Automated Motion Detection Security System Notifier using Raspberry Pi with Telegram

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Abstract— **Technology is a double-edged sword when it changes the way we perform everyday activities for the better. Unfortunately, misfits will always find new ways to misuse technology to facilitate their misdeeds. CCTV are great security measures that can be used to catch culprits in action, but other than banks, hospitals, shopping malls, academic institutes etc., a CCTV solution is beyond most household budgets and require continuous monitoring. Because mobile phones are the primary hand-held device, it is only logical to integrate these with a CCTV solution. Motion Detection Security System Notifier using Raspberry Pi with Telegram is as the name suggests. Using Raspberry Pi, a motion detection system is developed through the method of background subtraction, which works by subtracting the static from the background frame from the constantly changing foreground. The change of value in noise and pixel density between the background frame and the foreground indicates motion. Each time a motion is detected, the system will automatically send the frame to the user via Telegram to notify that there has been movement in the area as captured in the frames. A prototype is first developed in a virtual environment using VirtualBox software before running it on the Raspberry Pi. This paper will show the relevance of the project.**

Keywords—Motion Detection, Security Camera, Raspberry-Pi, Telegram, Background Subtraction

I. INTRODUCTION

In order to combat burglaries, robberies and other crimes, it is helpful to equip the residences with a monitored security system. Security aspect has turned out to be the most crucial factor governing in our daily life. Thus, using advanced technologies, those criminals may not easily circumvent the locked doors and closed windows. Implementation of CCTV, or Closed-Circuit Television, allows recording monitored areas, but this equipment comes at a high cost that it is prohibitive for many users.

Automated motion detection security system notifier using Raspberry Pi with Telegram introduced to improve the current technology as an effective hardware and software. Raspberry Pi indeed an innovative and advanced technology despite of its small size and relatively inexpensive. Raspberry Pi is a magnificent hardware because it is compatible along with a standard PC and an embedded device. Besides, like another computer, Raspberry Pi supports Linux option called Raspbian and supplies easy input or output makes it perfect for controlling nearly anything [1][2].

The main purpose of this study is to build a motion detection system using Raspberry Pi and can upload image to the SD card. The Raspberry Pi with Telegram application alert the user if any motion is detected. Thus, this project aims to build a low-cost security camera integrated with the latest technology, Raspberry Pi and to be user friendly, which would notice the users promptly.

II. LITERATURE REVIEW

Motion detection works on the basis of frame differencing [3]. Frame differencing is the process of comparing the locations of pixels after each frame. However, motion detection systems experience quality issues usually caused by noise distraction, background disturbance, variable scene illumination and also the shadows of static and moving subjects. Different strategies have been introduced to overcome these issues such as background subtraction, temporal differencing and optical flow [4].

Background subtraction is an ordinary yet effective way to deal with detecting un-static object in the stationary background. This technique is mainly to create a foreground mask by using static cameras. Method of background subtraction cannot deal with quick picture variations and large diverting movement [5]. Even though it is very sensitive to dynamic scenery and background changes that are usually because of lighting and extraneous events but it serves the whole perfect feature of data [4]. Besides, implementation Telegram app is required as an interface between the user and the system.

Telegram has an application programming interface (API) that is not equipped mostly in other applications. Plus, the API system in Telegram has allowed users to create bots. That has to be the strong point where Telegram application is the best and most suitable application to be utilized in this project. Raspberry Pi has been shown to be beneficial for motion detection [6]. The Raspberry Pi device is smaller, light and has low power consumption, thus making it more environmentally friendly [7]. These aspects make the Raspberry Pi device is more helpful and convenient than the usual PC based face recognition system. Raspberry Pi has an open source type of code, which is free to use and allows advanced programming with Linux software [7].

III. METHODOLOGY

This project was fully developed by using Python language to create the Telegram server and the motion detection program. Python language is a broadly used general purpose, high- level and top-notch programming language. The diagram below shows the result of the project.

A. Project flowchart

A flowchart is important for a project to be done effectively and efficiently and without any mistakes. The overall flowchart methodology of this research is available in Fig. 1. It involves five steps to yield the final output of this research. The method requires a proper and suitable plan to develop motion detection system.
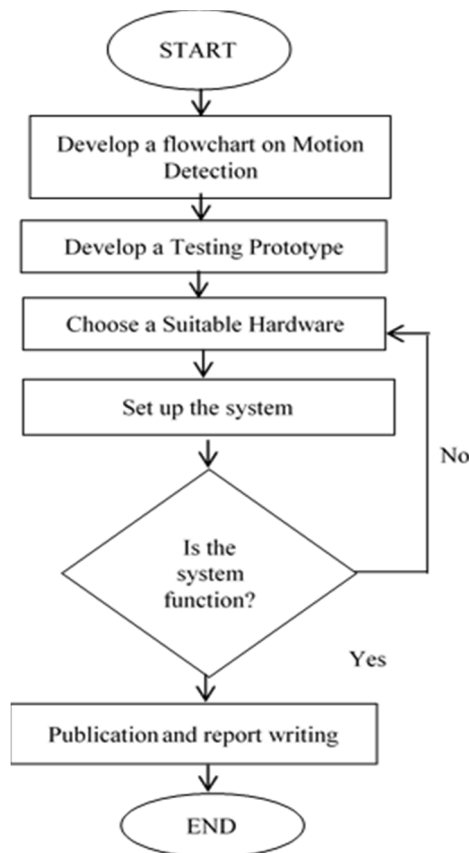
Next, we develop motion detection system prototype and create software for emulating this on a PC. Then, the appropriate hardware is selected to be programmed on the system. An integrated system is then set up and tested for functionality. Finally, the findings are assembled as a final report for the entire project.

B. Motion detection flowchart

Fig. 2 depicts the steps taken to realise a motion detection system. The project starts by switching on the prototype using Raspberry Pi that runs the Telegram server. The algorithm starts when the sensor is turned on and motion is detected in the controlled area. If there is any unrecognised motion, then the frame will be captured and saved on the SD card. The user is alerted through the Telegram application. If no motion is detected, then the sensor will continue sensing any incoming motion.
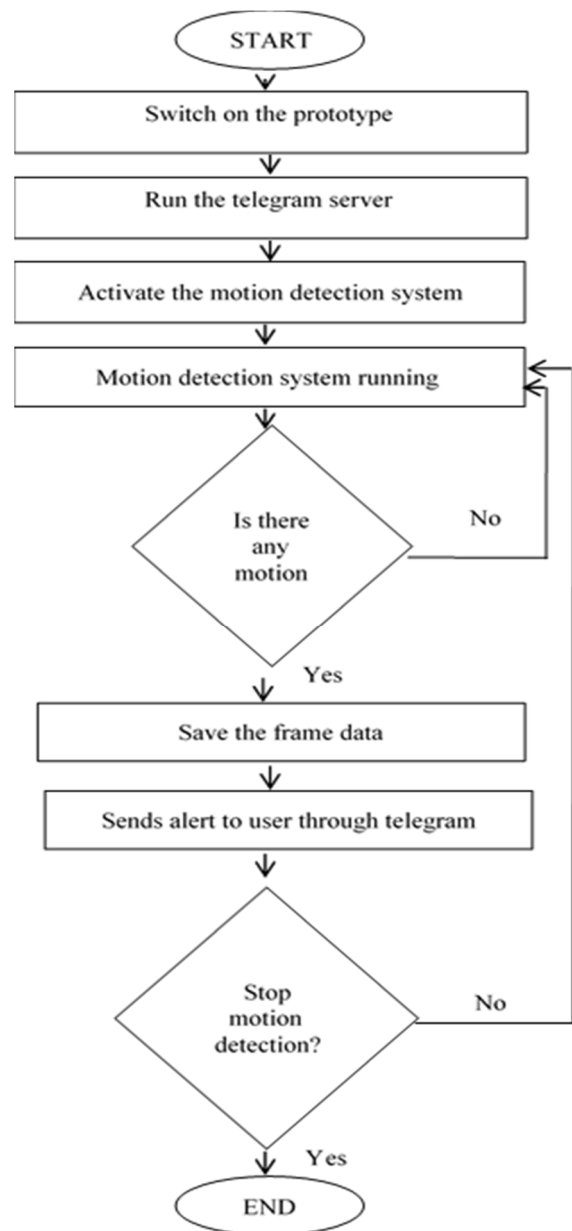

Fig 2. Motion detection flowchart.

Fig 1. Project flowchart.

C. Background subtraction algorithm

The algorithm proposed in this motion detection project is background subtraction. The first step in background subtraction is to build a background model of the scene and then compare each current frame of the scene with the model of the background in order to estimate and identify the amount of motion or difference in pixels between the background model and the current frame. The background model was updated by moving it closer to the current frame [8]. This is done so that the regions of motion captured in the scene can be estimated effectively.

The algorithm begins by indicating the background frame to be modelled as the first frame. The first frame is basically a grey scale image of the background frame in the area of interest and the current frame is the grey scale image of the current frame. From the two frames, the differences between them both must be computed. The difference is calculated by a simple subtraction that contains the whole value of both pixel intensity frame differences as described in (1) [8].

Delta = Background Model (First Frame) – Current Frame

(1)

The resulted image from the frame delta cannot be assumed as the final result because it might contain some irrelevant movement that is unrelated to the motion that is wanted to be captured [8]. For example, a tree leaf moving due in the wind can affect the motion detection system. This becomes the reason why the result from the frame delta must be the threshold. The threshold is what that identifies and determines whether the movement is a motion or not.

The image that was obtained is the one where they all share the same pixel values. The pixels that do not changes are zeroed out while all the change in pixels in the region of motion are highlighted. Then, the resulting image will contain both relevant and irrelevant area of motion. The undesired result that has both the wanted and the unwanted movement needs to be filtered out based on the threshold value calculated from the frame delta in (2) [8].

For each pixel(x)
If I(x) > threshold
    I(x) -> White
    Else
    I(x) -> Black

(2)

D. Develop a prototype

Before choosing suitable hardware on which to develop the motion detection security system, the system is first developed on the laptop. A 'virtual box' is created using the Raspbian environment and the system is set and programmed inside the virtual box. This is to ensure the system is working and can be up and running before programming it into the suitable hardware [9].

The testing prototype is developed on a Lenovo G40 using Raspbian on Virtual Box Oracle VM. VirtualBox previously named Sun VirtualBox, is a free and open-source facilitated hypervisor for x86 virtualisation. VirtualBox was procured by Sun Microsystems in 2008 and subsequently, by Oracle in 2010.

E. Choosing the most suitable hardware

To ensure the project's success, a fit and suitable hardware must be chosen. Before deciding the suitable hardware, a lot of research on motion detection must be done to confirm the hardware can be used to achieve the project's objectives. The best hardware for a motion detection security system is the Raspberry Pi 3 model B+ as depicted in Fig. 3 [10].

The new electronic device, Raspberry Pi, is an installed framework that acts as a mini-computer and has had a significant effect on young programmer [10]. Raspberry Pi has is significantly different to the Arduino board. Arduino is the most utilised platform for electronics projects and acts as micro-controller, whereas the ultimate Raspberry Pi acts as a mini-computer. Considering the potential of this type of electronics device, the Raspberry Pi might soon transform the computer era in the future soon.

Compared with the old version of the Raspberry Pi, this latest Raspberry Pi 3 model B has a lot of benefits. Raspberry Pi 3 has a built-in Broadcom BCM2837 type of CPU with a 1.2GHz quad core with Cortex-A53 as its processor. Compared with the Raspberry Pi 2 shown in Fig. 4, the latest CPU BCM2837 of the Raspberry Pi 3 is clearly more competent and impressive than the Broadcom version that is built into the Raspberry Pi 2 [11].

Furthermore, compared with the Raspberry Pi 2, the Pi 3 model has an excellent graphics processing unit (GPU). Even though both of these GPUs belong to the Video Core IV family, the GPU in the Raspberry Pi 3 operates 900MHz while the Pi 2 model is just 400MHz [11]. After the prototype was developed, the motion detection system was programmed on both the Raspberry Pi 2 and Raspberry Pi 3 model to enable the comparison.

Fig. 3. Raspberry Pi 3   Fig.4. Raspberry Pi 2

F. Setting up the system

First, Raspbian is downloaded from the Raspberry Pi weblink. Raspbian is a Debian-based PC operating framework for Raspberry Pi. There are a few adaptations of Raspbian including Raspbian Stretch and Raspbian Jessie. Since 2015, it has been formally recognised by the Raspberry Pi Foundation as the essential operating framework for the group of Raspberry Pi single-board PCs [12]. The option between Raspbian Stretch with Desktop and Raspbian Stretch

Lite are suitable for this project. Both versions actually worked, however the model chosen for this project needed to complement well with the system created as explained in the previous subsection.

IV. RESULTS AND DISCUSSION

This section comprises the result of the project Motion Detection Security System Notifier using Raspberry Pi with Telegram. The diagram of the overall process of this project from the starting point of activating the Raspberry Pi until receiving the captured photos on Telegram were discussed, all the interface and result are also displayed and explained further in this section with the aid of diagrams.

A. Activation of motion detection system

The motion detection system is activated after the coding and integration of the system is applied into the Raspberry Pi operating system. Along that time, the main prototype (Raspberry Pi 3) is turned on in advance and run the Telegram server. The command prompt in Raspberry Pi directly open the Telegram server. Python is run by accessing the file trigger.py as shown in Fig. 5.

Fig. 5. Running the trigger.py file

The Telegram application is opened in the mobile device and the "/Start" command is sent using the Telegram Bot as the first interaction between the user and bot [13]. Then, the Telegram server on the Raspberry Pi received the message from the mobile device chat ID that has been set in the coding. Finally, the motion detection system is activated on the Raspberry Pi.

When the Python file trigger.py is running, the server will listen to any single instruction that is coming from the Telegram bot. Anytime there is an instruction coming from the Telegram bot that basically comes from the user, the command prompt will display a message that the server has received a message coming from the Telegram bot chat ID as shown in Fig. 6.

Fig. 6. Raspberry Pi linked with Telegram Raspberry Pi

After the motion detection surveillance system is activated, the Pi camera will start analysing and the first frame that appears in the Pi camera is captured. Then, the first frame is set as the background image for the motion detection algorithm. Fig. 7 shows that the motion detection program

has started on the prototype. For the time being, the room status is set as 'Unoccupied' as there is no motion currently detected the bottom left of the security feed shows the time stamp as in CCTV recordings.

Fig. 7. 'Unoccupied' room status.

When the prototype detects motion, a green box appears on the area of affected area. The green box indicates motion occurring in the foreground and the room status is automatically changed from 'Unoccupied' to 'Occupied' as shown in Fig. 8. If no motions occur in the monitored area, then the camera will continue to monitor the area of interest until there is motion detected [14]. The motion detection system will continue to monitor the area until the system is deactivated.

Fig. 8. 'Occupied' room status.

Each time motion is detected, the frame data the captured frame data is temporarily saved in the 'Videos' folder in the prototype's system before it is sent to the Telegram bot. When there is new motion detected, the previous saved frame data is overwritten by the latest captured frame data. If no motion is detected, then the frame data that were captured will be saved in the folder until the next motion appears and the new frame data replaces it.

Thus, the user will be notified when there is new motion detected as shown in Fig. 9. The motion detected in the security feed will be surrounded by a green box, which indicates motion in the targeted area. Motion detection data will be forwarded to the Telegram user Telegram as long as motion is detected.

Fig. 9. Motion notification alert.

After running the program for some time, the user has the option to switch off the surveillance system by sending the command '/Stop' on the Telegram bot. The Telegram server will send a text reply 'Surveillance system was ended, serving you was great!' to the Telegram bot.

B. Application of background subtraction algorithm

From the algorithm, the frame's delta image is produced when current frame is subtracted from the background frame. The frame Delta image has a whole black background with the area of motion highlighted in a lighter color (white). This shows that larger frame deltas indicate motion in the image. The resulted frame delta is shown in Fig. 10 and 11.
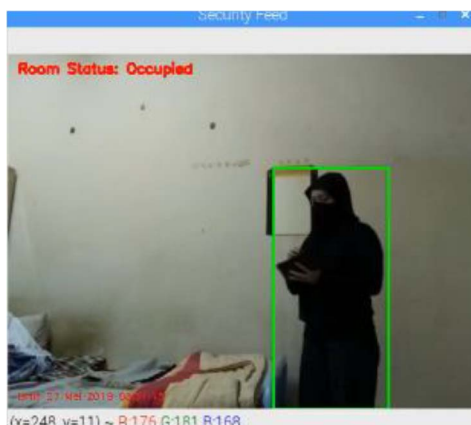

Fig. 10. Security feed of motion detection system.

Fig. 11. Frame delta of motion detection system.

As stated before, the result image from the frame delta might not be the final result as it may contain irrelevant movement. The threshold from the frame delta is what this project encountered. The region of motion is filtered to obtain the thresh image as in Fig. 12. The background of resulted thresh image is black while the region of motion is white.

Fig. 12. Comparison between thresh feed and frame delta feed.

C. Telegram notification

After the motion is successfully captured as in the following result, the final image is sent to Telegram after starting up the Telegram server by sending the '/Start' command. This can be done after installing telepot in the Raspberry Pi program. In order to utilise the Telegram Bot API, a bot account must be requested from the BotFather [13][15]. BotFather will give a personal token to be used to start using the telepot to access the bot account. The '/Start' command is sent to the Telegram server to make sure that the Telegram bot will initiate a connection with the Telegram server. For example, the frame data captured by the motion detection system on the server is sent to the user chat ID that is set on the server instead of sending the image to any other random Telegram users. The Telegram server will know from which user the message was received and to which user it needs to send the required message according to the chat ID that is set in the program. Therefore, when the room status changes from 'Unoccupied' to 'Occupied', the Telegram server will automatically send the captured frame to the user's Telegram bot, thereby alerting the user of motion taking place in the area of interest.

V. Conclusion

Automated motion detection system has been proposed as a significant solution for monitoring property crimes. In this paper, the improvised and integrated system is introduced using an advanced technology, Raspberry Pi, which will notify the user directly if motion is detected on the Telegram application. One of the limitations the system encountered is that it only operates with a stable electricity supply. In addition, despite that the project produced a reliable motion detection system at relatively low cost. At the same time, this project could give benefits to many individuals and other related premises.

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