Face Recognition Based Home Security System

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A thesis submitted to the Department of Electrical & Electronic Engineering in partial fulfillment of the requirements for the degree of
Bachelor of Science

Electrical & Electronic Engineering
BRAC University
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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

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Ethics Statement

We, hereby, declare that this thesis is based on results we found ourselves. The materials of work conducted by other researchers are mentioned in References. This is to affirm that this thesis report is submitted by the authors listed for the degree of Bachelor of Science in Electrical and Electronic Engineering to the Department of Electrical and Electronic Engineering under the School of Engineering and Computer Science, BRAC University. We, hereby, declare that the research work is based on the results found by us and no other. The materials of work found by other researchers have been properly acknowledged. This thesis, neither in whole nor in part, has been previously submitted elsewhere for assessment.

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We would like to express our utmost gratitude to several individuals for their guidance, support, motivation and inspiration in accomplishing our Thesis project. Only by means of their constant financial, intellectual and spiritual support, this work has been completed.

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Abstract

With the help of recent technological advancement the world is moving towards an era of advance security systems. For every single purpose or system the main concern is safety. As software based security system creates a good vive in the security industry because of its robustness so people are more interested to use it in different places like office or even at home. For ensuring an efficient security system and a solid surveillance camera vision has been used vastly nowadays. In this research an image processing based low cost home security system has been approached for home safety and surveillance. Different image processing algorithms based on python, deep learning, Convolutional Neural Networks has been used for better output. Algorithm based on Haar Cascade Classifiers using open CV gives the desired results for low cost components. An IOT based mobile application which is also a part of the total system helps the user to ensure a notification based surveillance system when the user is away from home. Different experimental analysis based on different data sets justify the efficiency as well as sustainability of the total system for real life scenario.

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1.1. Introduction:

Protection of any kind of system is one of the major factors to make an effective model. In this 21st century everyone is concerned about the security issues of any system as almost in every sector uses of software has been increased day by day. Almost in every system software based solution has been incorporated for better and easier operation. If we take security for any structural monument or any building as an example then we can see that there are also different types of software based surveillance system used for security purposes. As IOT is expanding day by day in this modern era that's why people are interested in using software based home security system so that they can do surveillance when they are away from home. In this research a home security system has been approached based on image processing and IOT. As verification is a key section for security system so image based verification will work flawlessly in this system. Different algorithm has been approached for getting the best result. Algorithm based on python, deep learning and convolutional neural networks has been approached for image processing. OpenCV based haar cascade classifiers also been approached for processing the images. As IOT is getting more popular day by day an ip based web application has been approached for notification based surveillance where user can

directly give their decision to the system when they are away from home. Different types of data set has been collected for training and verifying the total system.

1.2. Motivation

In this era of technological development all the developing countries are enjoying the modern technologies to develop their lifestyle. With the help of new devices everyone enjoys an easier daily life. In countries like Bangladesh where the price of technological devices are high and everyone cannot afford modern devices, there we can introduce a new low cost device for home security so that people can enjoy technology within a low cost. As most of the people are interested to use new technologies so the low cost solution will surely fulfill the needs accordingly. With the motive to provide a low cost smart home security system to the general people of our country we have chosen this topic. We get motivated from the desire of general people who really wants to enjoy a life full of technology.

Chapter 2: Literature Review

For making an effective research gathering knowledge from related previously done work is one of the main factor. As the system is based on face detection so we have focused on previous research work based on face recognition and different algorithms. Different IEEE research paper has been studied for collecting the related knowledge. Firstly a paper with a title of A Fast Face Recognition System Based on Deep Learning [1] has been studied. In this paper a real time face recognition method based on FPGA has been proposed. This method makes an accurate and fast face recognition system. The accuracy rate for this system is nearly 99.25%.

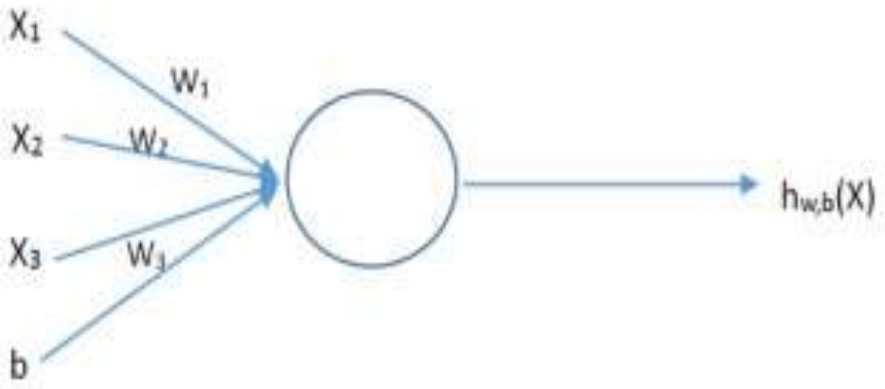

Fig.1 Neural Network for FPGA Method

The next paper we have go through has a title FaceTime — Deep learning based face recognition attendance system [2]. In this paper the total process of developing a face recognition system based on deep learning has been described.

Convolutional neural network has been used for face detection and face embedding. The overall accuracy of this system is 95.02%.

Fig.2 Face recognition model based on Deep Learning

The next paper we have go through with a title of Secure and Hassle-Free EVM through Deep Learning Based Face Recognition [3]. In this paper an EVM system has been approached which can capture the facial movement of a voter using a deep CNN based algorithm and also it can verify the facial movement with the pre captured data sets. After completion of voting the data will be erase from the database for removing the extra load.

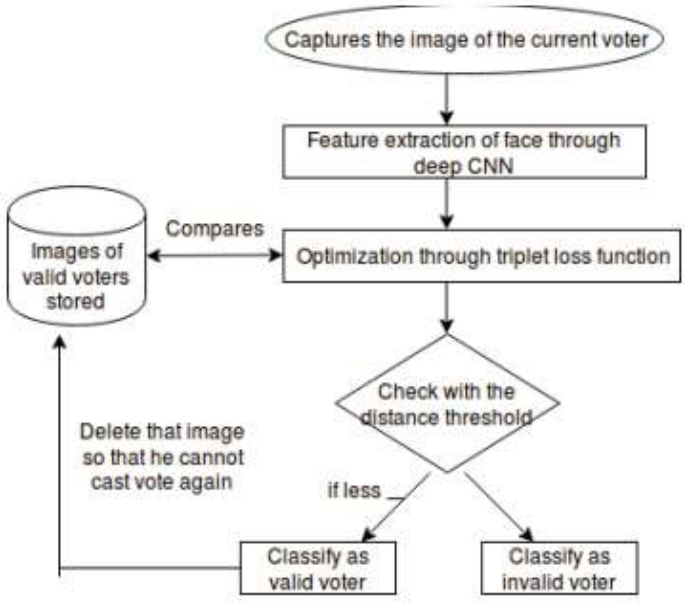

Fig.3 Face recognition based EVM block diagram

The next research paper we have studied has a title of Occluded Face Recognition Based on the Deep Learning [4]. In this paper a new method has been approached for recognizing the occluded face using deep learning. The system for the recognition has been trained using the CNN & deep learning. The achieved accuracy of this model is up to 98.6%.

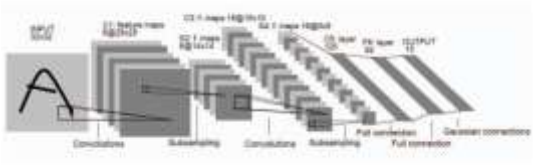

Fig.4 Occluded face recognition model

The next paper with a title of Robust deep learning features for face recognition under mismatched conditions [5] has been studied. In this paper a system has been described for face representation based on deep learning. The system is trained using the VGGFace2 dataset. The system used CNN based models to extract 2048 dimensional vectors from the images of different faces. The system achieve 91.8% of accuracy cumulatively.

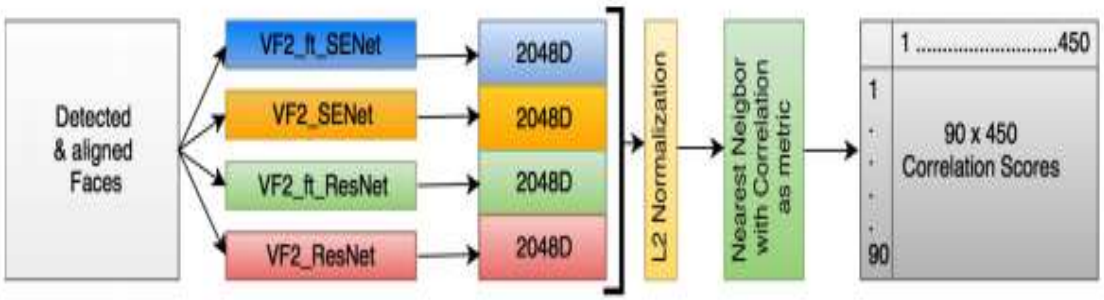

Fig.5 Robust model for face recognition based on deep learning

The next research paper we have studied has a title Missing Child Identification System Using Deep Learning and Multiclass SVM [6]. In this paper a model has been described for identifying reported missing children using the photos from data set. The Convolutional Neural Network and a deep learning process with highly effective procedure has been used for the recognition of face. The accuracy of this model is 99.41%.

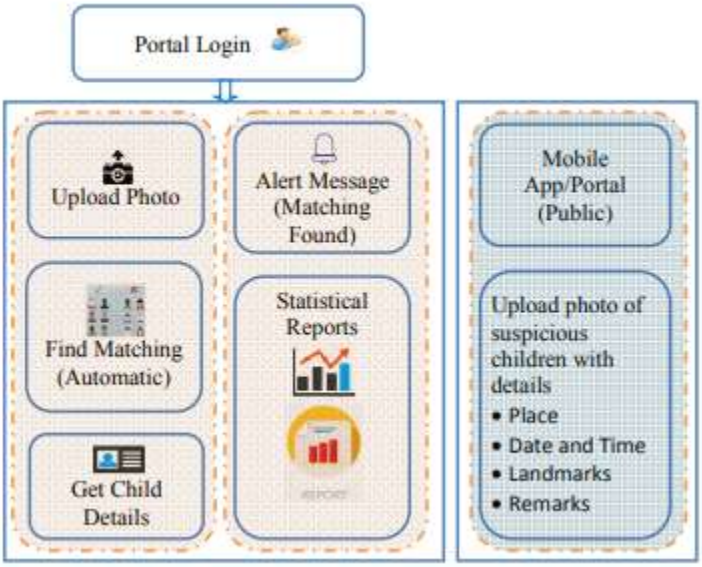

Fig.6 Child face identification model using deep learning

The next paper we have go through has a title of Double Supervision Face Recognition Based on Deep Learning [7]. In this paper a new type of model named double supervision face recognition has been discussed for identifying the problems regarding to face recognition based on deep learning. Two different types of supervision named softmax & triplet has been used for this model.

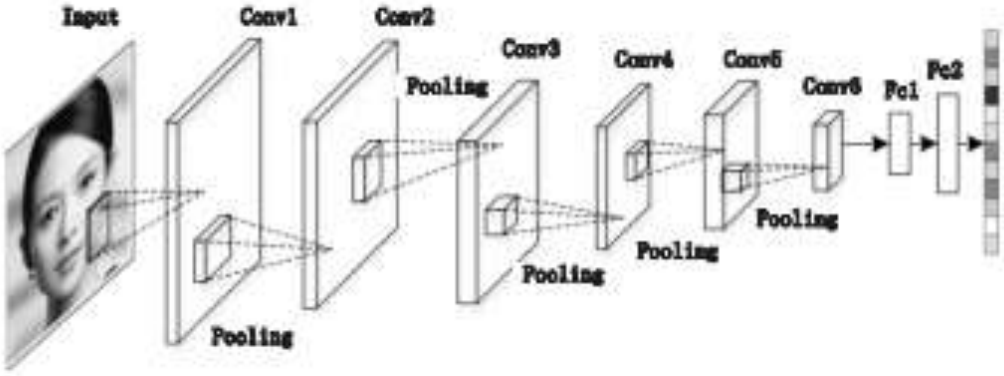

Fig.7 Double supervision based face recognition model using deep learning

The next paper with a title of FDAR-Net: Joint Convolutional Neural Networks for Face Detection and Attribute Recognition [8] has been studied. In this paper for face detection and face attribute recognition a jointly build novel Convolutional neural network called as FDAR-Net has been approached. The FDAR-Net can detects 71 frames per second with a constant accuracy.

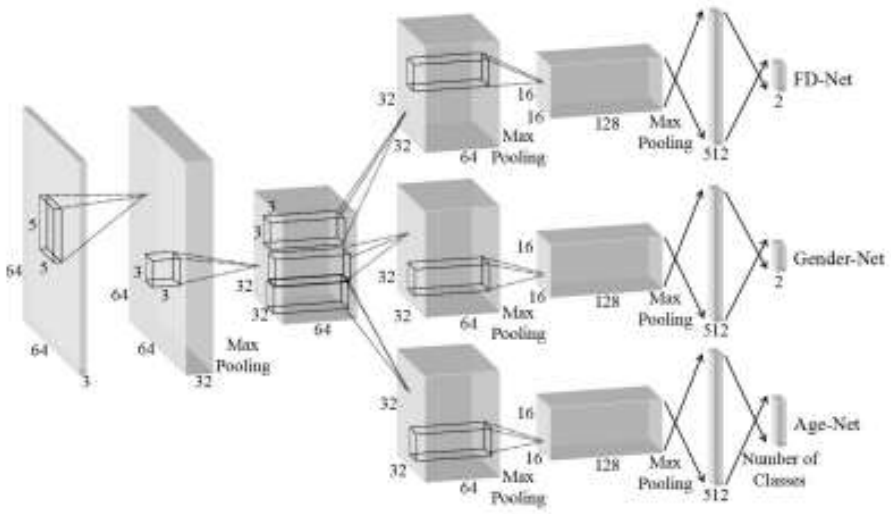

Fig.8 FDAR-Net Joint CNN for face recognition

The next paper has been studied named Trunk-Branch Ensemble Convolutional Neural Networks for Video-Based Face Recognition [9]. In this paper a framework has been discussed based on convolutional neural network for video based face recognition.

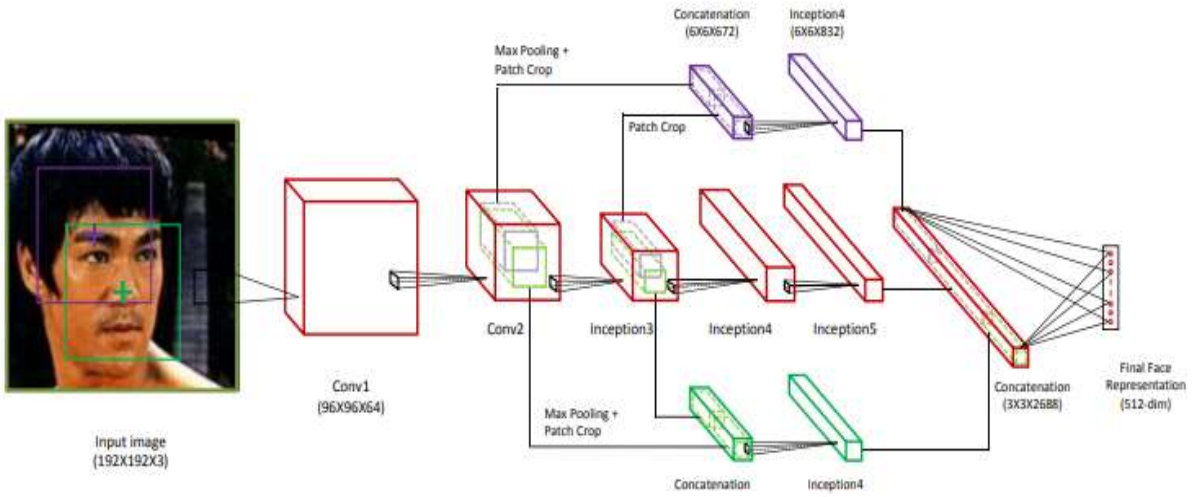

Fig.9 Trunk-Branch Ensemble Convolutional Neural Networks for Video-Based Face Recognition

The next paper has been studied with a title of The Effects of Augmented Training Dataset on Performance of Convolutional Neural Networks in Face Recognition System [10]. In this paper a few number of images of the employees of an office has been taken as data set using different filters. Finding the suitable data augmentation option for face recognition by trying different data augmentation is the main focus of this paper.

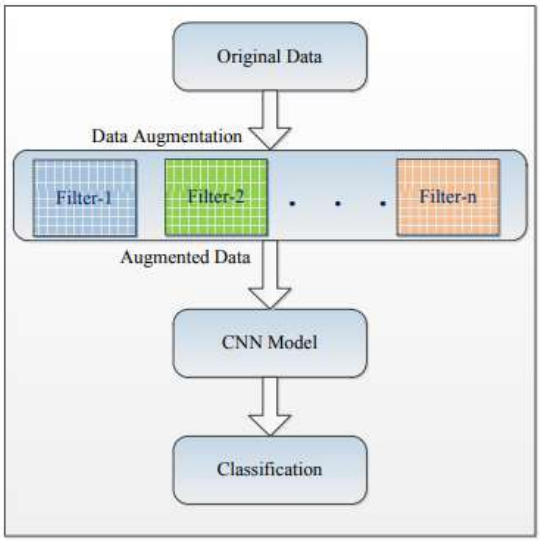

Fig.10 The Effects of Augmented Training Dataset on Performance of Convolutional Neural Networks in Face Recognition System

The next paper with a title of Thermal face recognition using convolutional neural network [11] has been studied. In this paper an architecture of a convolutional neural network has been described for thermal face detection. Difference between conventional recognition like LBP, HOG with CNN has also been discussed in this paper.

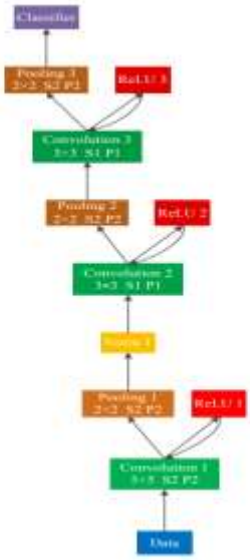

Fig.11 Thermal face recognition using convolutional neural network

The next research paper we have studied named Face recognition from near-infrared images with convolutional neural network [12]. In this paper for recognition of NIR face, a convolutional neural network has been discussed. The proposed system has been experimented with PolyU-NIRFD database and the recognition percentage is also higher.

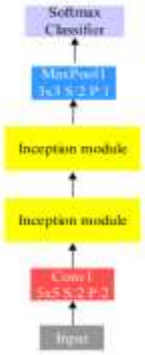

Fig.12 Face recognition from infrared images with convolutional neural network

The next paper we have go through is Facial Expression Recognition using Convolutional Neural Network on Graphs [13]. In this paper different steps has been followed for recognizing the facial expressions on graphs. Images has been converted to undirected graphs by combining fixed & random points method. Proposed method has been evaluated in CK+ and JAFFE datasets and the percentage of recognition is higher.

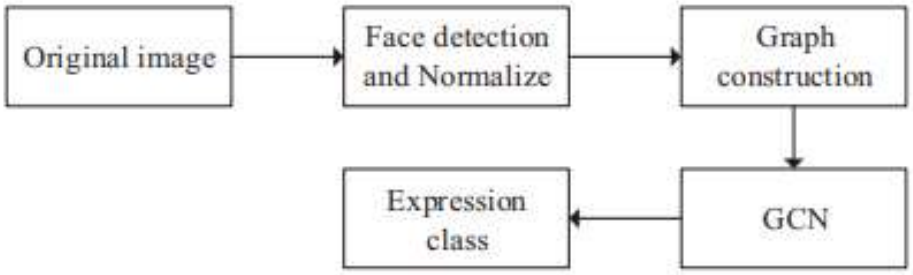

Fig.13 Facial Expression Recognition using Convolutional Neural Network on Graphs

The next research paper named Face detection and recognition for home service robots with end-to-end deep neural networks [14] has been studied. In this paper a deep convolutional neural network based face recognition framework has been proposed for home service robots. A robot is also been developed based on the proposed framework. Different experiments are conducted on WIDER and LFW datasets for verifying the system.

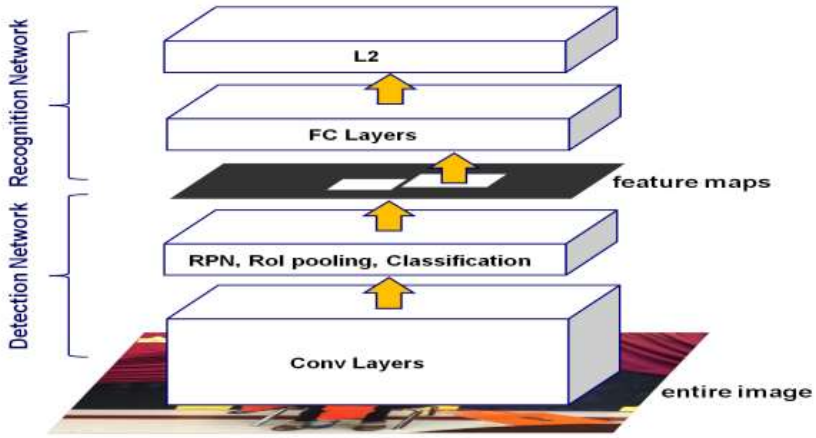

Fig.14 Face detection and recognition for home service robots with end-to-end deep neural networks

The next paper we have studied is Deep convolutional neural network applies to face recognition in small and medium databases [15]. In this paper a combination of local binary pattern (LBP) and deep convolutional neural network has been approached for face recognition. In this research local binary pattern (LBP) features of face images has been taken as input in CNN network to diminish the possibility of poor stability of CNN gray scale.

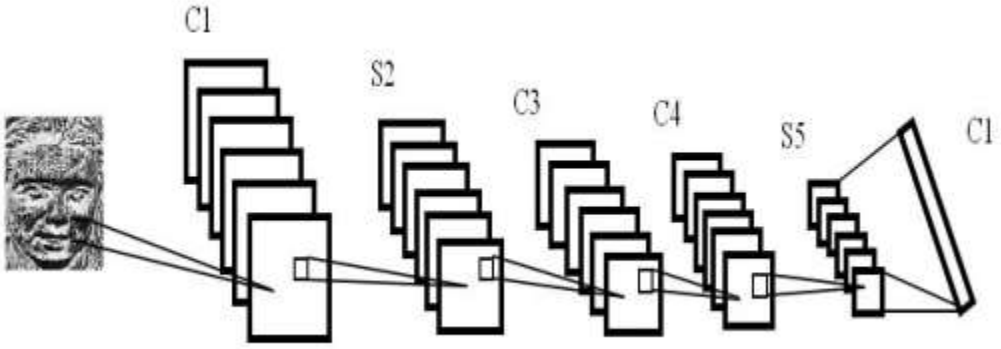

Fig.15 Deep convolutional neural network applies to face recognition in small and medium databases

The next paper named Multi-Faces Recognition Process Using Haar Cascades and Eigenface Methods [16] has been studied. This paper proposes a solution for making a fast face recognition system. This proposed system works using a hybrid process of haar cascades and eigenface method. This system also detect multiple faces within a solo detection process. The accuracy of this proposed method is 91.67%.

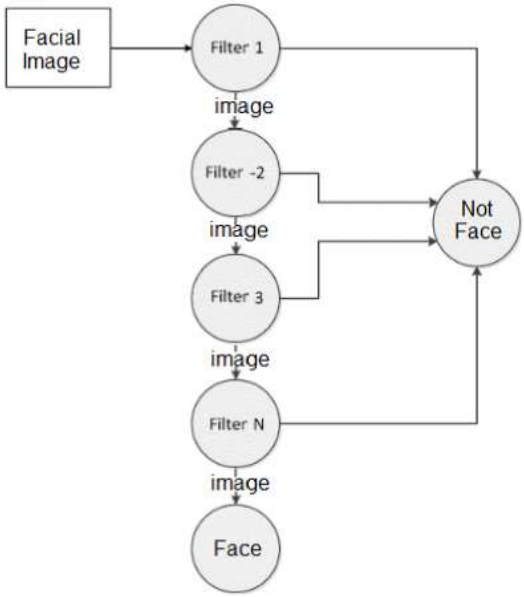

Fig.16 Multi-Faces Recognition Process Using Haar Cascades and Eigenface Methods

The next research paper is studied with a title of Face Detection using Haar Cascades to Filter Selfie Face Image on Instagram [17]. In this paper a model has been discussed for filtering the selfie images from Instagram based on search result using data extraction & human face detection technique with haar cascade method. According to the experiments this proposed method has an accuracy of 71.48%.

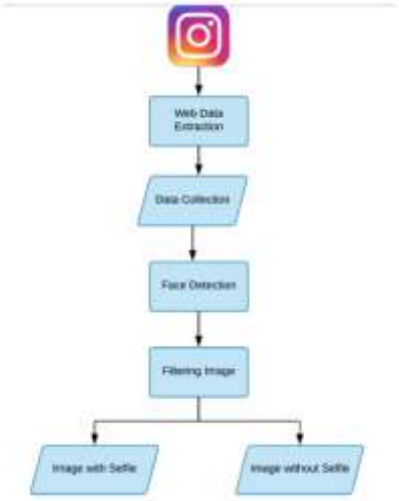

Fig.17 Face Detection using Haar Cascades to Filter Selfie Face Image on Instagram

The next paper we have go through is Face Detection Using Haar Cascade in Difference Illumination [18]. In this paper a face detection method has been described using the haar cascade in difference illumination. The proposed system recognizes faces with different illumination.

Fig.18 Face Detection Using Haar Cascade in Difference Illumination

The next paper we have studied named Eye-gaze tracking system by haar cascade classifier [19]. This paper proposes a real time Eye-gaze tracking system using the haar cascade classifier.

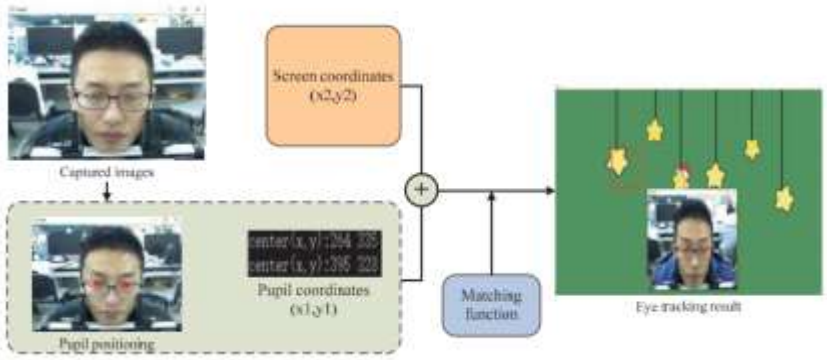

Fig.19 Eye-gaze tracking system by haar cascade classifier

The next paper with a title of Thermal image human detection using Haar-cascade classifier [20] has been discussed. In this paper a method has been approached for

detection of human presence on thermal images using haar cascade classifier. The method can detect multiple human face image at a time.

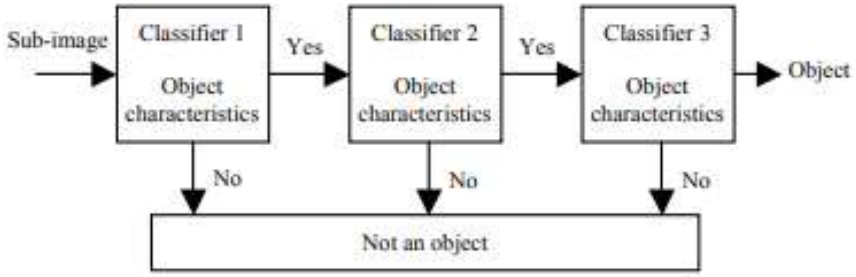

Fig.20 Thermal image human detection using Haar-cascade classifier

The last research paper we have go through named Haar Cascade Algorithm for the Visually Impaired to Detect and Recognize Objects [21]. In this paper a model has been approached which can detect and recognizes objects using haar cascade classifier. The model is consist of Raspberry pi, camera and an audio feedback device. Mainly the proposed system provides information about objects to the blind people for their help.

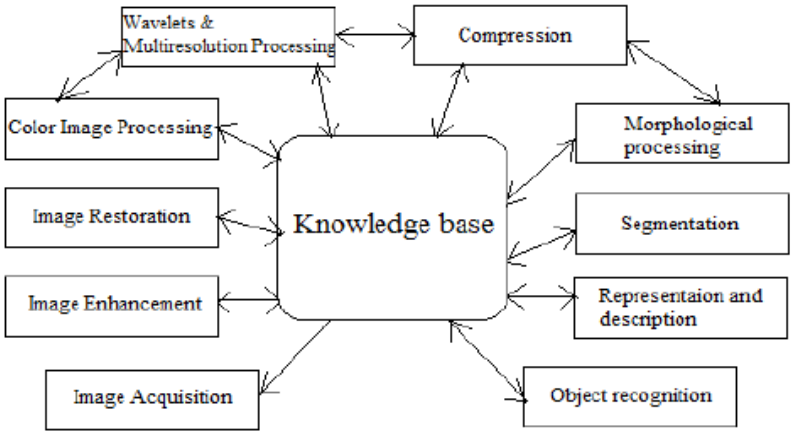

Fig.21 Haar Cascade Algorithm for the Visually Impaired to Detect and Recognize Objects

Chapter 3: System Overview

The proposed system is consist of different sections, so the total system is divided into three major subsystems. Each of the subsystem work collaborating with each other for a better outcome. The subsystems are as follows

Hardware: In this subsystem we have developed a module for collection of images so that it can be processed in the central processing unit to control the lock of the door. This subsystem consists of two different sections. The sections are as follows

Device: As our system is fully dependent on the image processing and detection of human faces so we need to collect the face data from the outside of the entrance of any home. That's why a device has been developed. This device consists of a Raspberry pi, a camera module and a desktop computer. The camera module is compatible for the Raspberry pi. The camera module will collect the face data as images from the outside of the house. Then it will initially process it in the Raspberry pi for making it compatible for the desktop computer for final processing.

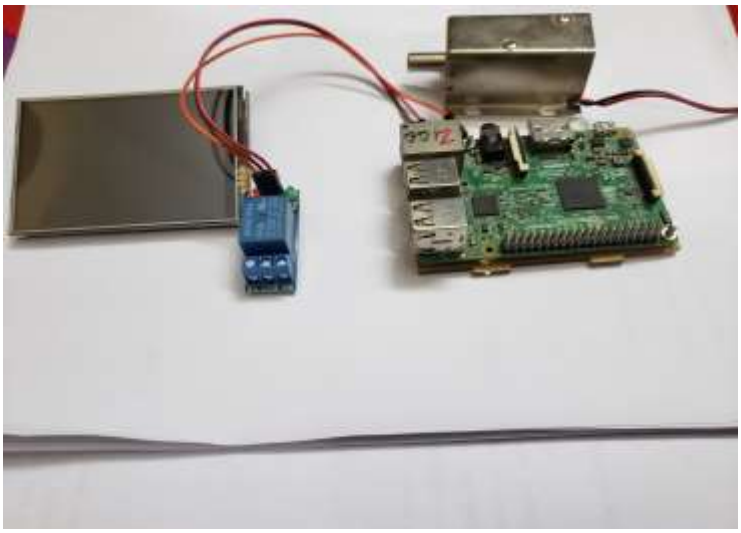

Figure 3.1 Central Device Raspberry pi and relay

Locking System: As our model is for ensuring home security so the main criteria for our system is locking the main door of a home so that based on face detection command system can open the door. For that we need to control the door lock. As conventional door locks are fully manual which cannot be controlled by virtual of wireless commands, so we have used an electric controlled lock for this system. The lock with a dimension of 54mm X 38mm X 27mm generates linear motion using solenoid. The lock operates with 12V DC power source. The operating current of this lock is 1A. When there is no power connection in the lock then it will be in locked position and when the lock is connected with power then it will be in unlock position.

Figure 3.2 Solenoid Lock

Software: Different types of software has been used for dedicated task for this system so that the performance of each section can achieve maximum percentage of accuracy. We have used two different types of software for executing our commands. The software are as follows

Portable Desktop Software: For the final stage of image processing and the detection of face we have used a portable desktop software named Open CV. The software is highly known for real time computer vision. As our system needs to detect human faces in real time that's why this software will help us to detect face.

As this software is platform independent so we can use them in any kind of operating system. Also there are a couple of library offered by the software which will help us to achieve our goal. This software is installed in the desktop computer so that it can be operated using python commands. When the device send the face image data to the central processing unit then the software will take them as input and start processing them as custom designed commands and detect faces.

IOT Mobile Application: As our system offers a notification based surveillance so IOT has been included in the system. A custom designed software has been designed for enabling IOT in the system. The developed software can access the main system through IP address. When the system finds an unknown face as input then it will directly send a notification to the custom designed IOT software. If the user is outside of home at that moment then user can see the captured image on their phone through the IOT software and also send a command to the main system through IP. If the command is negative then the system will not unlock the lock and if the command is positive then the system will unlock the door so that the person can get entry. In this way IOT has been incorporated into this system.

Chapter 4: Methodology

Face Recognition: There are a lot of possible methods available for detection of human faces. As we are focused on generating maximum amount of accuracy for our face detection method so we have decided to try a couple of selected methods for our system so that we can select the final method for detecting face through our system. The methods are as follows

Open CV using Python & Deep Learning: This is the first method we have tried for our system. In this system we have used deep learning for recognizing the face. Generally for deep learning the designated network has been trained to take input a single image first. Then it will make an output or leveled that image per instructions. But the method deep metric learning is dissimilar from the conventional method. In this method the output is not a single image with level, but a feature vector with real value. For a test case we have used a random picture which has an output feature vector 128-d. This feature vector will help the system to detect the face. For train up the network we have used triplets.

Python Based Classical & Deep Learning: This is the second method we have applied into our system to recognize faces. In this method we have used classical and deep learning along with python. Total three steps has been incorporated in this method. For this method we have taken a random test image. Firstly the system will generate an image pyramid from the input image. Then the system will process the image in three different ways. The model is named as multi task network as

each of the sections are trained in separate task. Based on those three process the system the system makes three different kinds of prediction named classification of face, Bounding box regression and localization of facial landmark.

Convolutional Neural Networks Using Dlib: This system is based on convolutional neural network (CNN) which is also a network with feed forward quality for computer vision. Automated image pretreatment with a dense neural network has been offered by this system. Data set with grid like topology can be processed with CNN. In this process firstly input image has been combined with a set of filters. Based on the number of filters we have to choose the parameters and dimension for this system. The filter dimension for this system is named as stride length. Conventional values for dimension is in between 2 and 5. For the test case the output of CNN for this system is in binary style. If there is any face detected by the system then it will show 1 otherwise it will show 0.

Haar Cascade Classifier Using Open CV: This method is fully depended on cascade classifier which will operate with Open CV. For this system the classifier will be trained with hundreds of sample images to grab the face we want to detect. After the training of cascade classifier the system will match the real time face image with the training data set for detection. In this system four steps will be followed for generating best results. The steps are selection of haar features, integral image creation, training of adaboost, cascading the classifier.

After analyzing four different methods we have found that the last one named haar cascade classifier based face detection using Open CV is the best compatible for our system. As this system needs less processing features which can be covered by a low cost system, so we have selected this method for our system.

Methodology: This part is mainly focused on how we have developed the system and the methods we have followed for executing our system in real scenario. This total methodology part is divided into three different sections. They are as follows

Dataset Collection: For haar cascade classifier the first criteria is to collection of dataset. As we are ensuring home security so we need to collect datasets as much possible. In opencv we have generated a custom command based on python by running this command we can automatically collect hundreds of pictures of a single persons face through the webcam. As the python command is too much smooth that's why we have generate a faster dataset collection procedure.

We have selected three different people for collection of data. For three people we have generate 300 different picture through our python command. We have spent 2-3 minutes for generating all the datasets pictures which showed that the system is faster.

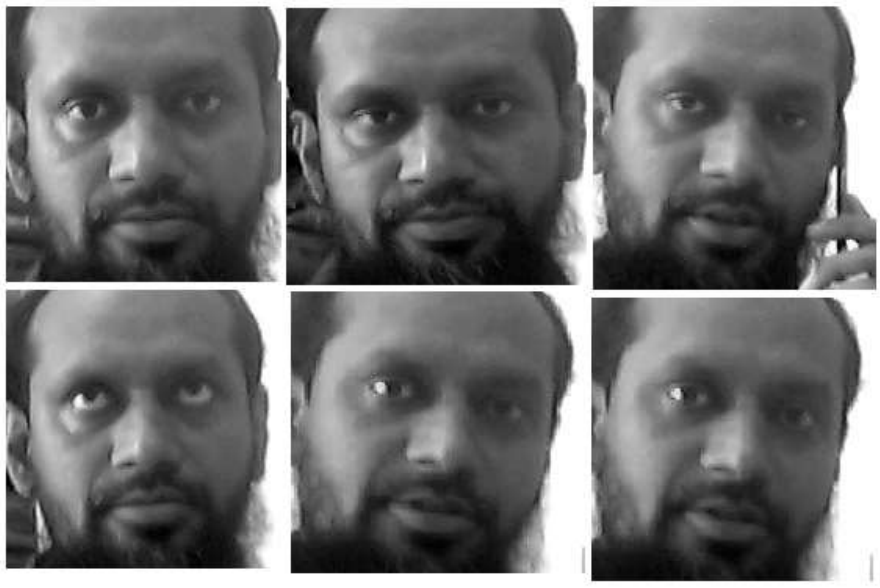

Fig 4. Dataset-1 Md.Khalilur Rhaman

Fig 4. Dataset-2 Sadman

Fig 4. Dataset-3 Wadud

Training Dataset: After the collection of data sets we have to train the data set or we have to train the cascade classifier. There are couple of steps we need to follow for this training procedure. The steps are as follows

Haar Feature Selection: In this portion we need to focus on different point of an image input. If we classify the image model based on the criteria then we need to focus on dark eye region with a comparison to cheeks. The bridge region of the nose with a comparison to the eyes. Some specific location of eyes mouth and nose.

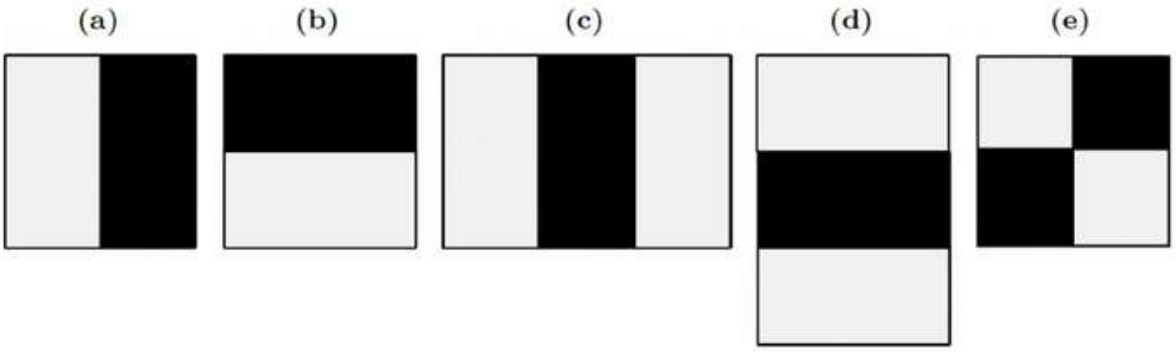

Fig 4.1. Haar rectangle

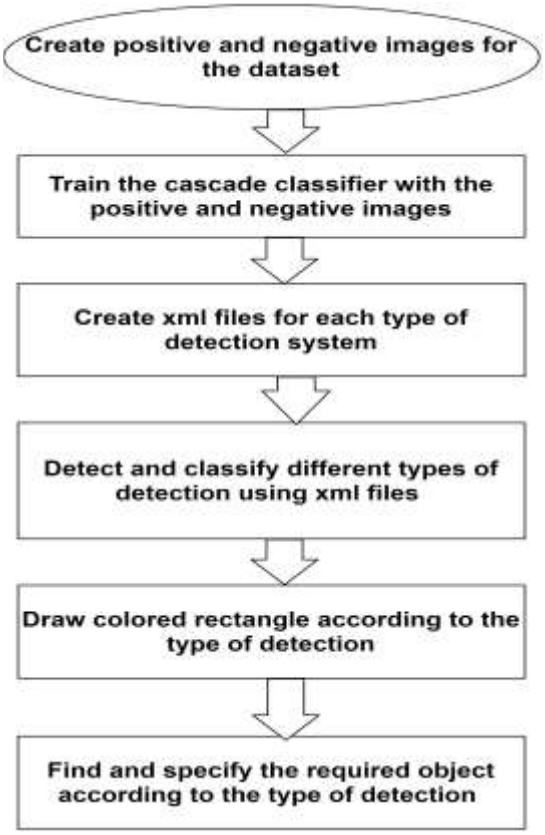

Figure 4.2 Flowchart of training cascade classifier

In the above picture we have five different types of rectangle a,b are mainly for edge detection, for detection of lines in the images c,d has been used. In the e it is diagonal pair of rectangle.

Figure 4.2: Recognition of Face

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