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Design of an Arduino-Based Smart Home Security System Using PIR Sensors and Mobile Notifications

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Abstract: This research aims to develop a home access security system with a combination of Arduino-based sensors and buzzer methods and to address the problem of home downtime. This research has 3 methods, namely observation, laboratory research, and library study. This study was created to develop a tool for detecting a car using a PIR sensor that can be controlled using a smartphone and notifications directly go to the Telegram application that can be monitored anywhere and anytime, so that when homeowners live for a long period of time they are not too worried while the tool we created uses sensors located on 4 sides of the house. In the design of this tool, the author hopes that it can be developed to be more sophisticated and have even more useful benefits.

Keywords: Arduino, home security equipment, passive infrared sensor, buzzer alarm, prototype

INTRODUCTION

With the advancement of technology, many crimes frequently occur, such as theft or break-ins, while residents are away, working, or on vacation during festive periods. The methods and techniques used to commit these crimes are increasingly sophisticated; therefore, security must be further enhanced by leveraging technology. Security is essential in various sectors of life today, and privacy also plays a role in the importance of a security system. This is especially true for home security, especially when it comes to preventing crimes such as theft, burglary, and other crimes.

One system currently being developed is a security system that directly informs homeowners by sending notifications via the Telegram app, thus preventing the risk of losing valuables. The inspiration for this research cannot be separated from previous research, one of which is a journal taken from the "Student Journal of Computer and Information Technology Applications" entitled "Room Security System Using Passive Infrared Sensors and Arduino ESP32-Based GSM SIM Modules", this research aims to help secure a room with a room security system by providing a warning in the form of a sound indicator from the buzzer and sending messages from the GSM (Global System for Mobile Communication) SIM (subscriber identity module) to a cellphone that has been successfully realized according to the design (Samuel Hasudungan Nababan, 2024). Another source of inspiration was the "Journal of Science, Technology, and Society" article, "Automatic Human Presence Detection Device Based on Arduino ESP32 Microcontroller Using PIR (Passive Infrared) Sensors. This study designed a Human Presence Detection Device, a device that can be used by humans for home or office security (Rahmat & Yanti, 2022). This device can also be used to locate human presence by detecting movement.

Another source of inspiration was the journal "Home Security System Using Passive Infrared Sensors. This study discussed motion detection devices. The method used in this study was a prototyping model process. The device was built using a passive infrared sensor and an Arduino microcontroller board. Test results showed excellent response to movement and the ability to send voice notifications(Wisnu Wiraditama et al., 2023).

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 22-31
ISSN 3089-106X
(online)

Considering the above issues, a computer system can also be used as a home security controller. By utilizing the Telegram app, the home security system will be even more secure, as homeowners can control the home without having to be present and monitor security via their mobile phones for any potential dangers.

To control this home security system, software is required, namely the Telegram app, a USB interface (software), a circuit (hardware), and a Passive Infrared sensor to detect human movement, a buzzer to notify when movement is detected by the sensor, and a camera to capture images when movement is detected by the sensor.

Based on the above issues, the author created a prototype-based tool entitled "THEFT DETECTION TOOL IN THE HOME USING A PASSIVE INFRARED SENSOR," a tool developed to enhance home security.

LITERATURE REVIEW

A detector scientifically refers to a device or system used to identify, measure, or observe a particular phenomenon or variable. In a scientific context, a detector is typically designed to provide accurate and reliable data about the object being studied(Susanto et al., 2022).

In computer science, a detector refers to a component or algorithm used to identify, detect, and respond to specific patterns or conditions in data or a system. In the context of computer science, detectors often utilize techniques such as machine learning, pattern analysis, and signal processing to produce accurate and useful results. This is explained in the book "Computer Vision: Algorithms and Applications (Desvira Annisa et al., 2025).

Machine Learning for Computer Vision," in a technological context, a detector is a device that utilizes sensors and algorithms to detect changes or the presence of objects in a system or environment, often for analysis or monitoring purposes(Kango et al., 2022).

Principles of Predictive Analytics", a detector is defined as an instrument capable of observing and responding to certain variables or conditions, either through direct measurement or data processing, to produce relevant information.

In general, a house is a building or structure that serves as a residence for an individual or family. It provides a space for rest, daily activities, and shelters occupants from the weather and external hazards. Typically, a house is equipped with basic amenities such as a bedroom, kitchen, and bathroom. Beyond its practical function, a home is also often seen as a place where social relationships and family life develop(Mujitomo et al., 2022).

Scientifically, a sensor is a device designed to detect physical or environmental changes and convert that information into a signal that can be measured, analyzed, or processed. Sensors work by measuring variations in one or more physical, chemical, or biological parameters and then converting them into a signal that can be interpreted by a processing system. Sensors are used in a wide range of scientific and engineering applications, from laboratory experiments and environmental monitoring to industrial automation and control systems. They enable the collection of accurate, real-time data from the surrounding environment or the system being monitored(Arifin et al., 2022).

Scientifically, Arduino ESP32 refers to a development board that uses the ESP32 microcontroller, designed by Espressif Systems. The ESP32 microcontroller is a system-on-chip (SoC) that integrates two Xtensa LX6 RISC (Reduced Instruction Set Computer) processor cores, flash memory, and wireless communication modules such as Wi-Fi and Bluetooth(Shokrollahi et al., 2024). The ESP32 operates at frequencies up to 240 MHz and is equipped with various peripherals, including an ADC (Analog-to-Digital Converter), DAC (Digital-to-Analog Converter), timers, and communication interfaces such as UART (Universal Asynchronous), SPI (Serial Peripheral Interface), and I2 Channel(Putra Pratama & Martias, 2023).

The Arduino ESP32 board allows users to program this microcontroller using the Arduino platform, which provides a C/C++-based programming environment and libraries that simplify software development(Annisa et al., 2024). This board is often used in Internet of Things (IoT) and home automation applications due to its wireless connectivity capabilities and high processing performance (Annisa et al., 2024).

A power supply is a piece of hardware that supplies electrical power to all components in a computer system or electronic device. Its function is similar to a power adapter, but computer power supplies are generally more complex and designed to power various devices within the system unit. This research uses a 12-volt power supply adapter(Majumder & Izaguirre, 2020).

The function of a computer power supply is to provide electrical current, converting opposing currents into direct currents. A computer power supply provides the DC (Direct Current) required by the computer's hardware. The power supply works by pressing the power button on the case. When the power button is pressed, the power supply performs a check and test before starting the system. Once the test is successful, the power supply sends a special signal to the motherboard. This signal is called a power good(Muttaqin & Santoso, 2021).

In general, a smartphone is a portable telecommunications device that combines the functionality of a mobile phone with advanced computing capabilities. Unlike traditional mobile phones, smartphones are equipped with an

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 22-31
ISSN 3089-106X
(online)

operating system that allows the installation and use of various applications. In information technology, a smartphone is a portable computing device designed to integrate various computing and communication functions in a single unit. Smartphones operate as embedded systems, combining hardware and software components to support various applications and services(Haidar et al., 2024).

METHOD

1. Research Stage.

Several important steps in system design include:

1. Requirements Analysis: identifying and analyzing user needs and the objectives of the system to be designed.
2. System Design: creating a model or blueprint of the system, including the architecture, components, and interactions between system components.
3. Implementation: developing and integrating system components according to the design.
4. Testing: conducting tests to ensure the system functions as expected and meets user needs.
5. Maintenance: Conducting regular system maintenance and updates to ensure optimal performance.

2. **Prototype/model design**

A good prototype design will produce a useful design for current needs. In this design stage, the author created a tool using acrylic. Acrylic is used in tool prototypes for several reasons: it is easy to cut, shape, and process using standard tools such as saws and laser cutters. Acrylic can be transparent, making it possible to see the inside of the prototype or check its functioning without having to open the entire tool.

3. **Manufacturing Flow**

The design stage is a step in determining the path of a system that has been built. The manufacturing flow of the tools that the author carried out in designing this system is:

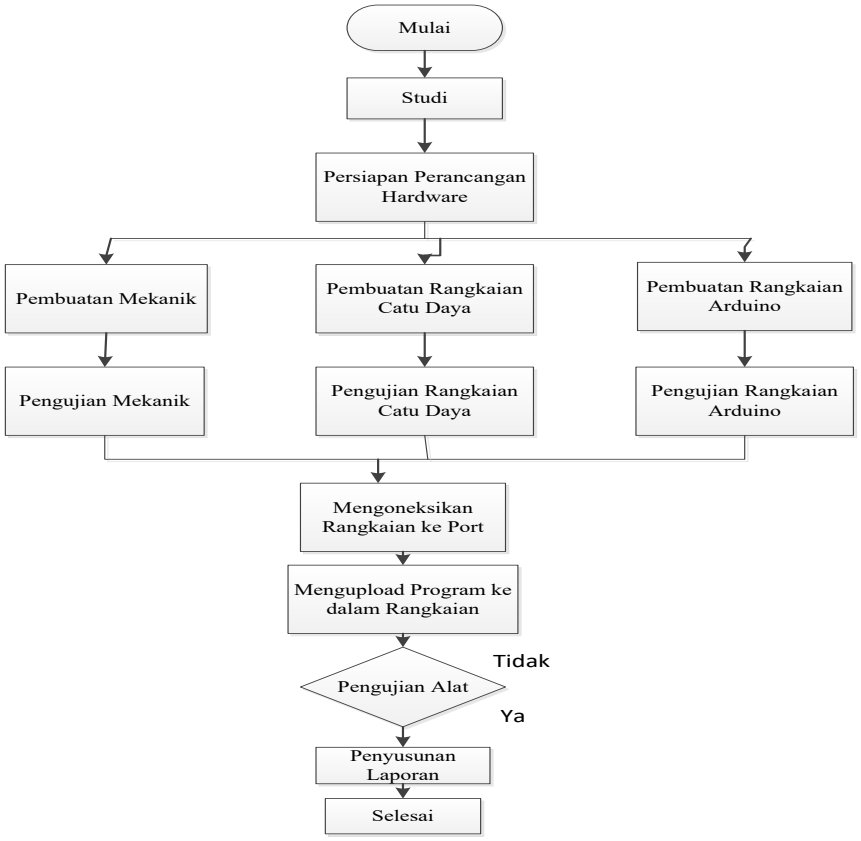

Figure 1. Manufacturing Flow

4. **Hardware design**

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 22-31
ISSN 3089-106X
(online)

In designing this hardware system, it will be described with a block diagram which is a basic description of the system design to be designed.

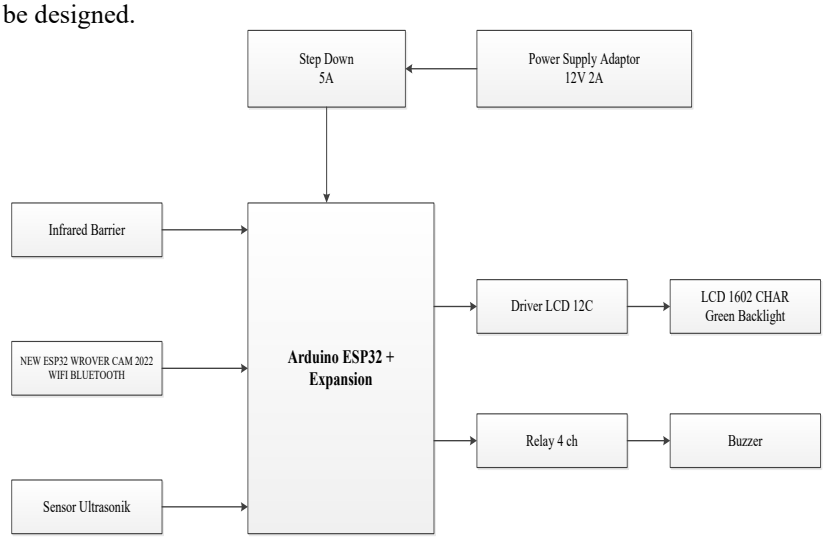

Figure 2. Design Block Diagram

RESULT

1. Program Design in the Arduino IDE

The following illustrates the process of connecting a prototype home security device to the Arduino IDE via a USB cable to the micro USB port on the Arduino ESP32 microcontroller. This ensures the device runs according to the program.

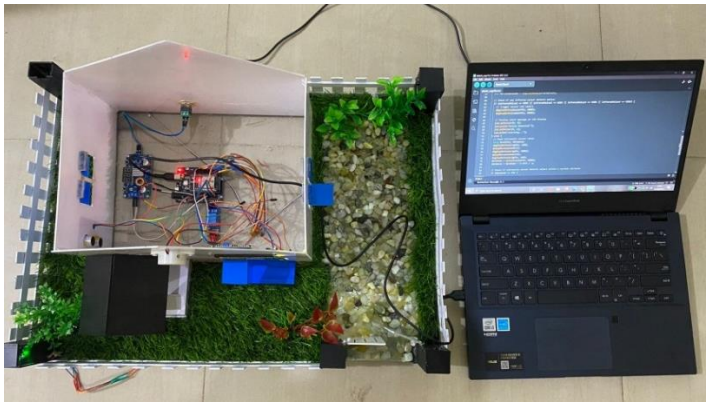

Figure 3. Program Design in the Arduino IDE

The circuit or sketch in the Arduino IDE software for connecting the Arduino ESP32 to other components is shown below:

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 22-31
ISSN 3089-106X
(online)

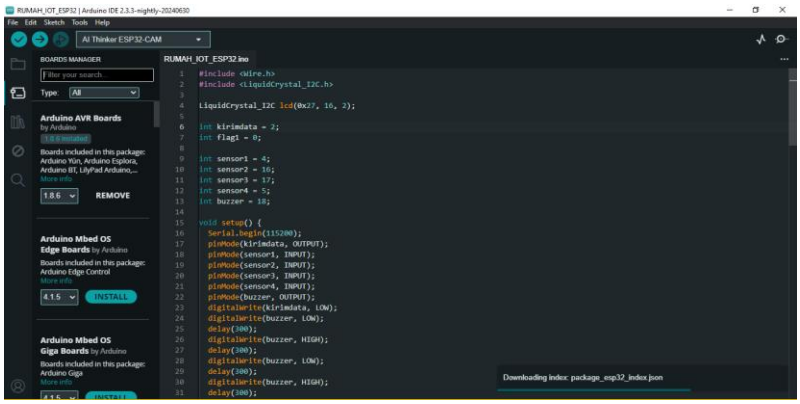

Figure 4. Initial Program Sketch

Figure 4 shows the initial programming process in the Arduino IDE, including WiFi and an LCD (Liquid Crystal Display), pinning the passive infrared sensor and buzzer, and triggering the ultrasonic pin to detect sound frequencies.

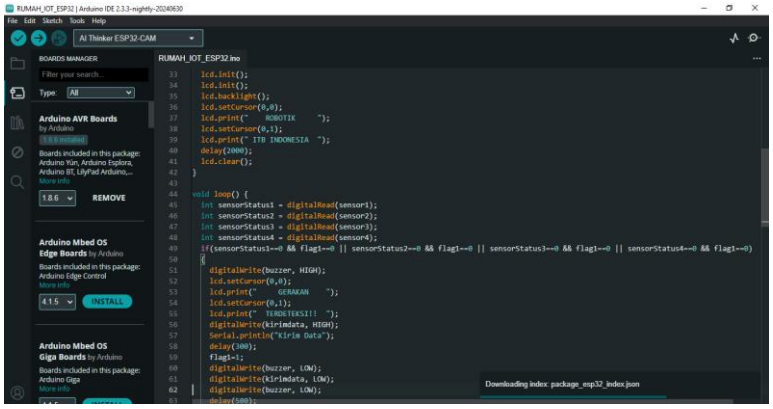

Figure 5. LCD Character Sketch

Figure 5 shows the programming process for the LCD (Liquid Crystal Display). When the house is unoccupied, it displays a warning such as "Home Security System," indicating that the prototype house is protected by a security system.

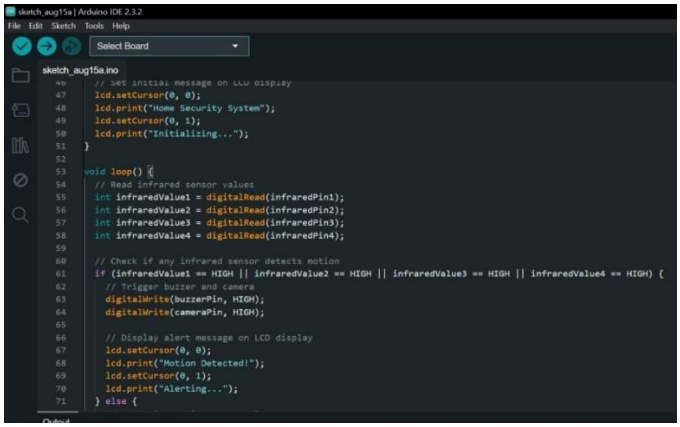

Figure 6. Passive Infrared Sketch

Figure 6 shows the process of four passive infrared sensors. If even one infrared sensor detects or reads a passing heat source, the data is automatically sent to the Arduino ESP32 to activate the buzzer or alarm. The Arduino ESP32 also sends a command to the LCD (Liquid Crystal Display) to display the message "Motion Detected," meaning movement has been detected or "Alert."

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 22-31
ISSN 3089-106X
(online)

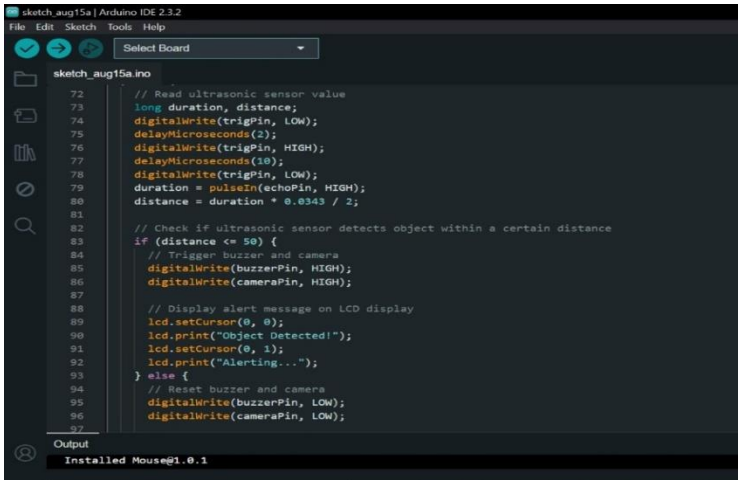

Figure 7. Ultrasonic Sketch

Figure 7 shows the process when the ultrasonic sensor detects the presence or absence of suspicious movement when the house is empty. The data is automatically sent to the Arduino ESP32 to activate the buzzer or alarm if movement is detected. The Arduino ESP32 also sends a command to the LCD (Liquid Crystal Display) to display the message "Object Detected," meaning object has been detected or "Alert."

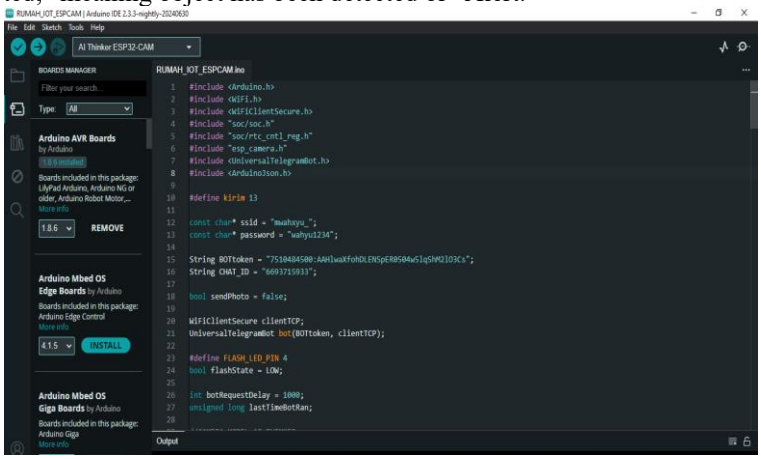

Figure 8. ESP CAM32 Sketch

Figure 8 shows the process when the ESP CAM32 detects suspicious movement when the house is empty. The camera automatically takes a picture and sends it to the Telegram app. The data is also automatically sent to the Arduino ESP32, which activates the buzzer or alarm when movement is detected. The Arduino ESP32 also sends a command to the LCD (Liquid Crystal Display) to display the message "Object Detected" or "Alerting."

2. Final Design Results

System implementation is the procedure carried out to complete the system design contained in the approved design document, test the system, install the system, and start the new system.

In creating the control and monitoring system program for the Burglar Detection Device in the House Using a Passive Infrared Sensor, this prototype was designed using hardware and software that have been tested in the Robotics Lab at the Indonesian Institute of Technology and Business, and function as intended. The following is a display of the final design results, which are complete and ready for use using a road simulation:

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 22-31
ISSN 3089-106X
(online)

Figure 9. Front View of the Device

This front view of the prototype-based passive infrared (PIR) sensor-based home burglar detection device is a security detection system designed to detect the presence of people or objects moving around the front of the house using passive infrared sensors located on the right and left front fence. The front of the device also features a buzzer and an LCD (liquid crystal display) to support the device's operation.

Passive infrared sensors function by detecting changes in infrared radiation emitted by the human body or other warm objects. In this context, the result of this device is a prototype that demonstrates how the device will be installed and operated at the front of the house. This prototype typically takes the form of a model or simulation that allows for testing and evaluation of the detection effectiveness and sensor placement to ensure the system performs well in detecting potential security breaches before the final system is implemented.

Figure 10. Left Side View of the Device

The prototype-based results of a home burglar detection device using a Passive Infrared (PIR) sensor on the left side of the house are security detection systems designed to monitor the left side of the house using passive infrared sensors. These passive infrared sensors detect movement by capturing changes in infrared radiation from moving objects, such as people, in the monitored area.

Prototype-based results mean the system was developed in the form of an initial model or simulation that illustrates how the passive infrared sensor will be installed and operate on the left side of the house. This prototype is used to test and assess detection effectiveness and to make design adjustments if necessary, before the final system is implemented in real life.

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 22-31
ISSN 3089-106X
(online)

Figure 11. Right Side View of the Device

The prototype-based results of a home burglar detection device using a Passive Infrared (PIR) sensor on the right side of the house are security detection systems designed to detect the presence or movement of people on the right side of the house. The passive infrared sensor works by detecting temperature changes caused by the movement of hot objects (such as human bodies) within the sensor's range. Specifically, the results of this device are:

1. Motion Detection: The passive infrared sensor is capable of detecting movement based on the temperature difference between the human body and the surrounding environment.
2. Detection Range: On the right side of the house, this sensor is designed to cover specific areas where security breaches are likely.
3. Warning: When the sensor detects suspicious movement, the system can send a signal or warning via an alarm or notification to the homeowner.

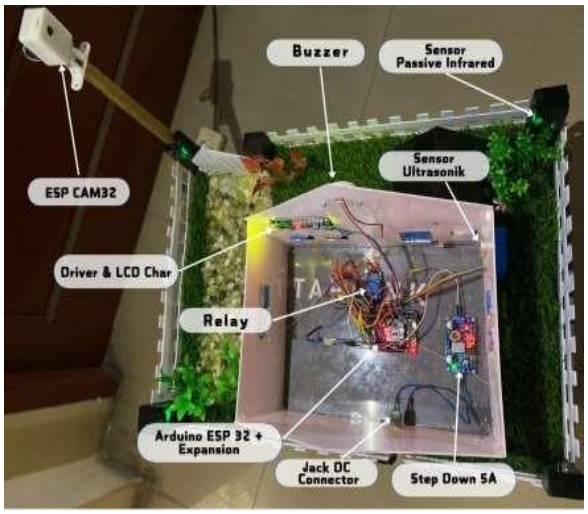

Figure 12. Top View of the Device

Figure 12 shows the final design of the physical design. The display above shows a simulation showing a miniature house made from 2 to 3 mm thick acrylic. The display above also shows the simulation results. Two passive infrared sensors will automatically detect suspicious movement within the home and then notify the homeowner so they can monitor the situation. The device includes a buzzer that sounds if suspicious movement is detected. The rear of the device also has a port for connecting a power supply adapter so the device can be connected to electricity.

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 22-31
ISSN 3089-106X
(online)

Figure 13. Motion Detection Results on Telegram

Figure 13 shows the results of the detection device sent to the Telegram application. If movement is detected by the sensors, this security detection system will automatically send an image file to the Telegram application. The home security system uses passive infrared sensors located on the right, left, front, and back fences of the house to monitor and detect movement within the home. Passive infrared sensors detect changes in infrared radiation from moving objects, such as people, which can indicate suspicious activity.
Prototype-based results mean the system was developed as a preliminary model or simulation to test and evaluate the design and effectiveness of detection in the backyard area. This prototype demonstrates how the sensors will be installed and operate in that area, allowing for functionality testing and design adjustments before final implementation.

DISCUSSIONS

This section discusses the working principles of a home burglar detection system using a passive infrared sensor. This device uses one Arduino ESP32 microcontroller with extensions, four passive infrared sensors, one LCD (Liquid Crystal Display) driver, one LCD chart, one relay, one camera shutter, one ESP32, one buzzer, one ultrasonic sensor, and one power supply adapter. The motion sensor used is a passive infrared sensor. This sensor is installed at specific points in the home considered to be high-risk areas for burglaries. The sensor activates when suspicious movement is detected in front of it. The sensor then provides input to the Arduino microcontroller, which then transfers the data to a database. The output is an alarm sound emitted by a buzzer, allowing the homeowner to immediately monitor the home to identify suspicious areas.

Based on the discussion above, the advantages and disadvantages of a home burglar detection device using a passive infrared sensor are as follows:

1. Tool Advantages
   a. The device uses four sensors to detect suspicious movement.
   b. It makes it easier for homeowners to control and monitor the condition of their home while away for an indefinite period.
   c. It has an animated image that resembles a previously created prop.
   d. The device has data in the form of image files that allow users to see the actions and their times, with notifications sent through the Telegram app.
   f. The burglar detection device automatically alerts anyone who detects suspicious movement through an alarm and notification from the Telegram app.
   g. The device is very helpful in terms of time and handling, making it more efficient and effective.

2. Tool Disadvantages
   a. The device we created utilizes electrical current, so in the event of a power outage, we use other precautions, such as providing a backup battery and running a generator to keep the system running.
   b. It is still a prototype, a simulation example, and has not yet been developed for real homes.

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025 ISSN 3089-106X
Page: 22-31 (online)

CONCLUSION

The conclusions that can be drawn from the results of the research entitled "Home Theft Detection Device Using Passive Infrared Sensors" are as follows:

1. In designing the burglar detection device, based on testing results, the passive infrared sensor can detect movement within a range of 2 cm to 30 cm, with a rotation range of approximately 35°.
2. The camera captures images of suspicious movement detected by the passive infrared sensor.
3. The device we created is directly connected to the Telegram app, so any suspicious movement is immediately notified to the homeowner.
4. The passive infrared sensor detects the presence or absence of suspicious movement when the house is empty. Data is automatically sent to the Arduino ESP32, which activates the alarm if movement is detected. The Arduino ESP32 also sends a command to the LCD (Liquid Crystal Display) to display the message "Object Detected" or "Alerting."

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