Bit-Tech (Binary Digital - Technology)
Vol.6, No.2, December 2023
Available online at: http://jurnal.kdi.or.id/index.php/bt

Designing Home Security With Esp32-Cam and IoT-Based Alarm Notification Using Telegram

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Article history:

Received 19 Sept 2023;
Revised 21 Sept 2023;
Accepted 07 Oct 2023;
Available online 28 Dec 2023

Keywords:

ESP-CAM
Internet of Things
Passive InfraRed Censorship
Security
Telegram Bot

Abstract

Nowadays, technological advances have entered human life. One of the security system solutions is the use of Closed Circuit Television (CCTV) as a monitoring medium, but it is still lacking. This is because more and more crimes are committed in homes where the owner is away. As a result, each home needs a security system that can protect the wealth and assets of the owner. Similarly, currently existing security systems are rarely able to provide data directly to homeowners if an outsider wants to commit a crime. So, research was conducted with the title "Home Security Design with ESP32-CAM and Internet of Things (IoT) Based Alarm Notification Using Telegram Application". With this device plan, it is believed that individuals who leave the house will feel safer. This device can detect an infrared wave produced by humans within its range and is equipped with an alarm/buzzer that produces output in the form of notifications on Telegram and alarm sounds on the device. The PIR sensor and ESP32-CAM integrated with the Telegram mobile device form the basis of this security system. This research has successfully implemented a device aimed at reducing home burglary issues by detecting human motion, triggering alarms, and enabling remote monitoring through Telegram. Additionally, the adapter utilized in the system produces an average voltage value of 5.196 V with an average error rate of approximately 3.9%.

I. INTRODUCTION

One solution in the framework of home security is the use of *Close Circuit Television (CCTV)* as a surveillance medium. Currently, the use of CCTV as a medium of continuous surveillance has been widespread, ranging from private homes to e-ticket systems and business premises. Homeowners' efforts to feel safer when their homes are empty include introducing a security framework for their homes by utilizing the advantages of CCTV [1].

Several factors that can lead to burglaries in homes, one of them being poorly protected home door security systems. Burglary cases sometimes occur not only due to the intentions of the perpetrators but are also opportunistic. Negligence or the lack of vigilance on the part of potential victims is one of the reasons for the high incidence of theft crimes. This necessitates the need for solutions related to a better security system [1].

Advancements in innovation have now entered people's lives, for example the rise of smart home applications that can provide space, security, and productivity to clients. Given the efficiency it provides, remote control is an indispensable control . User controls will determine how controls are performed automatically. Everyone needs to keep an eye on the state of the house. In addition, today's security systems are not even capable of notifying homeowners directly if a suspected stranger is trying to steal [2]

Given the importance of home security, security is needed as a mechanical repair to work successfully and professionally so as to secure the belongings at home , "This home security system prevents theft within the house. The concept of a smart home offers a comfortable and practical environment for its occupants."[3]. *The Internet of Things*, more commonly referred to as IoT, enables remote control of electronic devices through a web connection via Wi-Fi. The presence of emerging innovations allows everything that can be achieved to be done efficiently and quickly.

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doi: 10.32877/bt.v6i2.932

Based on previous research, namely "*Face Recognition-Based Door Access* System Using ESP32 Module and Telegram Application" this one still needs to be developed system with improved new features in the form of additional *passive infrared receiver* sensors for

detects suspicious objects and provides accurate information. Reports and alarms,sent to the buzzer [4]. Therefore, researchers conducted a study "Home Security Design with ESP32-CAM and IoT-Based Alarm Notifications Using the Telegram Application" It is hoped that people who leave the house will feel safe because of the design of this equipment. The device also has an alarm system that sends an output in the form of notifications on telegrams and buzzers when people within range emit infrared waves. a security system that integrates mobile communications, specifically telegram, with passive infrared receiver sensors and ESP32-CAM.

II. Related Works/Literature Review (Optional)

Devi & Slamet's research (2020), titled "Application of Internet of Things-Based Home Security System Using Blynk," employs the waterfall model as the system development approach. The primary goal of this research is to facilitate homeowners in remotely monitoring and controlling their doors while identifying guests and visitors.

Based on this study, homeowners can use the Blynk application to monitor their home's door by observing the obtained images, the temperature of individuals, opening and closing the door, and taking photographs. In this research, the researchers mention that they can determine the presence of individuals near the PIR sensor, and the ESP32-CAM will automatically take pictures of detected objects. The system does not yet detect the faces of individuals. The framework can display the internal heat readings from the MLX90614 sensor on a 16x2 LCD. When the device detects motion, measures the person's temperature, and takes a picture, it will automatically send a notification message to the homeowner's Android smartphone [5].

Koco, Joko, and Suwanto's research (2021), titled "Implementation of IoT-Based Automatic Door Monitoring and Control System Based on Object Proximity," is based on the waterfall model as the system development approach. This study aims to provide home security and prevent unauthorized access to the house.

According to the research, the RFID reader will not respond to access if it is more than 4 cm away. The automatic locking door takes only eight seconds to open, and after the timer expires, the door will automatically lock. Information about the door locking system is programmed based on location monitoring, and the location objects are interconnected through a set of Firebase user data. Homeowners can monitor the security of their homes by inputting the correct password and email into the database on the login page of the website. The website will also display every access activity related to the door lock [6].

Yoga & Budy's research (2022), titled "Home Security System Using Passive Infrared Receiver and SMS Gateway Based on Arduino," utilizes a seven-stage method, including requirement gathering, construction, evaluation, coding, testing, and system deployment. The objective of this research is to develop a home security system based on an Arduino and a passive infrared receiver with an SMS gateway.

Based on this research, it can be concluded that the study conducted on the PIR sensor placed at a distance of 30 cm to 150 cm from an object results in the buzzer sounding an alarm. Additionally, SMS notifications are successfully sent to the residents when the sensor detects motion or an open door. According to the research, a home security system using a PIR sensor and an SMS gateway can serve as a means of crime prevention, especially within a home setting [7].

III. Methods

In this research, the waterfall method is employed. The waterfall method utilizes a sequential and systematic approach, commencing with literature review, followed by planning, design, data analysis, and concluding with system outcomes.

a. Literature, A method for collecting data from journals, books, and web sources related to research writing.
b. Observation, Observing the working system in which the project is carried out directly.
c. Consultation, Conducting guidance related to research to supervisors.
d. Designing, Designing the tools to be built, including case design, software design, and hardware design.
e. Software design, and hardware design.
f. Implementation and Testing, Utilizing the tools to determine whether they function as expected or not.

Design, as highlighted by [8], plays a pivotal role in the enhancement of products and frameworks. It involves the strategic implementation of rules to provide an in-depth description of a device, process, or framework, enabling practical realization. [9] on the other hand, emphasizes that planning is a widely recognized method for comprehensively delineating procedures, complexities, and boundaries in completing tasks. In the context of these expert insights, design emerges as the cornerstone for structuring cycles and planning various systems.

The internet, according to [10]serves as a global information framework connecting devices worldwide, forming extensive networks that facilitate the exchange of diverse content, such as text, music, and videos. The WideWeb standard, commonly known as IP, allows general access to this vast realm of information, showcasing its immense breadth and depth.

IoT, widely regarded as the "next big thing" in technology [11]. introduces a concept where internet-connected devices seamlessly share information with each other and their surroundings. IoT innovation promises a multitude of opportunities, expanding the advantages of sustainable internet networks. This includes remote control, monitoring, and data sharing with real-world objects, ranging from gadgets to living organisms, all interconnected through dynamic sensors.

The Esp32-Cam module .[12]. a versatile component, integrates a microcontroller and offers compatibility with peripheral libraries through the Arduino IDE editor. Alongside WiFi and Bluetooth capabilities, it features an integrated camera and microSD storage.

PIR sensors, which detect infrared light, are passive sensors [13]that receive infrared radiation without emitting it. They respond to the natural infrared radiation emitted by objects, primarily identifying heat sources such as the human body.

BuzZers [14]components in electronic systems, convert electrical vibrations into sound, operating in a manner similar to loudspeakers. They consist of a coil attached to a diaphragm, which, when energized into an electromagnet, produces sound. Bells are commonly employed to signal process completion or device errors.

Smart home systems [15] empower architects with competitive advantages, enabling residents to monitor and control electronic devices within their homes. Smart Home systems can be easily controlled via Android or smartphones, often leveraging IoT technology for energy efficiency, comfort, and quality of life enhancements.

Telegram, as a messaging application, offers Bot services [16]featuring programming applications known as Telegram Bots. These bots are capable of performing automated tasks, with chatbots being the most prevalent type. Chatbots interpret user text or speech, provide appropriate responses, and have become increasingly popular since the introduction of the Wire bot programming interface in 2015. Third parties can create bots as the primary interface using the Telegram bot API, often initiated through BotFather or by creating a Telegram channel.

IV. RESULTS

Flowchart is a type of diagram that explains the flow of work, algorithms, or processes by utilizing graphic symbols[17]for figure flowchart, see Fig, 1.

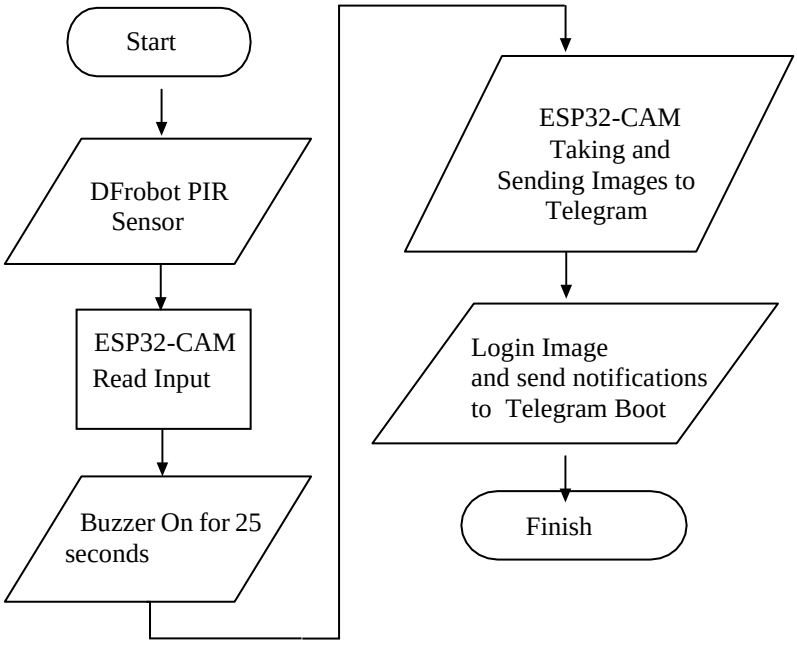

Fig. 1 *Flowchart*

The ESP32-CAM serves as the control focus of all modules that manage the information/yield cycle of the modules. The system that has been programmed and placed into ESP32-CAM will be the basis of the system in which the program is located Included. The working system can be seen in Fig, 2 of the System Block Diagram.

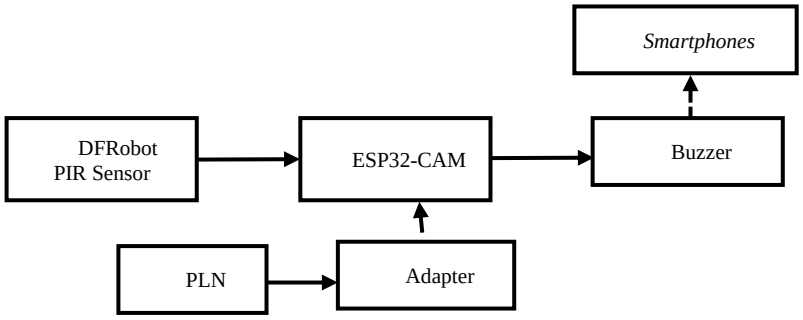

Fig. 2 *Block System Diagram*

A. Adapter Testing

Adapter testing is carried out for 5 attempts where the voltage output from the adapter will be measured using a multimeter, This test is carried out to find out whether the adapter is functioning as desired Table 1 is Adapter Test Result.

TABLE 1
ADAPTER TEST RESULTS

Measurement to-	MEASURING VOLTAGE (VDC)	Voltage Theory (VDC)	*Error %*
1	5.33V	5V	6,6%
2	5.31V	5V	6,2%
3	4.99V	5V	0,2%
4	5.36V	5V	7,2%
5	4.99V	5V	0,2%
Average	5,196 V	5V	3,9%

From the test results and analysis in table 4, the adapter test produces an average measuring voltage value of 5.196 V and an average *error* value of 3.9% so that it is concluded that the adapter can function so that it can be used for supply the voltage of the entire system, for figure Adapter Testing, see Fig, 3.

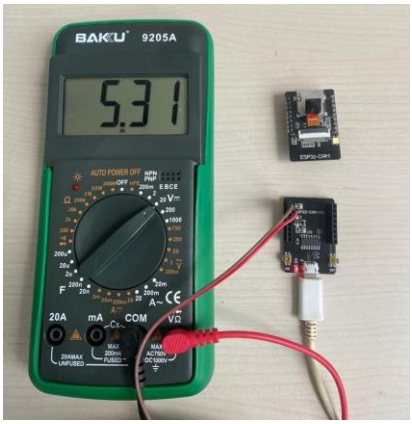

Fig. 3 Adapter Testing

B. PIR Sensor Testing

DFRobot PIR sensor testing is carried out repeatedly by testing the distance between the DFRobot PIR sensor and people using different distances. This test is used to determine the maximum distance results DFRobot PIR sensor can detect the movement of people. The test is carried out by testing the distance every 50 cm until the sensor cannot detect movement. Table 2 is PIR Sensor Test Result.

From the test results and analysis in table 2 of DFRobot PIR sensor distance testing, it can be concluded that in detection test 1 and detection test 3, DFRobot PIR sensors can detect the movement of people up to 6 m at a distance 6.5 m of people's movement is no longer detected, while in the detection test 2 DFRobot's PIR sensor can only detect movement up to 5.5 m when a distance of 6m of people's movement is no longer Detected, for figure PIR Sensor Testing, see Fig, 4.

TABLE 2
IR SENSOR TEST RESULTS

Distance	TEST DETECTION 1	Uji Detection 2	Test Detection 3
50 cm	Detected	Detected	Detected
1 m	Detected	Detected	Detected
1.5 cm	Detected	Detected	Detected
2 m	Detected	Detected	Detected
2.5 m	Detected	Detected	Detected
3 m	Detected	Detected	Detected
3.5 m	Detected	Detected	Detected
4 m	Detected	Detected	Detected
4.5 m	Detected	Detected	Detected
5 m	Detected	Detected	Detected
5.5 m	Detected	Detected	Detected
6 m	Detected	Not Detected	Detected
6.5 m	Not Detected	Not Detected	Not Detected
7 m	Not Detected	Not Detected	Not Detected
7.5 m	Not Detected	Not Detected	Not Detected

Fig. 4 PIR Sensor Testing

C. Buzzer Testing

The *buzzer* test was tested by changing the different input voltages of 0.5 V, 1 V, 2 V, 3 V, 4 V, 5 V, 6 V, 7 V, and 8 V, tested with Different input voltages. Table 3 is Buzzer Test Result.

TABLE 3
BUZZER TEST RESULTS

Testing To-	VOLTAGE (VOLTS)	Result
1	0.5 V	Quiet Sound
2	1 V	Quiet Sound
3	2 V	Sound
4	3 V	Sound
6	5 V	Sound
7	6 V	Sound
8	8 V	Sound

From the test results and analysis in table 3. Buzzer voltage testing when the *input* voltage given is 2 V, 3 V, 4 V, 5 V, 6 V, 7 V, and 8 V, volts, the buzzer sounds loudly, while at a voltage of 0.5 volts &; 1 volt the *buzzer* sounds softly. From the buzzer testing it can be concluded that at all tested voltages the *buzzer* can sound or turn on, for figure Buzzer Testing, see Fig, 5.

Fig. 5 Buzzer Testing

D. Telegram Bot Testing

This test aims to be able to find out whether the system receives the on or off *buzzer* command from Telegram Bot. Table 4 is Telegram Bot Buzzer Test Result Test Result.

TABLE 4
TELEGRAM BOT BUZZER TEST RESULTS

Testing To-	COMMANDS ON TELEGRAM BOTS	*Buzzer* On ESP32 CAM
1	*Buzzer On*	*Buzzer* Turns On
2	*Buzzer Off*	Buzzer Off
3	*Buzzer On*	*Buzzer* Turns On
4	*Buzzer Off*	Buzzer Off
5	*Buzzer On*	*Buzzer* Turns On
6	*Buzzer Off*	Buzzer Off
7	*Buzzer On*	*Buzzer* Turns On

Testing Telegram Bot can be concluded that Telegram Bot can function well to command Buzzer on and *Buzzer off*, for figure Telegram Bot Buzzer Testing, see Fig, 6.

Fig. 6 Telegram Bot Buzzer Testing

E. ESP32-CAM TESTING

In ESP32-CAM Testing by taking pictures and sending images to Telegram Bot if any movement is detected. The function of this test is to find out whether the camera is working properly or not. Table 5 is ESP32-CAM Test Result.

TABLE 5
ESP32-CAM TEST RESULTS

Testing To-	STATUS	ESP32 CAM	Telegram BOOT
1	Detect	ESP-32 CAM Shooting	Images Accepted
2	Not Detecting	ESP-32 CAM Not Shooting	Images Not Accepted
3	Detect	ESP-32 CAM Shooting	Images Accepted
4	Not Detecting	ESP-32 CAM Not Shooting	Images Not Accepted
5	Detect	ESP-32 CAM Shooting	Images Accepted

ESP32-CAM testing can be concluded that ESP32-CAM can function properly, when there is ESP32-CAM movement will take pictures and then will be sent automatically to Telegram Bot, and when there is no movement ESP32-CAM does not take pictures and does not send to Telegram Bot .The next test is done by giving commands from Telegram Bot to take pictures. The function of this test is whether ESP32-CAM can function properly or not if manually commanded from Telegram Bot. Table 6 is ESP32-CAM Test Results Telegram Bot Command.

TABLE 6
ESP32-CAM TEST RESULTS TELEGRAM BOT COMMAND

Testing To-	TELEGRAM BOT COMMANDS	ESP32-CAM
1	/photograph	Auto-Photographing and Sending To Telegram Bot
2	/photograph	Auto-Photographing and Sending To Telegram Bot
3	/photograph	Auto-Photographing and Sending To Telegram Bot
4	/photograph	Auto-Photographing and Sending To Telegram Bot
5	/photograph	Auto-Photographing and Sending To Telegram Bot

ESP32-CAM testing to be able to take pictures when given commands from Telegram Bot works well and as expected. for figure ESP32 CAM Testing, see Fig, 7.

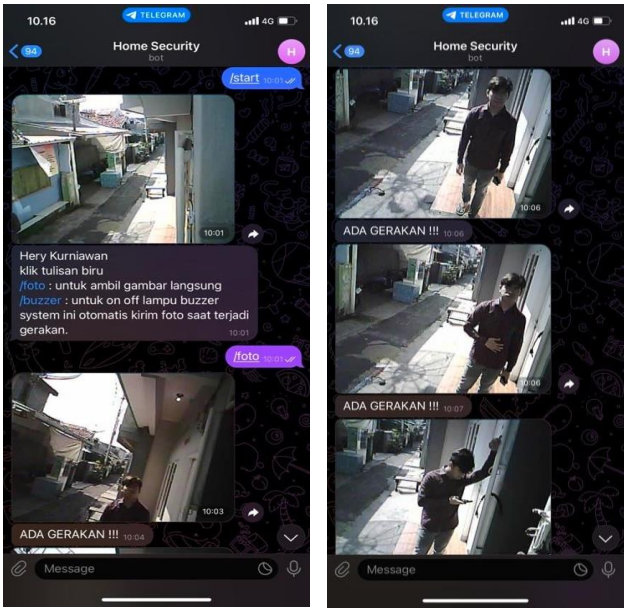

Fig. 7 ESP32 Cam Testing

V. DISCUSSION

The result of this research is a device that sounds an alarm and sends notifications via Telegram when there is a person within the range of the PIR sensor, thereby reducing the common issues of searching that often occur in households using the waterfall research method. From the results of the conducted tests, it can be stated that the system operates effectively, as shown in Table 8 below.

TABLE 8
ANALYSIS OF THE ENTIRE SYSTEM

Komponen	ACTION	Information
ESP32-CAM	Receive data from DFRobot PIR Sensor, take pictures and send notifications to Telegram Bot	Works Well
Buzzer	Sound after sensor detects movement	Works Well
Sensor PIR	Detecting the presence of people, as buzzer and ESP32-CAM input	Works Well
Telegram Bot	Can receive notifications and images when there are people	Works Well

In the making of this device, there are certainly many limitations that cannot be overcome. Suggestions for further development to enhance the performance of this device include using higher-quality cameras and microprocessors to obtain clearer images and better processing, adding a cooling system to the ESP32-CAM to prevent overheating, and incorporating a backup power source such as a UPS to ensure the device continues to function in case of a power outage, making it more reliable when implemented in the community.

VI. CONCLUSIONS

In this study, the tool has been implemented and functions well in accordance with the design planned by the researcher. This device can assist in reducing a common issue, namely theft, that frequently occurs at homes. The device is capable of detecting human movements, issuing alarms as warnings, and can be remotely monitored through Telegram. The adapter produces an average measuring voltage value of 5.196 V with an average error value of 3.9%. However, the device still has several limitations, such as a camera that struggles to capture clear images, occasional delays and overheating in the microcontroller. Therefore, it needs an upgrade with a better camera, such as a CCTV, and a higher-specification microcontroller like the Raspberry Pi or Jetson Nano.

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