Security System in A Private Room Using Esp32 Microcontroller with Telegram Bot

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ABSTRACT: Losing valuables in private rooms remains a common issue, often caused by the limitations of conventional security systems. This research proposes the design and implementation of a modern security system based on the ESP32 microcontroller integrated with a Telegram bot to provide real-time monitoring and control. The system is engineered to detect suspicious movements within a room and immediately notify the owner via the Telegram application. It consists of key components including a power supply unit, motion sensors for activity detection, the ESP32 microcontroller as the central processing unit, and the Telegram bot as the communication interface. When motion is detected, sensor data is transmitted to the ESP32, which processes the input and sends automated alerts through Telegram. Additionally, the system features remote control capabilities, allowing users to lock or unlock the room via Telegram commands. Testing results indicate that the system demonstrates high motion detection accuracy and fast response times with minimal latency in message delivery. The implementation of this tool significantly enhances room security and provides a practical solution for preventing the loss of valuables in personal spaces.

KEYWORDS: Security System, ESP32 Microcontroller, Telegram Bot.

I. INTRODUCTION

One of the most important aspects of life is security [1]. Everyone wants greater security in his or her home. Security is an important component of life, just like health. Thus the implementation of a security system is expected to provide a sense of security and comfort. Therefore, various innovations are made to provide a sense of security by utilizing technological advances that facilitate various human professions, even protecting assets owned. In addition, the implementation of a planned security system will certainly be able to reduce the number of crimes that occur in society, especially theft. People need security technology that has the characteristics of mobile technology, namely the ability to access or obtain information in a way that is simple, fast, and does not hamper their activities, because human mobility is increasing due to the activities they carry out in the current era of globalization. The development of mobile technology that meets human needs, such as the ability to communicate remotely from any location, is one example of mobile technology. One example is the use of the Telegram bot program. From the test findings, the system can send messages with little delay and identify movement with high accuracy. As a result, this technology can significantly improve the security of private spaces. It is hoped that this system can be a practical solution in reducing the risk of losing valuables.

In previous research, a security system has been developed in a private room with an Arduino microcontroller and SMS Gateaway [2],[16]. where previous research used a microcontroller in the form of an ESP 32 as a signal sending device. If a disturbance is detected by the sensor, the microcontroller will stop its movement. Three nursing home residents were monitored for movement using passive infrared sensors [3]. The activities of the elderly were effectively identified every day for seven days in this investigation. This aims to find out their way of life. The sensors were installed on the ceiling of the house. Due to this feature, communication can be sent to the intended recipient in a timely, accurate, and economical manner [4].

The purpose of this research is to create a home security system that uses PIR sensors to identify potential thieves. This can be very helpful in terms of efficiency because it uses a selenoid to show whether a door or window is closed or open, an ESP 32 microcontroller as the brain of the device, and a Telegram BOT to send messages to the homeowner in the form of microcontroller-based application notifications. cost and time spent monitoring the condition of the house.

II. OVERVIEW

A. ESP32

The innovative ESP32 microcontroller was created to give developers freedom and power for a variety of tasks [5]. Basically, the ESP32 is a development of previous microcontrollers with some fantastic new capabilities. Users can take full advantage of the ESP32 by understanding its main components. Significant advantages in terms of functionality and connections are offered by the dual-core CPU, WiFi module, Bluetooth, and several customizable GPIO pins. The reason why the ESP32 is the best choice for developers can perhaps be better understood by comparing it to other microcontrollers [6]. For example, the ESP32 improves processing performance for complex jobs by enabling the code to operate on two processor cores at once. In addition, the WiFi and Bluetooth modules make it easy for users to connect to the internet or other devices, which opens the door to exciting IoT applications. Here is the ESP-32 which is the brain of this final project, the ESP32 is also a 32-bit microcontroller based on the dual-core Xtensa LX6 architecture, although some variants have only one core. This microcontroller comes with integrated Wi-Fi and Bluetooth, enabling reliable and low-power wireless communication [7].

B. PIR Sensor

PIR sensors that detect movement are used to determine whether objects or people have moved or moved away from their field of view [8]. PIR is basically a pyroelectric sensor that measures the amount of infrared radiation. PIR sensors release heat and low-level radiation. To identify movement (change), the motion detection sensor is actually broken down into two parts. To connect with each other, these two components are wired. One produces a High or Low output if it detects infrared radiation from the other [9].

C. Selenoid Lock

Solenoid lock is an electromagnetic device used as a locking mechanism. Its main components consist of a coil (solenoid) and a moving iron core (plunger) [10]. When an electric current is applied to the coil, the resulting magnetic field will attract or push the plunger, thus opening or locking the locking mechanism [11]. Electric current flows through the solenoid coil, generating a magnetic field that attracts the plunger. This movement normally opens the lock.

D. Magnet Sensor

Devices that respond to magnetic fields and produce a change in state at their output are known as magnetic sensors or reed relays. similar to a two-state (on/off) switch that is activated by the surrounding magnetic field. These sensors are usually vacuum-packed and free from vapor, smoke, moisture, and dust [12].

E. Relay Module

Relay is an electrical component that functions as an electronic switch and is powered by electricity. A relay is simply a switch lever with a wire wrapped around a nearby iron rod (solenoid). Large currents and voltages (such as 4 A electrical appliances and 220 V AC) are often driven by relays that utilize small currents and voltages (such as 0.1 A and 12 V DC) [13]. Therefore, in this final project research, this will use a 1 channel Relay Module.

F. Buzzer

An electronic device that converts electrical vibrations into sound vibrations is called a buzzer. Since the basic operation of a buzzer is similar to that of a loudspeaker, it also uses a coil mounted on a diaphragm and electrified to become an electromagnet. Depending on the direction of the current and the polarity of the magnet, the coil will be pulled in or out. Since the coil is attached to the diaphragm, any movement of the coil will cause the diaphragm to move back and forth, causing sound [14].

G. Led

A semiconductor electrical component called an LED (Light Emitting Diode) releases light when an electric current passes through its active material. The light produced comes from the process of electrolumination, where electrons passing through the PN junction release energy in the form of photons. LEDs are widely used because they are energy efficient, durable, and available in a variety of colors and light intensities. And the function of the led in this journal is an indicator when someone enters [15].

III. METHOD

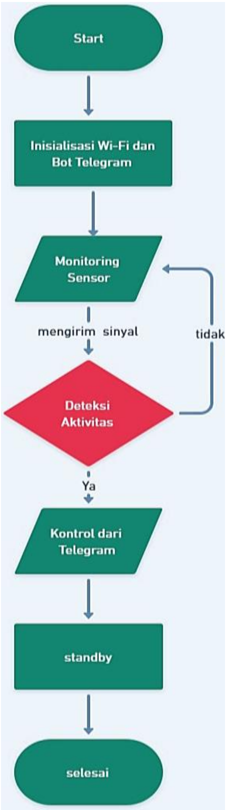

Fig 1. Flowchart of Final Project Completion

In the early stages of this research, a literature review was conducted which involved searching for information from books, journals, articles, or theses relevant to the research topic. This information is obtained from discussions and consultations with lecturers and experts in relevant fields. The following literatures studied are, The use of loT to monitor the security of private rooms, Security systems that can be monitored remotely. The methodology in developing a room security system based on ESP32 and Telegram bot is a framework or systematic steps used to design, build, and implement this system. The flow of the methodology for completing this final project is shown in the following flow chart.

System Workflow:

1. Start: The system is powered on and initialized.
2. Wi-Fi and Telegram Bot Initialization: ESP32 connects to Wi-Fi and activates Telegram bot.
3. Sensor Monitoring: The system monitors the motion sensor (PIR) and door status (magnetic switch).
4. Activity Detection: If motion is detected, Alarm is activated (red LED and buzzer), notification is sent to Telegram. If door is opened, Alarm is activated, notification is sent to Telegram.
5. Control from Telegram: /unlock Unlocks the lock solenoid, /lock Locks the lock solenoid, /status Sends system status, /reset Stops the alarm and resets the system.
6. Standby: The system returns to monitoring mode.

A. SYSTEM DESIGN

After the data collection stage from various references to identify some of the necessary components is completed, the next step is to design the system according to the design that will be used in the research later. The following are details of the hardware system.

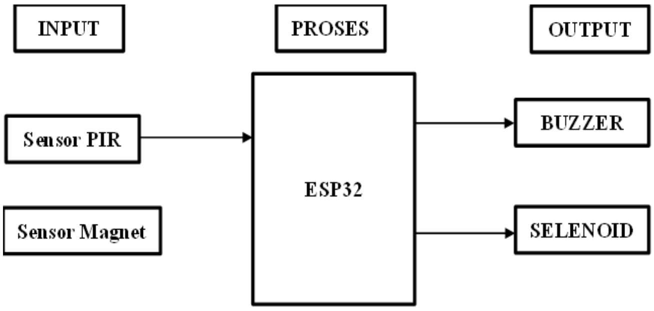

Fig 2. Concept Block Diagram of the System

This ESP32 and Telegram bot-based room security system consists of several main blocks that are integrated with each other to support its functionality. The power source block acts as an energy provider for all components, using an adapter or power supply that is regulated by a voltage regulator to match the needs of the device. The microcontroller block with ESP32 serves as the control center of the system, processing data from sensors, controlling actuators, and managing communication with the Telegram bot via Wi-Fi connection. The sensor block is responsible for detecting conditions in the environment, including PIR sensors for motion and magnetic door switches for door status (open or closed). Data from these sensors will be processed by the microcontroller to determine the system's actions. The actuator block is used to provide a physical response to certain conditions or user commands, with devices such as relays to control solenoid locks, buzzers as alarms, and LEDs as visual indicators. The communication block ensures smooth interaction between the system and the user via Telegram bot. With Telegram API integration, users can receive real-time notifications and send commands such as unlocking the door, locking the door, checking the system status, or resetting the alarm.

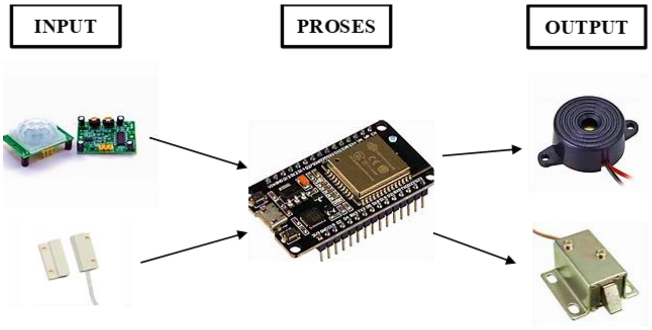

Fig 3. Hardware design

And there is also a design of the place object in the form of a plan for the placement of tools or components. The picture can be seen in the following.

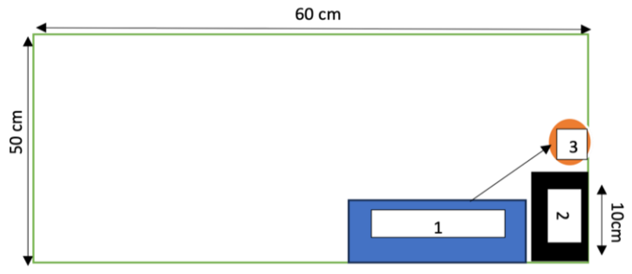

Fig 4. Plan of the Tool

Description:

1. A toolbox where all the components are located (except the PIR Sensor)
2. The door that serves as the detected object
3. PIR Sensor Placement

B. SOFTWARE DESIGN

The design of the Telegram application for the room security system is designed as the main interface for users to control and monitor the device. The Telegram bot acts as an intermediary between the user and the system, allowing easy communication through simple text commands. Users can send commands such as /unlock to unlock the solenoid, /lock to lock the door, /status to get system condition information, and /reset to stop the alarm and reset the device. Each command received by the bot will be processed by the ESP32, which then executes the appropriate action, such as activating a relay, reading a sensor, or stopping a buzzer. After the command is executed, the Telegram bot automatically sends a notification to the user, for example "Door unlocked" after the /unlock command or "System reset" after the /reset command. If the user sends an invalid command, the bot will respond with an error message, ensuring the system remains safe from unrecognized commands. In addition, this command validation feature keeps only users who have access to the bot in control of the device. This design makes it easy for users to remotely control and monitor the room with an intuitive and responsive interface. With Telegram bot integration, users get real-time notifications of activities detected by the sensors, ensuring the safety of the room is maintained anytime and anywhere.

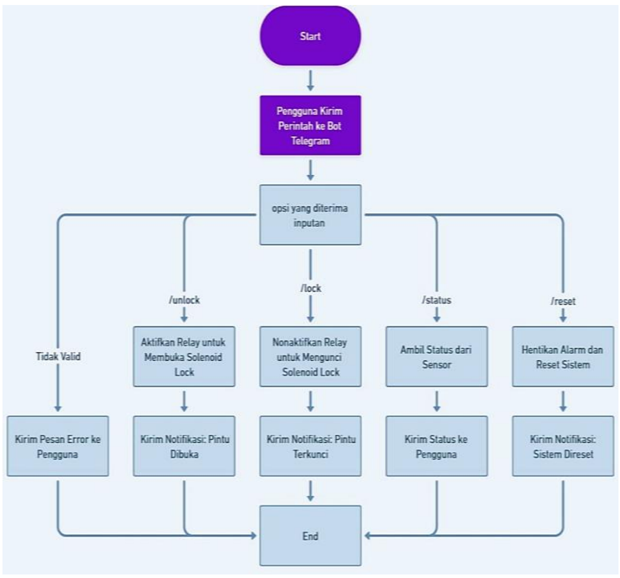

Fig 5. Flowchart of system software design

IV. RESULTS AND DISCUSSION

The results and discussion will contain the results of tests that will be carried out with a tool that has been designed, the following are the results of making the tool and the research data can be seen as follows.

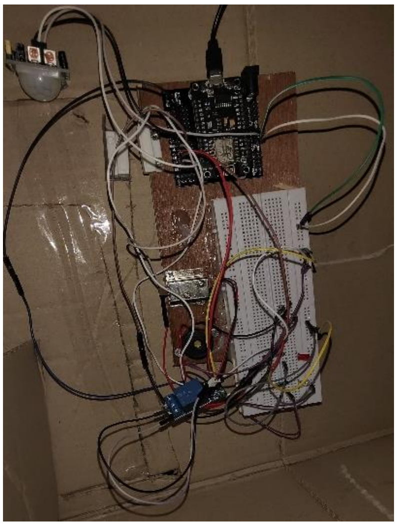

Figure 6. Research tools

A. PIR SENSOR TESTING

This test will test a pear sensor that has been programmed in the system, the results of the PIR sensor parameter readings will be compared with the real distance, the following is a data on the test results.

Tbl 1. PIR Sensor Testing Results

NO	Date, Time	PIR Sensor (CM)	Real Distance (CM)	Error (%)
1	02/01/2025, 09.33	10.15	20.16	0.01
2	02/01/2025, 10.33	20.03	20.02	0.01
3	02/01/2025, 11.33	30.00	30.00	0
4	02/01/2025, 12.33	40.10	40.10	0
5	02/01/2025, 13.33	60.09	60.09	0
		Average error		0.01

This test aims to measure the accuracy of the PIR sensor that has been programmed in the system. The sensor readings are compared with the actual distance to identify the level of error in measurement. Based on the data obtained, the PIR sensor was tested in five different conditions with a distance range between 10 cm and 60 cm. The measurement results show that the value detected by the sensor is very close to the actual distance, with a very small error rate. With an average error of 0.01%, it can be concluded that the PIR sensor has a very high level of accuracy and is reliable in systems that require precise distance detection.

B. MAGNET SENSOR TESTING

This test aims to assess the performance of the magnetic sensor in detecting the status of the door lock. This sensor functions to identify whether the door is locked (Lock) or unlocked (No Lock), based on the status of the sensor which is read as ON or OFF.

Tbl 2. Magnet Sensor Testing Results

NO	Date, Time	Magnet Sensor (ON/OFF)	Door (Lock/No Lock)
1	02/01/2025, 09.33	ON	No Lock
2	02/01/2025, 10.33	OFF	Lock
3	02/01/2025, 11.33	OFF	Lock
4	02/01/2025, 12.33	ON	No Lock
5	02/01/2025, 13.33	ON	No Lock

The test data shows that when the magnetic sensor is ON, the door is detected as No Lock or unlocked. Conversely, when the sensor is OFF, the door is detected as Lock or locked. Of the five tests conducted, the sensor readings always match the actual condition of the door. This proves that the magnetic sensor works well and can be relied upon to accurately detect the status of the door lock.

C. OVERALL TESTING

Tbl 3. Overall Testing Results

NO	Date, Time	PIR Sensor (CM)	Magnet Sensor (ON/OFF)	Door (Lock/No Lock)	Buzzer (ON/OFF)
1	02/01/2025, 09.33	10.15	ON	No Lock	ON
2	02/01/2025, 10.33	20.03	OFF	Lock	OFF
3	02/01/2025, 11.33	30.00	OFF	Lock	OFF
4	02/01/2025, 12.33	40.10	ON	No Lock	ON
5	02/01/2025, 13.33	60.09	ON	No Lock	ON

The overall test results show that all system components work well and are properly integrated with each other. The PIR sensor is able to detect the presence of objects with high accuracy, the magnetic sensor accurately identifies the status of the door lock, and the buzzer provides alerts according to the condition of the door. With these results, the system can be relied upon to effectively support security and monitoring.

D. TELEGRAM BOT TESTING

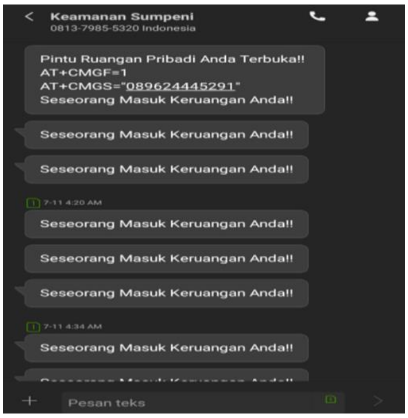

Fig 5. Telegram

This test is done by trying the telegram bot monitoring system that has been made such as, /start as starting the bot, /status to show the results of sensor parameter readings and outputs from research tools, /lock the command to lock the door, /unlock functions as a door unlocker. Based on the test results that have been made telegram bot has a function well according to the planned system.

V. CONCLUSION

Based on some test results, the system consisting of PIR sensor, magnetic sensor, and buzzer is proven to work well and has a high level of accuracy. The PIR sensor is able to detect objects with a very small error rate of 0.01% on average, making it reliable for precise distance measurements. The magnetic sensor also works well in detecting the door lock status, where an ON condition indicates the door is unlocked (No Lock), while OFF indicates the door is locked (Lock). In addition, the buzzer operates according to the door condition, issuing an alert when the door is unlocked and remaining off when the door is locked. Overall, the system shows optimal performance with integration between components that run according to their functions. With these results, the system can be relied upon to effectively support automated security and monitoring. And the telegram bot system has been successfully made according to what has been planned and the system is running well.

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