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Development of Monitoring System using Raspberry Pi with Instant Notification

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Abstract: Security is a major concern for all premise properties such as residence, industry and etc. Lack of secure system will give a window of opportunity for theft that causes damage, loss of property, and emotional misery. The monitoring system with a high alarm rate able to integrate system and communicate with user by using embed system of Raspberry Pi 4 Model B. The algorithms used in this research include dynamic programming algorithm (DPA) and application programming interface (API). It able to capture video for any motion detection in restricted areas such as user belongings and property. The system will immediate alert user via Telegram and email, for the further action to taken as the result proves within average of 2.3 second motion detection and user alert system of 3.8 second. The integration and embed system indicate the system efficiency of 92.65% with error tolerance below 3.1% using Support Vector Machine (SVM) as a tool to analyze system performance.

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1. Introduction

In modern days, security system is a major component to be installed and keep protect in many premises; residence, office, factory/industry and etc. A good alarm system does not give any opportunity/chance of thieve and robbery.

The demand for a sophisticated surveillance system that interfaces with the Internet to enable continuous monitoring of activities from anywhere, at any time, has grown as a result of Malaysia's rise in crime cases. According to the crime index, there were 52344 theft cases in 2020, which will make up nearly 80% of all instances [10]. Despite being widely used, closed-circuit television (CCTV) is still regarded as a passive monitoring system that requires constant and continuing human supervision, requires more time, is very expensive, and frequently produces corrupted files [14].

Internet of Things (IoT) technology creates a new platform for information sharing, productivity, and modern living [1]. IoT has facilitated modernity and ease in human lifestyle. Over the past few years, people have become more dependent on IoT to fulfil tasks like work, school, research, and daily chores. Consequently, this advancement has the ability to broaden the fundamental functions of a surveillance system [5].

Any organization needs a surveillance system, used to protect people and their possessions from various risks including theft and burglary.

Researchers and academics were motivated to create a non-passive surveillance system because of the drawbacks of passive monitoring technologies described above [17]. The majority of researchers then utilized Wireless Sensor Networks (WSN) for monitoring, taking full advantage of its features and advantages [15][4]. Due to the wireless connectivity, sensor nodes can be placed anywhere in a building, giving them the advantage of portability when being deployed [18].

The main objective is to build a system that can monitor belonging and property for security purpose, and 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. It gives an instant problem solving and crime prevention as the surveillance system using 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 by having ten second video recording.

2. Literature Review

The Raspberry Pi 3 computer, a USB webcam, a Passive Infrared Sensor (PIR) sensor, a current sensor, and an ESP8266 Wi-Fi module make up the system's hardware in this study. The Python programming language, the Arduino Integrated Development Environment (IDE), and the Raspbian operating system are all used in these articles. This paper describes a security system that sends the user a telegraph message with an image attachment in the event of an intrusion. As opposed to a surveillance system, the system described in this work is more general because it uses the Message Queuing Telemetry Transport (MQTT) protocol to read the state of numerous sensors as well as monitoring.

As long as the user is connected to the same network as the surveillance system, the monitoring system proposed in the research proposal by researcher(s) [13] enables consumers to monitor their homes live through mobile application. Additionally, a motion sensor that detects an intruder nearby will send an email notification with a picture attachment as well as two notifications through SMS and email. This project makes use of the Raspberry Pi, the Pi camera, the PIR motion sensor, the Ultrasonic sensor, the buzzer, and the LED. The applications employed in this study include MQTT broker, Node-Rack, and ThingSpeak. The investigation by is one more study utilizing Node technology [2].

An ingenious motion detection method that enables the Raspberry Pi to send email notifications with image attachments when motion is detected is described in research by [20]. The study also covered how to send emails using Transmission Control Protocol on port 55 and SMTP on port 587. In the study, researcher employ the Raspberry Pi 3 model B, PIR sensor, Pi camera, and female to female wiring. The email configuration in this study uses the Raspbian and Windows operating systems. This research has its own mail server so that only designated recipients may read the email.

N. Patil, S. Ambatkar, and S. Kakde 2017, proposed a surveillance system with a motion detector that sends an email to the user when motion is detected. The article makes use of the Raspberry Pi, a camera module, and a motion sensor. The notification is sent as an email attachment. The email notification is sent using a Python script, as suggested discussed.

In the study, T. Gualotuña, E. Macías, Á. Suárez, E. C., and A. Rivadeneira 2018, explains on a video surveillance system service that sends email and telegram notifications with a video attachment. The approach, however, is unique; the paper employs a Raspberry Pi B+ as a video streaming server and storage device, as well as an Atmega 328 Arduino as a microcontroller and CPU. The Raspberry Pi used in this article has a speed of 1.5 GHz, which is significantly faster than the 20 MHz speed of the Arduino used in the research reported [7]. The use of Arduino has an effect on the system's performance in terms of speed which it slows down the system.

3. Methodology

The system is designed to monitor personal, property and belongings, send instant email notifications with video attachments of detected motion near surveillance systems, send instant Telegram notifications with video attachments when the system detects motion, and allow live monitoring where users can view live video after the Python code is executed. Furthermore, it is a low-cost and simple-to-implement surveillance system.

The hardware for this system comprises of a motion sensor, a camera module, and a Raspberry Pi 4 Model B computer with 8 Gigabyte (GB) of Random Access Memory (RAM) [11]. The camera is integrated into the Raspberry Pi through a specific camera connector. A General-Purpose Input/Output (GPIO) pin on the Raspberry Pi connects it to the motion sensor. The GPIO4 pin, 5V, and GND on the Raspberry Pi have all been used.

Assembling component of a motion sensor and camera are attached to the Raspberry Pi. The Raspberry Pi's Python software must be launched in order to begin the camera's live feed of the residence, its contents, and its occupants. Any intruders will be caught by the property's motion sensor as they approach. Within 10 seconds, the camera module will start capturing the events. A Python script will send the 10 second video recording and transmit it to the user's email and Telegram. The camera module can carry on live streaming even after motion is no longer recognized detection based on the same script as shows in Fig. 1.

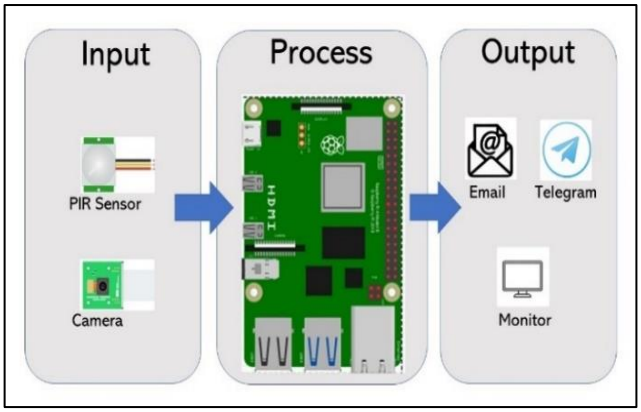

Fig. 1- System Flow.

In this investigation, a 32 GB storage memory is employed. Raspbian OS, the operating system for the Raspberry Pi, is installed using an SD card (Dow, 2018). The operating system affects how the camera module and motion sensor are set up, as well as how Telegram and email are integrated. All live recordings and ten seconds of video recordings will also be stored on the micro-SD card for forensic use.

In this study, application programming interface (API) is used. As an IoT standard, MQTT messaging protocol is used [12]. It serves as an exceptionally lightweight publish/subscribe message transport and is designed to connect faraway devices with little code footprint and little network bandwidth [9]. MQTT is used by many different industries, such as the automobile, manufacturing, telecommunications, oil and gas, etc. The MQTT API is most suited for this study due to a select few features. It is quick and effective, scales to many IoT devices, supports unstable networks regardless of speed, allows bi-directional communication, and last but not least, is security enabled.

There are three main types of client authentication methods accessible for any MQTT broker to verify the identity of MQTT clients, which is important for the security and optimization of the MQTT API protocol. Client ID, username and password, and client certificate are the available ways. Client ID, username, and password are the approaches that are used in this study.

The client id for sending Telegram notifications is hard coded in the script, whereas the username and password for sending email notifications are written and programmed by the researcher. The MQTT broker verifies the authentication credentials that a client sends it along with the CONNECT packet before accepting the MQTT session. In the CONNECT packet, which uses port 8883 for connection, the credentials are provided to the broker in clear text first and they are being encrypted at the transport layer with port 8883 mentioned above.

The user must first enable the connection by allowing the client's Telegram ID and email credentials to be hard coded in the Python code that runs on the IoT devices. The API will then start the MQTT Service, execute the script code, and finish the IoT system. The surveillance system's API structural diagram is shown in Fig. 2.

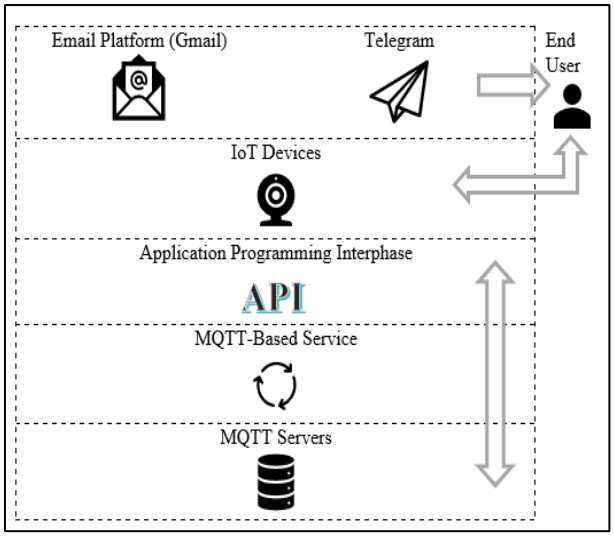

Fig. 2- API Structural Diagram

Algorithms called Dynamic Programming Algorithms (DPA) are used. The Dynamic Programming Algorithm is made up of Python, PHP, and JavaScript. Primarily written in Python, the script combines Telegram and Email notifications with the required hardware, such as a motion sensor and camera module. Regardless of the communication medium used, the Python code may be trusted for hardware and software integration [6].

Additional software needs used in the development of the suggested system include Thonny IDE and Raspbian OS. The code was written using Visual Studio Code and Thonny. For the Python programming language, an Integrated Development Environment (IDE) called Thonny was developed for free. It has the ability to perform step-by-step analysis and has an integrated debugger that can be used to run in order to fix faults.

The notification alert is sent via the Email API as well as the Telegram API. An open-source, cloud-based, cross-platform instant messaging service is called Telegram. File sharing, VoIP, and a number of other capabilities are also available. In this project, a ten-second video attachment will be transmitted over Telegram as an immediate warning if a motion sensor detects any intruder movement. Email can be used to communicate with others, exchange messages, or alert a system. Google Mail, also known as Gmail, is used for this project.

Setup of the Raspberry Pi, the camera module V2 and motion sensor, Telegram, and email will be broken down into five critical steps. For live streaming and video capture, the Raspberry Pi 4's camera port was connected to the camera module V2. Ten seconds of video recording were set up using Python code. H.264 video recording is the industry standard, thus that is how the video will be saved by default. The Python code will

convert it to MP4 because the majority of devices do not support this video format.

The system starts out with the capability to feed live video of the structure or property, and the motion is immediately activated. If the motion sensor notices motion, the live streaming feature will stop and record the intruder for 10 seconds. Even if the sensor doesn't detect any motion, the video recording features will continue to function. The flowchart for video notifications is based on Fig. 4.

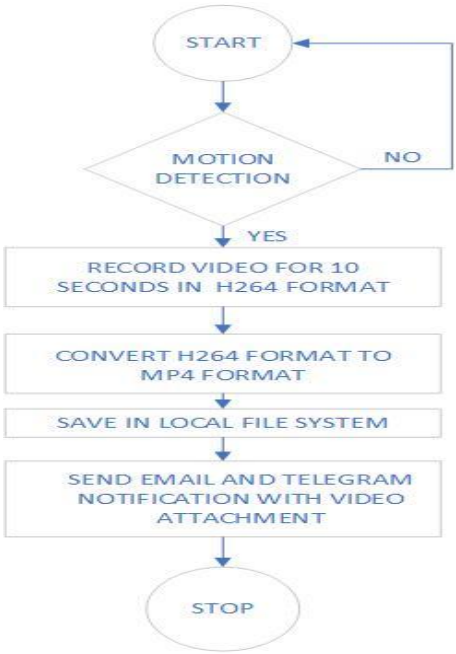

Fig. 4- Flowchart of The Video Notification

Users can access the surveillance system using any device, including smartphones, tablets, laptops, and computers, thanks to Python coding. Not all users are allowed to sign into the web application, which increases security and assurance. Only the owner of the monitoring system is authorized to sign into the dashboard. The live streaming video flow chart is based on Fig. 4.

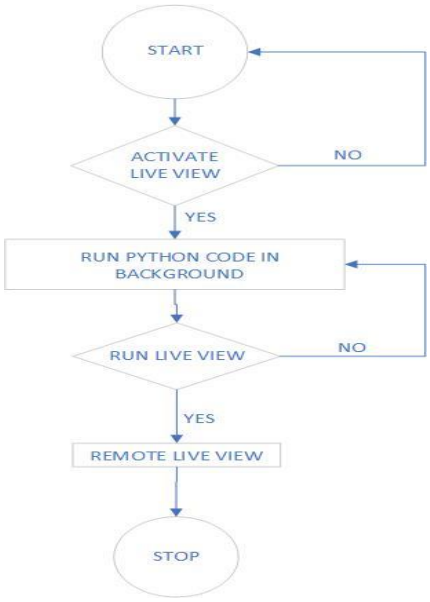

Fig. 4- Flowchart of The Video Notification

4. Result And Analysis

The camera module can first automatically save the file after ten seconds of video recording. The Camera Module's saved videos are displayed in Fig. 6. When a crime occurs, the videos are essential as a backup for forensic investigation. The films will be available to the authorities via local files as well as email and Telegram. By introducing a command in the Python code, these files were taken. "raspistill o nameOfFile.jpg" and "raspivid -o nameOfFile.h24" are the commands used [3] and these files will be stored in the memory automatically.

The Motion Sensor will then immediately send an email notification when it senses movement. The display on the Telegram notification when a Raspberry Pi attached motion sensor detects movement. The Python code had previously been established to specify the sender and recipient of the message with video recording.

Next, an immediate Telegram notice will be sent when the Motion Sensor detects movement. When a motion sensor coupled to a Raspberry Pi detects movement, Figure 8 displays the Telegram notification. With the help of the Telegram bot's user token, the recipient of the notification has already been set. The Python code's setting of the token as shows in Fig. 5.

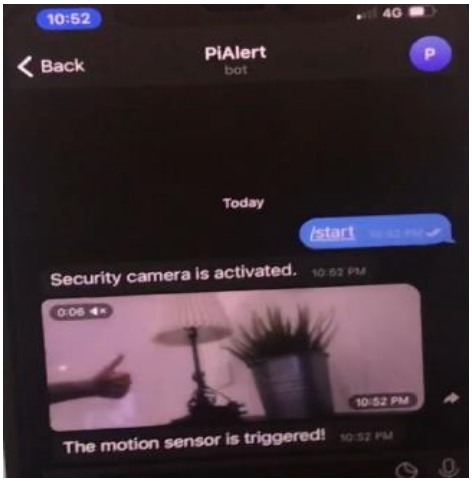

Fig. 5- Saved Image and Video.

The reliability and capability of the sensor were examined next. The motion sensor's responses to movement and light conditions are displayed in Table 1 and Table 2 below. The sensor is unable to detect subject movement at distances greater than 3 meters, based on the test that has been conducted within a range of 1 to 5 meters. Movement of the test subject can be detected in both light and dark environments in the presence of light. In conclusion, the motion sensor detection range and light condition restriction on subject movement is 1-3 meters apart. The flames can only be located within 1-2 meters, though.

Table 1: Sensors Respond to Movement

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

Table 2: Sensors Respond to Light Condition

Testing subject	**Light Condition**	
	Light	Dark
Human	✓	✓
Cat	✓	✓
Ball	✓	✓
Fire	✓	✓

Conclusions can be derived from the test results in Table 3. Specifically, the delay between sending and receiving a telegraph or email alert is 2 seconds for repetitions 1-3 and 3 seconds for repetitions 4 and 5. Different video file sizes and the state of the internet network connection can have an impact on this disparity. The Raspberry Pi's sensor and camera continue to function even without internet access, but the video is preserved instead of being sent straight to telegram and email as an alarm. When the internet is back up and running, it will be transmitted.

Table 3: Testing Result of Notification

Testing	**Time (hour: minute: second)**		
	Sending	Received	Delay
1	10:18:20	10:18:22	2 second
2	10:18:30	10:18:32	2 second
3	10:19:12	10:19:14	2 second
4	10:19:40	10:19:42	3 second
5	10:20:02	10:20:04	3 second

5. Discussion and Conclusion

The Raspberry Pi starts a completely new era in terms of modern technologies. not just for its size, but also for what it is capable of. It can be used for nearly anything because of its portability [8]. The surveillance system project serves as an example of this. With the advancement over the prior research, this study has succeeded in achieving its four goals, which were described in detail in the introduction.

The goals were to monitor people, property, and belongings, to send instant email notifications with video attachments when nearby surveillance systems detect motion, to send instant Telegram notifications when motion is detected, and to build a microprocessor-based surveillance system that is cost-effective. When the system detects motion, the research has improved to deliver an instant Telegram and email message with a 10-second video file.

With this enhancement, the efficiency, adaptability, security, and quick response whenever a threat is detected by the monitoring system have all been maximized. The system's drawback is that it can be challenging for non-technical people to set up without a clear written manual, and it significantly relies on internet connectivity to send the warning, making it challenging for people who live in rural areas with limited internet access.

More GPIO pins in the Raspberry Pi can be utilized to this surveillance system to maximized its functionality and research applications. More features and applications can make daily tasks and activities easier for users. To sum up, this project can be expanded to completely employ the suggested system with cutting-edge technology like an AI recognition feature or other detection, making it a full security system.

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