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Internet of Things: Home Security System based on Raspberry Pi and Telegram Messenger

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ABSTRACT

Installing security cameras in their homes is a common practice to keep an eye on things while they're away. However, when an unauthorized person is picked up by the security camera system, the homeowner is not notified directly. The fact that the camera continues to record footage even when no activity is detected is another disadvantage. Using Telegram Messenger, this research creates an Internet of Things (IoT) based home security system. The Raspberry Pi camera will capture a picture and send it to the user via Telegram Messenger when the PIR (Passive Infra Red) sensor detects human movement. Homeowners can select between two functions offered by the bot on Telegram Messenger: the ability to take pictures or videos. The maximum object detection distance between the sensor and the test subject was 6 meters, according to the test results. It was demonstrated by the testing that the system could identify, capture, and communicate the results to the user. Sending communications pertaining to object detection takes 4.73 seconds. It takes 5.73 seconds for a photo request to be fulfilled, and 14.86 seconds for a movie.

Keyword : Home security; Raspberry Pi; IoT; PIR Sensor; Telegram Messenger

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1. INTRODUCTION

The rate of crime from 2021 to 2023 is still high, albeit erratic, particularly when it comes to crimes that impact homes, such robbery and theft. It was estimated that 1,628,634 thefts and thefts involving domestic abuse would occur in 2023. Out of 100,000 individuals, 140 are susceptible to encountering criminal activity. When homeowners go on extended trips and leave their homes unattended, there is a high incidence of thefts. Despite the fact that certain residential areas have security guards already, human frailties might give burglars an opportunity.

Various studies offer systems that can increase the level of security in the home. As in previous research, there is an Arduino Mega-based prototype that uses a password to enter the house. The password is entered via the 3x4 keypad. Inside the house, a webcam is added to record the situation and a PIR sensor to detect movement as well as a trigger to activate the LED lights in the house (Nataliana, Anwari, & Akbar, 2017). In another study entitled sleepycam, it uses a PIR sensor as a human movement detector and a camera to record movement with a Raspberry Pi-based main device. This research focuses on the main issue of power consumption. The system is designed to consume lower power through a wireless camera that is active only when the sensor detects movement and the use of frame comparison on the camera (Mekonnen, Harjula, Koskela, & Ylianttila, 2017). Apart from that, various other studies on home security systems include home security systems based on computer parallel ports and light sensors (Alfirman, 2012), online-based home security systems using mobile devices (Abidin, 2014), but these studies did not use applications. Telegram Messenger on its research. There is also research on room security systems with PIR sensors equipped with lighting control based on the ATmega 8535 microcontroller and DS1307 type RTC (Real Time Clock) (Zain, 2013).

Technology from the Internet of Things (IoT) is used in this study. This research focuses on how the Internet of Things can use popular instant messaging apps to remotely monitor homes. Because Telegram Messenger is open source, it was used for this study. Users can view the source code, protocol, and Application Program Interface (API) that are all included with this benefit. Users will find it easier

to construct extra applications, like the ones used in this research, as a result. As the Raspberry Pi runs the same operating system (OS), Telegram Messenger is an instant messaging software that supports Linux-based OSs. Another benefit is the bot feature, which is absent from other instant messengers. Bots are automated response accounts that can react to specific messages in accordance with our orders.

A PIR sensor, which is used in this security system, can identify the presence of people. In the event that the sensor is active, the Raspberry Pi's attached camera will be triggered, taking a picture that will be sent to the homeowner over the Telegram Messenger app. The Telegram Messenger bot then asks what we would like to do next. It can either take a picture or record a video of the current circumstances at home and give it back to the user. In the event that something questionable occurs, users can get in touch with local security or the police right away. Using images or videos serves the purpose of elucidating the subject of the offender captured on camera, hence facilitating future identification efforts. If it's only a snapshot, it can be that the person captured on camera is in an awkward pose that makes them difficult to identify.

2. RESEARCH METHOD/MATERIAL AND METHOD/LETERATURE REVIEW

The way this security system works is that when the system is active and the PIR sensor does not detect any human objects, the system will be in standby condition. When the PIR sensor detects movement, the Raspberry Pi camera will immediately take a photo, then save the photo on the external memory on the Raspberry Pi, then send the photo to the Telegram Messenger user as well as notify the user. The Telegram Messenger bot will immediately offer 2 options for the next process, namely to take a photo again or take a video. If the user chooses to take a photo or take a video, the bot will give the Raspberry Pi a command to take a photo or video via the Raspberry Pi camera and send the results directly to the user. Photos use JPEG format while videos sent use MPEG format with H264 codec and 720p resolution. The video is then converted into GIF format when it reaches the user. If the user does not carry out the next command, the system will return to standby. In the next section we will discuss system design starting from the hardware and software that will be used. This home security system design stage is explained through block diagrams and system flowcharts.

System Block Diagram

System Block Diagram In planning a Raspberry Pi-Based Home Security System using the Telegram Messenger Application using a Raspberry Pi camera and PIR sensor, a block diagram is needed to understand the working principle of the tool. The block diagram is as in Figure 1 with an explanation of each part as follows :

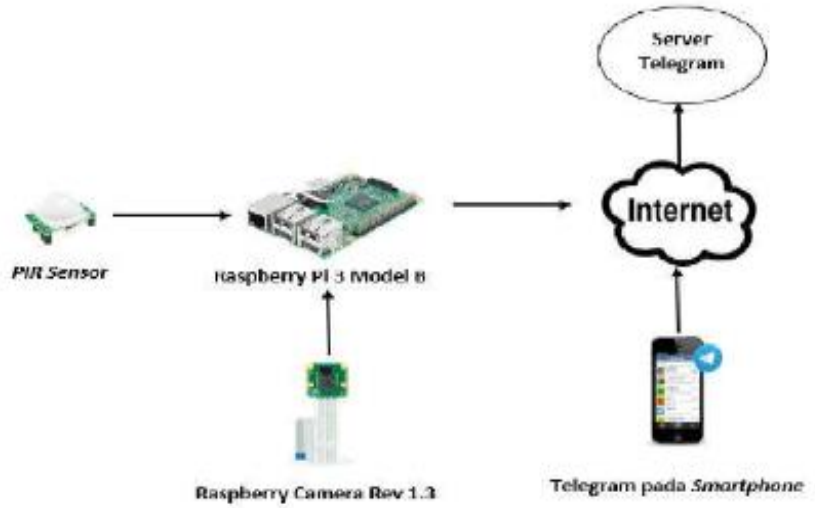

Fig 1. System Block Diagram

The PIR sensor module used is the HC-SR501 type, the output of the sensor is in digital form so it can be directly connected to the GPIO pin on the RaspberryPi module. The output pin on this sensor

will produce a voltage of 0 volts when it is idle or does not detect movement and 3.3 volts when the sensor detects movement. The digital representation of 0 volt voltage is digit 0 and 3.3 volt voltage is digit 1.

The rev 1.3 type Raspberry Pi camera is connected to the CSI (camera serial interface) port which consists of 15 pins on the Raspberry Pi. The camera functions to take photos every time movement is detected or record the surroundings and can take photos and videos with commands from Telegram Messenger. The Raspberry Pi camera has a resolution specification of 5 mega pixels which supports 1080p and 720p video resolutions. Photos received on the user's Telegram Messenger have dimensions of 640 x 480 pixels (±20KB) or 1280 x 720 pixels (±60KB). The resulting video uses the MPEG video format with the H264 codec. However, when sent to Telegram Messenger, it will be converted into GIF format by the Telegram Messenger cloud server so that it can be run on the Telegram Messenger application on a smart phone.

Raspberry Pi 3 model B reads data from the PIR sensor, then processes and processes the data. Accessing the Telegram Messenger Server to inform users of censorship responses. The external memory on the Raspberry Pi also functions as a temporary storage place for photos and videos before being sent to the Telegram Messenger server and users. Receive instructions from users via Telegram Messenger and program Telegram Messenger bots using the Python language.

3. RESULTS AND DISCUSSION

Multiple tests must be conducted for the system as a whole as well as for each component in order to establish system performance. These tests consist of the following: 1. Determining the PIR sensor's sensitivity to the object's distance; 2. Determining the sensor's ideal angle; 3. Examining the impact of room temperature on the PIR sensor; 4. Verifying the successful transmission of images and videos; and 5. Determining the delay in sending images or videos. In the meantime, Figure 5 depicts the system's ultimate output.

Fig 2. Device Realization

A. PIR Sensor Range Testing

This test measures how far the PIR sensor can work to detect movement. Four experiments were carried out at each predetermined distance to test the sensitivity of the PIR sensor. In Table 1 are the test results of the sensitivity of the PIR sensor to detect an object based on distance.

Table 1. PIR Sensor Range Testing

Object Distance (Meter)	Test Result										Success Percentage
	1	2	3	4	5	6	7	8	9	10	
1	B	B	B	B	B	B	B	B	B	B	100%
2	B	B	B	B	B	B	B	B	B	B	100%
3	B	B	B	B	B	B	B	B	B	B	100%
4	B	B	B	B	B	B	B	B	B	B	100%
5	B	B	B	B	B	B	B	B	B	B	100%
6	B	B	B	B	B	B	B	B	B	B	100%
7	B	B	G	B	B	B	B	G	G	B	100%
8	B	G	B	B	G	G	B	G	B	G	100%

9	G	G	G	G	G	G	G	G	G	G	100%
10	G	G	G	G	G	G	G	G	G	G	100%

From Table 1 it can be concluded that the maximum distance the PIR sensor can work to detect movement is 6 meters. This is because at a distance of 6 meters the success rate of the PIR sensor is still at 100%. At a distance of 7 and 8 meters the PIR sensor can still detect movement but the success rate is below 90% and at a distance of more than 8 meters the PIR sensor cannot detect any more movement.

B. PIR Sensor Sensitivity Angle

Test steps were carried out to determine the optimum angle of the PIR sensor in detecting horizontal and vertical movement. In Figure 7 you can see that objects, in this case humans, will cross the PIR sensor at varying angles ranging from 30o, 45o, 60o, 85o, 90o, 105o, 120o, 135o, 150o. The distance between objects passing from the PIR sensor is 3-4 meters. This distance is still within the range of the PIR sensor. In accordance with table 1, it is known that the maximum range of the sensor is 6 meters. Measurements were carried out in a closed room and had air conditioning (AC). The temperature is set at 25^0 Celsius. Room temperature is measured using an analog thermometer which shows a reading of 25^0 Celsius.

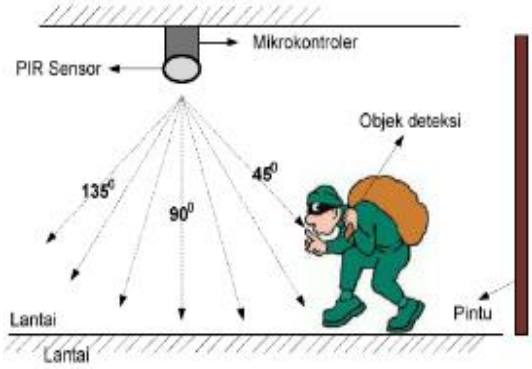

Fig 3. PIR Sensor Coverage Angle Testing (viewed from the side)

In the illustration in Figure 3, it can be explained that the placement of the controller device (in this case the Raspberry Pi) and also the PIR sensor are embedded in the ceiling of the house. Where the PIR sensor transmits a data reading signal in the direction below it with a transmission pattern that can be an ellipse or circle (similar to antenna polarization: circle or ellipse). With capabilities like this, objects will not only be read in the horizontal direction but can be read in the vertical direction. As for the previous test in Table 1, it was found that objects could only be read at a maximum distance of 6 meters, more than that the accuracy was less than 100%. This shows that at a distance of more than 6 meters there is a possibility that the sensor will read incorrectly (fail to detect). In this case, a distance of 6 meters is the optimum reading distance. Therefore, the position of the sensor must be placed at a height of no more than 6 meters from the object to be detected during testing.

C. PIR Sensor Sensitivity to Room Temperature and Passing Objects

Testing the sensitivity of the PIR sensor to room temperature is carried out by placing the PIR sensor in an air-conditioned room and setting the temperature as desired at 18o-30o C. Then the room temperature is measured using an analog thermometer which shows the desired number. Then an object (human) with a normal body temperature of 36o - 37oC crosses the PIR sensor at a distance of 3-4 meters.

By carrying out this test the final results obtained are as in Table 3, namely the percentage of success of the PIR sensor in detecting movement at different room temperatures ranging from 18^0-30^0 C.

Table 2. PIR Sensor Testing for Room Temperature

Room Temperature (^{0}Celcius)	Test Results
18	Terdeteksi
19	Terdeteksi
20	Terdeteksi
21	Terdeteksi
22	Terdeteksi
23	Terdeteksi
24	Terdeteksi
25	Terdeteksi
26	Terdeteksi
27	Terdeteksi
28	Terdeteksi
29	Terdeteksi
30	Terdeteksi

Based on Table 2, it can be concluded that in experiments above room temperature of 18o-30o C, there was no significant effect on the success of the PIR sensor in detecting movement of objects (humans).

D. Delay Measurement

The delay measured is the delay of the entire system, in this case the delay is measured from the time the PIR sensor detects human movement until the user receives the requested photo or video. As shown in the test in Figure 11, the device is installed near the entrance and then someone tries to enter through the door. It appears that the Telegram Messenger bot directly sends messages to users. The delay measurement method uses a stopwatch. Measurements were carried out 10 times. As an Internet of Things application, the internet factor is of course the main factor that influences the measured delay component. Testing was carried out on two different networks, namely Indiehome's Fiber to The Home (FTTH) network and PT's 4G network. Telkomsel. Measurements use services on the "speedtest.net" website.

Fig 4. Data Download and Upload Speed Measurement Results for (a) Telkom's Indiehome FTTH Network, (b) Telkomsel's 4G Network

From the results of data speed measurements using speedtest.net for PT's FTTH network. Telkom and PT's 4G network. Telkomsel, as in Figure 4, for the Indiehome FTTH network the download speed reached 14.51 Mbps and the upload speed was 1.71 Mbps, while for the Telkomsel 4G network the download speed reached 29.64 Mbps and upload reached 4.71 Mbps. Using the ICPM protocol for ping tests on the Indiehome FTTH and Telkomsel 4G networks respectively resulted in response times of 2 ms and 24 ms.

4. CONCLUSION

From the results of the tests and analyzes that have been carried out, the following conclusions are obtained: The maximum distance that the PIR sensor can detect the movement of an object is 6 meters. This means that at a distance of more than 6 meters the detected object will fail to be detected. The sensitivity angle of the PIR sensor can work when the sensor position in the horizontal direction is 90o to 1350 and the position in the vertical direction is 60o to 1200. In other words, outside this angle, even if something comes in it will still not be detected. Room temperature which is lower than human body temperature does not have a significant effect on the sensitivity of the PIR sensor. The entire system is proven to work well in detecting, recording and sending the results to the user. From the test results and information on internet connection specifications recommended for implementing this system, based on the delay obtained, PT Indihome's FTTH internet network is used. Telkom with a minimum bandwidth specification of 10 Mbps. This is because the resulting delay in sending object detection messages was 4.73 seconds. For a photo request to be received it takes 5.73 seconds. And for a video request to be received it takes 14.86 seconds.

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