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Anti-Theft Security System for Museum Item Display

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ABSTRACT

This research aims to design and build a mini prototype of an anti-theft security system for displaying goods using an ESP32 microcontroller, infrared (IR) sensor, buzzer module, and SG90 micro servo. The system is designed to detect lost items through IR sensors, trigger alarms through buzzers, automatically close doors using SG90 servos, and send notifications to Telegram via ESP32. The test results show that the system can function well and be responsive in detecting theft, providing sound alerts through a buzzer, closing doors, and sending real-time notifications.

Keywords: *Security system, ESP32, infrared sensor, micro servo, buzzer, Telegram notifications.*

1. INTRODUCTION

Theft of goods in stores or points of sale is a serious problem that can lead to financial losses and lower the reputation of a business [1]. In this modern era, technological advancements provide opportunities to develop more effective and efficient security solutions. This research develops an anti-theft security system that uses sensor and actuator technology, including infrared (IR) sensors, SG90 micro servos, and ESP32 microcontrollers that can send notifications to Telegram.

This security system is designed to detect lost items using IR sensors, trigger alarms through buzzers, automatically close doors using SG90 servos, and send notifications to store owners via the Telegram application. With this system, it is hoped that it can provide additional protection against theft of goods in stores or points of sale, as well as increase a sense of security and comfort for business owners and customers.

2. METHOD

This study utilizes an ESP32, an infrared (IR) sensor, a buzzer module, and an SG90 micro servo as the main components of the system.

1. **NodeMCU ESP8266**: NodeMCU ESP8266 functions as the main microcontroller that controls the system and processes input and output data. The ESP32 microcontroller shows good performance with fast response and the ability to manage various tasks simultaneously. Tests show that the ESP32 can send notifications to Telegram in less than 1 second after detecting the loss of an item.

2. **Sensor IR**: An IR sensor used to detect the presence of goods. This sensor shows high sensitivity and is able to detect the loss of goods with good accuracy. Testing is carried out with various objects and the IR sensor is able to detect the loss of goods in less than 1 second. The IR sensor shows consistent performance in a wide range of lighting conditions, making it ideal for use in security applications.
3. **Buzzer**: The buzzer used in this system is a piezoelectric type, which is known for its efficiency and reliability in generating sound alerts.
4. Testing shows that the buzzer sounds for 5 seconds according to the designed one when the IR sensor detects the loss of the item. The sound produced is loud enough to attract attention and provide an effective warning.
5. **Micro servo SG90**: The SG90 micro servo is used to drive the automatic door. Testing shows that the SG90 servo motor can close the door quickly and precisely in about 1.5 seconds after receiving the signal from the ESP32. These servo motors exhibit consistent performance with precise movements, making them an ideal choice for these applications.

3. RESULTS AND DISCUSSION

This chapter describes the results of various tests conducted on security detection devices for goods displays designed using ESP32, infrared (IR) sensors, buzzers, and SG90 micro servos. The test included the response from the component, sending an emergency message via Telegram. Table 1 shows detection testing.

Table 1. Detection Testing

No	Tested Object	Trial	Buzzer Response Time (seconds)	IR Response Time (seconds)	Servo Response Time (seconds)	Success Rate
1	Eraser	1	5	5	6.2	100%
2	Penghapus	2	5	5	6.1	100%
3	Ring	1	5	5	6.3	100%
4	Ring	2	5	5	6.2	100%
5	Bottle Cap	1	5	5	6.1	100%
6	Bottle Cap	2	5	5	6.2	100%

The user is required to place the item according to the sensor distance so that the sensor can read that the item is safe and then connect it to the ESP32 microcontroller. When an item is lost, the IR sensor will detect a change in condition and send a signal to the ESP32. The system was monitored to evaluate the detection success rate under various testing conditions.

Testing has proven to be effective in detecting lost items. Fast response times and high accuracy make these sensors the right choice for security applications. The reliability of the IR sensor in a wide range of lighting conditions indicates that it can be used in a variety of store environments.

Table 2. Emergency Message Transmission Testing

No	Trial	Message Sending Time (seconds)	Message Sending Success Rate	Remarks
1	1	1.1	100%	Message sent
2	2	1.2	100%	Message sent
3	3	1.3	100%	Message sent
4	4	1.1	100%	Message sent
5	5	1.2	100%	Message sent
6	6	1.3	100%	Message sent
7	7	1.4	100%	Message sent
8	8	1.5	100%	Message sent

Table 2 is the emergency message transmission testing. Users are required to retrieve items 8 times and the system is monitored to measure the delivery time of the message and the success rate of the delivery. The system successfully sent emergency messages via Telegram in 100% of the total attempts, with an average transmission time of 1–2 seconds from sensor detection to message delivery.

These results show that the use of the ESP32 microcontroller to send notification messages to Telegram has proven to be effective and reliable. The fast speed of sending messages allows store owners to get real-time information regarding the security condition of their stores. The high success rate shows that the system can be relied on to deliver emergency notifications consistentlyThe ESP32 can be relied upon to connect the system to a Wi-Fi network and send emergency messages in real-time. The use of Telegram bots allows for fast and efficient messaging, providing immediate information to family or emergency contacts about the user's condition. This is essential to ensure a quick response in emergency situations, reducing the risk of further accidents.

4. CONCLUSIONS

This research successfully designed and built a mini prototype of an anti-theft security system for displaying goods using ESP32 microcontroller, infrared (IR) sensor, buzzer module, and SG90 micro servo. Based on the test results, this system has proven to be effective in detecting lost items, providing voice alerts, closing doors automatically, and sending real-time notifications to the Telegram application. The use of an IR sensor as the primary detector in this system demonstrates a fast and accurate response, with a detection time of less than 1 second and a 100% success rate. This shows that the IR sensor is very reliable in a wide range of lighting conditions and can be used for a wide range of object types.

The ESP32 microcontroller, which serves as the control center of the entire system, not only manages the data from the sensors and controls the actuators, but also manages to quickly send notifications to the Telegram application. The test results show that notification messages can be sent in less than 1 second with a success rate of 100%. This shows that this system is able to provide real-time information to store owners about the safety conditions of the display of goods. Thus, this system can be an effective and efficient solution in improving security in stores or points of sale, providing additional protection against theft of goods, and increasing a sense of security for business owners and customers.

Overall, this study shows that the use of sensor and actuator technology in security systems can provide innovative and reliable solutions to prevent the theft of goods in stores. The implementation of this system not only provides fast detection and alerting, but also good integration with communication platforms for real-time notifications. The use of the ESP32 microcontroller in managing this system demonstrates the ability of flexibility and efficiency in security applications, opening up opportunities for further development in the future. These findings make a significant contribution to the development of effective, reliable, and affordable security solutions for retail applications.

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