Automatic Email Alert on the Internet of Things-based Smart Motion Detection System

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Abstract. The main problem in this research is the increasing prevalence of theft and burglary cases. This incident was caused by the busyness of every person in his daily life so that he forgot the security of his house. The IoT-based home security system that utilizes the PIR sensor as a human motion detector and then sends a notification in the form of notification via SMS or e-mail is one solution to overcome the problem that was previously proposed in previous research. However, to further clarify the warnings sent from the system, a home security system is needed that can attach images in the notification. In this study developed an IoT-based home security system. The IoT security system developed, can automatically send email alerts by attaching images when the PIR sensor detects human presence. The IoT system requires a Raspberry Pi as a microcontroller that has been connected to the internet, a PIR sensor to detect human movement and Pi Camera to win images when there are human encounters that are within the range of PIR sensors. Experiments in the study show that the IoT system can automatically send email alerts by attaching images when PIR sensors detect human presence in various light conditions with a range of 0-5 meters and the speed of sending email alerts affected by conditions of internet network connections and files size of image sent.

Keywords: Email alert, Image, IoT, PIR sensor, Raspberry Pi

1 Introduction

The percentage of villages experiencing cases of theft during 2018 is in the range of 11.42 - 73.76 percent of the total villages in Indonesia [1]. Based on Data from the Central Bureau of Statistics, the most significant theft cases were in West Java Province with 27.76 percent present including theft or burglary. This incident can be caused by everyone's daily activities, which result in neglected home security [2].

The solution to addressing home security issues has been done in previous studies, namely the creation of IoT-based security systems. Research [2], [3], [4], [5], [6] explains the detection of human movement with the help of PIR sensors, IP cameras, and smart cam applications based on auto motion detect then sends an alarm in the form of an alarm, SMS notification and notification real-time e-mail to homeowners. It is just that the lack of an existing security system IP Camera is not used to take pictures when human movement is detected by the PIR sensor which is then attached to the email notification as an alert email. Another disadvantage is that there are no images sent to the SMS or e-mail notification. Homeowners cannot see or distinguish the notification from people who do not know or known people. In IoT, everything is expected to be able to interact and communicate with each other, such as exchanging data and information related to environmental conditions. Thus, IoT reacts autonomously to events or

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events in the environment and provides services with or without direct human intervention [6]. The development of IoT-based home security systems is a solution to address the shortcomings of previous research.

The IoT security system makes it possible to control and monitor home conditions remotely in real time over the internet network [7] [8]. One of the challenges that will be solved is related to the development of IoT-based security systems, namely the process of automating sending email alerts by attaching images captured by Pi Camera when the PIR sensor detects human presence and knowing the things that affect the sending of email alerts that attach the image.

Raspberry Pi (Raspy) is a microcontroller used in this security system and also a server for sending alert emails [9]. Utilizing email services in sending notifications is currently felt to be the most effective compared to the use of SMS services because users of SMS services are decreasing especially at Indosat providers [10] while 33.58 percent of the total Indonesian population is users of email services [11]. The Raspy used is equipped with a Wi-Fi module, and another module is added, namely, the PIR sensor to detect human movement. As with the human senses, sensors can sense the environment [12]. This PIR sensor can filter the wavelengths of passive infrared light between 8 to 14 micrometers, waves of passive infrared light produced from the human body range from 9 to 10 micrometers while those produced by nanometer-sized animals [13]. Raspy is also equipped with a Pi Camera module to capture images when human movement is within the range of a PIR sensor at a distance of 0 to 5 meters.

2 Related Work

Research [2], presents an architecture related to home security and some prohibited places such as army areas, government, and private places, etc. Also, the owner/administrator can get email alerts. It only in the form of notification email without an attachment to the image captured by the camera.

Research [3], PIR sensors can detect motion, the webcam can capture objects, and the system sends notifications to the smartphone at a maximum distance of 5.5 meters, and the buzzer can be activated immediately when motion is detected. Since the characteristic of the webcam is static, then the shooting process cannot be done where the direction of movement occurs. Also, to the next development, it is good to add moto servo or use an IP camera that has auto-tracking.

Research [4] [14], implemented an IoT-based home security system to monitor the state of the house that utilizes the PIR sensor to detect human movement and then sends an email notification to the homeowner when the PIR sensor detects a movement. In this study, it was no equipped with the camera to capture an image when the movement of human is detected by the PIR sensor.

Research [5], built a security system using the SMS gateway based reporting feature. This system is built by having three users, namely the homeowner, security guard, and admin as the manager. The reporting features of the homeowner's display consist of 4 types of reporting, namely fire, theft, murder, and emergency. The way the system works is that when one report occurs, the homeowner and security guard will get an SMS alert. This study is not equipped with a PIR sensor or camera to generate notifications, but it utilizes reports from the application dashboard originating from the owner's house to admin.

Research [6], built a smart home system capable of controlling all electrical devices such as TVs, fans, electric tubes, refrigerators, and washing machines. The system is also able to

provide notifications to users about any errors or damage that occurs to the device by sending an email or SMS, but only give an alert such as a broken refrigerator.

Table 1. Comparison of Related Research

Researcher	The scope of research							
	Module		Notification			Platform		
Year	Camera	PIR Sensor	SMS	Email	Email with image	Arduino	Or Raspberry Pi	Home Security
Pooja A. Dhobi, Niraj Tevar (2018)			√	√		Arduino		
S. Tanwar, P. Pately, K. Patelz, S. Tyagix, N. Kumar, MS Obaidat (2017)	√	√		√			Raspberry Pi	√
Budianingsih, Agus Riyanto (2018)			√					√
Dodon Yendri, Rahmi Eka Putri (2018)	√	√	√				Raspberry Pi	√
Rajes Khana, Uus Usnul (2018)		√		√		Arduino		√
Proposed Research	√	√		√	√		Raspberry Pi	√

Based on table 1 the comparison of related studies, comparisons or differences in the research conducted with previous research, there is a notification, where the research conducted develops notifications sent via email by attaching images as alert emails.

3 System Design

The home security system for smart motion detection based on the Internet of Things (IoT) involves hardware and software. The system is designed to be able to send email alerts by attaching images automatically when human movement is within the range of the PIR sensor. Sending email alerts to the homeowner requires an internet network connection. In general, the relationship between devices and internet networks is illustrated in Figure 1.

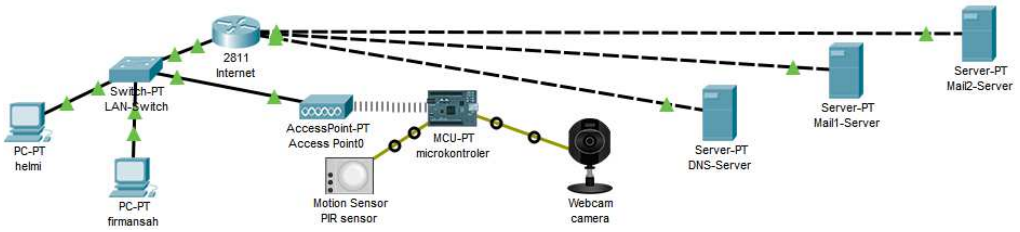

Fig. 1. Network Topology

Figure 1 illustrates the network topology in the IoT-based home security system developed. The microcontroller (raspberry pi) gets internet access from Wi-Fi networks that are already connected to the internet because raspberry pi by default is equipped with a wi-fi module. The protocol used for data communication uses the protocol of Transmission Control Protocol (TCP) on port 55, while the port used by SMTP to send email is port 587. The network security system is described in figure 2.

Based on figure 2, a firewall is used in the ICMP protocol, which is blocked by the ICMP protocol (ping blocked). Make sure the device configuration with other devices then configure the device with the internet network is done correctly so that the system can work properly. In general, the design of a home security system is presented in the figure 3 flowchart diagram so that it can be understood based on the sequence of steps from one process to another.

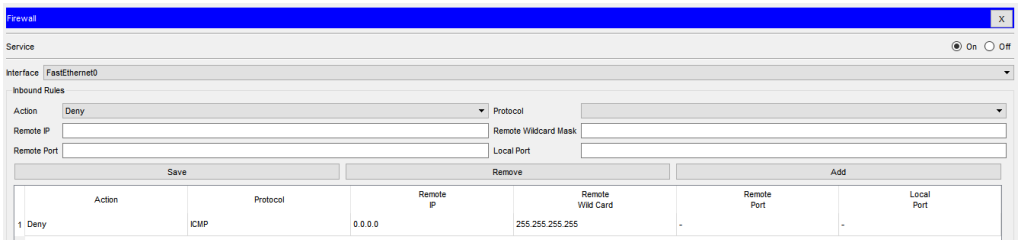

Figure. 2. Firewall

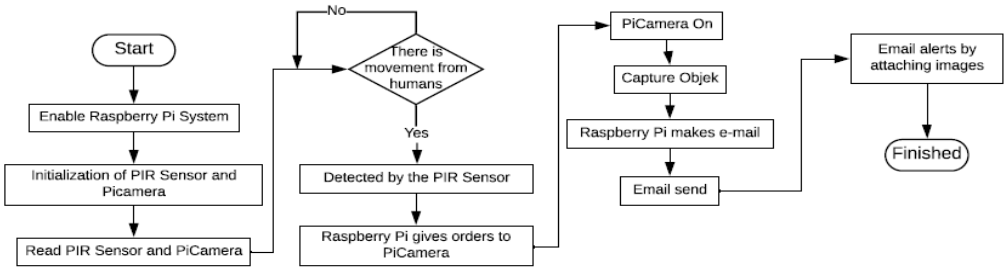

Figure. 3. Flowchart Diagram

Based on figure 3, the flow of the home security system starts with activating the raspberry pi system. The system will initialize the PIR and Pi Camera sensors and will read the connectivity with the PIR and Pi Camera sensors because the home security system uses a PIR sensor and Pi Camera that is connected to the Raspberry Pi. PIR sensors are used to detect

human presence, and Pi Camera is used to capture images when their presence is detected. Every time there is a movement of people who come within range of a PIR sensor, the PIR Sensor will trigger the Pi Camera to take pictures via the Raspberry Pi. The Raspberry Pi sends commands to Pi Camera to click on images and save them. After that, the Raspberry Pi creates an e-mail and sends it to the mail address specified with the image you just clicked on. The email contains messages and images of intruders as alert emails.

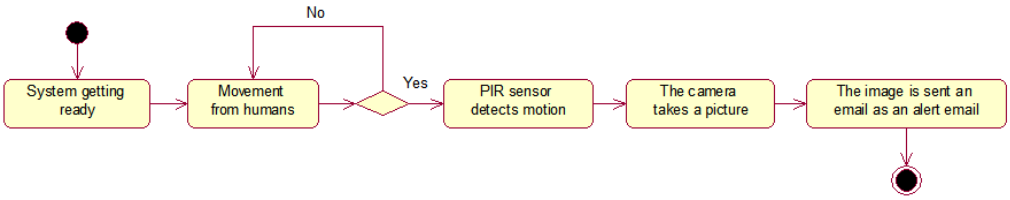

Figure. 4. Activity Diagram

Based on figure 4, when the Raspberry Pi is supplied by electricity, the system is ready, or the system is active, then when there is movement of humans coming in at the PIR sensor, the movement will be a valuable input for the PIR sensor and the program will detect movement, every it happens, it will trigger the PiCamera to take pictures via raspberry pi, then the image is sent via email to the homeowner as an alert email.

4 Result and Analysis

There are four main stages carried out on research related to the development of this home security system, namely: hardware preparation, software preparation, system configuration, testing.

4.1 Hardware Preparation

This stage analyzes the hardware needed in the development of IoT-based home security systems. In general, the hardware requirements will be presented in table 2 and will be illustrated in figure 5, and the prototype can be seen in figure 6.

Table 2. Hardware Requirements

Hardware	Function
Raspberry Pi 3 model B+	As a server and microcontroller
Sensor PIR	Detects human movement
Pi Camera	Take a picture
Kabel Jumper Female to Female	Connects sensor PIR with Raspberry Pi
Memory MicroSD	Install the operating system and storage media on the Raspberry Pi
Power supply	Provides electrical power on the Raspberry Pi
Computer screen	Configure and program the Raspberry Pi
VGA Cable	Connects a computer screen with Converter HDMI to VGA that is already connected to the HDMI port on the Raspberry Pi
HDMI to VGA Converter	Connects a Raspberry Pi that has an HDMI port with a VGA cable that has been connected to a Computer screen
Keyboard	Configure and program on the Raspberry Pi
Mouse	configures and makes a program on the Raspberry Pi

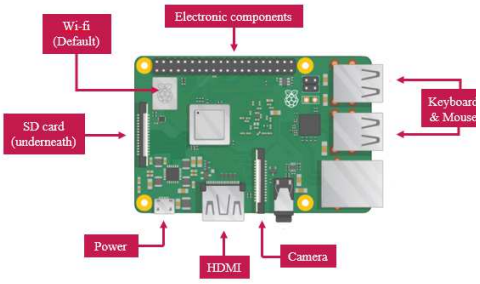

Figure. 5. Illustration of hardware design

Figure. 6. Hardware System Prototype

4.2 Software Preparation

This stage analyzes the software that is needed in the development of IoT-based security systems. In general, the software requirements will be presented in table 3.

Table 3. Software Requirements

Software	Function
Operating System Windows 10	Running software or other applications.
Operating System *Raspbian Jessie*	The Operating System has been optimized and is specific to the Raspberry Pi

4.3 Testing

The testing phase is done to ensure that every function and every device on this system is functioning correctly. Tests carried out several variables from this Internet of Things based security system and their analysis. The design variables that will be tested include:

1. Testing the PIR sensor

Table 4. PIR Sensor Test Data

Testing	Distance (meters)				
	1	3	5	5.1	5.2
1	Detected	Detected	Detected	Not Detected	Not Detected
2	Detected	Detected	Detected	Not Detected	Not Detected
3	Detected	Detected	Detected	Not Detected	Not Detected
4	Detected	Detected	Detected	Not Detected	Not Detected
5	Detected	Detected	Detected	Not Detected	Not Detected

Based on the test data in Table 4, namely PIR Sensor testing, testing at a distance of 1-5 meters PIR sensors can detect human movement while testing at a distance of more than 5 meters PIR sensors cannot detect human movement. In conclusion, the range of PIR sensor detection limits on movements of humans is 0 - 5 meters apart.

2. Testing on several conditions

The test results in table 5 human movement in bright conditions, dark conditions, and night conditions, but there is light. The test results show that the system can detect movement in various lighting conditions, but light conditions affect the quality of shooting. The parameters of bright and dark light conditions in this test refer to the results of the study [15].

Table 5. Testing With Various Light Conditions

Light Conditions	PIR Sensor	Pi Camera	Email Alert
Light	Detected	Take a picture	Send email alert
Dark	Detected	Take a picture	Send email alert
Night but there is a light	Detected	Take a picture	Send email alert

3. Test the duration between sending and receiving emails when a human movement is detected.

Table 6. Duration of sending and receiving emails

Testing	Time (hour: minute: second)			File Size	Dimensions	Pixels (Px)
	Sending	Received	Delay			Width (W) Height (H)
1	16:29:07	16:29:22	15 second	702 kb	1440x900	W:1440px H:900px
2	16:29:47	16:30:02	15 second	702 kb	1440x900	W:1440px H:900px
3	16:30:17	16:30:32	15 second	702 kb	1440x900	W:1440px H:900px
4	16:49:03	16:49:20	17 second	737 kb	1440x900	W:1440px H:900px
5	16:49:38	16:49:55	17 second	737 kb	1440x900	W:1440px H:900px

Based on the test data in table 6, conclusions can be drawn. Namely, the duration between sending and receiving email alerts on repetition to 1 - 3 is 15 seconds, while on repetitions to 4 and 5 are 17 seconds. This difference can be influenced by different image size files and internet network connection conditions. When the internet access on the raspberry pi is off, PIR sensor and the pi camera still work, but the result of the image captured by the pi camera is saved first and not directly sent as an email alert dan the image will be sent if raspberry pi has got the internet access.

5 Conclusions

The Internet of Things based Smart Motion Detection System has been successfully implemented with the mechanism of sending email alerts automatically by adding the results of shooting when there is human movement. This system can work optimally at a distance between 0-5 meters with various light conditions, but it affects the quality of the captured image. The average duration of sending an email is 15 seconds depending on the quality of the image captured by Pi Camera. So that the response of this system is still categorized as real-time. The weaknesses of this system are the quality of the image captured that is not clear and has not got the response yet from the email receiver towards the system when an email alert is received.

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