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DEVELOPMENT OF SURVEILLANCE SYSTEM WITH AUTOMATED EMAIL AND TELEGRAM NOTIFICATION USING OPEN-SOURCE APPLICATION PROGRAMMING INTERPHASE (API)

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ABSTRACT

Theft results in harm, property loss, and emotional suffering. Everyone needs a security system to protect their possessions because of the alarming amount of theft that occurs daily. This project aims to develop a low-cost surveillance system that makes use of a Raspberry Pi 4 Model B, a camera module, and a motion sensor to record video and detect motion in protected areas such as user property and belonging. Application Programming Interphase (API) and Dynamic Programming Algorithm (DPA) are the algorithms employed in this project. According to the study's findings, an IoT system can automatically send email and Telegram alerts with a ten-second video attachment when a motion detector detects an intruder within a range of 0 to 2 metres. The speed of sending the alert is influenced by the state of the Internet Network Connection. Due to immediate notice, which enables immediate action, remote monitoring, and the presence of proof in the form of video recordings, it is anticipated that the relevance of this surveillance system can lower the theft rate in Malaysia

Keywords:
Email notification - Telegram notification - Internet of Things - Raspberry Pi - Video Forensic

INTRODUCTION

Internet of Things (IoT) for technological activities open a new medium for information sharing, productivity, and modern lifestyle. IoT has improved human's lifestyle for ease and modernization. Human reliance towards IoT has been increasing over the past few years to complete various activities such as work, study, research, and daily errands. Hence this improvement has the potential to expand the basic purposes of a surveillance system.

Surveillance system is vital in any organization. The major aim is to safeguard people and their belongings from numerous threats such as theft and burglary. The surge in crime cases in Malaysia has increased the need for a sophisticated surveillance system that integrates with the Internet to allow continuous monitoring of activities from anywhere, at any time. There are 52344 cases of theft in 2020, accounting for about 80% of all cases based on crime index (Mahidin, n.d.). Even though closed-circuit television (CCTV) has widely employed, it is still considered passive monitoring system that necessitates continual and ongoing human supervision, takes more time, highly expensive, and the captured files are frequently corrupted (Rezvy & Prasannan, 2018).

Because of the limitations of passive surveillance systems outlined above, researchers and academics were drawn to develop a non-passive surveillance system (Rani & Indora, 2019). Most of the researchers then leveraged the advantages and benefits of Wireless Sensor Networks (WSN) for monitoring (Pathak, 2017) (Narkhede & Khadke, 2016). Sensor nodes can be put in any part of a building because of their wireless connectivity, providing them the advantage of portability in deployment (Sasongko & Sucipto, 2021). The first objective is to build a system that can monitor belonging and property for security purposes. Second objective of this research is to design a surveillance system that integrate with open-source application programming interphase (API). The open-source API can provide a cost-effective surveillance system. Third and fourth objectives are to give an instant problem solving and crime prevention as the surveillance system uses two medium of communication which are Telegram and Email. These implementations are to provide a complete and

relevant evidence for forensic investigation in case any crime happens. This is because the surveillance system provides a ten second video recording to identify the intruder.

LITERATURE REVIEW

The IoT-based security system (Sharma & Sharma, 2019) presented in the study proposal by the researcher(s) comprises monitoring for intruders, LPG leakage, and electrical short circuits. In this study, the system's hardware consists of a Raspberry Pi 3, a USB webcam, a PIR sensor, a current sensor, and an ESP8266 Wi-Fi module. This article employs Python programming, the Arduino IDE, and the Raspbian operating system for its software. This study describes a security system that, in the event of an intrusion, send the user a telegram message with an image attachment. The system presented in this work is more general than a surveillance system since the MQTT protocol are used to read multiple sensor's state and not only for monitoring.

The surveillance system described in the research proposal by researcher(s) (Noorjannah Ibrahim et al., 2019) allows users to monitor their home live via mobile application as long as the user is in the same network as the surveillance system. Plus, after motion sensor detects an intruder nearby and sends two notifications which are an email and SMS, both SMS text message and email notification has an image attachment. The Raspberry Pi, Pi camera, PIR motion sensor, Ultrasonic sensor, buzzer, and LED are all used in this project. MQTT broker, Node-Rack, and Thing Speak are the software used in this study. Another study that is using Node technology is the research by (Luu et al., 2019).

Widiyasono et al. (2020) provide a study that describes a clever motion detection system that enables the Raspberry Pi to send email notifications with image attachments when motion is detected. The researcher also discussed how to send emails using SMTP on port 587 and Transmission Control Protocol on port 55. The Raspberry Pi 3 model B, PIR sensor, Pi camera, and female to female wires are used in this study. The Raspbian and Windows operating systems are used in this paper's software to set up the email. To guarantee that only intended recipients may read the email, this research has their own mail server.

Researchers (Patil et al., 2017) have proposed a surveillance system with a motion detector that notifies the user via email when motion is present. The Raspberry Pi, a camera module, and a motion sensor are used in the article. The alert is delivered as an email attachment. The research provided by (Patil et al., 2017) is somewhat similar to (Widiyasono et al., 2020) but differs in terms of email notification methods. The email notification is sent using a Python script, as suggested by the researcher(s) (Patil et al., 2017), however the research by (Widiyasono et al., 2020) utilizes its own server.

A video surveillance system service that provides email and telegram notifications with a video attachment has been proposed in the study by (Gualotuñ et al., 2018). The approach taken, however, is distinct; the paper makes use of a Raspberry Pi B+ as a video streaming server and storage, and an Atmega 328 Arduino as a microcontroller and CPU. The speed of the Raspberry Pi utilized in this article is 1.5 GHz, which is substantially quicker than the 20 MHz speed of the Arduino used in the research reported by the researcher(s) (Gualotuñ et al., 2018). The system's performance in terms of speed is impacted by the use of Arduino. Table 1 contains a detailed summary of all relevant research.

Table 1: Detailed Summary of Relevant Research

Researcher			***N. Patil, S. Ambatkar, S. Kakde)***	***T. Gualotuña, E. Macías, Á. Suárez, E. C., A. Rivadeneira***	***H. Sharm , M. Sharma***	***S. Noorjannah Ibrahim, A. H. Hasan Basri, A. Liza Asnawi***	***N. Widiyasono, A. Rahmatulloh, H. Firmansah***	***This paper***
Year			***2017***	***2018***	***2019***	***2019***	***2020***	***2022***
The scope of research	**Notificati**	**SMS**				/		
		Email	/	/		/	/	/
		Telegram		/	/			/
	Attachmen	**Text**						
		Image	/		/	/	/	
		Video		/				/
	Platform	**Arduino**		/				
		Raspberry Pi 2	/	/				
		Raspberry Pi 3			/	/	/	
		Raspberry Pi 4						/
	Live Streaming			/		/		/

METHODOLOGY

The system has been designed to monitor personal/property/belonging, give instant email notification with video attachment of detected motion nearby surveillance system, send instant Telegram notification with video attachment when the system senses motion and allow live monitoring where users can view live video after the Python code executed. Plus, it is a cost savvy and easy-to-implement surveillance system.

This system's hardware consists of a Raspberry Pi 4 Model B computer with 8GB of RAM, a camera module, and a motion sensor (McManus & Cook, 2021). Through a designated camera port, the camera is incorporated within the Raspberry Pi. The Raspberry Pi is connected to the motion sensor by a GPIO pin. The Raspberry Pi's GPIO4 pin, 5V, and GND have been utilised. Figure 1 depicts the surveillance system's whole hardware installation.

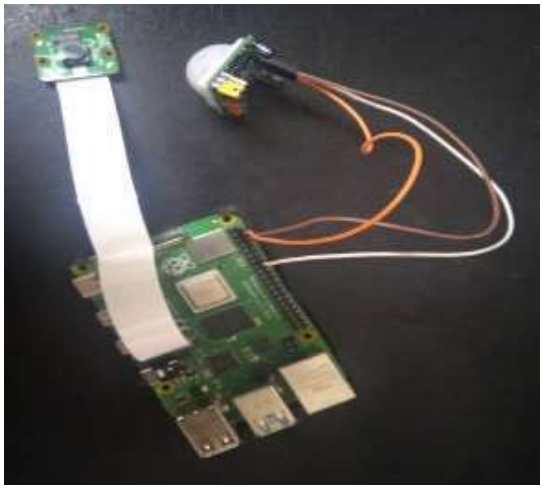

Figure 1: Complete Hardware Installation

The Raspberry Pi is connected to a motion sensor and camera as shown in Figure 2 (Ahmad et al,2019). Launching the Python script on the Raspberry Pi will start the camera's live video of the home, possessions, and people. The property's motion sensor will detect any intruders as they approach. The camera module will then begin recording the events after ten seconds. A Python script will send the user's email and telegram the ten second video recording. The same script permits the camera module to continue live streaming even after motion is no longer detected.

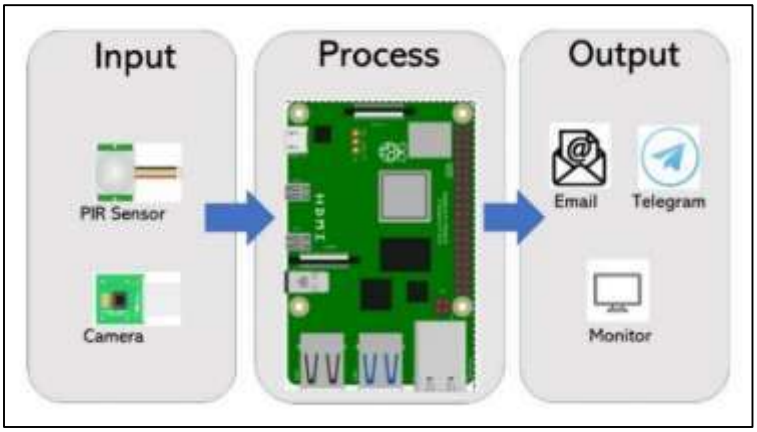

Figure 2: System Flow

A 32 GB storage memory is used in this study. The SD card serves as the installation medium for Raspbian OS, the operating system for the Raspberry Pi (Dow, 2018). The configuration of the camera module and motion sensor, as well as their integration with Telegram and email, depend on the operating system. Additionally, the micro-SD card will store all live recordings and ten seconds of video recordings for forensic purposes.

Application Programming Interphase (API) is utilized in this research. The MQTT messaging protocol is a standard for IoT (MQTT - the Standard for IoT Messaging, n.d.). It is intended to connect remote devices with a tiny code footprint and low network bandwidth by acting as an incredibly lightweight publish/subscribe messaging transport (Ramlee et al, 2019). A wide range of industries,

including the automotive, manufacturing, telecommunications, oil and gas, etc., use MQTT. There are few characteristics of MQTT API that make it best fit in this research. It is lightweight and efficient, can be scale to multiple of IoT devices, support for unreliable network no matter speed, it allows bi-directional communication and lastly, it is security enabled.

Regarding the security and optimization of MQTT API protocol, there are three different types of client authentication methods available for any MQTT broker to confirm the identity of MQTT clients. The methods are client id, username with password and client certificate. The methods that are used in this research is client id and username with password. To send the Telegram notification, the clients' id is hard coded in the script, while to send email notification, the username and password are hard coded in the script by the researcher. Before accepting the MQTT session, the MQTT broker verifies the authentication's credential that a client gives to it along with the CONNECT packet. The credentials are sent in the CONNECT packet to the broker in cleat text format unless encrypted at the transport layer i.e., using port 8883 for connection. Figure 3 shows the API structural diagram of the surveillance system. First, user activate the connection by allowing the client's id from Telegram and credentials from email to be hard coded in the Python that is programmed in the IoT devices. Next, the API will activate the MQTT Service, run the script code hence, complete the IoT system.

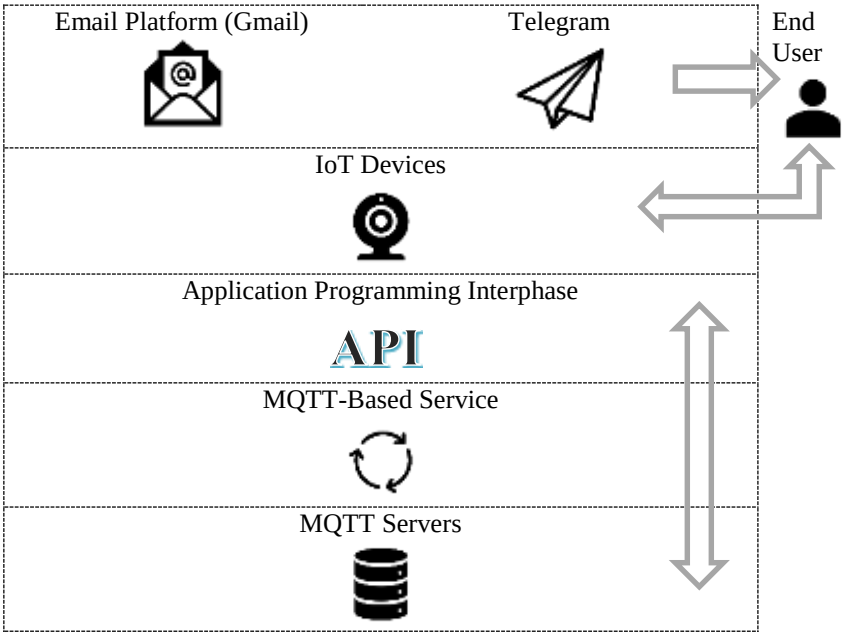

Figure 3: API Structural Diagram

Dynamic Programming Algorithm (DPA) are the algorithms that are utilized. Python, PHP, and JavaScript make up the Dynamic Programming Algorithm. The script for combining Telegram and Email notifications with the necessary hardware, such as motion sensor and camera module, is created primarily in Python. The Python code can be reliable for integration of hardware and software regardless of any communication technology (Fatima, 2019).

Thonny IDE and Raspbian OS are additional software requirements that are utilized in the construction of the suggested system. Thonny and Visual Studio Code are used to create the code. Thonny is a free Integrated Development Environment (IDE) for Python that was created specifically for the Python programming language. It contains a built-in debugger that can be used to run in order to fix errors and it provides the ability to perform step-by-step analysis.

Both the Telegram API and the Email API are used to send the notification alert. Telegram is a cloud-based, cross-platform instant messaging program that is free and open source. Additionally, it offers VoIP, file sharing, and a number of other features. In this project, when a motion sensor detects any intruder movement, a ten-second video attachment will be sent over Telegram as an instant warning. Email is a means of message exchange, a channel of contact between people, or a system notice. For this project, Google Mail, or Gmail, is utilized.

The procedure will be split down into five crucial steps: setting up the Raspberry Pi, the camera module V2 and motion sensor, Telegram and email. The camera module V2 was linked to the Raspberry Pi 4's camera port for live streaming and video recording. Python code was used to configure video recording for ten seconds. The video by default will be saved in H.264 format since H.264 format video recording is the industry standard. The majority of devices did not support this video format, thus it will to be converted to MP4 by the Python code.

The system begins with the ability to stream live footage of the building or property and the motion is turned on right away. The live streaming feature will halt and record the invader for ten seconds if the motion sensor detects motion. The video recording features will keep working even if the sensor doesn't pick up any motion. The video notification flowchart is based on Figure 4.

Figure 4: Flowchart of the Video Notification

Python code allows users to access to surveillance system using any devices such as phones, tabs, laptops, and computers. To add some security and assurance, not all users can sign into the web application. Only allowed user which is the owner of the surveillance system may sign into the dashboard. The flow chart of live streaming video is based on Figure 5.

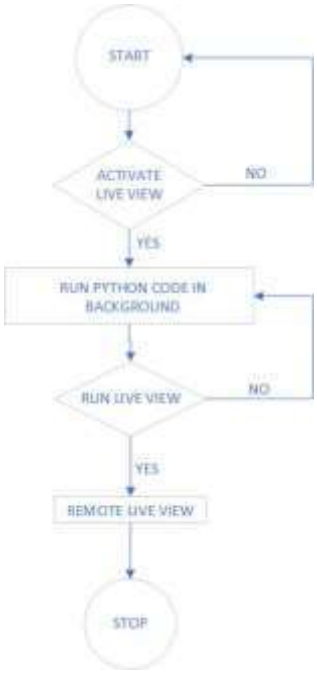

Figure 5: Flowchart of the Video Notification

RESULT AND ANALYSIS

First, the camera module can record video for ten seconds and automatically save the file. Figure 6 shows the saved videos from the Camera Module. The videos are vital to be the backup for forensic investigation when crime happen. Not only the authorities will have the videos from the email and Telegram but also from local file. These files were taken by inserting command in the Python code. The commands used is 'raspistill o nameOfFile.jpg' and 'raspivid -o nameOfFile.h24' (Amos et al., 2021). These files will be automatically saved in the memory.

Figure 6: Saved Video

Next, when Motion Sensor detects movement, it will send instant email notification. Figure 7 shows the Telegram notification when motion sensor that is attached to Raspberry Pi detect movement. The sender and receiver of the notification with video recording has already been set at the Python code.

Figure 7: Saved Image and Video

Next, when Motion Sensor detects movement, it will send instant Telegram notification. Figure 8 shows the Telegram notification when motion sensor that is attached to Raspberry Pi detect movement. The receiver of the notification has already been set with the identification of user token from Telegram bot. The token being set in the Python Code.

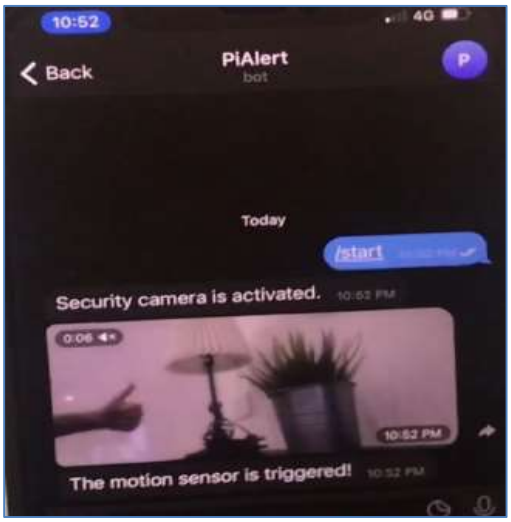

Figure 8: Saved Image and Video

Next, the sensor capability and reliability were tested. Table 2 shows the behaviours of motion sensor towards movement and light condition. Testing performs at a distance of 1-5 meter of several testing subject movement while testing at a distance of more than 3 meters, the sensor was unable to detect the subject movement. In the light condition, movement of the testing subject is able to detect both in light and dark conditions. In conclusion, the range and light condition of the motion sensor

detection limit on movement of subject is 1-3 meters apart. However, the fire can only be detected within 1-2 meters.

Table 2: Behaviours of Motion Sensor

Testing subject	Distance (Meter)					Light Condition	
	1.0	2.0	3.0	4.0	5.0	Light	Dark
Human	✓	✓	✓	✗	✗	✓	✓
Cat	✓	✓	✓	✗	✗	✓	✓
Ball	✓	✓	✓	✗	✗	✓	✓
Fire	✓	✓	✗	✗	✗	✓	✓

Based on test data in Table 3, a conclusion can be drawn. Namely, the duration between sending and receiving notification on telegram and email alerts on repetition 1-3 is 2 seconds, while on repetition to 4 and 5 are 3 seconds. This difference can be influenced by different video size files and internet network connection conditions. When the internet access on the Raspberry Pi is off, sensor and the camera still work, but the video captured is saved first and not directly sent to telegram and email as alert. It will be sent when the internet connection is restored.

Table 3: Duration of Sending and Receiving in Telegram and Emails

Testing	Time (hour:minute:second)			File Size	Dimension
	Sending	Received	Delay		
1	10:18:20	10:18:22	2 second	200 kb	480x320
2	10:18:30	10:18:32	2 second	200 kb	480x320
3	10:19:12	10:19:14	2 second	200 kb	480x320
4	10:19:40	10:19:42	3 second	220 kb	480x320
5	10:20:02	10:20:04	3 second	220 kb	480x320

DISCUSSION AND CONCLUSION

When it comes to today's technology, the Raspberry Pi opens a whole new chapter. Not just because of its size, but also because of what it can do. Because of its portability, it can be utilized for almost anything (Halfacree, 2020). This is demonstrated through the surveillance system project. This research has achieved four objectives that has been explained in detail in introduction with the improvement from the previous research. The achieved objectives are monitored through personal/property/belonging, give instant email notification with video attachment of detected motion nearby surveillance system, send instant Telegram notification when the system senses motion, and built cost effective of microprocessor-based surveillance system. The improvement of this research that has been achieved sends instant Telegram and email notification with ten seconds video attachment when the system senses motion. This improvement has maximized the efficiency, flexibility, security, and instant response whenever threat is triggered by the surveillance system. However, the downside of the system is that it can be hard for non-technical person to setup without proper written guide and it also relies heavily on the internet connectivity to send the alert where it might be hard to those whoe live in rural area where the internet access is limited.

This surveillance system can be improved for future research by utilizing more GPIO Pins to maximize its function and uses. More function and uses can ease user's daily routines and activities. To conclude, this project can be extended to fully utilize the proposed system with latest technology such as AI recognition feature or other detection where it can be one complete security system.

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REFERENCES

Ahmad, S., Saha, A., Chek, L. W., Mekhilef, S., Azam, T., Ahmed, M., Orabi, M., Ghoneim, S., Alharthi, M., & Alamri, B. (2019). SMART HOME AUTOMATION AND SECURITY SYSTEM DESIGN BASED ON IOT APPLICATIONS. *ASEAN Engineering Journal*, *9*(2), 57–71. https://doi.org/10.11113/aej.v9.15513

Luu, P. V., Weed, J., Rodriguez, S., & Akhtar, S. (2019, December 23). An AI-based web surveillance system using raspberry Pi. Journal of Advances in Technology and Engineering Research, 5(6). https://doi.org/10.20474/jater-5.6.2

Amos, D., Bader, D., Jablonski, J., & Heisler, F. (2021). *Python Basics: A Practical Introduction to Python 3*. Real Python (realpython.com).

Narkhede, Y. V., & Khadke, S. G. (2016, February 5). Application of Raspberry Pi and PIR Sensor for Monitoring of Smart Surveillance System. International Journal of Science and Research (IJSR), 5(2), 736–737. https://doi.org/10.21275/v5i2.nov161248

Dow, C. (2018). *Internet of Things Programming Projects: Build modern IoT solutions with the Raspberry Pi 3 and Python*. Packt Publishing.

Fatima, N. (2019). IoT based Interactive Home Automation with SMS and Email Alert System. *International Journal for Research in Applied Science and Engineering Technology*, *7*(10), 569–574. https://doi.org/10.22214/ijraset.2019.10085

Gualotuña, T., Macías, E., Suárez, L., C., E., & Rivadeneira, A. (2018). Low Cost Efficient Deliverying Video Surveillance Service to Moving Guard for Smart Home. *Sensors*, *18*(3), 745. https://doi.org/10.3390/s18030745

Halfacree, G. (2020). *The Official Raspberry Pi Beginner's Guide (The Official Raspberry Pi Beginner's Guide: How to use your new computer)* (4th ed.). Raspberry Pi Press.

Ramlee, R., Yong, E. L. C., Subramaniam, K., Khmag, A., & Rahman, A. S. (2019, September 16). Home Switching using IoT System via Telegram and Web User Interface. International

Journal of Recent Technology and Engineering, 8(2S6), 814–819. https://doi.org/10.35940/ijrte.b1151.0782s619

Mahidin, D. S. D. M. U. (Director). (n.d.). Department of Statistics Malaysia Offical Portal. Department of Statistics Malaysia Official Portal. Retrieved October 19, 2022, from https://www.dosm.gov.my/v1_/

McManus, S., & Cook, M. (2021). *Raspberry Pi For Dummies (For Dummies (Computer/Tech))* (4th ed.). For Dummies.

MQTT - The Standard for IoT Messaging. (n.d.). Retrieved October 19, 2022, from https://mqtt.org/

Noorjannah Ibrahim, S., H. Hasan Basri, A., & Liza Asnawi, A. (2019). Development of web-based surveillance system for Internet of Things (IoT) application. *Bulletin of Electrical Engineering and Informatics*, *8*(3), 1108–1116. https://doi.org/10.11591/eei.v8i3.1520

Pathak, G. K. (2017). A Review of IOT based SMS & Email Enabled Smart Home Automation System. *International Journal for Research in Applied Science and Engineering Technology*, *V*(XI), 2872–2875. https://doi.org/10.22214/ijraset.2017.11395

Patil, N., Ambatkar, S., & Kakde, S. (2017). IoT based smart surveillance security system using raspberry Pi. *2017 International Conference on Communication and Signal Processing (ICCSP)*. https://doi.org/10.1109/iccsp.2017.8286374

Rani, R., & Indora, S. (2019). A Review IoT Based Camera Surveillance System. *International Journal of Computer Sciences and Engineering*, *7*(6), 793–800. https://doi.org/10.26438/ijcse/v7i6.793800

Rezvy P. A,, & Prasannan, N. (2018, March 31). IOT Based Surveillance System for CCTV. International Journal for Research in Applied Science and Engineering Technology, 6(3), 959–963. https://doi.org/10.22214/ijraset.2018.3153

Sasongko, M. Z., & Sucipto, S. (2021). Desain Prototype IoT Menggunakan Bot Telegram Berbasis Text Recognition. *RESEARCH: Journal of Computer, Information System & Technology Management*, *4*(1), 21. https://doi.org/10.25273/research.v4i1.7420

Sharma, H. K., & Sharma, M. (2019). Iot Based Home Security System with Wireless Sensors and Telegram Messenger. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3341106

Widiyasono, N., Rahmatulloh, A., & Firmansah, H. (2020). Automatic Email Alert on the Internet of Things-based Smart Motion Detection System. *Selected Papers from the 1st International Conference on Islam, Science and Technology, ICONISTECH-1 2019, 11–12 July 2019, Bandung, Indonesia*. https://doi.org/10.4108/eai.11-7-2019.2297829