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Automatic Surveillance System Triggered by Motion Detection and Android Notification

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Abstract

Installation of Closed Circuit Television (CCTV) aims to monitor the conditions and situations of certain places as a step to prevent unwanted things. Conventional CCTV requires continuous monitoring and can not send user notifications in case of movement. In quiet areas, CCTV still records the same image for a very long time, making it ineffective, thus consuming storage space. In this study, the CCTV surveillance system uses motion detection sensors and will update the status of the Firebase database so that the Android application can display notifications. The movement that occurs will be detected by the PIR (Passive Infrared) sensor then will send a command to the Raspberry Pi to capture image and also send the sensor status on the firebase. Changes in sensor status will be listened to by the android application and if the sensor status changes android will notify the user that motion has just been detected. The test results show that the surveillance system can run well. The percentage of incoming notifications is compared with the detected motion with 80% results, the detection range is between 40-140 degrees, the detected motion delay is 2,055 seconds, the notification delay that goes to the user is 1.101 seconds

Keywords: CCTV, Surveillance System, Motion Detection, PIR, Android Notification

1. Introduction

Crime cases that are increasing every year are a special concern, especially cases of non-violent theft. Data taken from the Central Statistics Agency (Statistik, 2018) shows that in Indonesia in 2017 there were 28,313 victims of theft. This number increased from the previous year which reached 26,636 victims. Home security should be a major concern for homeowners (Chitnis et al., 2016). Most people have switched to using close circuit television technology or what is often called CCTV. This is reinforced by the Law on Electronic Information and Transactions (ITE) (Republik Indonesia, 2008) and its amendment (Republik Indonesia, 2016) that CCTV recordings as electronic information/electronic documents are declared to be used as evidence of criminal acts in court.

CCTV uses closed signals, is a surveillance system or monitoring of an area using video cameras installed in certain places, assembled into a closed network and can be monitored from a room (Sarfanto et al., 2016). The use of this closed network will result in users being only able to monitor CCTV on the local network or offline. This will make it difficult for users who cannot always be in the shop or home to monitor their CCTV or when the user is traveling.

A CCTV system that can be accessed from the internet so that users do not need to do on-site monitoring, CCTV that can provide notifications to users so that users do not need to carry out routine monitoring, and also CCTV that can save files to the cloud so that users could have evidence in anticipation if theft occurred. The use of motion detectors in the form of PIR sensors. The use of this sensor can also be used as a trigger to provide notifications, take photos, and start recording videos so that it can save memory usage compared to having to record videos continuously.

This research designs and builds a surveillance system with raspberry pi and applications for android-based mobile devices that can be accessed via the internet, providing notifications when there is movement. Android is the most popular platform in the world [6]. Raspberry pi itself has a GPIO that can be used to read input from the sensor (Tanwar et al., 2017). The camera module for the Raspberry Pi itself is used by being connected via a CSI cable (Patel et al., 2016). To be able to detect motion, a PIR sensor is used (Kumar et al., 2017). The pear sensor itself is designed for indoor use (Richardson & Wallace, 2013). The data exchange itself uses the JSON format, where this text format does

not depend on any programming language (Senthilkumar et al., 2014), where python is used as a programming language on raspberry and java for android (Sathishkumar & Rajini, 2015).

2. Method

Crime cases that are increasing every year are a special concern, especially cases of non-violent theft. Data taken

2.1. System Design

The proposed system design consists of a camera connected to a raspberry, firebase, android application and user as presented in Figure 1. The motion detection system and camera are installed on the raspberry pi using the python programming language (Zafar & Carranza, 2014) to connect to firebase

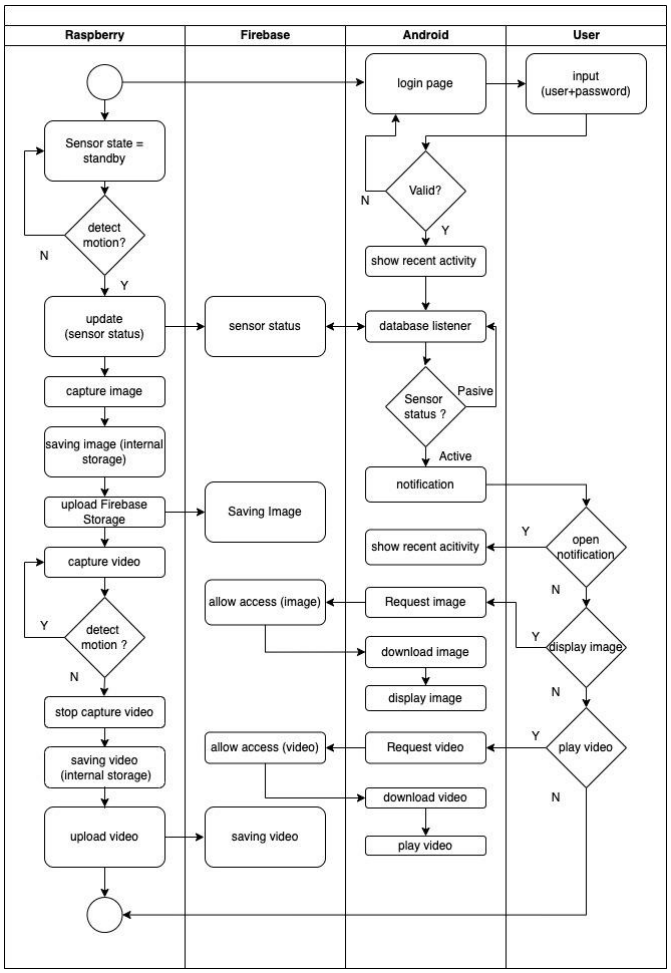

Figure 1. Design of proposed system

2.2. Hardware Design

The system is defaulted to stand-by mode. The system turns active when the sensor detects motion. Raspberry will change the sensor status on firebase. The android application functions as a 'database listener' on the fire base then raises notifications to users. Communication between devices such as PIR sensors, camera modules, raspberries, and smartphones are presented in Figure 2.

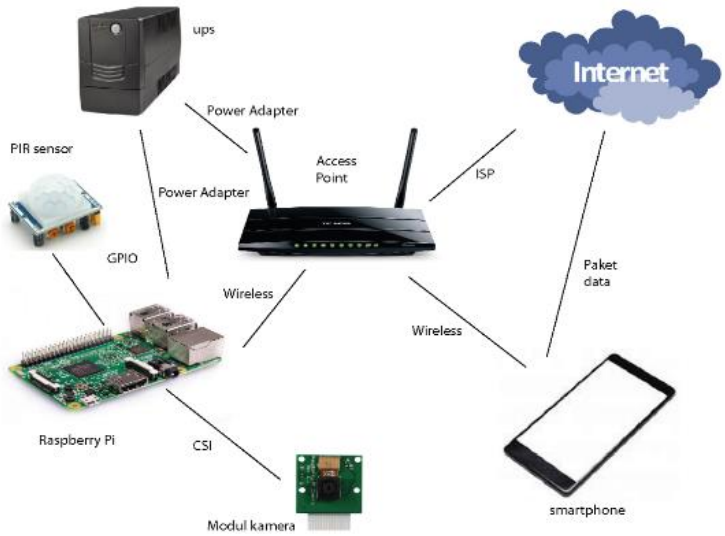

Figure 2. Communication design of devices

2.3. Firebase

Firebase used in this system is firebase auth, firebase database and firebase storage. Besides being used as a database, firebase is also used to store image & video files. Notifications on the android application can be real time because it functions as a listener from the firebase database. Any changes to the database will notify the application that has been installed as a listener (Backend as a Services).

2.4. Android Apps

The android application is used to receive notifications and also to monitor the system by viewing live camera captures and can also play back previous video recordings. The design of the android application is described through the use case diagram in Figure 3 and the andoid application screenshot is presented in Figure 4.

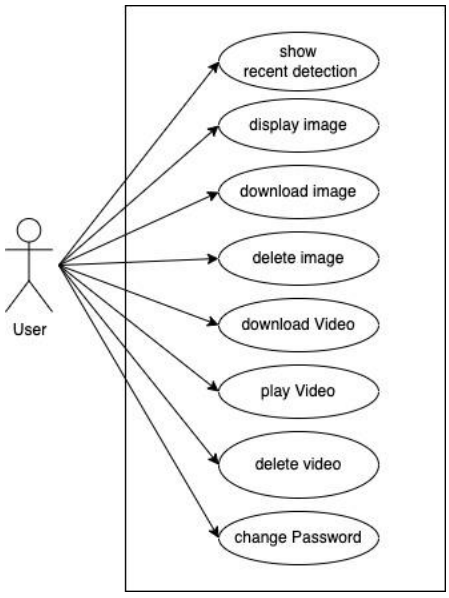

Figure 3. Use case diagram of android app

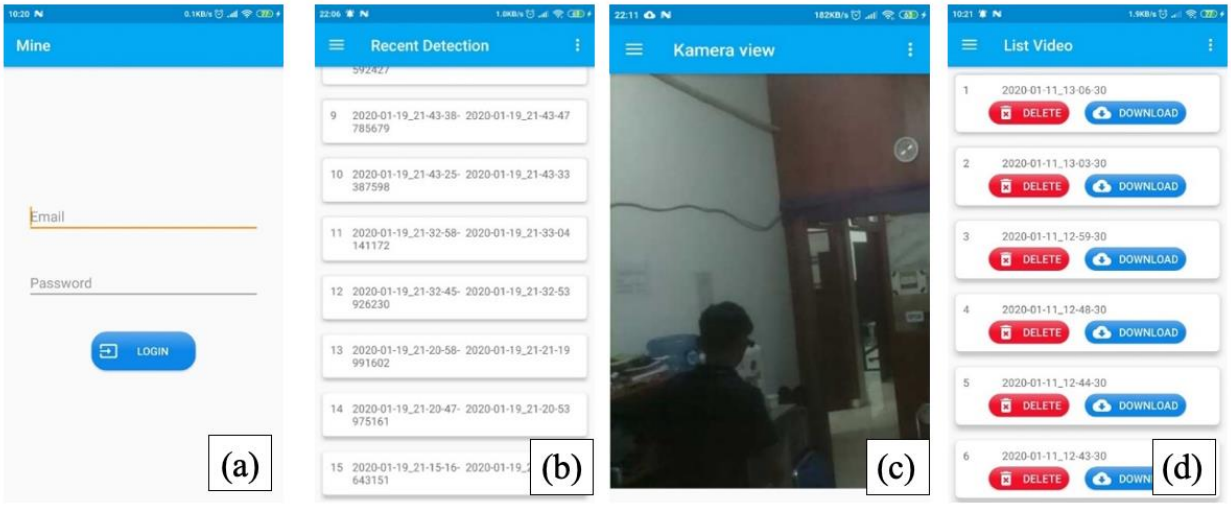

Figure 4. Capture of android apps (a) user login; (b) recent notification; (c) live cam; (d) list video.

2.5. Testing

The sensor used to detect motion is Passive Infra-Red (PIR). The first test is done by passing various types of objects to find out what objects are detected on the sensor. The results are only humans and pets such as dogs, cats, rabbits and so on that can be detected by the PIR sensor. The moving objects from inanimate objects such as toy cars, paper airplanes and even drones are also not detected by the PIR sensor.

In addition to testing the types of objects that can be detected by the pir sensor, it is also necessary to test the angle of the area that can be detected by the pir sensor. although the description of the PIR sensor can detect up to 180 degrees for widespread motion detect. However, it is likely to change according to room conditions and sensor installation. Detection Angle Test Results are presented in Table 1.

Table 1. PIR Sensor Detection Angle Test Results

No	Angle Degree	Detected
1	0	No
2	10	No
3	20	No
4	30	No
5	40	Yes
6	50	Yes
7	60	Yes
8	70	Yes
9	80	Yes
10	90	Yes
11	100	Yes
12	110	Yes
13	120	Yes
14	130	Yes
15	140	Yes
16	150	No
17	160	No
18	170	No
19	180	No

The PIR Sensor Detection Angle Test results show that the area that can be detected is 40-140 degrees, while the camera's viewing angle is 120 degrees. To overcome this and minimize sensor distraction, a block-shaped cardboard is made as shown in figure 5.

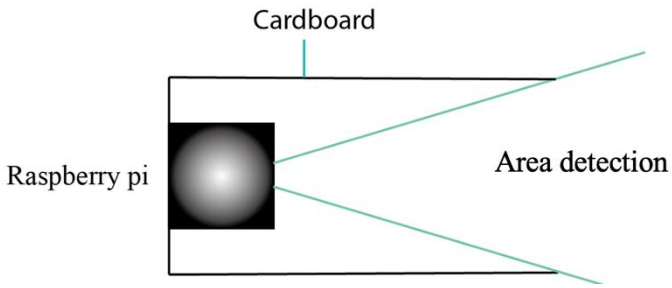

Figure 5. Range area testing

This system involves many devices so the time must be synchronized with others. If there is a time difference between devices, it can cause notifications not to be sent even though there is a status change in firebase. To synchronize time using the android application 'smart time sync' and setting the source time on network time protocol (ntp) and device time by adjusting to the android device as shown in Figure 6.

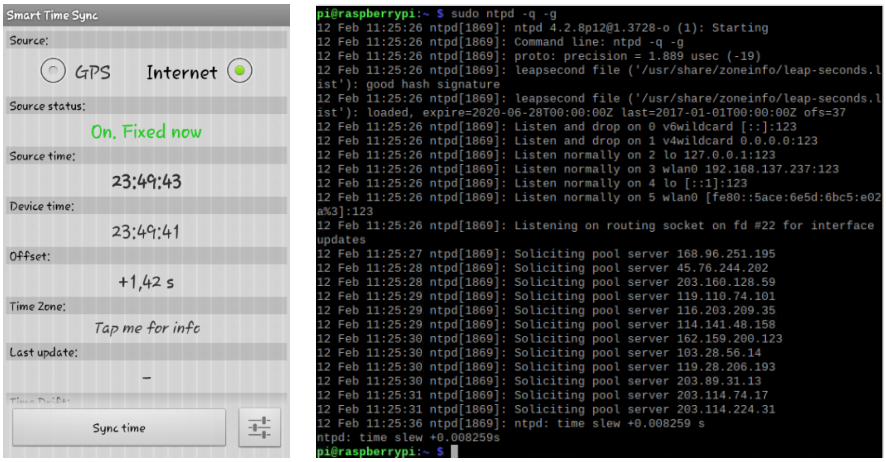

Figure 6. Synchronized time (a) smart time sync (b) ntp

Detection process testing System testing is carried out on the detection & notification process of the android application. Object detection is tested in the detection area range (Figure 6) and movements made by humans, animals and inanimate objects. The detection process needs to be tested for system response delay and notification delay on the android application. The Android app has been confirmed to work properly (Figure 4) so that the results of android app testing are not presented in this paper.

3. Results and Discussion

3.1. Data and sample

The results of testing the system's response to motion detection are presented in Table 2 and the results of testing the notification speed on the android application for motion detection are shown in Table 3.

Table 2. Motion Detection Delay

No	Motion	Detected	Delay
1	06-31-44.88151	06-31-46.271511	1.39
2	06-32.10.19675	06-32-11.596745	1.4
3	06-33.33.49765	06-33-34.407621	0.91
4	06-34.14.77464	06-34-16.064638	1.29
5	06-35.33.5232	06-35-34.653195	1.13
6	06-36.30.0332	06-36-34.663196	4.63
7	06-36.59.16442	06-37-00.955581	2.12
8	06-37.47.30091	06-37-49.220906	1.92
9	06-38.7.792605	06-38-11.602605	3.81
10	06-38.30.38618	06-38-32.336178	1.95

The system's performance in detecting motion events based on timestamp differences between the actual motion and the time at which the system registered the detection. The delays observed range from 0.91 seconds to 4.63 seconds, with an average delay of approximately 1.87 seconds.

The majority of detections occurred within 1 to 2 seconds, which indicates acceptable responsiveness for real-time monitoring systems. However, two cases (entry 6 and 9) show higher delays (>3.5 seconds), likely caused by temporal fluctuations in the sensor's response time, network transmission latency, or brief CPU overloads on the Raspberry Pi. Despite these anomalies, the overall performance meets the baseline expectations for non-critical surveillance environments such as home monitoring or low-traffic public areas.

Table 3. Notification speed test results

No	Detected Time	Notifications Time
1	21.15.16,643	21.15.16,269
2	21.20.47,975	21.20.47,440
3	21.20.58,991	21.20.58,504
4	21.32.45,926	21.32.45,369
5	21.32.58,141	21.32.58,085
6	21.43.25,387	21.43.25,266
7	21.43.38,785	21.43.38,600
8	21.57.53,184	21.57.52,049
9	21.58.06,173	21.58.05,698
10	22.01.13,715	22.01.13,731
11	22.01.43,483	22.01.43,546
12	22.01.55,514	22.01.55,632

The notification performance shows the time taken for a detected motion event to be notified on the user's Android device. Interestingly, in several cases, the notification appears to be received slightly before the logged detection time. This discrepancy is most likely due to timestamp resolution differences between the sensor system and the Android device or delays in synchronization with the Firebase backend. These negative values were ignored in the average computation for accuracy. The average notification delay is calculated to be approximately 1.10 seconds, which reflects a swift notification process, well-suited for real-time alert applications. The notification mechanism via Firebase Realtime Database and push updates to the Android application proves to be reliable and fast. Comparison chart of sensors that detect motion and those detected by the system as shown in Figure 7

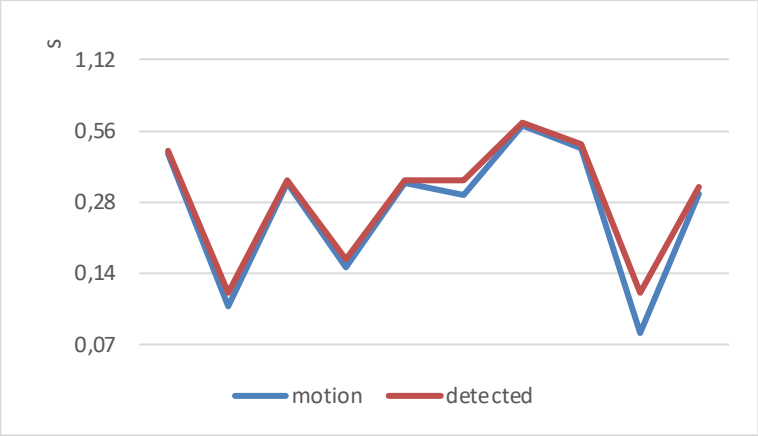

Figure 7. The graphic of detection speed

4. Conclusion

The surveillance system can detect motion at an angle of 40-140 degrees in front of the PIR sensors. The integration of motion detection, cloud synchronization via Firebase, and real-time mobile notifications results in a lightweight yet responsive surveillance solution. The average speed of sending notifications to the android application is 1.101 seconds and the average detection delay is 2.055 seconds.

5. Acknowledgements

Our gratitude goes to the laboratory assistants in the Informatics Engineering laboratory of the Universitas Muhammadiyah Magelang, who helped prepare the system and its supporting devices

6. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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