IoT Based Smart Agriculture Monitoring and Irrigation System Using Renewable Energy

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Abstract— **IoT based smart agriculture is very revolutionary approach in farming which utilizes the power of technology to optimize agricultural process. The traditional method of farming relied heavily on manual labor and traditional techniques that were often time-consuming and inefficient. IoT based smart agriculture involves the use of sensors, micro controllers, and other advanced technologies to collect and analyze data on various factors that affect crop growth, such as soil moisture, surrounding motion, temperature and humidity. By optimizing the use of water, farmers can reduce resource wastage while meeting the increased demand of food. The proposed IoT-based smart agriculture system includes a ESP32 control unit, soil moisture sensor, humidity sensor, PIR motion sensor, flame sensor and temperature sensor. The system aims to provide assistance to users in getting live data for efficient environment monitoring which will enable them to increase their overall yield. The system can also utilize the scope of renewable energy using solar energy.**

Index Terms— **IoT (Internet of Things), Solar Energy, ESP32, Smart Irrigation.**

1. Introduction

An Agriculture is the backbone of many economies, playing a crucial role in providing food security and livelihoods for millions worldwide. However, traditional farming methods are often inefficient, leading to resource wastage and environmental degradation. The advent of IoT and renewable energy technologies presents an opportunity to transform agriculture into a more sustainable and productive endeavour. The proposed Smart Agriculture Monitoring and Irrigation System (SAMIS) aims to address these challenges by integrating cutting-edge technologies into agricultural practices.

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The key components of SAMIS include an ESP32 microcontroller, which serves as the central processing unit, orchestrating data acquisition and control tasks. The system incorporates various sensors to monitor crucial parameters such as temperature, humidity, soil moisture, soil pH, flame, and motion. These sensors provide real-time data, enabling farmers to make informed decisions regarding irrigation scheduling, fertilizer application, and pest control. Moreover, SAMIS utilizes renewable energy sources to power its operations, reducing reliance on conventional energy and mitigating greenhouse gas emissions. By harnessing solar energy through photovoltaic panels, the system operates autonomously, even in remote agricultural locations with limited access to grid electricity. This not only enhances the resilience of farming communities but also contributes to sustainable development goals by promoting clean energy adoption. Furthermore, SAMIS features a user-friendly blank app interface, allowing farmers to remotely monitor and control the system using smartphones or tablets. The app provides visualizations of sensor data, alerts for critical events such as fire outbreaks or unauthorized intrusions, and customizable settings for irrigation schedules based on crop requirements and environmental conditions. In summary, the integration of renewable energy and IoT technologies in SAMIS represents a paradigm shift in agricultural management, offering a holistic approach to enhance productivity, conserve resources, and promote environmental sustainability. This journal elucidates the design rationale, implementation details, and potential applications of SAMIS, underscoring its significance in advancing smart agriculture practices for the benefit of farmers, communities, and the planet. This journal outlines the design, implementation, and testing of SAMIS, offering insights into its potential to revolutionize agriculture practices through sustainable and efficient monitoring and irrigation techniques.

2. Internet Of Things (IoT)

IoT (Internet of Things), which refers to the network of interconnected devices that communicate and exchange data over the internet. In this case, the various sensors and the ESP32 microcontroller form an IoT system that collects data from the agricultural environment and sends it to a central server or cloud platform for analysis and control. This allows for remote monitoring and management of the agricultural operation, providing farmers with valuable insights and control over their farm even from a distance.

3. Basic Working Principle

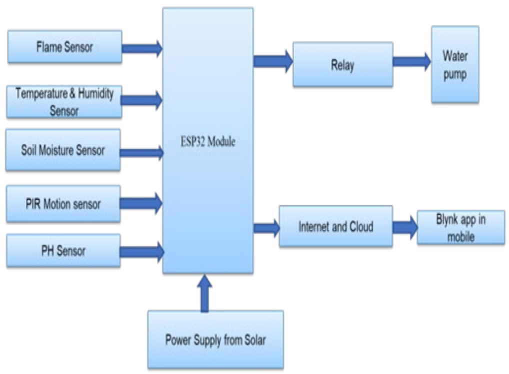

Fig.1. Block diagram of Smart Agriculture Monitoring System

The proposed system makes use several input and output devices, including a solar panel connected to a power source as well as temperature and humidity sensor an input devices, moisture and motor pump is an output device. The photovoltaic system is integrated in solar panel system, providing renewable energy from solar to power the connected water pump. The ESP32 is connected to five sensors— temperature and humidity, soil moisture, PIR motion sensor, flame sensor and PH sensor—and to the solar panels, which power the water pump. ESP32 Wi-Fi connectivity allows for the remote monitoring of weather-related variables such as temperature, humidity, and soil moisture. Farmers can view the overall weather conditions in the land area by using the internet from a remote location. They may control the soil moisture situation, determining whether or not the farmed area needs water, using a cloud application on their android phone.

4. Connection Diagram

The smart agriculture monitoring and irrigation system utilizes renewable energy and an ESP32 microcontroller to efficiently manage the growth environment for crops. The ESP32 acts as the brain of the system, orchestrating data collection and processing from various sensors. These include the DHT11 sensor for monitoring temperature and humidity levels, soil moisture sensor for gauging soil moisture content, and soil pH sensor for assessing soil acidity or alkalinity. Additionally, the system incorporates a flame sensor for detecting potential fire hazards and a motion sensor for security purposes. By integrating these sensors, the system ensures optimal conditions for plant growth while enhancing safety and security in the agricultural environment.

Powered by renewable energy sources, the system minimizes its environmental footprint while maximizing efficiency.

The ESP32 processes data from the sensors to make informed decisions regarding irrigation schedules and environmental adjustments. Based on predefined thresholds for temperature, humidity, soil moisture, and pH levels, the system triggers irrigation cycles to maintain ideal growing conditions for crops.

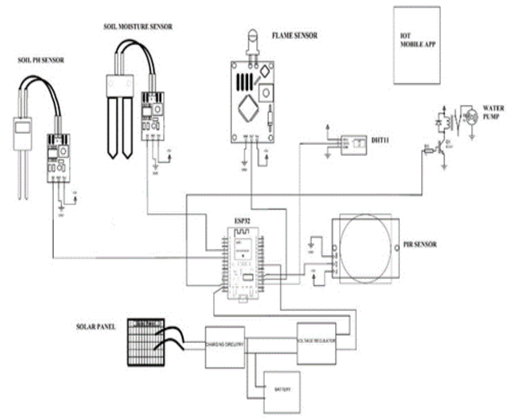

Fig.2. Circuit diagram of Smart Agriculture Monitoring System

Furthermore, it can promptly detect and respond to potential hazards such as fire outbreaks or unauthorized intrusions, enhancing overall safety and security on the agricultural premises. Overall, the integration of renewable energy, advanced sensor technology, and intelligent control mechanisms enables sustainable and productive agricultural practices.

5. Simulation

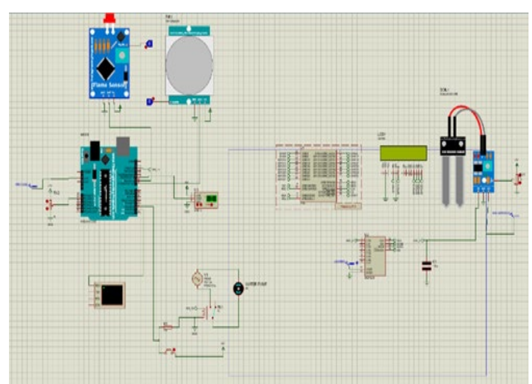

Fig.3. Simulation of Smart Agriculture monitoring in proteus

The integration of Arduino Uno and Raspberry Pi within the smart agriculture monitoring and irrigation system, simulated through Proteus, has showcased the potential of modern technology in revolutionizing farming practices. By connecting Arduino to sensors including the DHT11 for environmental monitoring, flame sensor for safety precautions, pH sensor for soil health assessment, and a water pump for irrigation control, has established a comprehensive system for real-time data collection and decision-making.

Concurrently, Raspberry Pi interfaced with a soil moisture sensor via an ADC, providing precise soil moisture measurements. The Raspberry Pi further enhanced the system's capabilities by displaying results on a virtual terminal, facilitating convenient monitoring and analysis of soil moisture levels. The simulation process in Proteus allowed us to validate the functionality and effectiveness of our integrated system before physical implementation, ensuring reliability and efficiency in real-world deployment.

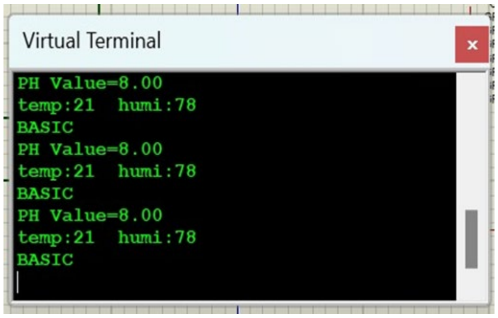

Fig.4. Simulation results on virtual terminal

Through meticulously configuring component properties and defining input signals, accurately replicated environmental conditions and sensor readings, enabling thorough testing and optimization of control algorithms. The seamless interaction between Arduino and Raspberry Pi, coupled with the visualization of results on the virtual terminal, exemplifies the potential of IoT and embedded systems in revolutionizing agricultural practices towards sustainability and productivity.

6. Hardware

The ESP32 WROOM 32 is a powerful and versatile microcontroller that's a popular choice for Internet of Things (IoT) projects. It boasts a dual-core processor for faster performance, built-in Wi-Fi and Bluetooth connectivity for wireless communication, and a good amount of memory for handling complex tasks. This feature set, along with its compact size and relatively low cost, make it a compelling option for creating connected devices that interact with the web or other wireless devices. Power of PH sensor connected to the 3V3 (3.3 volts) pin for power supply. Ground of PH sensor connected to the GND (ground) pin. The signal pin is connected to GPIO34, which is an input-only pin, suitable for sensor readings. Power of Soil Moisture Sensor also connected to the 3V3 pin. Shares the GND connection with the PH sensor. The signal pin is connected to GPIO35, another input-only pin used for sensor data.

The solar panel is connected through a charging circuit. This circuit is likely responsible for charging a battery that powers the ESP32 WROOM module, ensuring a stable power supply from the solar energy collected. Each sensor's signal pin is connected to a specific GPIO (General Purpose Input/Output) pin on the ESP32 WROOM that is configured to read the sensor's data.

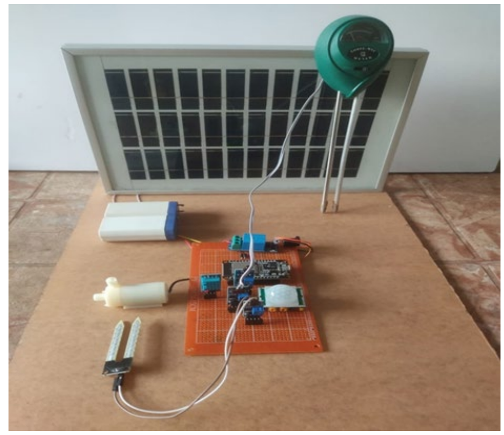

Fig.5. Hardware of Smart Agriculture Monitoring and irrigation system using Renewable Energy

The 3V3 and GND connections provide the necessary power to the sensors. It's important to ensure that the connections are secure and that the ESP32 WROOM's pins are correctly configured in the code to read the sensor data accurately.

DHT11 Sensor is used for measuring temperature and humidity. It's typically connected to one of the GPIO pins on the ESP32 for data communication. The flame sensor detects the presence of fire or flames. It's also connected to a GPIO pin on the ESP32, allowing the module to take action or send alerts when a flame is detected. PIR Sensor is a motion detection sensor. It's used to detect the presence of humans or animals moving within its range. Like the other sensors, it connects to a GPIO pin on the ESP32. The ESP32 is powered by a battery through a voltage regulator. The voltage regulator ensures that the ESP32 receives a stable voltage, which is crucial for its reliable operation. IoT Mobile App, there's an interface with an IoT mobile app. This means the data from the sensors can be sent to the app, allowing for remote monitoring and control. And the ESP32 WROOM can communicate with an IoT mobile app to display the sensor data or send notifications based on the sensor readings.

7. Results And Discussion

Blynk app uses to display and interact with various real-time data and control functions from the smart agriculture monitoring and irrigation system. Temperature and Humidity display gauge in blynk shows the real-time display of temperature and humidity readings from the DHT11 sensor in the monitored area. Soil moisture level display is the visual representation of soil moisture levels, indicating whether the soil is dry, moist, or saturated. Soil pH level display indicates the soil pH levels, showing whether the soil is acidic, neutral, or alkaline. Fire detection alert setup gives immediate alert notification on the app in case the flame sensor detects any fire or flame presence. Motion detection alert gives a flash notification on mobile phone whenever there is any motion detected in the monitored area like rogue or wild animals' entry, providing security monitoring capabilities.

The irrigation control provides a control buttons or sliders to manually initiate or adjust irrigation based on soil moisture readings.

Fig.6. Results on Blynk app

Based on the Blynk output for smart agriculture and irrigation system prototype, the analysis of the results:

- *Humidity*: At 61 percent, the air moisture level is moderate. This is generally suitable for most crops, but specific needs may vary depending on the type of plants and climate conditions.
- *Temperature*: The temperature is at 32°C. This is quite warm and could affect plants that are sensitive to heat. It's important to ensure that the plants being cultivated can tolerate such temperatures.
- *Soil Moisture Content*: The reading is at 0, which indicates that the soil is currently dry. This suggests that the plants may require watering soon to maintain adequate moisture levels for healthy growth.
- *pH Value*: A pH value of 7 is neutral and is typically ideal for a wide range of plants. It's good to see that the soil acidity is at a level that is generally agreeable for agriculture.
- *Water Pump*: The status is OFF. Given the soil moisture content is 0, it might be necessary to activate the irrigation system to provide the plants with the required water. Switching on the pump will provide enough water supply to the field

It's crucial to monitor these parameters regularly and adjust the irrigation strategy accordingly to ensure optimal growth conditions for the crops.

Fig.7. Results on Blynk app showing motion detected

Fig.8. Result showing flame detection

Fire detection alert setup gives immediate alert notification on the app in case the flame sensor detects any fire or flame presence. Motion detection alert gives a flash notification on mobile phone whenever there is any motion detected in the monitored area like rogue or wild animals' entry, providing security monitoring capabilities.

8. Conclusion

The smart agriculture monitoring and irrigation system using renewable energy presents a promising solution for modern farming practices. By integrating renewable energy sources, such as solar power, the system ensures sustainability and reduces reliance on traditional energy grids, thus mitigating environmental impact. Through real-time monitoring and data collection, farmers can make informed decisions regarding irrigation scheduling, fertilizer application, and pest control, ultimately optimizing crop yield and resource utilization. The inclusion of sensors like soil pH and moisture sensors enables precise management of soil conditions, leading to healthier crops and improved productivity. The incorporation of safety features such as flame and motion sensors enhance the security of agricultural assets, preventing potential hazards like fires or theft. Additionally, the development of a user-friendly interface through a blank app facilitates seamless interaction and control of the system, empowering farmers with intuitive management capabilities. Overall, this project underscores the potential of technology-driven solutions in revolutionizing agriculture, promoting sustainability, efficiency, and resilience in the face of evolving environmental challenges. Further research and refinement of such systems hold the promise of driving innovation and progress in the agricultural sector.

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