IoT Based Smart Crop Field Monitoring & Automation of Irrigation System

Abstract—**IoT Based Smart Crop Field Monitoring & Automation of Irrigation System offer a trans formative approach to optimizing agricultural practices, allowing farmers to achieve enhanced precision, efficiency, and sustainability. The system incorporates a network of sensors deployed throughout the crop field to collect real-time data on crucial parameters such as soil moisture, temperature, humidity, light intensity, and nutrient levels. The data is transmitted wireless to a central control unit, where it is processed and analyzed using advanced algorithms. Remote monitoring and control capabilities enable farmers to access this data and manage the irrigation system from anywhere using their smart phones, tablets, or computers. Automated irrigation control is a fundamental feature of the system, leveraging collected sensor data and predefined parameters to determine the optimal timing, duration, and quantity of water required by the crops. Weather integration plays a crucial role in the system's operations, incorporating real-time weather data and forecasts. Data analytic capabilities enable farmers to gain valuable insights and trends regarding crop health, water usage, and growth patterns. The system emphasizes energy efficiency by intelligently managing irrigation operations and can integrate with energy management systems and employ energy-efficient components to schedule irrigation cycles during off-peak hours and conserve energy consumption. The systems revolutionize traditional agricultural practices by providing precise monitoring, automated irrigation control, weather integration, data analytic, energy efficiency, scalability, and flexibility, allowing farmers to optimize irrigation management, enhance crop yield, conserve resources, and contribute to sustainable agriculture.**

Index Terms—**Wireless Sensor Network, Humidity, Moisture, Remote Sensing**

I. Introduction

Especially when there is insufficient rainfall, the irrigation system is one of the most important aspects of agriculture. A simple method for irrigating plants should thus exist. The large gap in agriculture sector turnover is the biggest challenge of our day. Most of the significant losses experienced in agriculture, whether material or monetary, are related to crop health and quality. A loss might occur if it turns out that the crops weren't up to par. We must keep crops in top condition and preserve their quality in order to stop this. For a farmer with big fields, it is almost difficult to supervise and maintain this. But at the moment, this is handled by hand. This is a risk since there is a serious shortage of laborers because many of them want to work in white-collar positions. Because of this, automated agriculture will be required in the future. Other than natural disasters, incorrect irrigation is the main reason crops are up to pace. The majority of the issue can be fixed if the irrigation problems are fixed. Therefore, this is the apex that requires technological renovation. For farmers, automating this step of the process will be quite advantageous. The automatic plant irrigation system will enable farmers to have less labor to do and ensure that the farms are always adequately watered[1]. This device is designed to help agriculturalists water their fields even when they are working alone. It has an intuitive, straightforward circuitry that requires the user to build the circuit and sensors, connect the pump to the circuit, and power-up the system. On power-up, the system will begin operating without requiring a trigger to keep it going.

II. System Design and Integration

A. Block Diagram

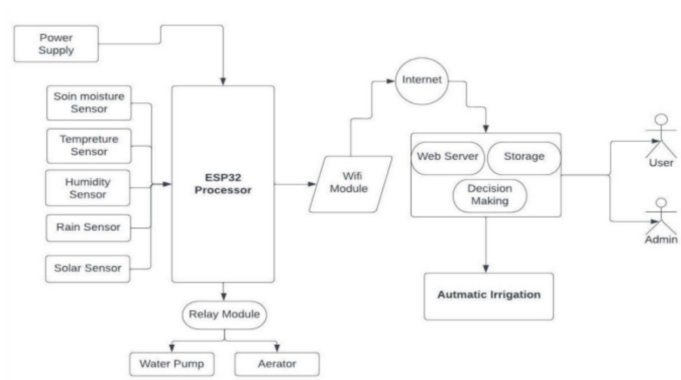

Fig. 1. Structure of the System

An ESP32 module, IoT-based smart crop field monitoring & irrigation system automation, temperature, humidity, raindrop sensor, solar sensors, relay module, buck converter, loads, and power supply make up the entire circuit. The ESP32 micro-controller serves as the system's CPU. It needs a steady 5V DC from the power source to function. The Micro-controller board's the power source's reliable 5V DC supply is linked to the VIN pin. The ESP32 I/O is connected to a 16x2 LCD display, and the Adapter Supply powers the micro-controller that powers it[2]. The ESP32 micro-controller offers Wi-Fi, uses the Internet to connect to the web server, analyzes every bit of information, then determines which instructions must be followed before sending the update to the system's administrator.

B. Flowchart of the System

The equipment's general functioning is shown in the flowchart above. If it can be stated right away, firstly, the micro controller will repeat the condition that the moisture level is 30% or 30% after reading the moisture from the soil sensor and sending it to it. According to that, if the set value falls below 30%, the relay will turn on and send an alert to the administrator recommending that the pump be completed immediately, or it will switch to semi-automatic mode, and if the set value rises above 30%, the relay will turn off. The flowchart demonstrates and explains everything that happens in the following way.

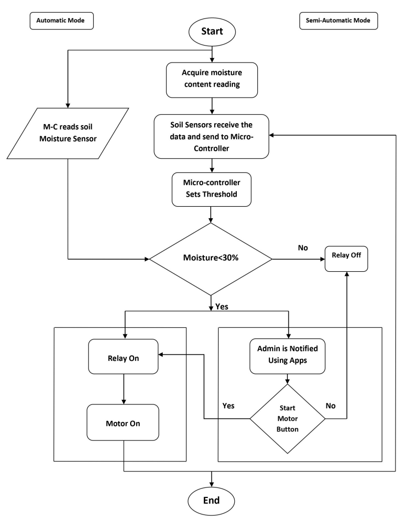

Fig. 2. Flowchart

C. Circuit Diagram of the System

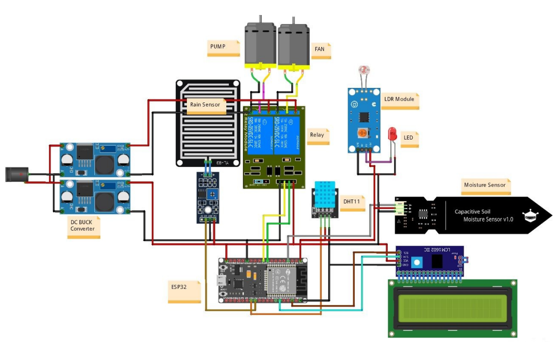

Fig. 3. Integration of the full circuit

Major component of this project is the ESP32. Through the use of a power adapter, a 2- amp AC to 9-volt DC supply voltage powers the entire project. The output generated by the buck converter thus produces 5 volts of DC. Micro-controllers, sensors, and other devices are powered via this 5-volt DC[3]. Through the 5V voltage input (VIN) pin, a step-down converter, also known as a DC buck converter, is linked to the ESP32. The controller receives the incoming data from the sensor and processes it further before sending it back. The field's temperature and humidity are monitored using a temperature sensor, a raindrop sensor that detects raindrops by running at 3.3-5 volts, and a DHT11 sensor that measures temperature and humidity. And the most helpful component is the relay module, which functions as a high-voltage switch and manages high-voltage devices like the submersible water pump of this project, which manages the gear motor for the pond, as well as an insignificant mini solar panel with a maximum work voltage of 5V and a maximum work current of 0–25 mA, from which this project will be able to function adequately in the absence of electricity[4]. On the project LCD Display and a mobile app display, all of the functioning output will then be shown here. This is how the system works basically.

D. Data Flow Diagram

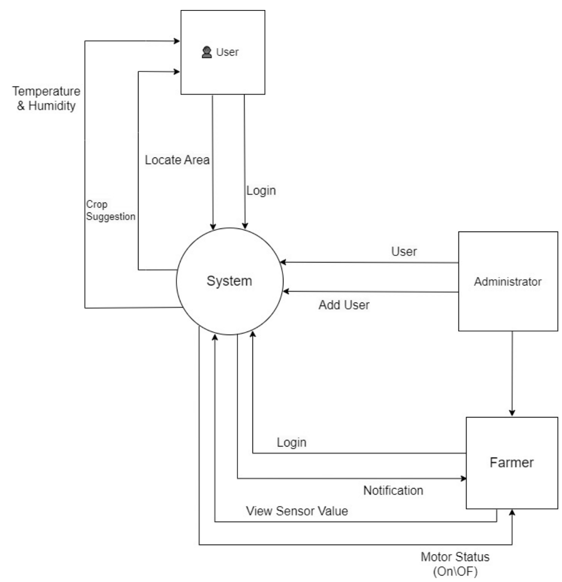

Fig. 4. Data Flow

The data flow diagram for this system evaluates system activities. The system has first of all been expanded to include the remaining subsections, including the administrator, farmer, and user. Everybody in this situation has a direct line of communication with the system, and the administrator receives all system information. When data is received, the farm is notified, and the user's guest ID can be used to log in from anywhere. It goes immediately to the system, where the administrator can see the updated data and keep an eye on it. When necessary, notice will be given.

III. Technologies Used

Software that is offered is a group of guidelines, facts, or programs that use technology to operate machines and carry out certain activities. Equipment, which describes the real physical components of a computer, is the exact opposite of software.

A. Arduino IDE

The Arduino Integrated Development Environment (IDE) is a programming software that connects to Arduino hardware, allowing for the upload and interaction of applications. It supports Windows, Mac OS, and Linux versions of the operating system, and can be modified to implement C and C++ programming languages[16]. Sketching is the process of writing a program or code in the IDE. Genuine and Arduino boards must be linked to the IDE to upload the sketch, which is saved as ”ino”. The code is compiled and run via the Upload button, and the related board receives the code upload. Before submitting the drawing, it is necessary to choose the appropriate board and ports, and a USB cable must be used to connect the board and PC. The Arduino Boot loader, a brief program programmed into the micro controller, is also available for uploading. The boot loader is programmed into the micro controller and flashes due to PIN 13. The Arduino IDE is a collection of GNU tools and the AVR Lab, making it a potential alternative to loading apps.

B. Blynk Apps

Internet of Things platform (Blynk) that aims to make smart IoT devices more useful and effective. Maybe used to read, store, and display sensor data and remotely operate equipment. A growing number of gadgets are connecting to the internet each working day as a result of the Internet’s growing popularity in recent years. An enormous rise in security worries has resulted from the recent development of such extraordinary advances in technology.The Blink server, which powers the whole Blink platform, is its most important component. This device-to-device communication is made possible by the cloud service provided by Blynk, which is centralized, dependable, and efficient. The Blynk server is also open source, which may allow for a more thorough and realistic construction of the project’s server.

IV. RESULTS AND DISCUSSION

It is now time to talk about the findings. Here, commands are written using the Arduino IDE, and the following things may occur: The goal of the project is to create an extensive hardware-based IoT Based Smart Crop Field Monitoring & Automation of Irrigation System”. This project calls for the use of PVC board. Finally, this project will operate and produce results after completion. The project’s capabilities will be realized once it has been put into operation.

- Field humidity and temperature are measured by the system.
- The system monitors the field’s temperature and humidity, drains any standing water automatically, stores the data on the storage device, and notifies the administrator.
- The system uses IoT to control the load.
- Loads can be managed using IoT via mobile applications.
- The project’s LCD panel and the app will both simultaneously display all data.

The results for both conditions are represented by graphs and documented based on the observations that were made.

A. Moisture Level Test:

Fig. 5. Visual summary of the moisture test

The shifting component of the graph mentioned previously illustrates the moisture level test, which demonstrates that the percentage moisture level grows at any moment and explains both the presence of water and its absence. There are several time intervals by which we may assess our moisture levels. If the graph is detailed, we may check the project’s various data at any moment, and in that case, we can witness live moisture monitoring once again. From 0 to100, 30 minutes’ worth of information for 1 week and 1 month may be considered a constraint, and 30 is our threshold if moisture falls below that[18]. The announcement will be sent to the administrator and the pump will be switched on in accordance with the rules. The pump will stop in accordance with the regulations if the moisture level rises above the threshold.

B. Temperature Level Test:

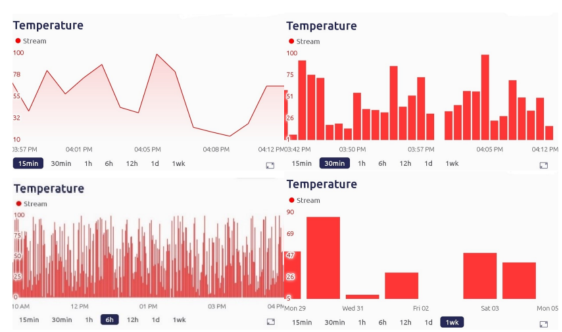

Fig. 6. Visual summary of the temperature test

The temperature during the level test is depicted by the change in position of the graph up top. From there, it is clear that the temperature level rises at any moment, depends on the weather, and has been controlled by the water temperature. There are also many periods determined for this to happen. How can we check the different information regarding the projects at any time. The graph will show temperature monitoring after it is specified. 30 minutes of data recording for 1 week or 1 month might be considered our threshold, with a range of 0 to 100. According to the guidelines, a notification will be sent to the administrator and the oxygen-generating motor of the fish pond will be turned on if the temperature exceeds. The gear motor will stop in accordance with the regulations if the temperature level reaches the threshold.

TABLE I
WITH WATERING, SOIL MOISTURIZE, HUMIDITY, AND TEMPERATURE

Test	Sensing Moisture	Sensing Humidity	Sensing Temperature
1	69	17	33
2	75	15	32
3	67	16	31
4	65	13	31
5	72	14	30
6	60	19	29
7	79	14	29

The most important details in this text are that soil moisture sensors are placed in dry soils and data on moisture is integrated with monitoring of water pumps and irrigation guidance. According to the study, the irrigation system with the water pump is turned off when the determined moisture percentage is 30% or below. If the sensor is submerged in water for the first test, the sensor will display moisture data of 69%, humidity data of 17%, followed by temperature data of 33%. A threshold value was set for prototyping and a humidity tolerance of 30% was taken into account.

TABLE II
WITHOUT WATERING, SOIL MOISTURIZE, HUMIDITY, AND TEMPERATURE

Test	Sensing Moisture	Sensing Humidity	Sensing Temperature
1	29	15	26
2	28	18	27
3	26	17	29
4	27	19	28
5	28	14	26
6	27	15	28
7	26	16	27

Installing soil moisture sensors in dry soils is an important step in the evaluation process. The study's conclusions show that the irrigation system with the water pump is turned off when the moisture percentage is 30% or below. If the sensor is immersed in dry air for the initial examination, the sensor will display moisture data of 29%, humidity data of 15%, and temperature data of 26%. To maintain the outside temperature at 30, this will continue.

V. COMPLETE PROJECT PROTOTYPE

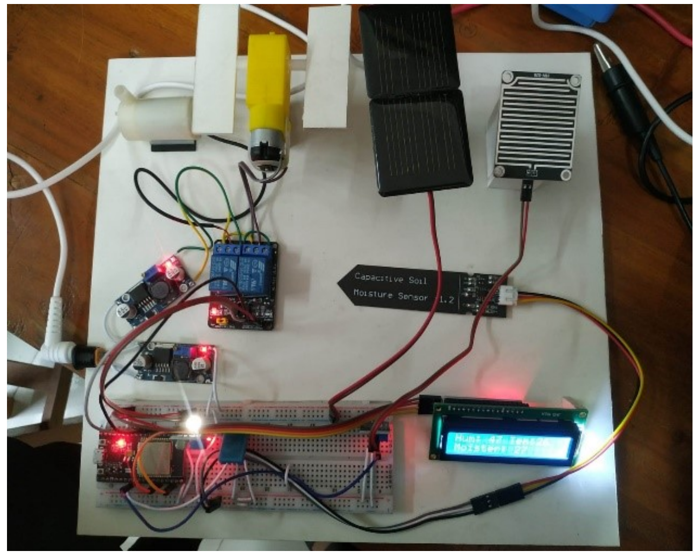

Fig. 7. Prototype

In addition to is a complete project prototype that has been completely executed, and which is the initial planning for this project, with the assistance of which all activities, including both inputs and outcomes, have been entirely accomplished[20].It assists stakeholders in evaluating the project's potential and making informed decisions about its future development by presenting the primary features, user interface, and data management. The prototype is used to collect input, identify changes, and iterate towards the construction of a successful and market-ready product.

VI. FUTURE SCOPE OF WORK

A few ideas can be taken into consideration for the project's future work in order to improve the system and make it more effective.

- We may include sensors to keep an eye on the PH of the soil or water levels inside irrigation tanks.
- It should be improved so that this method isn't restricted to managing just one plant, but may be used to handle numerous plants.
- Among the applications used, the one we'll use may be updated to ensure accuracy when information reaches the farmer. This will improve the system's ability to tell the user when any alerts are available for inclusion in the system.
- The entire system could need to be turned off if there are protracted blackouts, for which solar energy can be employed.
- Remote monitoring sensors with the ability to detect crop levels as well as development can be implemented in the future to the capabilities of the proposed system.
- Can additionally gauge the total quantity of water in a reserve tank that is comprehensible by this type of technology.

VII. Conclusion

An experimental device has been developed to monitor temperature, humidity, and moisture on land, gardens, and other locations. The ESP32 ESP32 has been used to simulate an autonomous plant watering system, which offers numerous benefits and requires less labor. The system starts watering when soil moisture falls below the reference level, resulting in water conservation. Sensors detect soil moisture content, and the system displays the motor's state on the LCD.

The engine is not turned on when the soil is sufficiently moist, but when it is low, it activates when water is needed. The system shuts off automatically when the field reaches the desired humidity level. Additional features include a solar sensor for power-free operation, raindrop sensors for automatic grass watering, and irrigation for fish farming in ponds. The control unit is reliable for use as a voltage compactor, operating more efficiently and at a lower cost than a PLC or micro-controller. The sensors can gather necessary signals from the plant's surroundings and control its operation as needed, potentially boosting agricultural productivity, saving time and money, and having practical applications.

References

[1] Bishnu Deo Kumar, Prachi Srivastava, Reetika Agrawal, and Vanya Tiwari. Microcontroller based automatic plant irrigation system. International Research Journal of Engineering and Technology, 4(5):1436–1439, 2017.

[2] P Rajalakshmi and S Devi Mahalakshmi. Iot based crop-field monitoring and irrigation automation. In 2016 10th International Conference on Intelligent Systems and Control (ISCO), pages 1–6. IEEE, 2016.

[3] Karan Kansara, Vishal Zaveri, Shreyans Shah, Sandip Delwadkar, and Kaushal Jani. Sensor based automated irrigation system with iot: A technical review. International Journal of Computer Science and Information Technologies, 6(6):5331– 5333, 2015.

[4] Khaled Obaideen, Bashria AA Yousef, Maryam Nooman AlMallahi, Yong Chai Tan, Montaser Mahmoud, Hadi Jaber, and Mohamad Ramadan. An overview ofsmart irrigation systems using iot. Energy Nexus, page 100124, 2022.

[5] Shatadru Bipasha Biswas and M Tariq Iqbal. Solar water pumping system control using a low cost esp32 microcontroller. In 2018 IEEE Canadian conference on electrical & computer engineering (CCECE), pages 1–5. IEEE, 2018.

[6] Alexander Maier, Andrew Sharp, and Yuriy Vagapov. Comparative analysis and practical implementation of the esp32 microcontroller module for the internet of things. In 2017 Internet Technologies and Applications (ITA), pages 143–148. IEEE, 2017.

[7] Paul Macheso, Sylvester Chisale, Chisomo Daka, Nelson Dzupire, Justice Mlatho, and Didacienne Mukanyirigira. Design of standalone asynchronous esp32 webserver for temperature and humidity monitoring. In 2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS), volume 1, pages 635–638. IEEE, 2021.

[8] Mr S Tanveer Ahammad, S Musthaq Ahmed, P Nagaprasad, D Nitish, and A Sai Charan. Iot-based smart irrigation system using esp32.

[9] Agus Kurniawan. Internet of Things Projects with ESP32: Build exciting and powerful IoT projects using the all-new Espressif ESP32. Packt Publishing Ltd, 2019.

[10] Mahir Dursun, Semih Ozden, et al. A wireless application of drip irrigation automation supported by soil moisture sensors. Scientific Research and Essays, 6(7):1573–1582, 2011.

[11] George Vellidis, M Tucker, C Perry, D Reckford, C Butts, H Henry, V Liakos, RW Hill, and W Edwards. A soil moisture sensor-based variable rate irrigation scheduling system. In Precision agriculture'13, pages 713–720. Springer, 2013.

[12] Roger D Woodson. Audel Water Well Pumps and Systems Mini-ref. John Wiley & Sons, 2012.

[13] Lala Bhaskar, Barkha Koli, Punit Kumar, and Vivek Gaur. Automatic crop irrigation system. In 2015 4th International Conference on Reliability, Infocom Technologies and Optimization (ICRITO)(Trends and Future Directions), pages 1–4. IEEE, 2015.

[14] James Kretzschmar, Jeffrey Anderson, and Steven F Barrett. Lab 5: Interfacing a 16x2 lcd to the msp430g2553. In MSP430 Microcontroller Lab Manual, pages 39–45. Springer, 2023. Binoy Seal, Omkar Shirke, Siddhesh Shewale, Abhilash Sirsikar, and Priya Hankare. Solar based automatic irrigation system. International Journal of Research in Advent Technology, 2(4):186, 2014.

[15] SN Lipnitskaya, VE Bugrov, AR Kovsh, MA Odnoblyudov, KD Mynbaev LA Nikulina, and AE Romanov. Increasing the light-output efficiency from chipon-board led modules. Journal of Optical Technology, 80(12):751–755, 2013.

[16] IIDI Arduino. Arduino ide, 2019.

[17] Srishti Rawal. Iot based smart irrigation system. International Journal of Computer Applications, 159(8):7–11, 2017.

[18] Badri Narayan Mohapatra, Rohan Vilas Jadhav, and Ketan Sunil Kharat. A prototype of smart agriculture system using internet of thing based on blynk application platform. Journal of Electronics, Electromedical Engineering, and Medical Informatics, 4(1):24–28, 2022.

[19] S Darshna, T Sangavi, Sheena Mohan, A Soundharya, and Sukanya Desikan. Smart irrigation system. IOSR Journal of Electronics and Communication Engineering (IOSR-JECE), 10(3):32–36, 2015.

[20] S Harishankar, R Sathish Kumar, KP Sudharsan, U Vignesh, and T Viveknath. Solar powered smart irrigation system. Advance in electronic and electric engineering, 4(4):341–346, 2014.

[21] Prakhar Srivastava, Mohit Bajaj, and Ankur Singh Rana. Overview of esp8266 wifi module based smart irrigation system using iot. In 2018 Fourth International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics (AEEICB), pages 1–5. IEEE, 2018.

[22] Saleh Elkelani Babaa, Muneer Ahmed, Shahid Ali Khan, and John Al-Jahdhami. Smart irrigation system using arduino with solar power. International journal of engineering research & technology (ijert), 9(05):7, 2020.