Low cost automated Facial Recognition system

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Abstract— **With the dawn of rising sophisticated technology where everything or rather everyone depends on smartphones, tablets and voice assistants. With such increase in the rate of people using technology to automate their tasks, it is impractical to hire a person for monitoring the CCTV or the IP camera feed for the intruders. Hence, the concept of automation can be implemented here as well. CCTV cameras present in a particular place are highly prevalent but then someone has to monitor the prospects of the recorded video. If an intruder comes in then, the person in charge has to raise the alarm to alert the security. Surveillance practices that are capable of facial recognition are becoming more common these days, but their prices remain high making it unaffordable for homes or small-scale businesses. So, the proposed facial recognition system is efficient as well as low-cost which not only recognizes the faces but also automates the task of alerting the user through e-mail and mobile notification so that no human intervention is required to alert the police. In addition to this, a log will also be generated with the details of the entry and the exit of the persons in the area where this system is installed. The proposed system uses a raspberry pi module and a camera module that fits in the CSI (camera serial interface) of the raspberry pi chip. Alternatively, a powerful USB camera can also be used to achieve the same task.**

Keywords: facial recognition; eigenfaces; PCA; viola jones; Raspberry Pi; camera module; automation; security; system;

I. INTRODUCTION

With the change in time and advancements in technology, there has been an increased interest in video surveillance and monitoring applications. The reasons for this interest are various, ranging right from security demands to military applications as well as for scientific purposes. The strong need to protect the assets and identity without losing it in the outer world with the help of user-friendly technologies is nothing but obvious. In the current scenario, a person needs a unique PIN to get cash from the ATM[4], a password for the computer and many such security methods for their personal devices such as tablets cell phones and for accessing the content on the internet. More reliable techniques such as the biometric methods of identification like Retinal and iris scanning methodologies, fingerprint analysis techniques that are both effective and accurate to an extent. But, the common setback in such type of biometric identifications depends on a huge deal on the cooperation of their participants[5].

Many sci-fi movies have already depicted the magic of facial recognition system in action. In any such film, the scenario would be about the fact that as soon as the camera sees a face, it immediately scans through the entire database and gives the exact details of the person including their address. It is accurate to such an extent that all their details can be found out right from their social security number to the minor facts such as petty thefts to every small detail which is available to know all about the person. Everything seemed so easy and planned out in the movies, but it is not the same scenario in the real world where people have different looks of the face due to the angles they are facing towards the camera, illusion, occlusion, and even due to the facial expression[9].

Since the process of face verification is a binary classification problem that is it works on a pair of input faces, there are two main elements which can verify the approach: face representation and face matching[1].

The features (descriptor) that are extracted are required not only to be discriminative but also unwavering to visible changes and noise. In Fig 1, it is shown how two pictures of the same person can differ when it comes to pose, expression, illusion and occlusion. Such problems cough up challenging problems for facial recognition[6].

II. RELATED WORKS

There have been endless iterations of the facial recognition technology used over the years for various purposes. When a moving object is tracked, it is a vital thing to be surveyed on[8]. The design of such a tracking approach can be influenced in many ways. Some of these factors include: environment (indoor, outdoor), object type (person, vehicle), light exposure (day, night, twilight, cloudy, raining, sunny), type of camera (fixed, pan-tilt-zoom, omnidirectional), camera size (single, multiple), purpose of tracking (behaviour analysis, people counting, traffic monitoring), and the list is endless [3]. Based on the above-stated factors a lot of methods have been proposed by various people and some of them are, an automatic system for obtaining high-resolution images of surveillance objects has been proposed. The system as soon as sees a particular face automatically starts detecting faces and processes it with the facial recognition technology. The system tracks the target with the help of a single pan-tilt-zoom (PTZ) camera while trying to zoom in for the image of the face. It relies on an efficient strategy which is helpful in the

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localization of the target to guide the camera to get a close-up of the required target [7]. In 2001, the Tampa Police Department installed cameras capable of facial recognition in their Ybor City nightlife district in an attempt to cut down crime in that area. That particular system has been egregious to do the job, and it was dropped in the year 2003 due to its ineffectiveness. People in the area were reported to be seen in masks and making obscene gestures at the camera hence restricting the camera to get a clear shot to identify anyone [10]. Hence the need to develop algorithms for tasks such as detection, tracking and recognition of objects using a distributed network of cameras has galvanized. Here the nature of image sensors provides quite a handful of challenges for data association across various types cameras. First, the nature of these problems falls under the context of visual sensor networks. Then as to how the real world constraints can be used in the favor to tackle these complex challenges. Examples of these real-world constraints are the presence of a 3D model where persistence of motion across cameras and color properties are illustrated. The prime focus of this work is to highlight the effective use of the geometric complexities induced by the systems used for imaging to obtain distributed algorithms for detection, tracking and recognition [11].

III. PROPOSED SYSTEM

The proposed method is to design a model which is efficient enough to catch intruders red handed in real time. People have already taken a step to increase their security within their surroundings but eventually have not yet come up with something elegant as well as cost effective.

The surveillance camera is made efficiently built with the help of the Raspberry-Pi chipset. The chipset is very smart and can be used according to one's need, but it needs to be programmed first. Along with the chipset, a camera module is required in this case a pi camera is attached
to it. This camera(8MP) is capable of taking high definition photographs so when these both combined, makes up an effective surveillance system.

There can be a skepticism about why not use the currently existing IP cameras. Well, the obvious answer to that question is Quality of the image. The camera that is integrated on the chip is an HD camera(8MP) which is comparatively cheaper than the available surveillance cameras in the market more over the current surveillance cameras costs nearly Rs.50,000 in the market and cannot be programmed to one's needs. Whereas the final build of this project will cost a maximum of Rs.7000 and would be a more efficient and feasible choice. To further set up the camera and interact with it a WI-FI adapter is required. Through this, the live video feed can be seen on a local authorized computer and the image database can be managed. The entire set up can be kept in a camera enclosure that can be bought easily to make it look like a typical surveillance camera. Now a little work is required before the camera is ready to be put into action. At present this setup is just a toy, so the code needs to embedded into the chipset with the help of an SD card to bring the novelty to life. The database is made up of the pics of the authorized persons. The system is programmed in such a way that the video feed is recorded only when motion is detected. Along with this, a log will also be generated with the details of the entry and the exit of the persons in the area where this system is installed. If the camera detects a face, then it crops only the facial part of the person and compares it with the existing database. If a match is found then the name, as well as the picture along with a timestamp, will be saved in the log. In case if there is no match then the word 'Unknown' will be printed in the log along with the timestamp. When this occurs the system has the superior capability to alert the owner and the security personnel of an intrusion or trespassing by sending a text message as well as an e-mail along with the details and the image of the intruder. In the background, this whole video feed is being recorded simultaneously while performing the facial recognition operations. This video feed can be saved to the SD card or the local system as well as in the cloud for easier accessibility.

Consider the following example to understand what the concept really is, assume that for a particular facility there are various restricted areas. In such areas, people are not allowed to enter without proper clearance. In such circumstances, if the system detects a face which is not registered in the database then it can alert the concerned authority along with a picture of the unknown trespasser. The log that is generated contains the details of the person (if a known person then the name is printed else the word unknown is printed), the time and date along with the photo reference in the database. The photos that are stored by the system will not have the default name, for example, the general way of a picture storage is IMG_001 instead it will be stored with the particular location of the camera so that it is easier to identify as to exactly where the trespassing was detected and hence it would be kept as MAIN-GATE_001 to specify that the location of capture was the main gate.

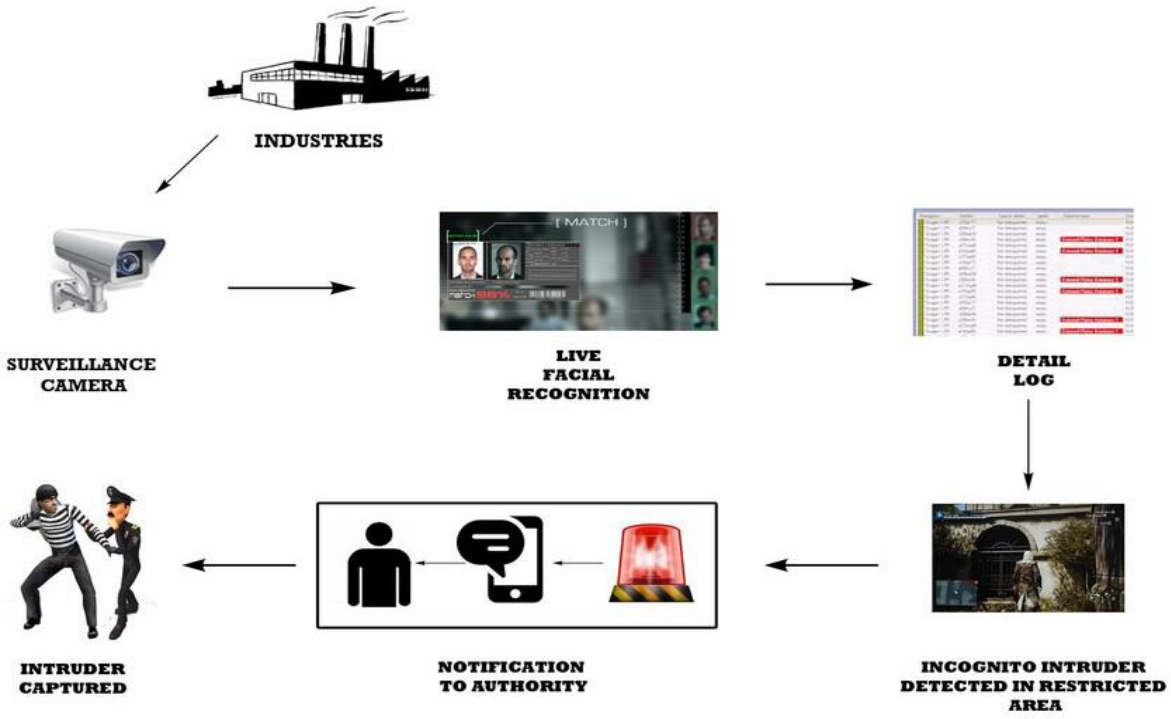

Fig. 2. The workflow of the project

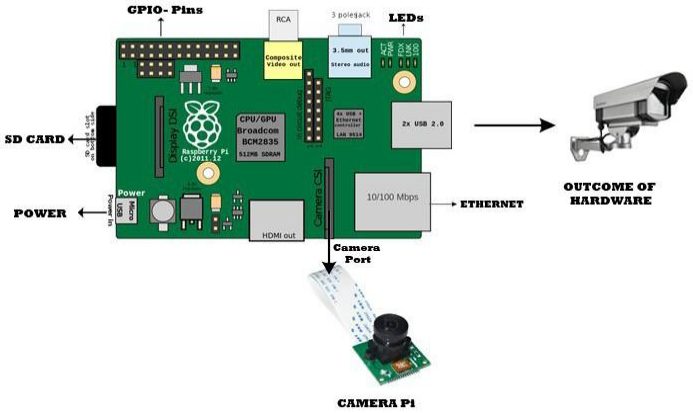

Fig. 3. System Components

IV.ASSEMBLY AND IMPLEMENTATION

In this section, the surveillance system shall be configured as mentioned above. Before starting this, a few components are needed.

A. Required components

Raspberry Pi Board: It is a compact size smart computer and is the heart of this surveillance system. When an image is captured by the camera, it is first stored in the SD card and then is accessed by the raspberry pi's CPU for the analysis.

Pi camera:

It gives the power of vision to the smart system. It is capable of taking high definition(8MP) images, videos and stores it in the SD card or a local system.

Wi-fi Adapter:

It helps in connecting the smart system to a local computer and also to the internet to send the text message and e-mail and also if you plan to upload the data to the cloud and sync with it.

SD card:

It contains the software to run the system. It also posses the database with which the captured images are to be compared with.

Camera Enclosure:

It abstracts all the components of the system and makes it look like a typical surveillance camera that is store bought.

B. Initial setup and Implementation

First, the OS for the system needs to be downloaded and installed on the SD card. Raspberry Pi runs on Raspibian OS, a variant of the Debian operating system. It can be downloaded from the raspberry pi's official website. By default, a lot of the required tools and libraries are pre-installed. After this, the SD card is inserted into the raspberry pi chip and is connected to a computer for configuring the WI-FI adapter and install necessary libraries like OpenCV to detect and recognize faces, python imaging library to handle them. OpenCV library offers a lot of algorithms to detect and identify the faces. The most common ones are Viola-Jones algorithm to detect faces and Eigenfaces, Fisherfaces to recognize them[2]. The algorithms mentioned above are going to be implemented first and for subsequent facial recognition, PCA(Principal Component Analysis) is used. PCA is derived from Eigenfaces and is known to mark a match as positive when a certain threshold of confidence level is met else it is

marked as negative. PCA is known to decrease the dimensions of the face images and converts them to grayscale without losing the essential features. Thus, the facial images of many people can be stored in the database.

Here, the code is written in two sections. First one is to capture faces and create a database and the another section is to fetch the image which is used for identifying or comparing the images in the database. The two parts are written in two separate python files. First one is run only when a person's face needs to be entered in the database and the second one is called only when motion is detected.

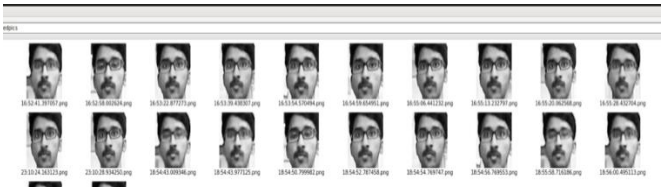

Fig. 4. Sample database containing pictures of the same person with different facial expressions

The database is used to train the system for the positive faces. It is advised to take pictures of multiple facial expressions of each person to increase the accuracy. This is linked to an XML file and the path for the database is written in a text document which is accessed from the python code. Facial features are extracted for the comparison with the help of the Haar feature-based cascade classifier that is present in the OpenCV library[13]. As Viola-Jones algorithm spontaneously adapts to incremental updates to the database, has a negligible tendency to render false positives Or negatives. Now, for the motion detection part, the motion package from the motioneye's repository that is present in Github needs to be installed[12]. After the installation, the motioneye's control panel can be accessed by typing the raspberry pi's IP address followed by the port number in the browser of a system that is present on the same network. It is possible to modify the settings as well as view the live stream from the camera. Motioneye can be configured to store the video and images continuously or only when motion is detected. To access the control panel the valid credentials are required. Hence, it is safe to say that only authorized people can view the feed.

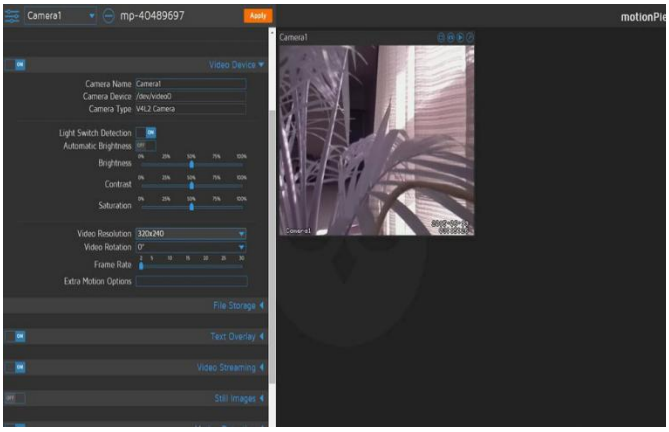

Fig. 5. Motioneye interface with live video streaming

The mobile notification part is handled by a third party service called Twilio which is widely known for it's trusted service. It provides an SMS API to send messages to the registered numbers. This service can be implemented in the system with the help of boilerplate code that is present on Twilio's SMS API documentation. Register with Twilio to get a number and an API key that can be used in the code. Twilio offers different plans depending on the requirement, the free plan is just enough for now. The obtained API key can be used in the code after downloading Twilio python library. So, with the help of Twilio service the owner and the security can be notified of an intrusion or trespassing in the restricted areas by sending a pre-defined text message.

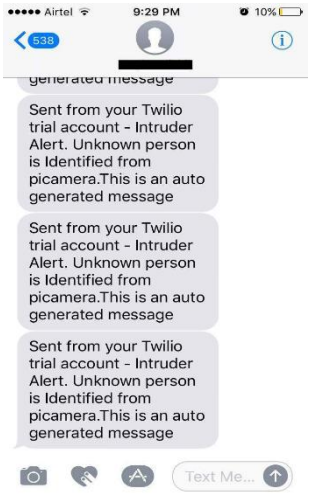

Fig. 6. Text message that is received when an intrusion occurs

Along with the text message an email will also be sent to the owner and the security personnel in case of an intrusion. This can be achieved by adding few lines of code and importing the SMTP library that can send an e-mail with the help of SMTP (Simple Mail Transfer Protocol). The content of the e-mail, receivers can be specified and also the photo of the intruder along with a time stamp shall be attached.

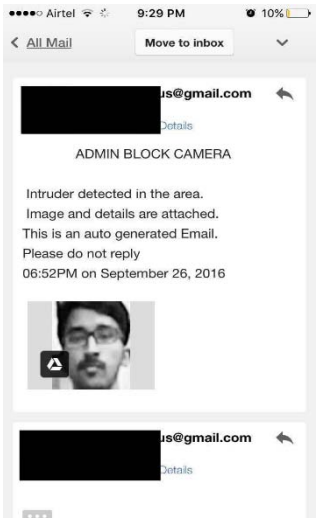

Fig. 7. E-mail that is received when an intrusion occurs

A simple code is written to generate a log whenever a face is detected by the camera. If the captured face is present in the database, then the name of the person along with the time stamp is printed else the word Unknown is printed along with the time stamp and that particular pic is saved in a separate folder to notify the owner and the security.

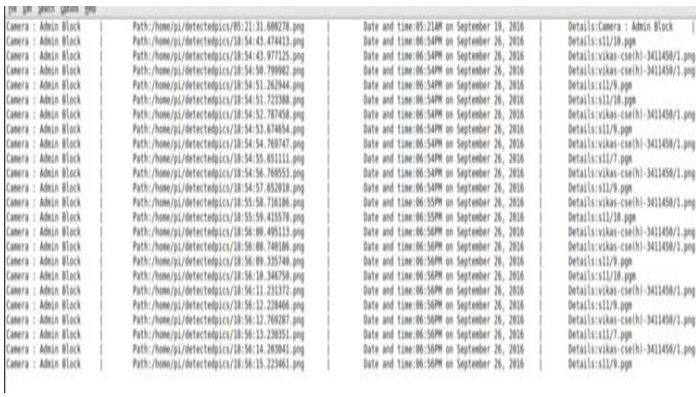

Fig. 8. Sample of the Generated log when a face is detected

Lastly, the whole setup is enclosed in a casing to protect it from dust, rain and also to make it look like a typical surveillance camera. The enclosure can be bought from any hardware store or can be 3D printed if desired.

V. CONCLUSIONS

The proposed system has been built and successfully tested in real time. The results obtained were satisfactory and in addition to this the system being built from the raspberry pi chip consumes less power than the conventional surveillance cameras.

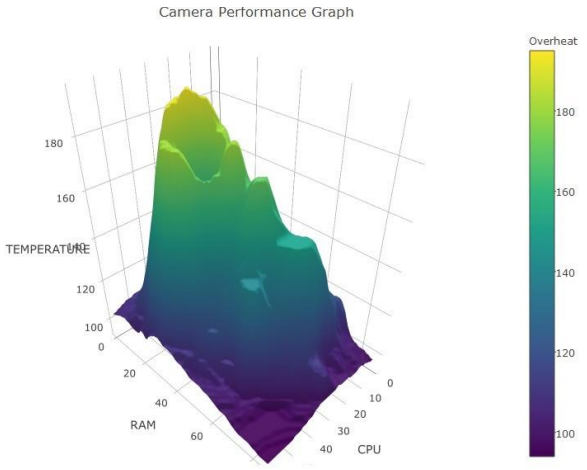

Fig. 9. 3D graph depicting various aspects of the system

A 3D graph depicting the performance of the ram, CPU and the temperature that is generated is plotted with the help of the observed values.

The concern about the intruders and the trespassers can be resolved with the proposed system and can be brought to standstill. Unlike the surveillance systems that are available in the market, this solution offers a smarter and secure automated approach at a lower price. The proposed system has shown satisfactory performance in the real time tests and assets a practical implementation. In the near future, the system would be made to adapt the machine learning capability as well as the recognition accuracy to identify the behavior patterns and alert the security even before an intrusion occurs.

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