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Implementation of Motion Sensors and Buzzers on Robots to Detect Object Movement

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Abstract

Technological advances in this modern era have brought many significant changes in various fields, including security and surveillance. One innovation that stands out is the use of robots to detect object movement. This research aims to implement motion sensors and buzzers on robots to detect the movement of objects around them. This system uses a Passive Infrared (PIR) sensor to detect changes in infrared radiation produced by object movement, and a buzzer as an auditory warning device when movement is detected. In addition, the robot is designed to operate automatically by identifying movement in certain areas. This research also evaluates the effectiveness of the system in detecting objects in various environmental conditions, such as light intensity and sensor detection angle. The results of this implementation show that the PIR sensor is able to detect object movement with good accuracy within a radius of 3 - 4 meters, while the buzzer succeeds in providing a fast and clear auditory response whenever movement occurs. This system can be further integrated with other components for the development of security robots or other smart robots.

Keywords: *Motion Sensor, Buzzer, Movement Detection, Robot, Pir*

1. Introduction

Technological advances in this modern era have brought many significant changes in various fields, including security and surveillance. One innovation that stands out is the use of robots to detect object movement. The implementation of this technology not only increases efficiency in the monitoring process, but also provides higher security guarantees. In this context, the use of motion sensors and buzzers on robots is an effective solution for detecting object movement. Motion sensors are devices that can detect changes in position or movement of objects around them. The buzzer can be said to be an electronic component which is classified as a transducer, simply the buzzer has 2 legs, namely positive and negative, to use it simply the buzzer can be given a positive and negative voltage of 3-12V[1].

Security is one of the important needs of humans, both for themselves and their property in the surrounding environment. However, limited human power to monitor a particular area or room is the main obstacle to realizing this desire[2]. Security is one of the important needs of humans, both for themselves and their property in the surrounding environment. However, limited human power to monitor a particular area or room is the main obstacle to realizing this desire. The results of this research are expected to make a significant contribution in the field of security and surveillance, as well as open up opportunities for further development in robotics and sensor technology. Overall, this step not only provides a practical and economical solution, but also encourages innovation in more sophisticated and responsive security systems. By reducing surveillance costs through reducing dependence on human labor and increasing the efficiency of surveillance systems, the use of robots with motion sensors and buzzers opens up opportunities for improving the quality of security in various sectors.

2. Theoritical Basic

2.1. Robotics

Robotics is a branch of engineering concerned with the design, construction, operation, and use of robots. Robots are automated machines that can perform specific tasks with little or no human intervention. They can have a variety of forms and functions, from industrial robots used in manufacturing processes to service robots used in healthcare or hospitality. Automation, on the other hand, is the application of technology to control and automate processes or systems.

2.2. Microcontroller

A microcontroller is a small electronic device which is a miniature computer on a single chip. A microcontroller has a central processing unit (CPU), memory (RAM and ROM), and input/output (I/O) devices all integrated on a single chip. Microcontrollers are often used to

control specific functions in embedded systems, such as household devices, automotive systems, medical devices, and various industrial applications. A microcontroller is a digital system that consists of a collection of integrated circuits (IC). In contrast to microprocessors such as computers, microcontrollers contain supporting components such as memory, current ports and the power required by the microcontroller is very important[3].

2.3. Motions Sensors

Motion sensors are devices used to detect movement in a certain area. This sensor can identify changes in position or presence of objects, humans or animals. Motion sensors are often used in various applications such as security systems, home automation, automatic lighting, and other electronic devices. The PIR sensor is passive, meaning that this sensor does not emit infrared rays but only receives infrared radiation from outside[4]

2.4. Buzzer

Buzzer is a tool or device that produces sound or sounds in response to an action or signal. Buzzers are widely used in various applications, such as in electronic equipment, alarm systems, household devices, and toys. There are several types of buzzers, including mechanical buzzers, electromechanical buzzers, and piezoelectric buzzers, each with a different way of working but the main function remains the same, namely producing a sound to provide a warning or certain indication. A buzzer is an electronic component that functions to convert electrical vibrations into sound vibrations[5].

2.5. LED

LED (Light Emitting Diode) is a diode that can emit light when it receives a forward bias current. LED (Light Emitting Diode) can emit light because it uses gallium, arsenic and phosphorus doping. The different types of doping above can produce light with different colors[6].

3. System Analysis and Design

3.1. Problem Analysis

In an effort to improve indoor security to prevent rampant theft, various challenges arise that require appropriate solutions, one of which is a robot based on motion sensors and buzzers on robots to detect object movements. This robot is equipped with a motion sensor that is able to detect suspicious movements in the monitored area. When the sensor detects movement, the system automatically activates the buzzer as an alarm to provide immediate warning to people nearby or even intimidate criminals. Existing systems may not be responsive or accurate enough to detect movement, especially in changing environments such as areas with low lighting or extreme temperatures.

There are several limitations to sensor technology, including detection range and sensitivity to small movements that can cause detection errors. Additionally, the buzzer response may be delayed or fail to sound when required. Environmental factors, such as signal interference and lighting variations, can also affect system performance. System maintenance and component reliability are also concerns, and are important to ensure that end user needs and expectations are optimally met.

3.2. System Analysis

In this sub-chapter, an analysis of each system component that has been designed and implemented is carried out, namely motion sensors, microcontrollers, buzzers and LEDs. Each component is analyzed individually to evaluate its performance before integration into a complete system. A bottom-up approach is applied to ensure that each component functions optimally before combining.

1. Motion Sensor Analysis
   Motion sensor analysis in this system uses a PIR sensor, which includes aspects of sensitivity, detection accuracy and time response. The sensitivity test shows that this sensor is capable of detecting movement at a maximum distance of 5 meters. In terms of detection accuracy, the sensor shows good performance with the ability to differentiate human movement from environmental disturbances, and has a low false positive rate. Additionally, the sensor has a fast response time, averaging around 1 second, allowing the system to respond to movement immediately.
2. Microcontroller Analysis
   The microcontroller plays a role in processing signals from the motion sensor and controlling the output to the buzzer and LED. In signal processing, the microcontroller is able to process data from motion sensors quickly without significant lag, thus allowing the system to respond to movement detection efficiently. Additionally, the microcontroller exhibits reliable communication capabilities with motion sensors, LEDs, and buzzers, ensuring that received signals can be transmitted and executed appropriately.
3. Buzzer Analysis
   The buzzer is used as a sound warning device when the motion sensor detects movement. This buzzer produces sound with a volume loud enough to be heard within a radius of 5 meters and has a frequency of between 2 and 4 kHz. Additionally, the buzzer sounds for 5 seconds whenever any movement is detected, thus providing an effective warning to the user.
4. LED Analysis
   LEDs are added as visual indicators to reinforce the warnings provided by the system. Tests show that the LEDs have sufficient brightness levels to be clearly visible under normal room lighting conditions and are effective in providing visual signals up to 5 meters away. The LED is set to light in conjunction with the buzzer when movement is detected, with a very fast response time, almost instantaneously after the signal is received from the microcontroller. Additionally, the LED can be set to flash or illuminate continuously, with the flashing pattern matched to the duration of the buzzer sound, creating a visual indication consistent with the audio alert.

3.3. System Requirements Analysis

System requirements analysis is the process of understanding and determining the hardware and software specifications required to build and run a detection robot system.

1. Hardware Requirements
    a. Arduino Uno
    Arduino Uno is a popular microcontroller used for various electronics and IoT projects. Its functions include controlling digital input/output, reading analog signals, setting Pulse Width Modulation (PWM) to control devices such as motors and LEDs, as well as serial communication with computers or other devices. Additionally, Arduino Uno supports external interrupts for quick response to certain events. Supported by a community and open-source libraries, Arduino Uno is perfect for rapid prototyping in IoT, automation, and robotics applications.
    b. PIR Sensors
    The PIR (Passive Infrared) sensor functions to detect the movement of living things based on changes in infrared radiation in the surroundings. When the sensor detects movement, it produces an output signal that can be used to activate other devices, such as automatic lights or security systems. PIR sensors are often used in applications such as alarms, automatic lighting systems, and human presence detection.
    c. Buzzer
    The buzzer functions as a sound or sound producing device, usually used to provide warnings or indications through sound. Buzzers are often used in electronic devices such as alarms, timers, and system notifications to provide auditory feedback to the user.
    d. LED
    LED (Light Emitting Diode) functions as an efficient light source and is often used for visual indication, lighting or display in various electronic devices. LEDs are used in applications such as status indicators, general lighting, digital displays, and decoration.
    e. Jumper Cables
    This tool is used to connect several existing components.
2. Software Requirements
    a. Windows 10
    This operating system is used as a basic platform for connecting and testing the necessary software. Windows 10 provides support for development software such as Arduino IDE and Fritzing.
    b. Arduino IDE
    Arduino IDE is an integrated development environment used to write, compile, and upload code to the Arduino Uno microcontroller. This IDE supports various libraries and has a large community, which uses development and troubleshooting.
    c. Fritzing
    Fritzing is open-source software used to create circuit schematics and circuit diagrams. This facilitates the design and documentation of electronics projects, as well as aids in the visualization and assembly of hardware components.

3.4. Flowchart

A flowchart is a pictorial diagram that represents sequential flow in one or two directions. Flowcharts are used to represent and design programs. Therefore the image must be able to represent the resource in the programming language. Charts and algorithms can be created before or after the event. The pre-programmed graphics and algorithms used allow programmers to more easily determine the logical order created when creating and using programs. The purpose of the diagram is to show each step in solving the problem in a simple, detailed, good and good way to use flags[7].

By using symbols such as boxes for actions, rhombuses for decisions, and arrows to show flow, flowcharts are able to depict how various actions, decisions, and steps are related and interact in a process. This allows users to get a comprehensive picture of how each element in the system functions and how it contributes to the overall process flow. By visualizing workflows and processes, flowcharts make it easier to identify potential problems, improvement points, and areas that require special attention. It also facilitates more effective communication between different team members, as everyone can see and understand the same processes in a consistent and easy-to-understand way.

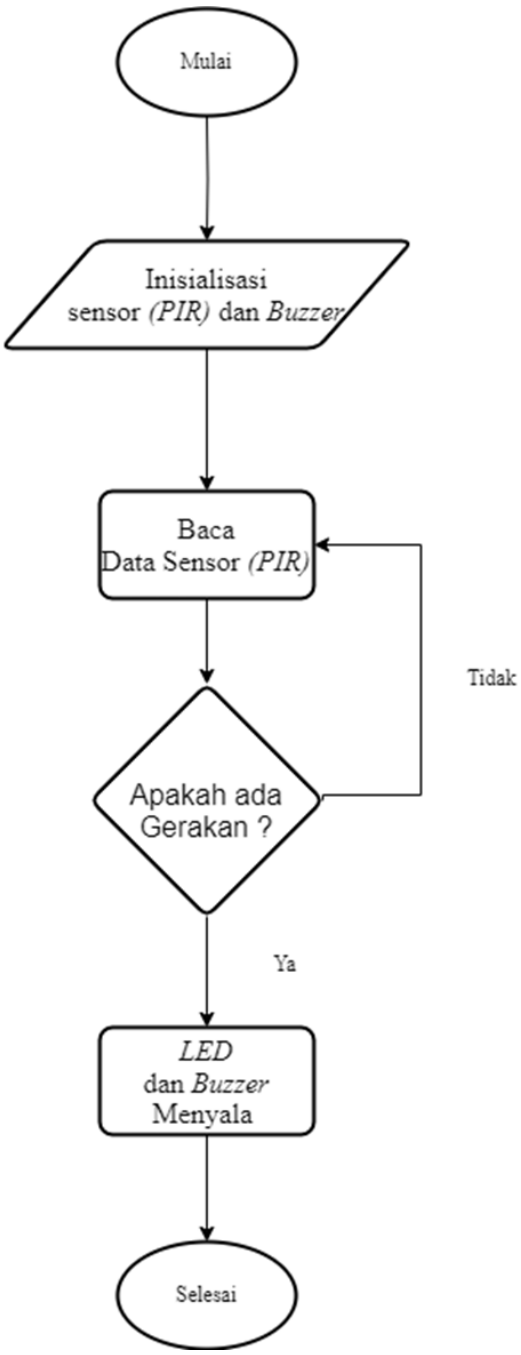
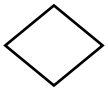
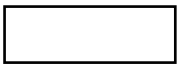


Fig. 1: Flowchart System

Table 1: Flowchart Table

Symbol	Information
	*Oval*, serves as a marker for the start and end points of the process of this system
	*Parallogram*, functions as a place of initiation or input and output
	*Diamond*, serves as a place for decision making
	*Rectangle*, where a process is executed

3.4.1. Information

Based on the flowchart, the system starts by initializing the PIR (Passive Infrared) sensor and buzzer. After initialization, the robot continuously reads data from the PIR sensor to detect the presence of movement. If the PIR sensor detects movement, the system will immediately activate the buzzer and LED (if any) as a warning indicator, notifying that there is an object moving around the robot. After activating the buzzer, the system will wait a few seconds to avoid repeated unwanted triggers (this process is known as debounce). After that, the system will return to the initial process to continue monitoring movements. If no movement is detected, the robot will continue to monitor the surrounding environment until movement is detected. This system can operate repeatedly and continuously as long as the robot is active, ensuring real-time detection of the movement of surrounding objects.

3.5. Tool Design Process

To assemble a prototype requires a design that must be carried out so that the tool can work well. At this stage, designing tools for installing the Motion Sensor (PIR), Buzzer, and LED to the pins on the Arduino Uno microcontroller uses jumper cables so that the tools and their functions can run well. The tool design process is carried out by designing the electronic circuit and frame design using the Fritzing application. With Fritzing, circuit diagrams can be created clearly and structured, making the physical assembly process easier.

3.5.1. Installation of Motion Sensor (PIR) to Arduino Uno

Equations should be numbered consecutively throughout the paper. The equation number is enclosed in parentheses and placed flush right, as in (1). Your equation should be typed using the Times New Roman font (please no other font). To create multileveled equations, it may be necessary to treat the equation as a graphic and insert it into the text after your paper is styled.

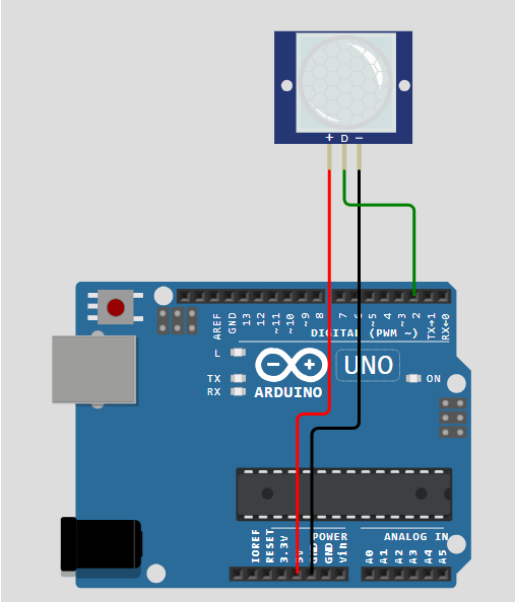


Fig 2: PIR Sensor Installation to Arduino Uno

In figure 2 you can see a picture of connecting the Arduino Uno with the PIR Sensor, the VCC pin of the PIR Sensor is connected to the 5V pin on the Arduino Uno to get power, and the GND pins of the two devices are connected to complete the circuit. The OUT pin of the PIR sensor is connected to pin 2 of the Arduino Uno then the physical installation is complete.

3.5.2. Installation of LED to Arduino UNO

The LED functions as a visual indicator to show that the system has detected movement. When the motion sensor (PIR) detects the movement of objects around the robot, the LED will light up as a sign that the detection was successful. This function provides direct feedback to the user or developer about the system status, making it easier to monitor whether the sensors are working properly or if there is movement detected in the area around the robot. Additionally, LEDs can also function as part of a warning system along with buzzers, amplifying visual notifications when movement is detected.

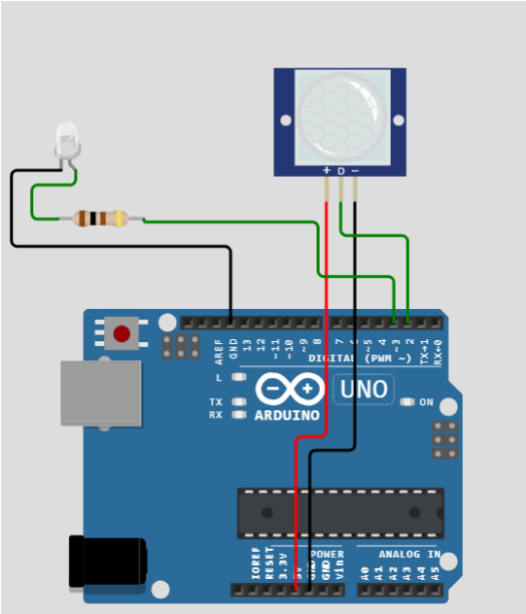


Fig 3: Installing LED to Arduino

In figure 3 you can see how the LED installation circuit is with the Arduino Uno, where the positive pin of the LED is connected to a resistor which is connected to pin 3 of the Arduino Uno and the GND pin of the LED is connected to the GND pin of the Arduino Uno.

3.5.3. Overall Hardware Design

After designing each piece of hardware, the next stage is the design stage for the entire hardware. Hardware such as PIR sensors, buzzers, LEDs are connected into one unit with the Arduino Uno microcontroller via predetermined pins. At this stage, the entire hardware unit is transformed into a prototype so that it can be concluded directly. Figure 4 is a schematic structure of the overall hardware of this research project

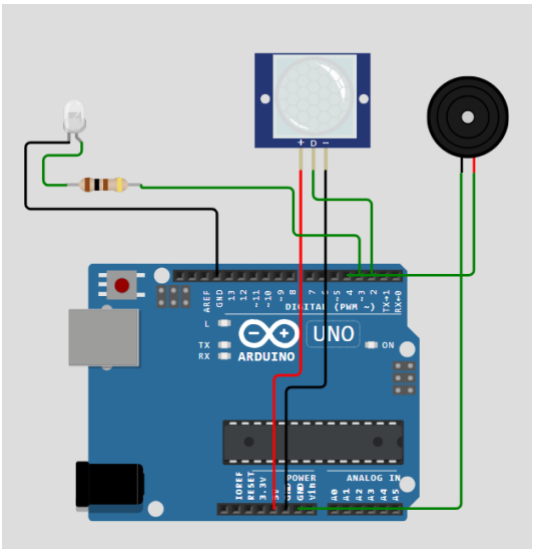


Fig 4: Overall Hardware Range

The following is an explanation of figure 4, the entire circuit of movement detection hardware using a PIR sensor and buzzer based on Arduino Uno.

1. Using Arduino Uno as the main microcontroller which regulates the entire function of this Robot.
2. Using a PIR sensor as a movement detector for objects that produce infrared radiation (such as humans or animals) around them. When the PIR sensor detects a change in the level of infrared radiation (that is, when there is movement of an object), it will send an output signal to the Arduino Uno pin.
3. Use a buzzer to provide warnings or sound notifications. When the PIR sensor detects movement, the buzzer will sound as an alarm or indication that a moving object has been detected.
4. Using LEDs as visual indicators. When the PIR sensor detects movement, the LED will light up to provide a visual indication that movement has been detected.

4. IMPLEMENTATION AND TESTING OF TOOLS

This chapter explains the implementation and application of an Arduino-based object movement detection robot system, starting from hardware preparation, programming to testing to ensure the system functions properly.

4.1. Hardware

The hardware used to design this Arduino-based movement detection robot is as follows:

1. Arduino
2. PIR Sensors
3. Buzzer
4. LED
5. Jumper Cable
6. Box

4.2. How The Tool Works

At this stage, the author will explain the working system of the Arduino-based object movement detection robot, which is as follows.

1. When the system is turned on, the motion sensor will continuously monitor the surrounding environment.
2. The previously programmed microcontroller will receive signals from the motion sensor. If the sensor detects movement, the microcontroller will process the data.
3. At this stage, the programming logic on the microcontroller evaluates whether the received signal meets the criteria to be considered as relevant object movement.
4. After the microcontroller confirms movement, the buzzer and LED will be activated to provide an audible warning
5. The sound produced by the buzzer can be adjusted in duration and pattern based on the programming implemented in the microcontroller. For example, the buzzer can sound continuously or in the form of repeated sounds according to the type of movement detected.
6. If movement is no longer detected, the sensor will return to standby state.
7. The microcontroller then turns off the buzzer and LED after ensuring that no further movement is detected within a certain time.
8. This process repeats continuously as long as the system is active. Sensors continuously monitor the environment, microcontrollers process data, and buzzers respond whenever movement is detected.
9. Finished.

4.3. Discussion Results

The results of this discussion are based on plans that have been made previously. In this section, testing is first carried out on the Arduino-based movement detection robot so that it can run as desired. The tests carried out were tests of several components in designing an Arduino-based detection robot. Testing is carried out to ensure that the components used work well or do not experience errors. The following are the results of designing an Arduino-based movement detection robot. The following is an explanation of each component.

1. Arduino Uno
   The Arduino Uno microcontroller functions as a data management center and a place where other components are connected to each other.
2. PIR Sensors
   Functions as a sensor that detects the movement of objects and sends the data to the Arduino Uno to be managed by the system.
3. Buzzer
   The buzzer functions as a sound indicator, which works according to the data obtained by the PIR sensor.
4. LED
   The LED functions as a visual indicator, which works according to the data obtained by the PIR sensor.
5. Box
   The box is useful for protecting and containing all the components inside. This box provides physical protection from damage and prevents direct contact with the external environment which could interfere with the function of the device.

4.4. Tool System Testing

The aim of testing this tool is to see the results and find out whether the circuit and design of this movement detection robot can work according to the design designed by the author. This test is carried out to determine whether each hardware device used is working properly.

1. PIR Sensors

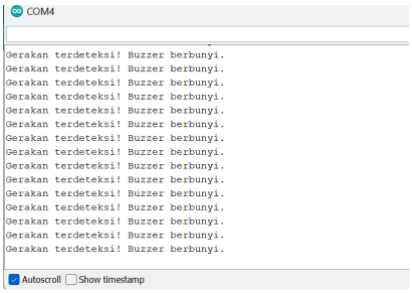


Fig 5: Checking PIR Sensors

In figure 5 it can be seen that the PIR sensor can function properly. In standby mode, the PIR sensor will continue to check until movement is detected and send the data to the Arduibo Uno for processing.

2. Buzzer And LED

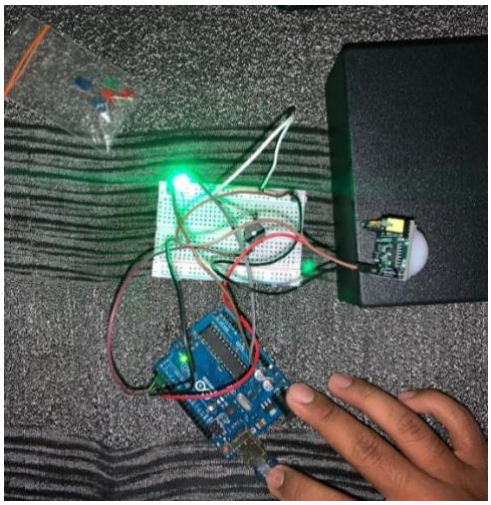


Fig 6: Buzzer And LED Testing

In Figure 4.3 it can be seen that the buzzer and LED can function properly when there is movement captured by the PIR sensor. This test was carried out to determine the effectiveness of the motion sensor and buzzer in detecting objects at various angles.

5. Conclusion

This research has succeeded in designing and developing a Movement Detection Robot using the Arduino Uno microcontroller. Some of the main conclusions from this research are as follows.

1. Implementation of motion sensors on robots to detect object movement has been successfully carried out. The motion sensor used is able to detect the movement of surrounding objects quite accurately in several conditions but experiences a decrease at certain angles.
2. The integration of a buzzer on the robot to provide a warning when object movement is detected also works quite well. The buzzer functions as a warning output that is active as soon as the motion sensor detects movement, but requires a 2-3 second delay so it cannot respond in real-time.
3. The effectiveness of using motion sensors and buzzers on robots in detecting object movement can be stated as not good enough based on the evaluation carried out. The combination of a motion sensor and buzzer provides a fast and accurate response to object movement, so that the objectives of this detection system are achieved. However, there are some limitations such as sensitivity to angles and detection distance that can be improved to improve overall system performance.

References

[1] M. D. Nurrasyiid, N. Alfarizal, dan A. Rahman, "Modelling Smart Robot Inventory 3 Axis Menggunakan Sensor RFID," *J. Ampere*, vol. 8, no. 2, hal. 153–164, 2023, doi: 10.31851/ampere.v8i2.12801.

[2] G. A. Salamena, "Implementasi Sensor Gerak (PIR) sebagai Detektor Gerakan Manusia dalam Ruang," vol. 4, hal. 9342–9351, 2024.

[3] S. Refly dan H. A. Kusuma, "Analisis Konsumsi dan Fluktuasi Arus dan Daya pada Mikrokontroler Menggunakan Sensor INA219," *J. Sustain. J. Has. Penelit. dan Ind. Terap.*, vol. 11, no. 1, hal. 44–48, 2022.

[4] A. Juliansyah, R. Ramlah, dan D. Nadiani, "Sistem Pendeteksi Gerak Menggunakan Sensor PIR dan Raspberry Pi," *JTIM J. Teknol. Inf. dan Multimed.*, vol. 2, no. 4, hal. 199–205, 2021, doi: 10.35746/jtim.v2i4.113.

[5] S. Sutarti, T. Triyatna, dan S. Ardiansyah, "Prototype Sistem Absensi Siswa/I Dengan Menggunakan Sensor Rfid Berbasis Arduino Uno," *PROSISKO J. Pengemb. Ris. dan Obs. Sist. Komput.*, vol. 9, no. 1, hal. 76–85, 2022, doi: 10.30656/prosisko.v9i1.4744.

[6] Y. A. Cahyono, "Komponen Elektronika Dan Cara Kerjanya," *Portaldata.Org*, vol. 2, no. 4, hal. 116–122, 2022, [Daring]. Tersedia pada: http://portaldata.org/index.php/portaldata/article/view/122

[7] H. Purba, "Konsep Dasar Pemahaman Algoritma Pemrograman," *J. Arjuna*, vol. 1, no. 6, hal. 290–301, 2023, [Daring]. Tersedia pada: https://doi.org/10.61132/arjuna.v1i6