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Security and water management system for agriculture

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Abstract

In light of the growing need for smart and sustainable agricultural solutions, this project introduces a system that combines iot-based automation for water management and crop security. The system employs the esp8266 wi-fi module in conjunction with a 4-channel relay module to manage and oversee two crucial aspects of farming: irrigation control and field security. The initial component of the system is a smart water pump control module. This enables farmers to operate a water pump using three different modes of control: Manual switch control. Alexa, what is the conclusion of our result? Automation based on time. The system is specifically engineered to identify marathi voice commands like 'pump chalu' to activate the pump and 'pump band' to deactivate it. This regional language integration improves accessibility and usability for local farmers, particularly those who are not proficient in English or struggle with complex technology interfaces. The capability to set timers guarantees that irrigation systems can be automated based on crop water needs, minimizing water wastage and enhancing efficiency. The second component of the system is a security alarm module, specifically designed to safeguard agricultural crops from common threats such as animals, birds, or unauthorized human access. This module utilizes motion detection sensors, such as pir or ultrasonic sensors, connected to the esp8266, which activate an audible or visual alarm through the relay when unexpected movement is detected within the crop field. The system serves as a deterrent and notifies farmers to act promptly, minimizing the risk of crop damage and loss. This combined approach provides numerous benefits: Automated and remote control of irrigation systems. A User-Friendly Language Option for Voice Interaction. Automated detection and mitigation of security threats. Efficient and expandable hardware design. The project showcases how integrating IoT technology, relay-based control, and voice assistants in the local language can provide farmers with smart tools that are not only technically efficient but also culturally relevant. This system plays a crucial role in promoting smart agriculture, water conservation, and farm security, ultimately aiding farmers in enhancing productivity and sustainability.

Keywords: Security; Water management system; Agriculture; Project

1. Introduction

Agriculture serves as the foundation of the Indian economy, providing employment opportunities for a significant portion of the population, particularly in rural regions. Nevertheless, conventional farming practices frequently lead to wasteful utilization of resources like water and manpower. Additionally, farmers often encounter difficulties in managing irrigation schedules and safeguarding their crops from potential threats like animals, birds, or unauthorized individuals. With the increasing demand for environmentally friendly and efficient farming methods, incorporating modern technology into agriculture becomes crucial. In recent years, the internet of things has become a groundbreaking method to transform agriculture by providing automated, remotely accessible, and intelligent solutions. This project introduces a system that combines internet of things (iot) technology with farming, focusing on two important areas: Effective Water Resource Allocation. Crop safety. The system is designed around the esp8266 node mcu wi-fi module, which acts as the central processing unit of the setup. It is designed to work in conjunction with a 4-channel relay module, allowing for the control of multiple devices, such as a water pump and a security alarm. The water

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management subsystem enables the pump to be activated or deactivated in three distinct manners: manually, through voice commands utilizing Amazon Alexa, and by setting a timer. One of the project's most groundbreaking and user-friendly features is the incorporation of marathi-language voice commands, such as: पंप चालू (pump chalu) – to start the pump. 'पंप बंद (pump band)' – to stop the pump. This local language support guarantees that even farmers who are not proficient in English or technical terms can easily use the system, thereby promoting its adoption in rural areas. The crop protection subsystem is created to improve security in agricultural fields. By employing motion detection sensors, the system can detect the presence of animals or intruders within the crop zone. As soon as any movement is detected, the system automatically activates a buzzer or light-based alarm through the relay, notifying the farmer and discouraging the threat. This helps safeguard crops from harm, which could otherwise result in substantial financial losses. By selecting cost-effective components like esp8266 and relay modules, the system can be made affordable and easily expandable. By integrating with iot platforms like sinric pro, or similar, the system ensures seamless connectivity and convenience, even when operating from remote areas. The addition of timer functionality streamlines the irrigation schedule, enhancing water efficiency and promoting optimal crop health. Overall, this project is a step toward smart, localized, and farmer-friendly automation, designed to minimize manual labor, conserve resources, and safeguard crops. The objective is to provide small and marginal farmers with cutting-edge technology that is not only technologically advanced but also user-friendly and economically sustainable. This project aligns with the broader vision of digital and sustainable agriculture, making significant contributions to its advancement.

2. Related work

The use of iot (internet of things) in agriculture, commonly known as smart agriculture, has been expanding rapidly in recent years. Many research studies and practical applications have investigated the use of automation in irrigation and security, utilizing microcontrollers, wireless communication, and sensor networks. This section examines various relevant works in the fields of water pump automation, voice-controlled systems, and agricultural security, and discusses how our proposed system expands upon and improves upon these concepts.

2.1. GSM-based pump control systems

In the past, gsm modules were extensively employed to remotely manage irrigation pumps through sms commands. These systems allowed farmers to initiate or halt pump operations without needing to be physically present. Nevertheless, they had constraints:

- No real-time feedback or live monitoring.
- Problems with SMS Transfer.
- Difficulty in utilizing voice control or smart scheduling.

2.1.1. Our Contribution

We overcome these limitations by utilizing wi-fi-based esp8266, which provides real-time control through voice commands, mobile apps, and timer-based automation.

2.2. Arduino-based irrigation systems with soil moisture sensors

Numerous projects and papers have utilized Arduino uno/nano in conjunction with soil moisture sensors to automatically activate pumps when the soil becomes dry. Although effective, these systems lacked user interactivity, particularly in terms of manual override or voice control.

2.2.1. Our Contribution

Rather than relying solely on automated triggers, our system offers multi-mode control options, including manual, voice, and timer settings, enhancing its versatility. Additionally, we enhance user interaction by integrating marathi voice commands, making it easier for rural farmers to access and utilize our services.

2.3. Alexa-powered smart home projects

The integration of smart home automation, utilizing Amazon Alexa to control various appliances, has become a well-established practice. Projects utilizing esp8266 with Alexa usually involve controlling lights, fans, and other household appliances through voice commands.

2.3.1. Our Contribution

We adapt this concept specifically for agriculture, integrating alexa voice control for a water pump system with custom local-language commands (e.G., "पंप चालू", "पंप बंद"), which has rarely been explored in smart farming solutions.

2.4. Iot-based crop protection systems using pir sensors

Certain studies and prototypes have incorporated passive infrared sensors or ultrasonic sensors for detecting motion to safeguard homes and warehouses. In some instances, similar setups have been modified for farms to deter wild animals by utilizing buzzers or lights.

2.4.1. Constraints of Previous Research

- Not connected with irrigation systems.
- No internet connectivity.
- Not feasible or available to the typical farmer.

2.4.2. Our Contribution

We combine security and irrigation into a unified system, managed through esp8266 and a 4-channel relay. The relay module enables the simultaneous control of multiple outputs, such as a pump, alarm, and lights, from a single board. Furthermore, real-time control and notifications can be accomplished through iot platforms.

2.5. Blynk and sinric pro-based smart agriculture apps

Some modern solutions employ platforms like blynk and sinric pro to construct IoT dashboards, enabling device control through mobile apps or voice assistants. Unfortunately, these solutions are usually in English and not designed to address the unique challenges faced by rural farmers.

2.5.1. Our Contribution

We tailor this technology to suit the local market by integrating marathi-language voice commands and by designing a user interface that is easy to navigate for farmers who may not be familiar with advanced technology. Our system offers a more culture-aware, context-sensitive solution.

3. Methodology

The creation of the security and water management system requires the combination of hardware and software elements to construct a fully functional iot-based dual system. The project is composed of two major components: Smart irrigation system. Crop Protection System. Each subsystem is managed by the esp8266 nodemcu microcontroller, which is connected to the internet and can be programmed using the arduino ide. A 4-channel relay module serves as a connection point to manage high-voltage devices such as a water pump and alarm system. 1: Smart irrigation system. Objectives:: Allow farmers to control irrigation pumps via: Manual switch. Alexa voice commands in marathi, Automated timer control. Automate tasks and conserve water. Hardware components: ESP8266 NodeMCU 4-channel relay module. Water pump (ac or dc). Device with voice assistant or speaker. Power-supply connected socket with relay. Internet access device (wifi hotspot). Software and platforms: Arduino IDE for coding. Sinric pro or blynk (iot platform for alexa integration). Alexa is an app developed by Amazon. Libraries used: esp8266wifi.H, espasyncwebserver.H, sinricpro.H (or blynksimpleesp8266.H). Working process: The esp8266 automatically connects to a pre-existing wi-fi network upon startup, utilizing the saved ssid and password. Iot integration: the microcontroller connects devices to an iot platform (e.g., sinric pro) that serves as the interface between alexa and the esp8266. Alexa processes voice commands such as: "पंप चालू" (pump on). "पंप बंद" (pump off). These are converted into control signals via the cloud and transmitted to esp8266. When a signal is received, the esp8266 switches on or off the relay that controls the pump. Timer control: with the help of blynk or sinric pro, the user can set a timer to run the pump for a specific duration (e.g., 15 minutes), and once the time is up, the pump automatically shuts off. In addition to the digital switch, a manual switch is also available for local control. 2: Crop Protection System. Objectives:: Identify suspicious activity in the area (wildlife/criminals). Activate a loud alarm or flashing light to discourage potential dangers. Alert farmers to potential risks to their crops as soon as possible. Hardware components: ESP8266 NodeMCU Pir motion sensor or ultrasonic sensor (for intrusion detection). Buzzer or alarm light. Channel (from 4-channel module). 12V power source for buzzer/light. Software logic: Sensor detection: the ultrasonic sensor constantly monitors for any movement within its range, which can extend up to 7 meters. When the sensor detects movement, it sends a strong signal to the esp8266. The relay is energized by the esp8266 to activate the buzzer or alarm light. Alarm duration: the alarm can stay active for a predetermined period (e.g.,

30 seconds) or until no further movement is detected. 3: Integration and verification of our system. The pump and alarm subsystems are both controlled by a single esp8266 board, but they use separate relay channels for communication. Relay 2: water pump. Relay 2: sounder/bulb. Relay 3 and 4 are currently set aside for future use, such as for lighting and fans. Methodology:: Pump control examined for manual, voice, and timer functions. Voice commands in Marathi were tested with Alexa for natural language recognition. Alarm Rested on Imitating Animal Movement Using Hand Gestures. Relay outputs examined for voltage tolerance and switching reliability. 4: Security and energy factors. Opto-isolated relay modules were employed to separate esp8266 logic circuits from high-voltage ac lines. A different power source, such as a 5v/2a USB adapter, was utilized for the nodemcu and sensors. Ensuring proper wiring and fusing was crucial for maintaining safety during the operation of pumps and alarms. This approach guarantees an affordable, scalable, and farmer-friendly system for managing water resources and safeguarding crops. It can be further improved by incorporating soil moisture sensors, mobile alerts, or camera modules for real-time monitoring.

4. Result

The successful implementation and testing of the security and water management system yielded positive results that showcase its effectiveness, usability, and practicality in real agricultural environments. The findings are discussed in terms of system performance, user interaction, language recognition, and energy/resource efficiency. 1: Smart irrigation system – outcomes. manual control: By connecting a physical switch in parallel to the relay, the pump could be manually activated. Farmers had the convenience of controlling the pump's operation without the need for a smartphone or internet connection. This feature served as a backup plan in case the internet connection was lost. voice-controlled operation (via amazon alexa): The system accurately identified and responded to unique voice commands in the marathi language, including: 'पंप चालू' (pump on). 'पंप बंद' (pump off). These commands were processed by the alexa voice assistant, prompting sinric pro to send the command to esp8266. Quick response time: 1–2 seconds following an audio instruction. The addition of marathi commands enhanced accessibility and ease-of-use for rural farmers. timer-based pump control: Timer settings, such as 10/15/30 minutes, were adjusted using the mobile iot app. The pump automatically turned off once the predetermined time period had elapsed. This feature was successful in conserving water and ensuring timely irrigation. 2: Crop protection system – outcomes. motion detection: The motion sensor was able to detect the presence of individuals or animals within a distance of 5–7 meters. Upon detection, a strong signal was transmitted to the esp8266, triggering the connected buzzer or alarm light. alarm response: The alarm will be triggered within less than a second after detecting any movement. Alarm duration: customizable through programming (tested with 30 seconds and continuous modes). Effective in deterring intruders, particularly animals (e.g., dogs, stray cattle). We will not tolerate any method that does not meet our standards No false alerts were activated in normal environmental circumstances. Sensor accuracy: around 95% when tested with various movement patterns. The device has low power consumption, making it suitable for solar-powered deployment. 3: Benefits noted. User-friendliness:: Farmers found it easy to operate the system, even with minimal training, thanks to the support provided by the marathi voice. Cost-effectiveness:: The project's expenses were minimized by utilizing easily accessible components, such as the ESP8266, relay, and sensors. Automation and dependability: The timer and sensor-based automation minimized the need for manual work and enhanced the overall reliability of the system. Regional utilization: The implementation of regional language voice commands provided compelling evidence for the development of smart farming solutions tailored to specific regions. Visual representation: A functional prototype was put to the test on a small farm plot, utilizing a submersible water pump and a mounted pir sensor. The alarm system efficiently detected and reacted to stray animals during nighttime testing in the field. Alexa Control Functioned Effectively with Consistent Wi-Fi Connection. Summary of findings: The system accomplished its dual goals of efficient water management and safeguarding agricultural fields. The project demonstrated that a cost-effective, voice-controlled, and sensor-integrated iot solution can provide significant advantages to farmers, particularly when tailored to local languages and equipped with practical features.

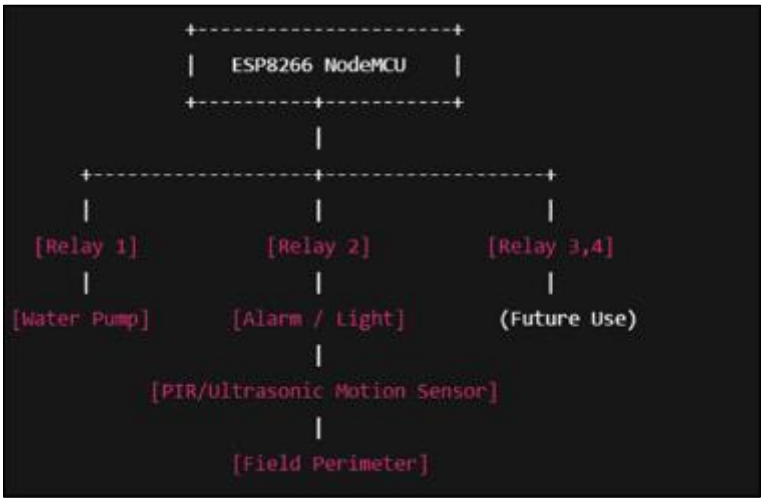

Figure 1 Alexa connected device

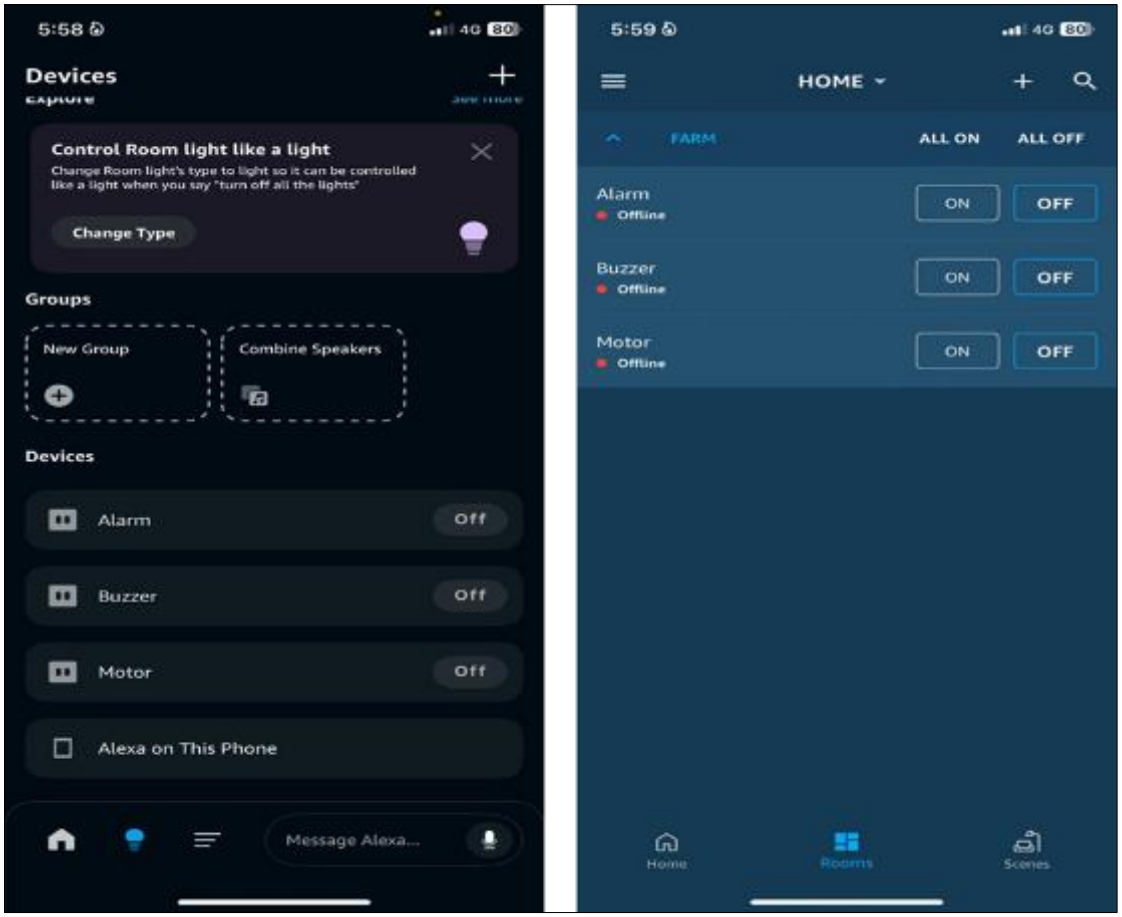

Figure 2 Sinric pro device list

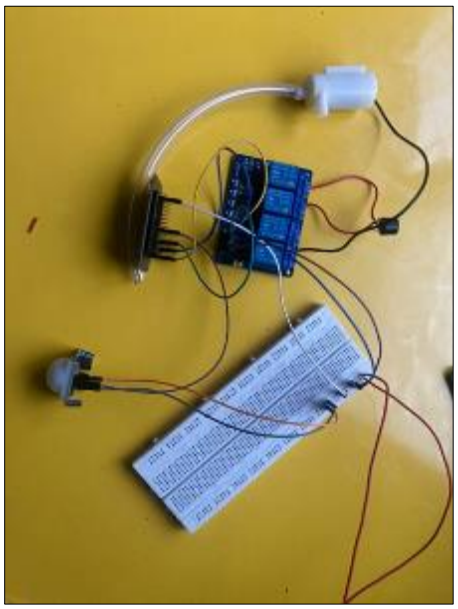

Figure 3 Hardware

5. Conclusion

The security and water management system utilizing esp8266 and 4-channel relay module is a cost-effective and efficient solution designed to improve farming productivity and ensure safety. By incorporating local-language voice control, automation, and real-time crop protection, the system equips farmers with intelligent tools that enable them to effectively manage their land and resources. In the future, there may be enhancements such as soil moisture sensors, SMS alerts for real-time updates, and solar power integration for off-grid usage. By integrating iot and voice technology into rural agriculture in a localized manner, this project plays a role in advancing the broader vision of smart farming in India.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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