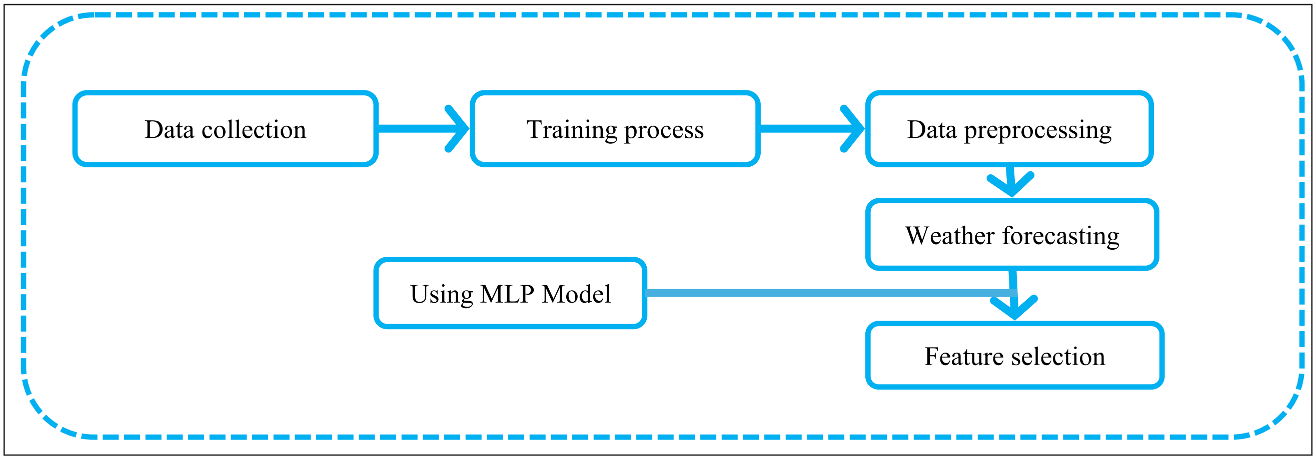

Fig. 1: Weather Forecasting Module

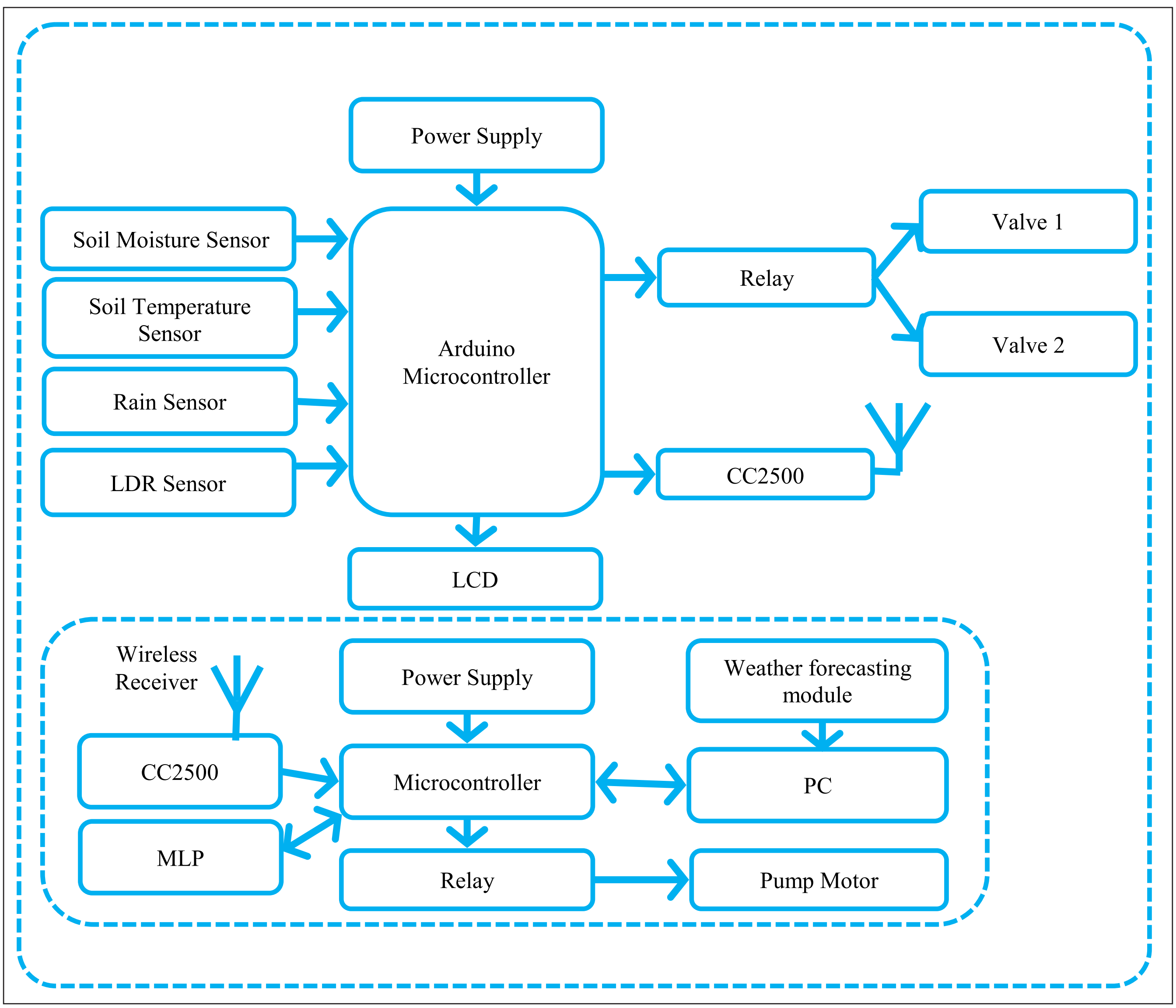

Fig. 2: IoT Module

A. System Model

i) Weather Forecasting

Step 1: Gather historical weather data from reliable sources or use real-time data from weather APIs.

Step 2: Clean the data, handle missing values, and normalize if necessary.

Step 3: Select relevant weather parameters such as precipitation, maximum and minimum temperature, wind speed, humidity, etc.

Step 4: Train a Multi-Layer Perceptron (MLP) neural network using the selected features to forecast weather patterns.

Step 5: The MLP model is predict weather conditions based on collected data.

Step 6: The processed data is sent to the microcontroller control the process.

ii) IoT Module

Step 1: The sensors and actuators are to the Arduino board to get the real-time data.

Step 2: The sensor data are collected, processed, and perform appropriate actions based on weather conditions.

Step 3: The CC2500 transceiver helps to make the communication between the microcontroller and IoT sensors.

Step 4: The whole process is monitored to perform accurate actions.

Step 5: The data is continuously monitored and perform appropriate actions based on the current environment data. This system reduces the resource usage and improves the crop yield.

B. System Module

i) Weather Forecast

Our system leverages a weather API to obtain real-time environmental data, while our machine learning model, trained on the collected data, enables accurate prediction of future weather conditions. it provides visibility into current environmental conditions and presents accurate weather forecasts spanning the next five days. The user can also enter the city name to get the current environment data.

ii) Data Collection

The data are collected from various types of data from sensors which are in the farm. The soil moisture sensors, temperature and humidity sensors, rain sensor and other environmental sensors collect the environment data. The collected data is then transmitted to a central database for analysis and for processing.

iii) Training Module

We are training machine learning model using historical data gathered from farming system. We are training and working with machine learning models specifically Multilayer Perceptron (MLP) models. We trained our model with different varieties of parameters such as crop yield, irrigation requirements, and so on. The weather condition and sensor values are usually considered as input parameters for prediction.

iv) Sensor Data Collection

The real-time data is collected from various sensors which are placed in the farming land. It calculates the moisture level, temperature, light intensity level and rain level to process the irrigation. The collected data are sent to the receiver which connected with PC to predict the environment and reply message is sent to the microcontroller to control the irrigation.

v) Water Irrigation

It automates the irrigation process by utilizing data from sensors and weather conditions and the valve is automatically closed and opened based closed the prediction. The optimal timing and amount of water needed for irrigation to ensure efficient water usage and maximize crop yield. The system can also detect water leaks or irrigation system malfunctions.

VI. Proposed Work

Our system incorporates multiple sensors, which include temperature sensors, soil moisture sensors, rain sensors, and LDR sensors, enabling the continuous monitoring of the present earth condition of the farm. The tiny Arduino Nano microcontroller is employed to allow sensors to be linked, data to be got and then transmitted it via the CC2500 transceiver to the receiver. Two LCDs are used for sensor data visualization to transform the data into comprehensible representations. Moreover, there are two motors— one for sowing seeds and other for drain off of redundant water from the land. The water extraction device will turn out to be booted once the water height crosses the guard threshold marked earlier. The other LCD display placed solely at the transmitter is meant for transmitting the environmental information while the third one positioned only at the receiver is meant for the purpose of displaying real-time environmental data. In intent, both the transmitter microcontrollers and the receiver microcontrollers all use the Nano microcontroller. Harvested data is put through MLP algorithm which is our machine learning algorithm from Multilayer Perceptron (MLP) algorithm for weather prediction. The model based on training had been drawn from Kaggle. Next is to train the model real-time data is then keyed-in once the algorithm runs it determines the output. Based on the result of the algorithm, one might proceed with other cultivation procedures or watering system activities. When the sensor value shows that soil moisture greater than a threshold, the microcontroller will receive a signal, and then the pump motor will be automatically off. However, in contrast, this is equipped with an automatic control that activates the pump motor on the finding out that the moisture level has gone under the specified limit. On the other side, the system is smart enough to predict the amount of rain and keep its motor off if the algorithm has predicted rain. The water flow is controlled by using solenoid valve. The valve is opened and closed automatically based on the prediction and real-time environment data.

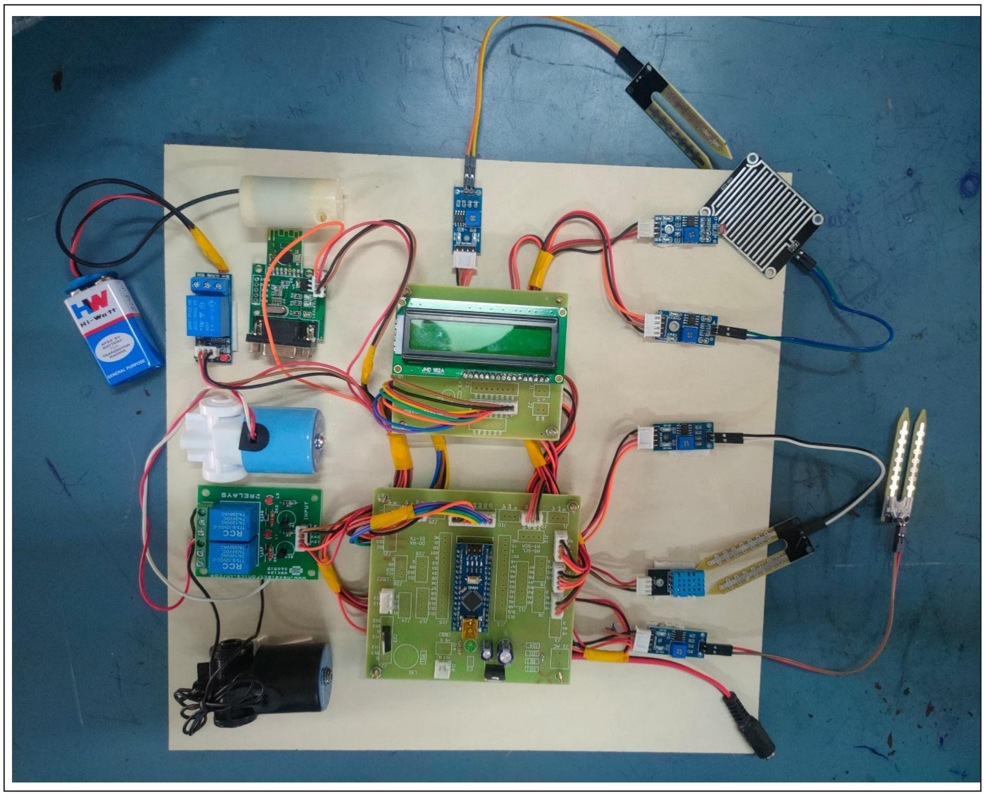

Fig. 3: Environment Data Collection

The Fig. 3 represents the transmitter of the project. The data is collected by using various sensors in the farming land and it transmits to the receiver by using CS2500. The Arduino microcontroller get the data from the sensor, and it sends to the receiver. The two-soil moisture sensor get the soil moisture data from land. If the soil moisture level is higher than threshold value, then the respective valve is closed automatically.

Each valve relates to separate relay module to open and close the valve. The LDR sensor indicates the light intensity level, which indicates the sun light. The data send to the receiver the receiver is connected with the laptop or PC the data is stored in the database. The stored data is processed through our model then it will predict the result based on the data. The irrigation flow is processed based on the result.

The Fig. 4 represents the accuracy of rainfall prediction and taking time for prediction results. Prediction results compared with the neural networks and KNN, Irregular woodland, Choice Tree and XG boost algorithm. Neural network methods are highly predicted accuracy of the input data.

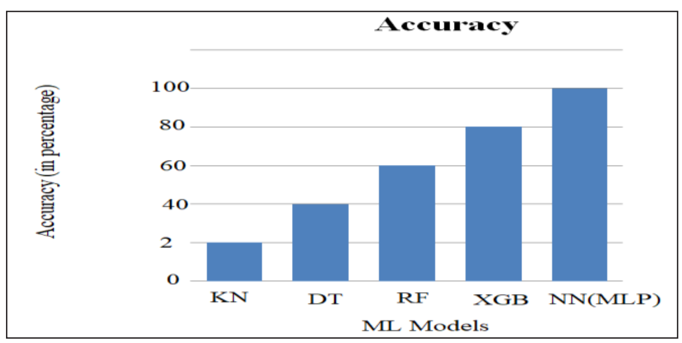

Fig. 4: Accuracy Analysis

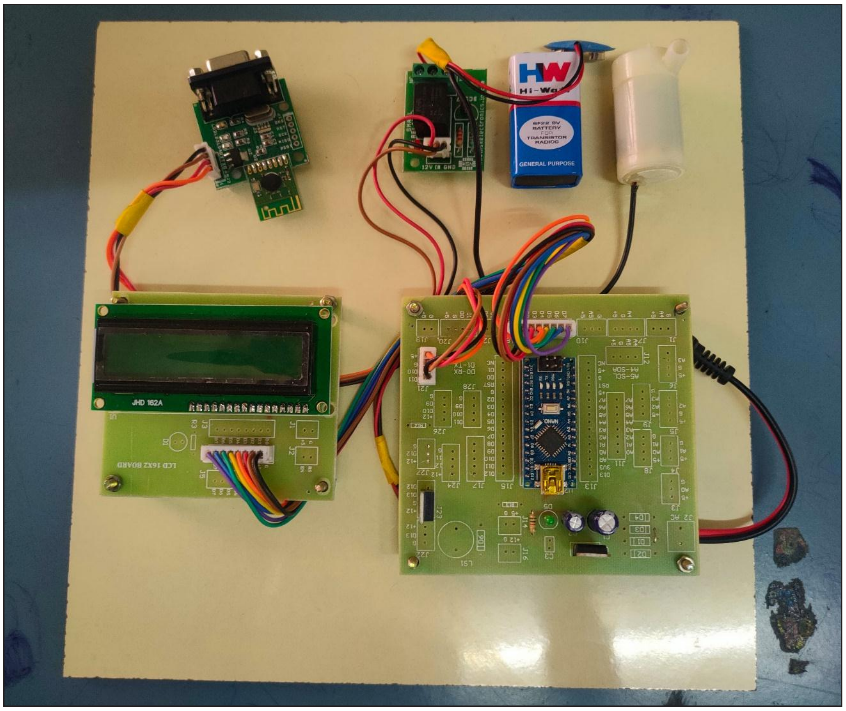

Fig. 5: Control System

The Fig. 5 represents the control system of our project it will get the data from the environment, and it processed through our machine learning model. The model processes the real-time environment data and predict the weather, then the result is transmitted to nano microcontroller to control the irrigation.

VII. Experiment and Result

We realized good results with MLP that provides prediction for the weather conditions, and we have a few cases where it went bit further than we expect. The method used allocated the surveillance of spatial environmental conditions, containing temperature, soil moisture, rainfall, light, and air flow in the farming environment through the deployment of sensors at specific locations. Subsequently to the data collection, a complex processing step, spanning about several hours, served to reduce the dataset to a smaller size, which was then the input to the MLP algorithm that was the subject of additional refinements.

At the next phase the group proceeded with the complicated work including rigorous and considerable testing and validation process in order to confirm the model precision. The algorithm shown accuracy rate of 85% provides evidence of the diversity of the patterns it can classify and various types of weather. The fact that the seasonal weather change can be accurately predicted is very special in that sector. In this sense of real life, it is of particular importance that seasonal précised weather prediction is a pre-condition for successful and optimal planning, use of resources, and decision-making procedures in precision technology. The Fig. 6 represents the accuracy of the MLP algorithm.

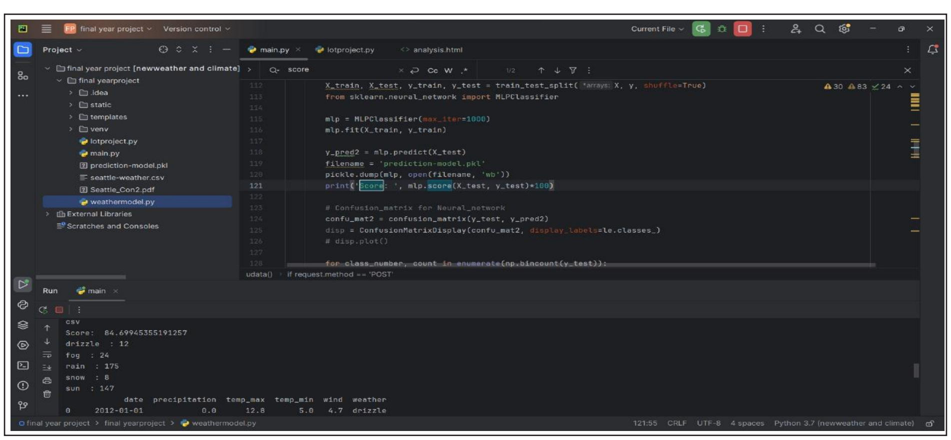

Fig. 6: Accuracy Score of MLP Algorithm

VIII. Conclusion

Machine Learning analysis is the process of getting enough right data of high quality to be used to train the system in question. But farmers might choose a machine learning approach and combine it with building whole systems in order to keep the devices in the precise settings. Still, it is difficult due to a tremendous variety of devices and frameworks. In spite of the fact that integration with the technologies of IoT (Internet of Things) in smart agriculture will greatly improve irrigations and give weather forecasting, surface water monitoring, and rainfall monitoring it is a step in the right direction. Farmers can achieve a number of benefits from a fully IoT smart agriculture against the environment and a society by having real-time data collection, analysis, and automation. Like this, IoT devices provide the corresponding irrigation systems by monitoring soil water levels and weather patterns which are the elements of precisely demand-based irrigation. This enables farmers for them to take advantage of the water management strategies, conserve water, and regulate the moisture their crops need as this helps to uplift their yields and solve the water use conservation challenge. IoT enabled equipment for the rainfall monitoring on the other hand empowers farmers with very accurate and quickly captured weather data thus enabling them to better schedule the agricultural activities. This will become possible through educating farmers on the interpretation of weather forecast and therefore help them mitigate risks and increase productivity. Besides that, it comes in handy when they can forecast the rainfall early enough to avoid soil erosion and flooding by taking preventive steps to preserve the crops and their livelihood.

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