ADVANCED SECURITY SYSTEMS FOR HOME SURVEILLANCE

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Abstract*— In modern times, Security and surveillance in households have become somewhat of an especially important necessity. Advancement in technology has made it possible for everyone to access or break into different houses easily. The main purpose of our project is to build an advanced surveillance system that can be used to detect the different faces or any movement that may occur while in the view of the surveillance camera. This system is also supported by an application that has unique features to make it more user friendly for the users. Not only is the user notified when an unauthorized entity is detected, the user is also allowed to add different faces or objects that will be ignored during the process of theft detection. This has been achieved using unsupervised machine learning where a given set of data is compared with the actual live feed from the surveillance camera to check for any anomalies in its surroundings. The Dataset or the data used in the proposed system are a few images in the format of .JPEG and .JPG which can be stored in the given location manually by the user or through the application itself. The proposed model recognizes the images in any of the available formats. The modules used in this system are powered by a strong python module named Open CV. This module supports various face recognition algorithms such as Haar Cascade, Eigen Faces, Fischer Faces, Local Binary Pattern Histogram (LBPH), etc and this module is responsible for all the image recognition, classification, and identification. The images extracted from the dataset are real time Image frames obtained from the user webcam, both are compared using the Face Recognition module in python which uses the Regions for – Convolutional Neural Network Algorithm(R-CNN) and Unsupervised learning approach to detect and differentiate between objects in Real Time. This system also includes a message transmitting feature which works with the help of the Simple Message Transfer Protocol (SMTP) module in python. Whenever an unknown user is identified by the system an email is sent to the admin or the user using the SMTP message transfer module which registers the mail address of the user when the initial setup of the system takes place. Hence a robust, secure and user-friendly device is developed that can always keep your house theft free.

Keywords— Face Recognition, Open CV, R-CNN Algorithm, SMTP Message Transfer Module, Unsupervised Learning.

I. INTRODUCTION

Intelligent homes, also known as smart residential homes, are moving towards wireless remote control, multi-media control, and high-speed data transmission. In recent times safety and security is becoming increasingly popular due to its many benefits, and during these times the safety of one's home should not be vulnerable. At present, there are many surveillance systems that are used in various residential places, but they fail to do the job that is required from them as there are many effortless ways to bypass them. The only purpose that the existing surveillance cameras do is record all the events that may occur which can be easily erased or stopped. Therefore, the project developed is a system that implements advanced machine learning techniques to always keep the residential houses safe and secure. Not only does this system record all the different events that may occur, but it also uses different artificial intelligence techniques, unsupervised learning, and contour detection to detect and recognize different faces that are captured by the camera. At present, the application of intelligent home wireless communication technologies includes IrDA infrared technology, Bluetooth, ZigBee technology, and so on. IrDA is a short distance for half-duplex point-to-point communication. Besides, it is inconvenient and has a high error rate, which makes IrDA not applicable to family network communication. Bluetooth technology is limited by network capacity, and it costs a lot. So, Bluetooth technology is not suitable for home networks with many nodes. ZigBee technology has a moderate transmission range and larger network capacity. The project has made use of Wireless Fidelity, i.e., Wi-Fi. Even though Wi-Fi consumes high power, it has better range, security and supports multiple users at the same time.

II. REALTED WORKS

Jun Hou et al.,[1] proposed a wireless monitoring system that implements real time surveillance of home security. This intelligent remote monitoring system was developed for home security using ZigBee technology and GSM / GPRS network. This system uses messaging and sending mms as a means of warning the user in case of any abnormal activity. The system also uses a variety of sensors to enhance the system's reliability.

Umesh Kapale et al.,[2] Proposed a project that operates in the form of the Embedded Real-Time Surveillance System Based Raspberry Pi SBC for internal detection that enhances monitoring technology to provide critical safety in our lives as well as consistent performance and alert operation. This system depends on the integration of cameras and motion detectors into a web application, where the motion detectors and cameras are controlled using the raspberry pi that monitors all the different activities that occur.

Khanna Samrat et al.,[3] proposed a system that involves remote controlling of appliances, intrusion detection, system security and autoconfiguration such that system automatically adjusts the system settings on running

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hardware support check using different wireless communications and latest mobiles for security purpose.

Xin Zhang et al.,[4] Proposed a home surveillance system that utilizes computer vision techniques to recognize intrusions and detailed threat information including classifying types of trespassers and specific weapons used. This project had 3 distinct stages of computer vision algorithms which include an optimized convolutional neural network (CNN) for threat and intrusion detections, cascading classifiers for locating any potential intruders with correcting mechanism to overcome undetected threats from the first stage, and principal component analysis (PCA) to efficiently train the facial recognizer to accurately differentiate passersby from potential intruders.

Muhammed Javel Iqbal et al.,[5] Proposed an aerial surveillance system that uses quadcopters equipped with state-of-the-art image processing technology that captures detailed photographs of every object underneath. In this project the quadcopter can be used to monitor desired premises for any unusual activities, like the movement of persons with weapons and face detection to achieve the desired surveillance. After detection of any unusual activity, the proposed system generates an alert for security personals. This system makes use of Faster R-CNN algorithm that is modified for fast learning and feature detection.

Ramadan TH Hasan et at.,[6] It is a research paper that presents the main OpenCV modules, features, and OpenCV based on python. It also presents common OpenCV applications and classifiers used in these applications like image processing, face detection, face recognition, and object detection.

Vishvajeet Raj et at.,[7] Proposed a system to detect motion that will aid the existing home security system. This system makes use of the open CV module present in python to achieve the same. Background subtraction of a scene is executed and the frame to be analyzed is kept as the foreground. Therefore, a background is obtained from which subtraction is done to get the unique frames. As a result, a scene with a black heritage is obtained where movement can be detected.

Chaoyu Lin et al.,[8] Proposed an advanced surveillance system where they use a real time priority method and some improvements of moving object detection to make a moving object detector using OpenCV and DirectShow Framework. By using different object detection techniques along with different OpenCV modules for background extraction and background subtraction, a live motion detector is made.

Arjun Raj A et al., [9] Proposed a smart attendance system that is based on face recognition done using the python module OpenCV and a raspberry Pi. This application makes use of LBPH face recognizer to identify the face of the person in real life. It then compares the image with the training data to determine who is present and who is not.It also makes use of GSM to send a message to the parents phone number if the student is absent.

Maliha Khan et al.,[10] Proposed a principal component analysis face recognition system that aims to reduce the large amount of data storage to the size of the feature space that is required to represent the data economically. This system was made in python using the OpenCV module as well various algorithms for face recognition such as Haar Cascade, Eigenface, Fisher Face and LBPH.

Mangesh Kale et al.,[11] Proposed an attendance system used to manage student class attendance using the face detection and openCV module. This project was made using the haar cascade algorithm along with the local binary pattern histogram for face recognition and detection. The training for each student is done after which the system generates a spreadsheet which provides the number of students present in classroom.

Souvik Das et al.,[12] Proposed an image recognition system from videos and images using haar classifier in python. They have used the OpenCV module for face detection. They then obtain an accurate and speedy tracking of the head positions. This technique is predicted on utilizing python for correct classification and identification of the face.

Ashlesha Shembekar et al.,[13] Proposed a project which provides a secure automatic door unlock using raspberry pi. The Pi camera is used for capturing the images which then makes use of the OpenCV module to train and store human faces for recognition. If the image captured matches with the authorized used then the system supplies power to unlock the locker.

Dr Dinesh D. Patel et al.,[14] Proposed a research project that made use of the face recognition in OpenCV module to make an attendance system. A training database was created by training the system with the faces of the authorized people. They are then saved which is later made use of to detect and compare the faces to indicate whether a student is present or not.

M.Jayamanmadha Rao et al.,[15] Proposed a high-level security system in ATMs by making use of the OpenCV module in python to analyze the person authorized identification by capturing the human face. First the user must enter the PIN number and if it is correct authorization is done otherwise an OTP is sent to the user's phone. If authorization is done then transaction is completed otherwise it is declined. Once the transaction is completed a mail is sent to the user with the image which was captured at the time of withdrawal.

III. METHODOLOGY

The work presented here involves VI stages. These stages are Data Collection, Data Encoding, Data Comparison, Anomaly detection, Message Transfer through Email and User System Interface, Unsupervised learning, model accuracy.

A. Data Collection

This program works on the basis of standard RGB based images. These images are further encoded into 3 Dimensional vectors for the model to understand and compare them with the testing data. Data collected for this program is either in the form of .jpg or .jpeg format. These images are obtained when the user chooses to add a certain image to the path that the project has provided in the system through the application. The image is captured instantly the moment the camera recognizes that it is an image which is not present in the dataset and adds it to the mentioned path.

B. Data Encoding

To compare two forms of data, our raw format of data needs to be converted into 3d vector format. This is achieved by

using a python module named open cv where the project is given the data by attaching a certain path which is used to extract the images either in a windows or Linux operating system After the images are extracted the data is then encoded into 3D vectors and now these images are totally in the form of usable data. After the images from the mentioned path have been encoded, the image samples from the live camera enter the further process of encoding. Frame by frame image from the camera is encoded first and now the image samples are ready to be compared.

C. Regional for – Convolutional Neural Network

Regional for – Convolutional Neural Network is a two-stage detection Algorithm. The first stage identifies a subset of regions in an image that might contain an object. The second stage classifies the object in the region. It uses the concept of Edge Boxes where the objects in the image are cropped out and are resized. Then the Convolutional Neural Network classifies the cropped regions. Finally, the regions that are bounded by boxes are trained using CNN features. Similarly, Open CV uses this algorithm to classify objects as an object is first captured from the image and then CNN features are applied to the objects in the image to classify or differentiate between other images or find similarities between them.

D. Equations

After the given number of images have crossed the level of encoding, they are ready to be compared for the similarities in physical appearance. This is achieved by using another module in python called the face recognition module. In this module no prior dataset is given to be trained, instead the images that are encoded are used as a cluster of vectors for the model to learn and to be trained. This approach of training the model is called Unsupervised learning. From what it has learned, it predicts whether the testing data which is received from the camera as a sample in the form of vectors is matching with the data that is have provided. If the vectors that are being compared are matched, the id which is stored for that particular person is reflected and if it recognizes an unknown person counter measure are taken.

E. Some Common Mistakes

When the device has encountered a person, whose image is not given in the data set, the person with his photo is sent to a new folder where his facial data is stored and this data is further sent to the user if he wants to add it to the data set or ignore it for once. If any person attempts to move an object off the frame or displace it from the camera frame, the system captures that and an alarm system is triggered to alert the user that a particular object has been displaced from that particular camera frame.

F. Message Transfer through Email & User System Interface

The user is given an interface to control the working of this system and this is achieved in the form of a mobile application. The mobile application is developed using the Python Kivy Framework. This framework helps us solve the problem of attaching the backend DVR console of the camera system to the front-end GUI elements of the application. Once the Camera system has identified an Unknown person the DVR sends an email to the registered user and this email is further acknowledged by the application. This is achieved by having active internet connectivity and registering the MAC address of the particular DVR console in the application. Simultaneously, A notification is received on the application as well alerting the user whenever an unknown entry is encountered.

G. Unsupervised Learning

This particular system uses the help of unsupervised learning. In unsupervised Learning a particular system is neither trained nor tested for accuracy or prediction of testing data. In Unsupervised Learning the model gets a cluster of points or in our case a cluster of images (in vector format) and this cluster is further used to predict the data is further provided through the camera. Mainly the module used in this project is OpenCV which is used for comparison of two facial structures. OpenCV uses the R-CNN algorithm. The model accuracy recorded for the tested prototype gives an approximate value of 98%.

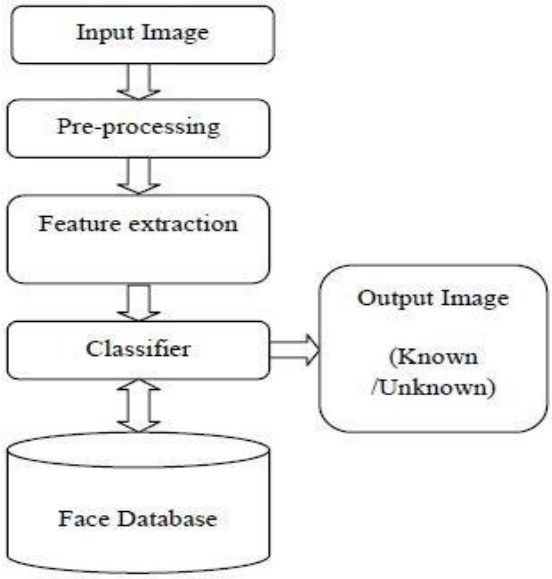

Figure. 1. shows the block diagram that represents the complete flow of data in our application.

H. Our model when compared with other models

Model	%WER
Xin Zhang et al. [4] (Trained CNN)	97.12
Xin Zhang et al. [4] (Multi SVM)	75
Xin Zhang et al. [4] (LMK NCN)	90.64

Ramadan TH Hasan etal.[6] (Haar-Like CMT Cascade)	68
Ramadan TH Hasan et al. [6] (Extra Tree)	86.4
Ramadan TH Hasan et al. [6] (RadialSVM)	97.4
Proposed Model (R-CNN)	98

Table 1. Published Error Rates

Table 1 shows the %WER of different techniques. This Project uses the R-CNN Model respectively. Under the Trained CNN model by training the model with 96×96×3 images, CNN can extract features, such as eyes and faces, from each layer and detect trespassing objects in various conditions. The training loss, validation loss, training accuracy and validation accuracy of the trained CNN, are 5.92%, 8.68%, 97.73%, 97.12% respectively for the final epoch. The CNN is trained by datasets with 75 epochs and 30 batches for each epoch. Our trained CNN achieves higher accuracy of 97.12% to detect multiple trespassing objects, compared to 75% for Multi SVM algorithm and 90.64% for LMKNCN algorithm. Haar Cascade is an effective method for detecting objects. It's a machine-learning-based method in which a cascade of actions is learned from a large number of positive and negative images. It becomes used to seeing things in different frames. Haar Cascade also has a total value accuracy of 68%. The Extra Trees algorithm works by creating a large number of unpruned decision trees from the training dataset. Predictions are made by averaging the prediction of the decision trees in the case of regression or using majority voting in the case of classification. It has a total accuracy of 86.4%. Radial kernel support vector machine is a good approach when the data is not linearly separable. The idea behind generating non-linear decision boundaries is that the project needs to do some nonlinear transformations on the features Xi which transforms them into a higher dimensional space. This model has a total accuracy of 97.4% and has the best accuracy. When compared this model to the other models like CNN or trained CNN, the faster R-CNN was superior in all parameter tests compared to CNN with a difference of 6.14% for accuracy, 17.28% more precision, and 19.06% for recall value.

I. Tested prototype with computer camera

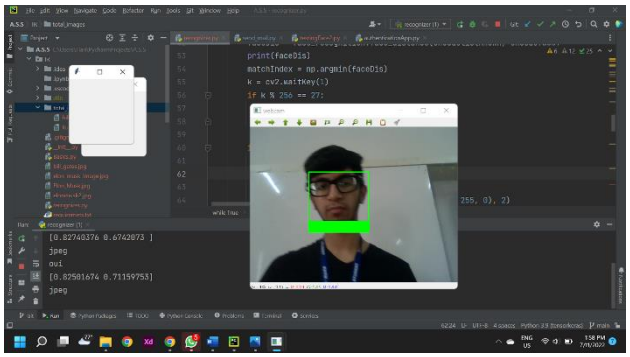

Fig 3.7.1 Face unidentified whose image is not stored

Figure 3.7.1 shows that an unidentified face has been detected as it does not recognize this face as a part of the dataset that was given initially.

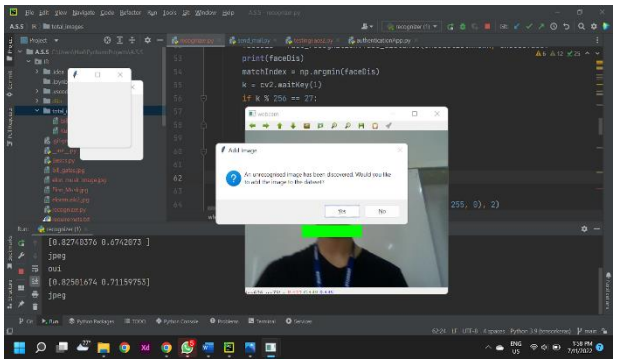

Fig 3.7.2 Unidentified Face Detected, Request to Add It to The Dataset

Figure 3.7.2 acknowledges that the face detected is unidentified and it makes a request on what step to take next, i.e., to add this face into the database or send an alert.

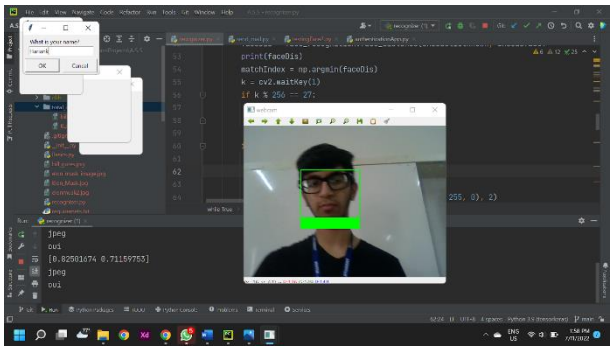

Fig 3.7.3 Adding Unidentified Face to The Dataset

Figure 3.7.3 requests a name for the new face that was detected so that it can be added into the existing database.

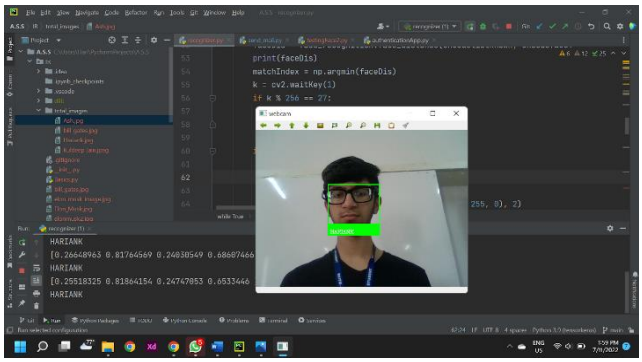

Fig 3.7.4 Face Added and Is Now Recognized

Figure 3.7.4 shows that the face has now been added into the database and it can now be recognized.

ACKNOWLEDGMENT

The work presented here provides a new insight on the importance of security in houses and a very efficient way to do so. Using this system will help us achieve an intelligent home that works on a low-cost, low-power wireless communication network. The system is also user friendly as the users get immediate notification as well as an email whenever an anomaly is detected. The app also offers many other features that enables everyone to easily use and control the surveillance systems at any point of time. Further the face detection algorithm can also be applied to different objects present in the household and the project can extend the program to not only detect different faces but also to keep track of all the different objects present in and around the house.

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