REAL-TIME VIDEO SURVEILLANCE USING RASPBERRY PI

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Abstract- *In the present time, security is an important part of everything, from houses to multinational buildings. And so security cameras have been placed in each and every corner of the globe. These cameras have emerged from a person monitoring them day-and-night to being accessible from any part of the world by concerned people. This paper portrays the surveillance system which comprises a Raspberry Pi 4 circuit board and Pi camera to monitor as well as stream the feed live in real-time.*

Keywords: Video Surveillance, Raspberry Pi, Raspberry Pi Camera, License Plate Detection, Motion Detection, Email, OpenCV.

1. Introduction

With the development of technologies in every area of life today, the risks to safety and security have also risen. Security and monitoring are now essential components of society to ensure that people are safe. And as a result of this need, video surveillance cameras are being installed everywhere. Video surveillance is now the go-to method for keeping an eye on and controlling everything. *The act of viewing a scene or scenes and looking for specific behaviours that are wrong or that may signal the emergence or existence of improper behaviour is known as video surveillance.*[1] From observing the public at the entrance of sporting events, to checking the public transportation (train platforms, airports, etc.), and around the perimeter of secure institutions, particularly those that are directly delimited by communal spaces, are all common uses of video surveillance. The identification of regions of concern and the identification of individual cameras or groups of cameras that may be able to observe those areas are all part of the video surveillance process. [1]

A few years ago, the security cameras were checked and watched over manually each day. However, with the advancement of technology, systems are now designed so that no humans are needed to sit still for long periods of time in order to check security cameras. Video surveillance has become the most reliable way to keep an eye on people and events happening in specific places since the invention of video cameras and recorders. Thanks to the internet and wireless connections, surveillance can now be viewed from anywhere in the world.[2]

The crime rate has dramatically increased in recent years. Numerous incidents, including theft, break-ins, and unwanted intrusions, take place without warning. This calls for the installation of a security system that can guard against unauthorised entry into both a person's home and high-security locations like casinos, garages, military bases, and locker rooms at banks. [3] Creating smart homes is one approach to securing our homes. The primary driver of such homes' corporate-based automation is surveillance. [4]

The proposed system focuses on home surveillance. It presents a real time video surveillance system wherein live streams and records of the video footage are provided to the concerned user whenever an unexpected motion is detected in the house. The implementation of so is done using OpenCV for coding, Raspberry Pi 4, and Raspberry Pi camera for motion detection. The operating system used for this project is Raspberry Pi OS. It sends an alert along with the image the camera captured when motion was detected.

2. Literature Survey

Table 1:- Related Work

TITLE	METHODOLOGY	FINDINGS
Apeksha P Kulkarni, Vishwanath P Baligar "Real Time Vehicle Detection, Tracking and Counting Using Raspberry-Pi" (2020) [5]	In this paper, traffic flow is monitored by using a computer vision paradigm, where images or sequence of images provides a betterment of the road view. In order to detect vehicles, monitor, and estimate traffic flow using low-cost electronic devices, this research work utilizes a camera module of	From the experimental analysis, it is evident that vehicles were detected at an accuracy rate of about 97.39%, and vehicles tracked at a rate of about 98.26%. Experimental results were implemented with OpenCV, which indicates that the accuracy rate reaches 97.1% for object detection and 98.4% for object tracking.

	raspberry pi along with Raspberry Pi 3. It also aims to develop remote access using raspberry-pi to detect, track and count vehicles only when some variations occur in the monitored area. The proposed system captures video streams like vehicles in the monitored area to compute the information and transfer the compressed video stream for providing a video-based solution that is mainly implemented in OpenCV by Python Programming.	
Jayendra Kumar, Sourabh Kumar "Real-Time Monitoring Security System integrated with Raspberry Pi and e-mail communication link" (2019) [3]	The proposed system is for the Smart Door lock technique with Raspberry Pi using IoT and is done by integrating webcam and motion sensor with e-mail. Raspberry Pi operates and controls motion sensors and a webcam for sensing and surveillance. For instance, whenever any motion is detected, the webcam streaming starts and the Raspberry Pi device alerts the owner through an e-mail on his registered mail-id.	The main advantage of this system is that it is developed on Raspberry Pi which provides much flexibility in terms of embedding more sensors and other hardware components into the system. Hence, it is highly efficient with the least chances of failure and real-time monitoring makes it quite an effective system to be implemented practically.
Thinesh Prathaban, Weilynn Thean "A Vision-Based Home Security System using OpenCV on Raspberry Pi 3 Model B" (2019) [4]	In this work, a vision-based home security system using OpenCV on Raspberry Pi 3 Model B was developed to improve the effectiveness of motion detection. This system applied the Haar-Cascade algorithm coupled with background subtraction as well as considered the Histogram of Oriented Gradients (HOG) during the development stage. The developed prototype was tested under a few conditions to determine the accuracy of motion detection and compare the results with a system that uses a PIR motion sensor for motion detection.	From the results obtained, the developed vision-based home security system using OpenCV has a 100% detection rate compared to the PIR motion sensor-based security system with a 76% of detection rate.
Oussama Tahan "A Raspberry-Pi based Surveillance Camera with Dynamic Motion Tracking" (2020) [2]	This system is designed to work as a real-time system for human detection and motion tracking. This system will be designed as smart automated video surveillance for monitoring people, detecting and tracking their movements. The monitoring system was implemented using raspberry pi 3model B+, a web camera, and two servo motors assembled by a pan-tilt and it was controlled using OpenCV and python.	The system we discussed in this paper is a real-time system for detecting and tracking motion using a camera and servo motors. It is hoped that the outcome of this system would serve in future research regarding this domain of work. In addition, the user will receive alerts and notifications through these platforms when the system detects an abrupt motion to inform him that something abnormal is happening.
Chetan B V, Bharath P K "Smart Surveillance System Using TensorFlow" (2021)	The proposed system for smart surveillance involves a security camera with the night vision capabilities interfaced with raspberry pi. OpenCV is used to	A smart surveillance system based on the raspberry pi using TensorFlow and OpenCV technologies has been implemented in this work. The proposed system is tested for the detection and classification of about 80 objects. Also, after the successful classification of

[6]	perform real-time image processing. This system proves to be a cost-effective way of surveillance, as it uses a credit card-sized chip Raspberry Pi (RPI). The methodology of the proposed system involves breaking down a video, captured by the camera in real-time, into separate frames. Each frame is processed using image processing tools in python. The preprocessed images (frames) are compared for changes in pixel values, to detect the movement of an object. Then, an object detection algorithm like Tensor Flow is used to detect the object and classify it. Later, a buzzer is activated to cognize the security system and personnel. Also, an alert notification is sent to the owner.	an object as a human being, the movement of the human being can be successfully detected by the algorithm used. The alert notification can be sent to a distant user through an SMS.
I Gusti Made Ngurah Desnanjaya, I Nyoman Alit Arsana, "Home security monitoring system with IoT-based Raspberry Pi" (2021) [7]	The home security monitoring system was created using Raspberry Pi as the control center of the system. It was connected with several sensors namely PIR sensor is used to detect objects that enter the room, a spycam is used to take pictures when the PIR sensor detects objects, temperature sensors, and gas sensors are used to detect the state of temperature and gas concentration, and telegram is used as a liaison application to send notifications from Raspberry Pi to tool users.	This system is able to monitor the security of the house from burglars or intruders, notify the temperature of the house and detect smoke or gas.
Jin Su Kim, Min-Gu Kim, "A study on implementation of real-time intelligent video surveillance system based on embedded module" (2021) [8]	An intelligent video surveillance system based on embedded modules for intruder detection based on informal learning, fire detection based on color and motion information, and loitering and fall detection based on human body motion. Moreover, an algorithm and an embedded module optimization method are applied for real-time processing.	The implemented algorithm showed a performance of 88.51% for intruder detection, 92.63% for fire detection, 80% for loitering detection, and 93.54% for fall detection. The result of comparison before and after optimization of the algorithm processing time showed a 50.53% decrease, implying potential real-time driving of the intelligent image monitoring system based on embedded modules.
A. R. Syafeeza, M. K. Mohd Fitri Alif, "IoT based facial recognition door access control home security system using raspberry pi" (2019)[9]	In this project, face recognition using deep learning techniques was introduced and the Internet of Things (IoT) was also being used to perform an efficient door access control system. The IoT system enables the user to control the door access.	In conclusion, Face recognition is able to recognize the face and be able to send a notification to a user when an unknown being has been detected through IoT.
Hanaa Mohsin Ahmed, Rana Talib Rasheed, "A Raspberry PI Real-Time Identification System on Face Recogniti	This paper's goal is to move face recognition toward a level where the system can substitute the use of a password and RFI-Cards for accessing security systems. The outcome of the submitted suggestion can be a working system utilizing recognition	Implementing face recognition using the Raspberry pi has also provided good results; the system suggested accuracy was 99.63% and could be simple in a reasonable way. Python was used as a programming language because it helped provide a free and ready environment.

on" (2020) [10]	of faces using OpenCV, Raspberry Pi, and an Android app on cell phones.	
Sudan Jha, Changho Seo, Eunmok Yang, Gvanendra Prasad Joshi "Real time object detection and tracking system for video surveillance system" (2020) [11]	In this paper, a system made by combining low-end edge computing environment and object detection tracking algorithms has been used for real-time video surveillance.This paper proposes N-YOLO algorithm, wherein the image instead of being resized like in YOLO (you live only once, a one-stage detection algorithm), is divided into fixed size images and and the detection results of each divided sub-image are merged using correlation-based tracking algorithm.	This paper has proposed a method in which a real-time object detection and tracker based on the N-YOLO Tracker with YOLO V3 is developed. It also uses image segmentation and image merging with tracking algorithm method for real-time object detection and tracking. The results imply that correlation-based object tracking combining with YOLO V3 produces the most efficient bounding box among the compared object detection algorithms. The limitation of this method is that it does not handle re-entering, as YOLO does not have reentered detection for frames. And it also gives a new ID to the object when trackers get it back.
Omar Elharrouss, Noor AlMaadeed, Somaya Al-Maadeed "A review of Video Surveillance systems" (2021) [12]	In this paper, different types of video surveillance systems as well as their components have been reviewed and analysed. Further they are compared to decide which one works the best.	THe different types of Video Surveillance System (VSS) used here are Analog VSS, Digital, network VSS, WNSs, etc. The comparison is based on the architecture of different proposed systems along with a comparison of functionalities and the analyses provided by each system are presented.
Swapnil Bagwari, P. Raja, Rajat Namdev "IoT based surveillance system using comparative analysis	In this paper, the authors have used three different threshold algorithms for motion detection: Iterative Self-Organizing Data Analysis Technique, Otsu's threshold algorithm and Kapur's Entropy thresholding. It has	The Percentage of Correct Classification (PCC), The Jaccard coefficient (JC) and the Yule coefficient(YC) has been used in this paper to evaluate the performance of the algorithms. The results imply that the Otsu and Iterative methods work best in both indoor and outdoor conditions. And hence they applied Iterative methods on the video
of different threshold algorithms for motion detection using Raspberry pi" (2018) [13]	introduced home surveillance systems both indoors and outdoors using the internet of things for more connectivity with the users.	surveillance system and the accuracy was found to be 98%.
Leonidas Deligiannidis "Cam-eye: An Affordable Real-Time Video Surveillance Solution" (2019) [14]	In this paper, authors have made a video surveillance system, cam-eye, through which we can record and access the live video via VPN or the iOS app using the color, infrared and thermal cameras and the Raspberry Pi zero circuit board. They also have provided a software wherein high definition videos are recorded and transmitted in real time. Also they have used the alarm triggering algorithms.	In this the camera has two modes, surveillance and monitor. In surveillance mode, the cameras can give MJPG streams output to the browser or the app.and in the monitor mode, the cameras record constantly in a circular memory buffer in H.264. And this has given the most inexpensive surveillance system.
M.Revathy, K.Vaishnavi, N.A.Lokesh, S.Sugun Paul "Smart CCTV Surveillance system using Raspberry Pi" (2021) [15]	This paper portrays design and implementation of Smart surveillance monitoring system using Raspberry pi and IR sensor. The camera streams the live video and records it whenever the motion is detected and saves it for future use. The video and notification of motion detected is sent to the user through email.	This approach provides reliability and privacy as well as an efficient video recording system. The user is the only one able to view the recordings and hence it is authenticated. Also actions can be taken quickly in short time.
K.V. Kalyan Chakravarthy, M.Vamshi Krishna "Colour	In this paper, the main focus is on the colour object detection from a group of live pictures fed to the system. They have	The Raspberry Pi is used to track the object any place it goes. (either by controlling the robot or inclining and panning the camera). JSV, RGB, YUV filters are used to get more accuracy than the

Object Detection in real time using Raspberry Pi and Image Processing" (2021) [16]	used the Otsu method to track by using Hue Saturation-value (HSV), luma and chrominance components (YUV), red-green-blue (RGB) colour-based tracking.	kalman filters to detect Red, Blue, Green colours which helps in detecting an object better.

3. Methodology

This surveillance system picks up movement in the house where it is installed. This is referred to as a home security surveillance system. When a motion is detected, the system records it as an image or video and sends it to the user via email. To implement the surveillance system, we used a Raspberry Pi 4 and a Raspberry Pi camera to monitor, record, and stream live feed video. We have used Python as the programming language, and OpenCV library..

First, the Raspberry Pi 4 was set up with the Raspbian operating system. The Raspberry Pi camera was set up and connected to the device after the OS had been successfully installed. Following that, the "raspistill -o image.jpg" terminal command was used to save the camera's image in the current directory in order to confirm that the camera was functional. After making sure that every piece of hardware was securely fastened and functioning properly, the coding was completed in the terminal. For this project to function better, a few small libraries and their associated dependencies were installed. Following that, the user's and the system's email addresses were configured in the mail.py file, which then connects to the gmail SMTP server and sends an email with a picture of the object the camera detected. The addition of the mail feature makes it simple for users to understand what kind of activity is being done and what action to take.

The main.py file was run after all the aforementioned steps had been finished. The project was successfully completed as a result of this. The security camera continuously monitors any movement within its field of view, and when motion is detected, an email alert with the image captured is sent to the user's Email ID.

This system used three XML files, which hold a sort of pattern that was learned using machine learning and a lot of examples, in its *main.py* file. These XML files use a haar cascade classifier to detect objects.

- ➔ facial_recognition_model.xml (which works for facial features detection)
- ➔ fullbody_recognition_model.xml (which works for full body detection)
- ➔ upperbody_recognition_model.xml (which works for detection of only upper body)

For live streaming, we explored some methods. To begin, we used a flask. Flask is a Python-based microweb framework. It is used to connect the user to the web browser. So, using Flask, we created a username and password for authentication. This was done to maintain security. When the user wants to see the live stream, he/she has to go to the host IP address, that is 192.168.0.102 (in our case), host ip="0.0.0.0" will make the page accessible by going to http://[ip]:5000/ on any computer in the network. Where ':5000' is the port number. After searching for an IP address, the user will be prompted for a username and password. If these two match the previously set password and username, the user will be able to access and view the live stream.

VLC media streaming was another method we tried. We used RTSP in that method. If we want to stream over TCP or UDP, this can be useful. To do so, we must include the Raspberry Pi's IP address in the network stream. We can then watch the live feed.

We chose the last method because the previous one was streaming delayed versions. So, in this case, we used a streaming server and set the port number, which is the postfix of the IP address. Finally, we were able to view the stream by entering the IP address into the browser.

4. Result and Discussion

The outcomes of this model are good with an accuracy of 70%. If motion is detected on the camera, a green frame covering the detected motion is created, as shown in the figure below. The captured image is sent to the user via Gmail in a matter of seconds. We used an 8MP Raspberry Pi camera, which provides a clear image to the user, making it easy for the user to identify suspicious activity.

Fig.1 Upper-Body Result

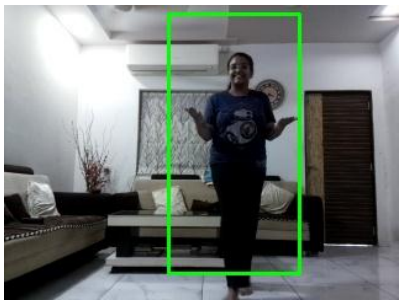

Fig.2 Full body Recognition Result

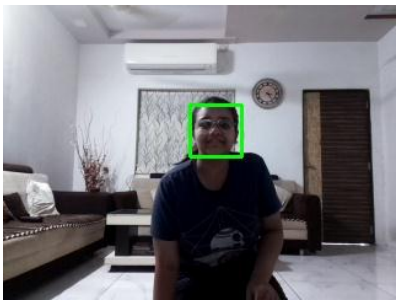

Fig.3 Facial Recognition Result

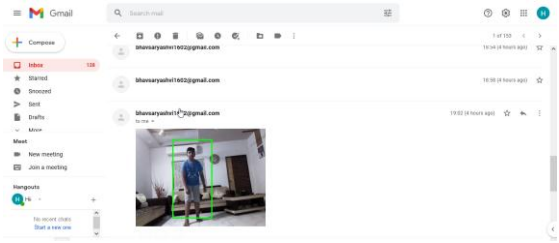

Fig.4 Email received

5. Future Works

In the future, many developments can be made to improve this project. We can increase efficiency by gathering data collected through camera recording and training the machine algorithm properly to receive better results. Here we will use the live recorded videos as training and testing data, it will help to increase the efficiency and accuracy as it has to monitor the same scenario constantly. Another update we can make is easy accessibility through social media. We can use any social media platform to receive a message along with photo if any unusual activity is detected. Everybody doesn't check there mail every day, but everybody uses a single social media platform to communicate, so we can send an alert message on that application so users won't miss any messages.

6. Conclusion

The components used to create this project were crucial. The Raspberry Pi 4 is a fast and versatile device. We get results quickly and precisely. The Raspberry OS and code were stored on a 16GB memory card. The raspberry camera has an 8MP resolution, which provides the user with a very clear image. This project is for home surveillance security systems. It has motion detection to detect any suspicious activity inside a room. For the purpose of catching any suspicious activity inside a room, it has motion detection. The OpenCV library was applied for motion detection because it facilitates quick and simple motion detection. In order for an SMTP server to send the user an email using the same mail Id, a new Gmail Id had to be made. The code is registered with both the sender and recipient email addresses. The user can stream and watch live feed to assess the situation at the house using the Raspberry Pi's IP address.

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