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PlantGuard:An Intelligent Bluetoot Enabled Monitoring and Irrigation System using Embedded IoT Components

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***Abstract*— In my university studies I've seen at first-hand look how critical agriculture is to the global food security, and I think efficient irrigation is absolutely essential if we're going to be able to continue growing crops sustainably. Typically, traditional irrigation methods involve manual judgment, and that can end up overwatering, wasting water, or not keeping the soil at the proper moisture level - problems that definitely have an impact on plant growth. We have created a project, namely, Plant Guard: An Intelligent Bluetooth- Monitored, Irrigated, and Controlled Smart System with the Components of the Embedded IoT, to address these issues. The concept was to integrate the information from sensors with smart control, so I'm excited I can tell you about what we have created. The main components of the system include a soil - moisture sensor that is attached to a NodeMCU microcontroller. It sends real-time moisture data to the system because we do not need to approximate when the soil is becoming dry. When the moisture value falls below a certain value, a relay controlled water pump is automatically switched on which helps us to keep the work of irrigation in optimal condition without any additional work. To top that, we have introduced a Bluetooth-enabled mobile application in order to have the benefit of monitoring the live-soil data on our phone, turn the pump on or off manually in case we too necessary and be alerted when moisture is at such a critical level.**

***Keywords*— Smart Irrigation System, Internet of Things (IoT), Soil Moisture Sensor, NodeMCU ESP8266, Bluetooth Communication, Automated Irrigation, Embedded Systems, Sustainable Agriculture.**

I. INTRODUCTION

Agriculture is one of the largest consumers of freshwater globally and inefficient irrigation regimes continue to be a major contributor to water wastage, loss of nutrients and reduced crop productivity [1]. In most farming set ups, people are still making irrigations decisions based on fixed schedules, manual observation, or simply their own experience. Such practices may prove simple to adopt, but they cannot generally work alongside the real water requirement of the crops particularly in areas where rain is erratic and irrigation facilities are limited.
There will be a risk of crops receiving either excessive or insufficient water which is detrimental to plant health and productivity in general.
Over the last couple of years, I have heard the emergence of Internet of Things (IoT) technologies as a possible solution to these inefficiencies allowing us to monitor and manage irrigation on-the-fly. IoT-based solutions allow farmers to always monitor the soil and the environmental situation and activate the irrigation strictly according to the actual needs of the field rather than guessing the needs [9], [5].

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These systems are demonstrated to improve the efficiency of water use, maximize the crop growth and reduce the time of direct human control. Still, despite all these advantages, many current IoT irrigation setups step heavily on constant internet connectivity, cloud services and complicated configurations. That makes them difficult to use for small-scale farmers, people in rural zones and for people who only have a local garden which internet isn't always good in.[18], [21].

The other strategy that struck me is the use of sensor networks by using embedded microcontrollers and provide localized decision making. Soil moisture sensors combined with one or more of the compact controllers can be used to monitor the soil situation and trigger irrigation only when the moisture level falls below a preset level. A bunch of studies have shown that such sensor-based irrigation methods reduce water consumption and maintain, or even improve, crop health and yield [2], [3]. They are particularly good to preserve excessive irrigation and provide plants with the necessary moisture.

Choosing the right technology for communication is important if smart irrigation is to be practical and affordable. Wi. cool thing that happens now is that Wi-Fi and GSM solutions allow you to access things remotely but they require more power and network availability. Bluetooth, on the other hand, is suitable as a low-cost, low-power alternative for short-range applications, such as small farms, greenhouses or home gardens [5], [9]. Bluetooth is offline and direct phone interaction is supported, which is awesome for people who don't be able to connect to the internet all the time.

Based on all this, the proposed Plan Guard system appears to be a crack between the automation, affordability and usability. It has combined together a NodeMCU microcontroller, a soil moisture sensor, a Bluetooth module, and a relay-controlled water pump for a smart irrigation control. The system can operate on automated,

threshold-based irrigations or allow the user to override the use manually through a smart phone app, thus ensuring efficient water use, while still allowing full control. Overall this approach demonstrates that easy to implement, locally controlled IoT solutions can meet the challenge of irrigation without the heavy costs and complexity of fully cloud dependent irrigation system.

II. Literature Review

Lately, entire IoT scenario is completely changing precision irrigation. Most of the kits available have aspects of soil moisture sensors, microcontrollers, and some kind of wireless connectivity to control automated watering and reduce water waste. The statistics indicate that sensor inspired systems indeed have the potential of saving a significant amount of water by only sprinkling realistically when it is needed on the ground. Big projects like the SWAMP pilot even proved that you can run a full blown IoT irrigation system on a farm. But the wrinkle is that these solutions typically require the ability to remain connected to the internet and to a cloud platform, which increases cost and makes them difficult to deploy in rural or remote locations where the connection can be wonky. To this end, thereby as flashy as cloud-connected systems are in providing you with fancy analytics and scalability, the complexity and costs of operation remain a bona fide obstacle to farmers who operate small, medium-sized operations.

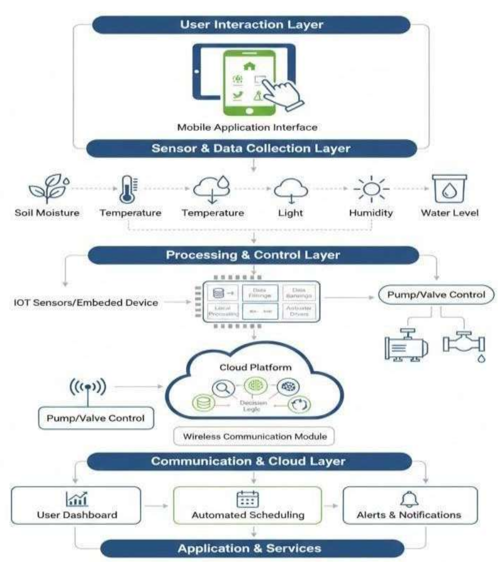


Fig. 1: Problem-Solution Illustration (Traditional irrigation vs Smart irrigation)

The vast majority of the literature I have read brings focus on the aspect of soil moisture as the triggering factor of the watering process and people can utilize the ESP8266 and NodeMCU to deploy a threshold-based autonomous mechanism. Other works go a step bigger using additional environmental sensors or a models a-la-machine-learning into the mix so as to achieve more accurate decisions, however, this naturally raises the bill and the overall stack makes it a more complex task to train. The choice of communication technology is also a major determinant on how efficient a system can turn out, since Wi-Fi and GSM enable connecting to the internet but consume a great deal of energy, at providing long distance it presents higher infrastructure costs due to LoRaWAN. Bluetooth on the other hand is a low cost, energy-efficient option that works well for localised irrigation setup.[19],[20] Even with a bunch of mobile apps that allow you to monitor and control everything from afar, they still almost all depend on access to the internet. Such a gap indicates that there remains the task of creating low cost, offline enabled irrigation systems providing a trade-off between automation, ease of use and price- this is what we need as incentive to the strategy we are suggesting.

III. System Methodology / Suggested Model

The proposed system, Plant Guard, was completed in a structured process of hardware system design, software development, and workflow integration. My goal was to create a low cost, reliable and a user friendly irrigation solution.[12]

A. Hardware Components

The hardware to be set-up will be: NodeMCU ESP8266: This is a takeover controller that in turn processes and also controls the irrigation logic. Applications to Services Provider of Technology/Toilet > Wait for next client, to receive soil moisture Sensor.water content of soil, value comparison with thresholds (dry,moist, wet) and map values into thresholds. HC-05 Bluetooth Module: It is used to enable the wireless communication between the controller and the mobile app. Relay Module: turn on switch or off switch safety control for the water pump. Water Pump - Water Pump supplies Irrigation whenever it is needed.
Note: Power Supply: It supplies stable energy to all the components.

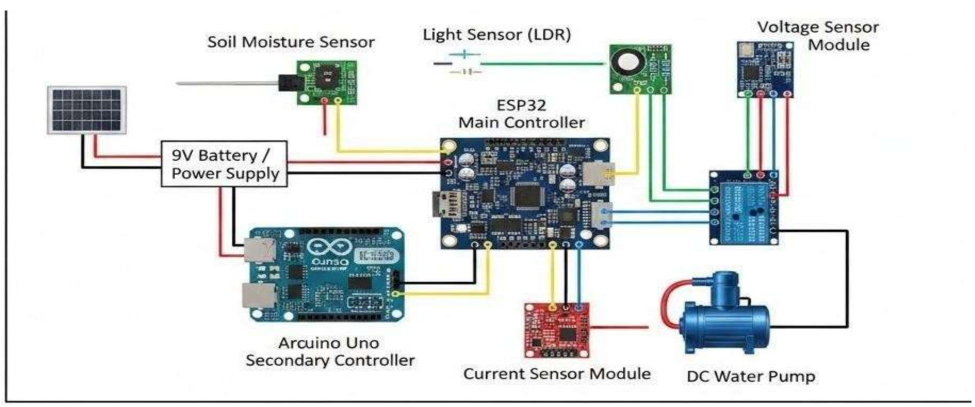


Fig 2: Circuit Diagram of the hardware Implementation

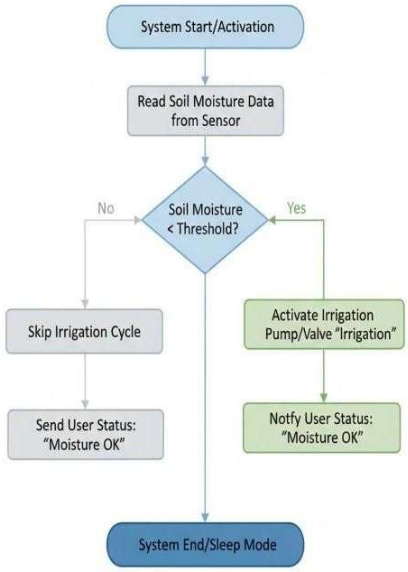
B. Software Components On the software side:

Pros & Cons Very Considerable scope for the replacement of the wireless module. Availability of resources: Arduino IDE: to programming and uploading control logic to the NodeMCU.
Serial Monitor - helped in calibration of sensors and to debug.
Mobile App (MIT App Inventor): This aids real time visualization of soil data as well as control of pumps.

C. System Workflow

Workflow stepwise outline When the scheme is referred to as a whole, the working process takes the following steps:

- Data Collection PD Soil sensor of real-time moisture level
- Processing: NodeMCU processes sensor data and applies threshold logic to it.
- Transmission: data is transferred by Bluetooth to the mobile application
- Control: the app allows to show values and automated or alleviated activation of the pump.



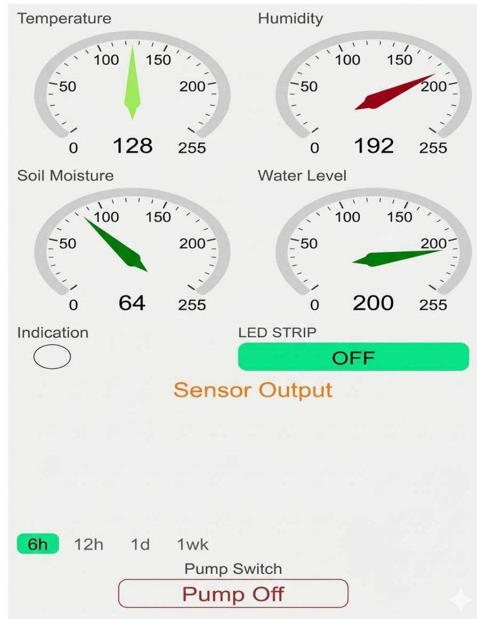


Fig 3: Workflow diagram of the Plant Guard system. Fig 4: Mobile Interface of the System

D. Data Flow

It will work in the following manner: Sensor -> NodeMCU - Bluetooth -> Mobile App Relay Pump. Irrigation is conditioned by a moisture variation below a certain point in automatic mode. In the case of manual mode, the user controls the pump directly from the mobile app.

II. Results and Analysis

We tested the Plant Guard system in the lab using both soil samples that were dryer, more moist and saturated in order to see how well it was able to sense moisture levels, talk to a phone and turn the pump on and off. These trials were intended to be a simulation of real irrigation situations and to verify that the system works as required.The monitoring and control of real-time for pumps must be implemented in a way that allows devices to withstand floods without damages.<|human|>The real-time monitoring and control of pumps should be applied in a manner that enables the devices to withstand floods without any damages.The system was able to transmit the real-time soil moisture data from NodeMCU to my app of a phone using HC- 05 Bluetooth module. The entire round trip could be completed between 0.8 and 1.2 seconds which is quick enough to make provision of real-time monitoring and control. When the moisture value reached the predetermined threshold of action, the pump automatically switched on using the relay. I could still turn the pump on and off by hand in the app so I had good flexibility.

TABLE I: SAMPLE SOIL MOISTURE READINGS VS IRRIGATION CYCLE

Time (min)	Soil Moisture (%)	Pump Status	Irrigation Mode
0	29 (Dry)	ON	Automatic
5	36 (Moist)	OFF	Automatic
10	41 (Moist)	OFF	Automatic
15	34 (Moist)	OFF	Manual Override
20	30 (Dry)	ON	Automatic

Continuous Operation and Stability You are expected to contend that your individual approach succeeded, and that this situation will persist going forward.<|human|>4.2 Agility and Stability You are supposed to argue that your personal style worked, and this will continue to happen in the future.I operated the system continuously for 6-8 hours to test the system for reliability. The sensor outputs remained stable and the pump was able to accurately turn off and on when the threshold was crossed. Bluetooth worked up to around 10 meters or so, with no data loss or disconnection.

TABLE II: SAMPLE SENSOR READINGS AND ACTUATOR RESPONSE

Reading No.	Temp (°C)	Humidity (%)	Soil Moisture (m³/m³)	Water Level (cm)	Pump
1	24.8	60	0.36	12	OFF
2	25.3	58	0.34	11	OFF
3	26.1	55	0.32	10	ON
4	27.4	52	0.30	9	ON
5	28.2	49	0.35	8	OFF
6	27.6	51	0.38	7	OFF
7	26.5	54	0.40	7	OFF
8	25.9	57	0.37	8	OFF
9	25.1	59	0.33	9	ON
10	24.6	61	0.39	10	OFF

The efficiency of water using is measured at 4.3.The time-based irrigation schedule also used could have reduced water consumption, as compared to the standard one, which allowed adding water to the system when needed, by approximately 25–30 percent. This indicates that threshold-based irrigation can actually help in reducing the waste of water to a great level.

Water Saving (%) = (Wtraditional − Wsmart) / Wtraditional × 100

A. Graphical Analysis

The graphs indicate the rapid rise in soil moisture immediately after a start of pump followed by gradual fall when the water evaporates. Temperature and humidity tracked in a logical way with the moisture levels and the water level sensor remained stable except when the pump was running.

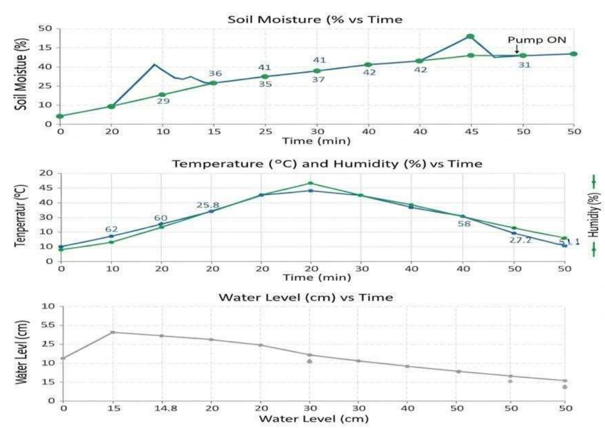


Fig 5: Sensor data visualization generated from the mobile monitoring interface during irrigation system testing.

III. CONCLUSION

The project Plant guard-An Intelligent Bluetooth-Enabled Monitoring and Irrigation System Using Embedded IoT Components show how we can beat the old fashioned irrigation hassles. I got involved a soil moisture sensor and a Nodemcu microcontroller to get the set up, in a way that the system can have eyes on the soil state in real time and turn on the pump automatically when the soil moisture level goes below a certain point. The Bluetooth-enabled mobile app even allows checking the soil conditions and manually controlling the pump if required by anyone.Our experiments confirmed that the sensors are reliable, that the wireless connection is reliable, and that when the pump is being powered, the pump includes little lag. This arrangement reduces water wastage by a significant margin compared to the previous method of watering and is more economical which qualifies it as ideal in small-scale agricultural farms not to mention in small household gardens. It is a good platform, which can become the next-generation smart farming technology.

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