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Farm Protection System for Animal and Human Theft Using Solar Photovoltaic-Powered IoT System

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Abstract

The agricultural sector in Malaysia plays a vital role in producing food and raw materials, significantly contributing to the country's economic well-being. However, this sector faces several issues, including weather fluctuations, declining soil quality, and wildlife attacks. Farmers may sustain large financial losses as a result of this damage, which can drastically lower crop output. The primary concern is the direct harm to crops, which leads to lower yields and financial difficulties. The aim is to design and develop an Internet of Things (IoT)-based protection system that can monitor unauthorized access or potential threats from animals and humans at any time. The project utilized the Blynk IoT platform to create a custom application for monitoring and controlling the protection system. The system itself incorporates motion sensors and alarms. Farmers will receive real-time notifications through the Blynk app. The system integrates several components such as Passive Infrared (PIR) sensors, a buzzer, a Light Dependent Resistor (LDR), and a light-emitting diode (LED). It is powered by solar photovoltaic (PV) technology, ensuring sustainability and environmental friendliness. When the system detects a motion, it triggers the buzzer, enabling farmers to improve security and reduce losses. The maximum detection range is up to 12 meters. This innovative technology offers constant security and monitoring without depending on traditional power sources by utilizing solar energy in the system.

1. Introduction

Farmers face risks from wildlife attacks, such as monkeys, wild boars, and humans, which can damage crops and decrease productivity [1]. The issue of wild animal attacks or thieves is a complex crisis due to the lack of protection for their crops. Uncontrolled wild animal attacks can result in severe financial and time losses for farmers. Wild animals' behavior can be influenced by human activity and environmental changes, leading to them entering agricultural regions for food. As natural habitats are transformed into agricultural land or urban areas, animals may be forced to search for food in areas with high concentrations of human activity.

To address this issue, a prototype protection system for a solar photovoltaic farm is proposed. This system will enable farmers to remotely monitor the state of their farms, especially during conditions that limit physical presence, such as at night. The IoT technology will allow farmers to monitor the real state of their farm at any time as long as the internet is available. Heavy rains provide cover and concealment for wild animals and potential intruders [2], making it difficult for farmers to monitor their surroundings effectively.

The project aims to create a prototype protection system for a solar photovoltaic (PV) farm, integrating motion sensors, alarms, and other security equipment to safeguard the farm. PV technology has been growing in significance in the last few years for several reasons that are indicative of the worldwide trend toward sustainability and renewable energy [3]. Solar PV farms are environmentally friendly, producing electricity without greenhouse gas emissions. The system should align with sustainable practices and minimize environmental impact. Energy storage will allow for the use of extra energy produced during the day, making it suitable for night or overcast days.

Inspired by [4] to secure farms from theft and alert farmers from potential damage caused by animals. Traditional methods like Hellkites, balloons, shot/gas guns, and string & and stone are often cruel and ineffective, requiring high installation and maintenance costs. The project aims to protect crops from animal damage and divert animals safely using an animal detection system that uses Global System for Mobile Communications (GSM), LED, buzzers, and IoT to alert and warn animals. Farmers can control speaker sounds through a web page to ward off animals without harming them. This innovative approach reduces environmental pollution and costs for farmers.

D. Ranparia, G. Singh, A. Rattan, H. Singh and N. Auluck [5] develop a device to protect the crop area that keeps wild animals away from fields without causing them any physical harm. This research came up with the idea of using an Infrared (IR) camera to monitor their crop. The study aims to create a device that protects crops from wild animal damage by delivering them from farms without physical harm. The device uses a convolution neural network (CNN) for image recognition and classification, and a high-resolution Infrared Night Vision camera to detect approaching animals' movements and images. The camera continuously captures video and sends it to a Raspberry Pi. However, this system did not use the Blynk application as a cloud server since it does not use an IoT system to notify the owner.

2. Methodology

2.1 Overview

Based on Fig. 1, the Blynk program was used to create an IoT monitoring system that includes a PIR sensor and an LDR sensor. The developed prototype demonstrates how the system works. The prototype includes a PIR sensor, a buzzer, and a microcontroller (NodeMCU ESP32), which are essential components for the future implementation of the system. Blynk, an IoT monitoring platform, leverages the microcontroller to coordinate data collection from sensors and automate system operations. By connecting the PIR and LDR sensors to an ESP32 via Blynk, users can remotely monitor and control the system through a mobile app or web interface. Blynk simplifies the process of creating apps for IoT applications, providing an intuitive platform for managing and visualizing sensor data.

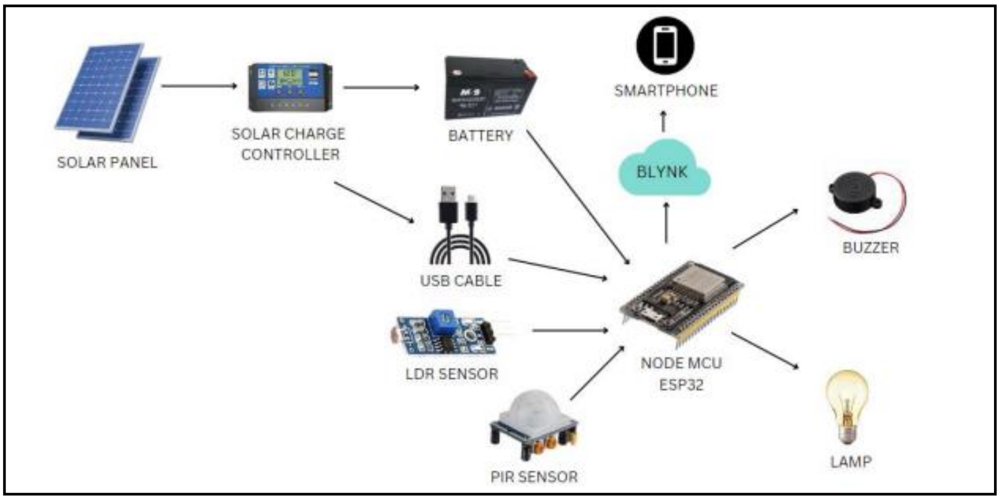

Fig. 1 *Connection of the project system design*

2.2 Flowchart of the System

Fig. 2 shows the flow of the system. The process of the farm protection system begins with the activation of the PIR sensor switch through the Blynk App. A PIR sensor is a kind of motion sensor that tracks variations in infrared light within its viewing area If the switch is off, the system continuously checks the switch conditions until it is turned on. Once the switch is on, the system monitors for any objects detected by the PIR sensor, indicating changes in infrared radiation. If no object is detected, the system loops back to check the switch conditions again.

However, if an object is detected, the system activates the buzzer to alert of a potential intrusion and sends a notification to the owner's mobile device via the Blynk App. Simultaneously, the system checks the status of the LDR sensor. An LDR sensor is used to detect variations in the intensity of light and convert it into an equivalent electrical signal. The response time that the LDR needs to react to variations in light intensity is in milliseconds. It assesses whether the light intensity exceeds a predetermined threshold value, such as 1000. If the light intensity is below the threshold, the lamp remains off. If the light intensity exceeds the threshold, the system turns on the lamp to ensure proper illumination.

By continually cycling through these operations, the system maintains watchful monitoring and management, successfully safeguarding the farm against invasions while optimizing energy use. The Blynk App's real-time notifications and automation capabilities keep farmers informed and allow them to make critical decisions quickly, improving farm management security and efficiency.

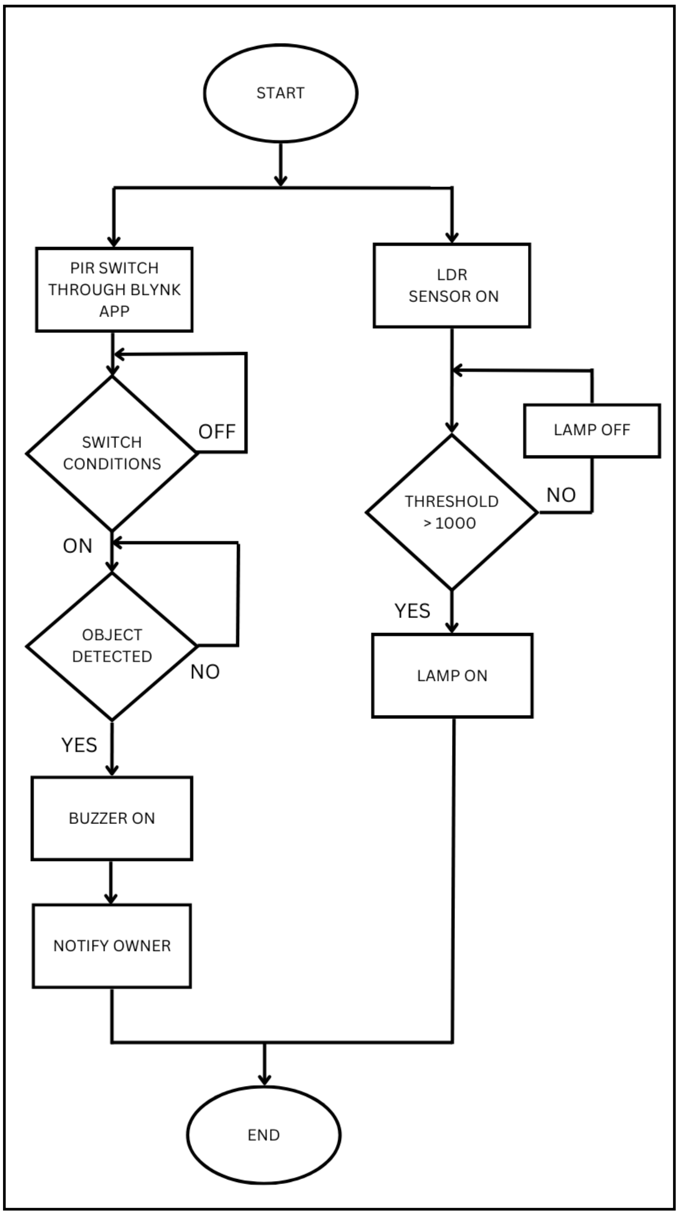

Fig. 2 *Flowchart of the system*

2.3 Hardware Development

This project utilizes hardware components such as the ESP32 microcontroller, a PIR (Passive Infrared) sensor, an LDR (Light Dependent Resistor) sensor, and the Blynk platform as a Cloud Application Server. The process begins when the farmer activates the system through the Blynk App. Without this activation, the farm protection system remains inactive. To employ an IoT-based detection system for security, the system must be equipped with sensors that collect data and transmit it wirelessly to the user's device, allowing for real-time monitoring of farm conditions from anywhere. The scale of the prototype was 30cm x 35cm.

The PIR sensor monitors for changes in infrared radiation, indicating the presence of an animal or human. If the PIR sensor is triggered, the buzzer sounds, and Blynk sends an automatic alert via short message service (SMS) to the owner, indicating a potential intrusion. The LDR sensor detects changes in light intensity, allowing the system to turn lights on at dusk and off at dawn, conserving energy during daylight hours.

Additionally, the system integrates with a solar PV panel. The solar panel and battery are connected to a solar charge controller. The battery stores energy from the solar panel and supplies it to the system, enabling it to function. Photovoltaic technology is a method of generating electricity from sunlight. Through this light energy, it can produce electricity. This setup ensures that the farm is protected and that the farmer is notified immediately of any intrusions, while also optimizing energy usage for lighting.

2.4 Monitoring System Development

The development of an IoT monitoring system for farm protection involves integrating various sensors, devices, and communication technologies to collect and analyze data for farm security and well-being. This system can communicate with mobile devices to continuously monitor the farm, eliminating the need for the owner to be physically present, especially at night when theft and damage by humans and wild animals are more likely. Animals such as deer and wild boar are more active at night, using the darkness as cover while they search for food.

The system uses sensors to detect motion and monitor the condition of the farm in the farmer's absence. The interface can be accessed directly from a smartphone, allowing the farmer to view the entire farm protection system through the Blynk application, provided there is an internet connection. Local encoding and Wi-Fi are required for system communication, with the Wi-Fi module integrated into the microcontroller to facilitate data transmission. This enables the microcontroller to send processed data to a central server or cloud platform. IoT technology is used in the apps to provide real-time data display and monitoring of each sensor input. The next stage involves writing programs to read data from the linked sensors on the NodeMCU-ESP32 microcontroller using C language code compiled with the Arduino IDE.

The Blynk app acts as a remote activation and control tool, allowing the farmer to activate and control the farm protection system from a distance. That means that the system may be turned on and off from anywhere, allowing for greater flexibility and convenience. Aside from that, the app monitors the farm in real-time by showing data received from several sensors (PIR and LDR). This allows the farmer to continually monitor the farm's circumstances while not physically there. Next, Blynk sends automatic warnings and messages to the farmer's mobile device if the PIR sensor detects movement or if other sensors indicate major changes. This instant notice allows farmers to respond promptly to possible risks, such as human or animal invasions.

3. Result and Discussion

3.1 Overview

This part presents the findings of the research that was done on the proposed project to run an IoT application on a farm protection system to obtain feedback. The setting of sensitivity PIR, LDR threshold and monitoring feedback on the Blynk platform will therefore be expanded in this chapter which are the key components of the project.

3.2 Final Prototype

This prototype consists of poles around the farm. At each pole built, there is a PIR sensor on the inside of the pole while on the top of the pole, there is an LED. Buzzer and LDR are placed in the "transparent box" as shown in Fig. 3. The Blynk app is a real-time monitoring alert to the owner allowing the notification. By integrating IoT technology into this system, the farmer can continuously monitor and enhance the overall security of the farm, thereby improving overall efficiency and convenience.

Fig. 3 *Prototype of the project*

3.3 Blynk Notification

As shown in Fig. 4, there is a switch for activating and deactivating the PIR sensor. The function of this switch is to help the users to control the PIR sensor remotely. Using a switch button to activate and deactivate the PIR sensor can provide a convenient way for users to enter the farm without triggering the sensor and causing the buzzer to sound. It provides flexibility and convenience while maintaining the system. Besides that, the display on the Blynk application shows the LED's status (on or off) based on the light intensity sensed by the LDR. The system can automatically switch off the LED during the day when there is enough natural light, saving energy for use at night when illumination is required.

Fig. 4 *Interface of Blynk Application*

Users can now easily manage and monitor their farm activities as shown in Fig. 5. Using the Blynk app, users can keep track of farm conditions instantly with updates displayed on LED monitors. Users can monitor the farm from anywhere and anytime as long as an internet connection is available. With real-time information and remote control to promote sustainable energy, this integration provides an efficient approach to issues faced by traditional farmers.

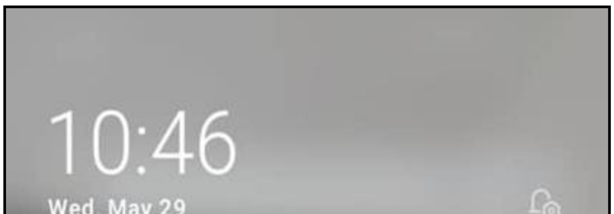

Fig. 5 *Notification that send by the Blynk*

3.4 Distance Detection Range

The distance sensitivity of the PIR sensor can be adjusted. Turning the potentiometer clockwise or counterclockwise will increase or decrease the detection range. For this project, the distance is adjusted to the higher which is it can be made up to 12m. Based on the PIR calibration made, the effectiveness of the detection range is shown in Table 1.

Table 1 *Effectiveness of PIR Sensor Detection Range*

Distance (m)	Detection Success Scale
1 < m < 6	High
6 < m < 8	High with a slight decrease
8 < m < 10	Decreased
10 < m < 12	Significant decrease
m > 12	None
	(More than the limitation)

At distances up to 6 meters, the PIR sensor was highly effective, with an excellent detection success scale. Between 6 to 8 meters, the effectiveness slightly decreased but remained high, with a good detection success scale. Next, between 8 to 10 meters, the effectiveness is decreased with the average detection success scale. At the maximum tested distance of 12 meters, the effectiveness dropped to a poor scale indicating some potential limitations at the furthest range. Based on this result, the PIR sensor is highly effective within the 1-10m range, its detection capability slightly diminishes beyond this range. Adjustments to the installation environment and sensor positioning can help maximize detection performance.

4. Conclusion

In conclusion, this project aims to design an IoT-based protection system to monitor unauthorized access or potential threats from animals and humans. The integration of IoT sensors in farm protection systems allows for advanced monitoring and surveillance beyond traditional security measures. These sensors collect real-time data on parameters like motion, which is transmitted to a central control system for continuous monitoring. The system also offers remote accessibility and control, allowing farm owners, security personnel, or authorized users to access real-time data, receive alerts, and control certain aspects remotely. This feature is crucial for farmers to monitor their farm security from a distance and respond promptly to emerging threats. Next, the second objective of this project has been achieved through the integration of the prototype of the farm protection system with the solar photovoltaic system as a power source. This innovative technology offers constant security and monitoring without depending on traditional power sources by utilizing solar energy. This project not only addresses immediate security concerns but also contributes to the broader goals of sustainability and resilience in the agricultural sector. With the achievement of the objective, user can monitor and control their farm automatically.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors are solely responsible for planning and designing the study, collecting data, analysing and interpreting results, and writing papers.

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