COMPARISON OF ALGORITHMS FOR THE DETECTION OF OCCLUDED FACES

Project report submitted in partial fulfilment of the requirement for the degree of Bachelor of Technology

in

Computer Science and Engineering/Information Technology

By

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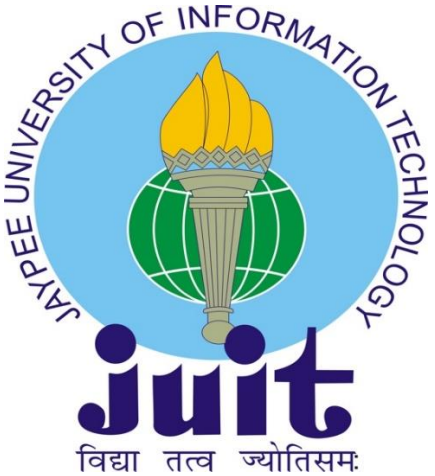
Under the supervision of

Mr. Nitin Kumar
to



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Candidate's Declaration

We hereby declare that the work presented in this report entitled **"Comparison of algorithms for detection of occluded faces"** in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science and Engineering/Information Technology** submitted in the department of Computer Science & Engineering and Information Technology**,** Jaypee University of Information Technology Waknaghat is an authentic record of our own work carried out over a period from August 2018 to May 2019 under the supervision of **Mr. Nitin Kumar,** Assistant Professor, Computer Science and Engineering/Information Technology.

The matter embodied in the report has not been submitted for the award of any other degree or diploma.

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This is to certify that the above statement made by the candidate is true to the best of my knowledge.

Supervisor Name: Mr. Nitin Kumar
Designation: Assistant Professor
Department name: Computer Science and Engineering/Information Technology
Dated:

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We would also like to thank our friends who were ever ready to help us with valuable technical inputs and help us hold on to our project implementation schedule even when the going was tough.

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Last but not the least we would like to express our sincere gratitude to our family members who stood by us and supported us in every phase of this project and gave us the much required moral support in carrying out this project successfully.

Akshit Singh
Yash Chowdhury

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LIST OF ABBREVIATIONS

PCA	Principal Component Analysis
LDA	Linear Discriminant Analysis
LGBP	Local Gabor Binary Pattern
KLD	Kullback-Leibler Divergence
KNN	K-Nearest Neighbour

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ABSTRACT

Due to growing demands in various application areas face recognition has attracted greater attention in the recent years. The advantages of using face as an identity over any other alternate methods, such as fingerprint identification, is relying on the fact that it is quite easy to use and is well accepted by the people as it doesn't require any physical interaction of the user and the system and generates better result.

Facial recognition is not dynamic enough to be used in practical security applications because of some problems associated with it and these are variations in pose and lightning conditions. During last few years, different algorithms have been designed to overcome these problems but very few have been designed in order to address the problem of partial occlusions. Occlusion detection in face verification is an essential problem nowadays.

Occlusion in face recognition is common in today's world but yet a challenging problem. We tried to build a system that could deal with images with occlusion and the another problem which was related to varying pose was tried to be minimised and the implemented algorithm has shown better results with varying pose. The challenging problem where our system fails is related to variation in illumination that is system gives false results when images are tested that were clicked in poor lightning conditions but still system is somewhat robust enough when it comes to security applications.

CHAPTER-1
INTRODUCTION

In last few decades many researchers have been working in the development of systems which could deal with partial occlusion or occluded images using different techniques. All these various methods are encompassed under wide area of technology known as image processing.

1.1 DIGITAL IMAGE PROCESSING

Image Processing [1] refers to the processing of images using operations that are mathematical so as to enhance or improve the quality of images or to extract useful information from them. In a way image processing could also be defined as mean of converting an image into the digital form. We can also define image processing [1] as analysis and manipulation of a digitalized image mainly for enhancing the quality of an image.

As seen below, the first grainy picture is processed to give a clearer image, so here the image is enhanced using image processing.

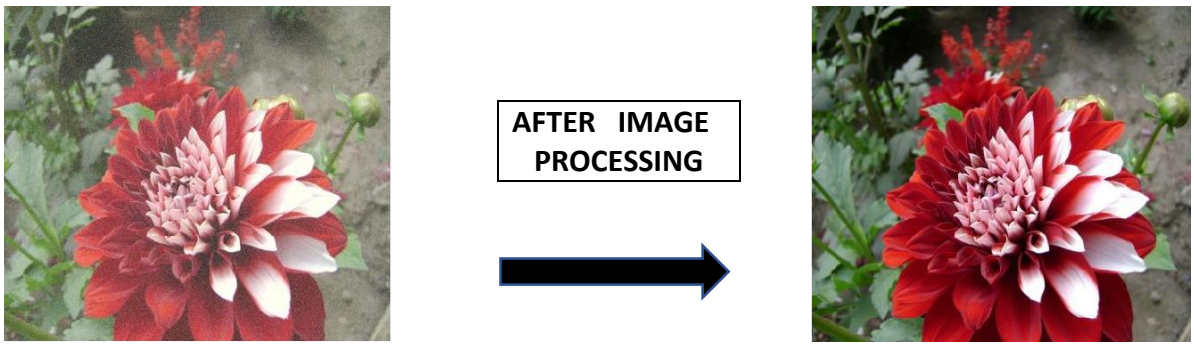


Fig 1.1: Contrast Enhancement [1]

When the image is represented as a two dimensional Image processing [1] usually refers to processing of digital image and the optical processing of image is also feasible or achievable. We can also go for analog processing of an image as well. Processing of an image also includes removal of noise [1] or any other irregularities that may be found in the image being considered function like f(x,y), the coordinates x and y are called the plane directions and the magnitude of this function(f) at any point gives the information about the intensity at that point.

So with finite and discrete values for the above mentioned coordinates, and amplitude, the image becomes a digital image.

1.2 APPLICATIONS OF DIGITALIZED IMAGE PROCESSING

The process of Digitalized Image Processing [1] accounts to the evolution of a system to process digital images. It finds a variety of applications [2] and some of the areas where digital image processing plays important role are:

- MEDICAL FIELD [2] With image processing we could get digital images of the areas which were not easily accessible before in human bodies.
- REMOTE SENSING [2] Similar to medical applications that is information about inaccessible terrain becomes useful with the help of image processing.
- COLOUR PROCESSING [1,2] Giving colour to historical images is quite easy with the help of image processing.
- ENCODING [1,2] The information can be encoded with in the images whenever a security of information is taken into consideration.
- VIDEO PROCESSING [1] A video is nothing but fast movement of pictures. With the help of image processing we try to eliminate or reduce unwanted noise and also try to detect the motion of objects etc.

As we have already gone through the introduction of image processing and its various application we are ready to discuss about one of its interesting area and that is Facial Recognition.

1.3 FACE RECOGNITION:

Human face plays an interesting factor while expressing any views or in initiating any kind of conversation and using human face expressions as the key to security had received greater attention in past few years. Face recognition [3] is nothing but training a machine to recognize face correctly and efficiently from a given set of data.

Face Recognition is a technology which is capable of identifying person's face from video frame or digital image. Face recognition is a kind of biometric system which is more effective as compared to other kind of biometrics as the user need not to make any physical contact with the system and there are some problems associated with fingerprint biometric [3] and that is at

times it gave false results. There have been cases when biometric gave false outputs for the individual who is pretending to be the one who he/she actually is.

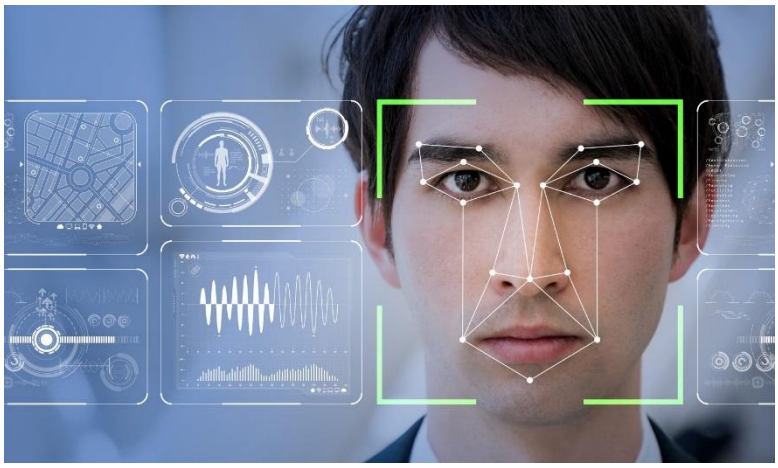


Fig 1.2: Face Recognition in OpenCV [5]

1.4 APPLICATIONS OF FACE RECOGNITION:

Face Recognition is having its important in various fields including safety and security. Some of its applications [4] are as follows-

- ENTERTAINMENT [4] Various applications such as Facebook, Snapchat uses face recognition to provide security to their users. Along with these apps virtual games and movies uses such techniques.
- SECURITY [4] Personal device login, File encryption, Database Security, Medical Records etc. uses facial recognition.
- LAW ENFORCEMENT AND SURVEILLANCE [1,4] Advance video surveillance, ATM Machines, Traffic Control, Enhancement of CCTV images and Suspect Investigation requires such techniques.
- FACE ID [6] – Apple introduced Face ID in iPhone X. Face ID has sensors that consist of two parts Romeo Module and Juliet Module. Romeo Module projects around thirty thousand dots on the face of the user and the Juliet Module actually reads this pattern and this pattern is stored in to device's CPU to confirm a match with user's face.

Fig 1.3: Face ID in iPhone X [6]

1.5 FUNDAMENTAL STEPS OF FACE RECOGNITION:

The fundamental steps [7] that are required to design a system that identifies face images from dataset containing a face and non-face images in lesser time and with greater accuracy rates.

- Capturing Images [7]
  In this step we generally try to collect the sample images in well- known existing conditions and this work is generally carried out in the start of the recognition process.

- Extraction of Features [7]
  Then the data which is collected after the first process of facial recognition, the features are extracted from the images we have in the database in order to design a template.

- Comparison Between the Extracted Features and the Existing image [7]
  After the second process or step of facial recognition the data which is collected is compared with the existing templates.

- Matching The Features [7]
  In the final step we have to make a decision that the face features are similar or matching to the existing images that is the collection of images we have in our database.

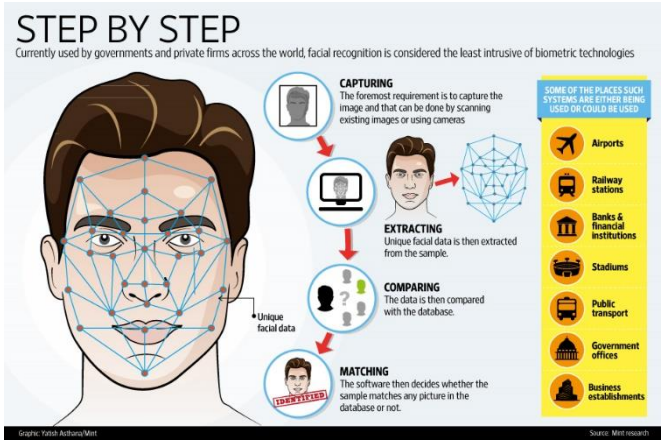


Fig 1.4: Fundamental Steps of Face Recognition [7]

1.6 PROBLEM DEFINITION

The increasing number of criminal activities in our daily life is of great concern and this is the reason which has led us to go for a project which could at least slower down the rates of such activities. The thieves covering their face while committing crimes cannot be easily recognized by CCTV cameras. Partition occlusion is still a challenging topic for many researchers because any kind of occlusion results in degradation of existing algorithms which had worked efficiently while dealing with non-occluded faces.

The criminals don't hide their faces out of humiliation or embarrassment but they do so in order to not to be recognized by cameras. Apart from these there have been cases of road accidents in which the defaulters ran away from the point where incident took place despite of having surveillance cameras everywhere so yeah it is still an issue when it comes to occluded face recognition. Number of accidents are increasing at an enormous rate and in half of the cases defaulters could not be recognized and the victims are the only one who suffers as the surveillance cameras are unable to determine the culprit in unfavourable background conditions.

There are various other kind of biometrics available but face based biometric is best when it comes to provide help while investigating the criminals or culprits. So we have tried to design a system which could recognize the persons face from the given set of database effectively in all robust conditions and in less time.

1.7 OBJECTIVE AND SCOPE OF THE PROJECT

The objectives of the project titles Comparative Analysis of Various Face Detection Algorithms are as follows:

- To compare various occluded face detection techniques.

- Detect the person's face in case of occlusions.
- Detect Person's face with varying pose.

Scope: There are several algorithms being used in this project like the Viola Jones algorithm (used for object detection) and Adaptive boosting algorithm. These algorithms are used in other applications also where edge detection, object recognition and detection need to be applied. The output from intermediate methods like frame extraction etc. can be used as an input for other applications. The application which can be made from this project can be also used for other detection monitoring in factories, plants. etc.

So in the first chapter we had a brief introduction about our face recognition and its applications and what are the guidelines to implement a face recognition system and what are its limitations and the problem associated with face recognition of images with occlusions and hence we discussed the objective and scope of the project.

1.8 ORGANISATIONS

The standard components of this report are as follows-

Chapter 1 includes the introduction of the project to give the basic idea what has to be implemented and to get familiar with some theoretical aspects.

Chapter 2 includes the literature review from numerous journals, papers from various conferences and websites. It gives basic idea of the related things that has been done related to our field.

Chapter 3 includes the system design, techniques and tools used for the implementation of the project.

Chapter 4 includes the performance analysis and results.

Chapter 5 includesthe conclusion, and future enhancementsoftheproject.

CHAPTER-2
LITERATURE SURVEY

Literature Survey means to engage in meaningful study of a set of theoretical works published before the current period of time. It is basically done to compare a set of theories established, on a particular topic, in a specific area of research, and experiments are conducted to establish those in a different manner than has been done till date. By doing so, a person proceeding to do a research work will be able to understand the benefits and shortcomings of the methods which have been used by other people in that area of research.

2.1 RELATED WORK

Xue Li [8] proposed a new method to overcome difficulties in the eyes detection of an user while using a non- intrusive method. Pre-processing in the form of Grey-scale transformation is done. They have applied the method of Adaptive boosting algorithm [8] which is used to remove irrelevant features that are not of greater importance while detecting the face, followed using the connected components method which was able to locate the eyes accurately and thus helps us to examine the state of eyes.

Their proposed approach showed the following stages:

a) Input Image
b) Face Detection as well as Recognition
   - Adaptive boosting Algorithm
   - Detect the face
c) Eye Detection and Location

   The face under testing was subject to different conditions also, as shown below, however the result has been consistent.

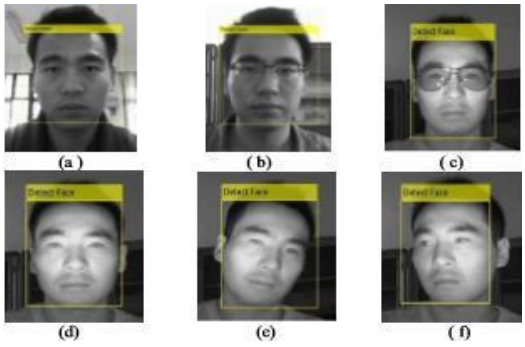


Fig 2.1: Detect faces under different conditions [8]

The mentioned method had been tested using a sample database consisting of 500 images that the accuracy in the detection of eyes was around 98% and the judgement regarding the state of an eye was approximately around 93%. The experimental results showed that this method displayed good robustness and high accuracy [8].

Viola- Jones [9] proposed together algorithms to design a system which is robust while dealing with occluded faces. Basically Viola-Jones Algorithm [9] Consists of four parts and these are as follows: Haar Features, Integral Image, AdaBoost training, Cascading.

Viola jones tried to eliminate the difficulty of features extraction and even introduced the concept of integral image which helps an individual to make calculations faster in which we don't have to examine each pixels but only the corner pixels to determine the area of a particular block. Along with this we use AdaBoost technology [8, 9] to remove the irrelevant features which are not important for facial recognition and also we divide the features into different cascade classifiers [9] which only passes the features of the image to the next classifier if matches each features of particular classifier. We would be discussing the algorithm in detail in Chapter4.

A final detector has various cascade classifiers [9] consisting of various features and the cascade classifiers were close to detect 100% of faces. The face detector can examine a 384 by 288 pixels' image in a very less time and it has all been possible due to the fact that we don't have to examine the entire features. Better results in detection were received by using scales which are around 1.25 apart [9].

Wenchao Zhang [10] proposed an algorithm that is a combination of LBP [10, 17] operators as well as Gabor Wavelets. Earlier works were based on face recognition using Eigen-faces [11] and fisher-faces [12]. We generally use facial points as features, descriptors or indicators for facial expression. Feature based [12] methods generally use properties between features of face such as chin, mouth, nose etc. to perform facial recognition but many algorithms are not satisfactory enough when it comes to variations due to aging and other factors in human images and rather class variations due to similarity between individuals and these variations can be local as well as global such as wrinkles appearing at the corner of the mouth and lightning.

Table 1. Recognition Rates of LGBP and KLD-LGBP

Methods	Session 1		Session 2	
	Sunglass	Scarf	Sunglass	Scarf
LGBP	0.80	0.98	0.62	0.96
KLD-LGBP	0.84	1.00	0.80	0.96

Note*: These values are taken from the paper [10]

As we can see clearly from above table that the recognition rates are more accurate in KLD – LGBP as compared to LGBP.

The earlier methods for face recognition were mainly focused on frontal view of images of the and images with one face only. However, the identification of face in different view is still a challenging factor. Traditional methods gave somewhat good results on frontal view of images or on single view.

So, an algorithm was proposed which uses the concept of PCA that is Principal Component Analysis [11] which eliminates the features that are not relevant in the recognition of faces. This algorithm was designed to identify same face from different views.

The Concept of Eigen Vectors [11, 12] and Eigenvalues [11, 12] were introduced to know the variation in the images and each Eigen vector has its corresponding eigenvalues and the Eigen vector with greater eigenvalues provides much more information in variation of the images as compared to the Eigen vectors with lower eigenvalues [11].

$$\mathbf{AX = \lambda X}$$

where A is Vector Function, Lambda is Eigenvalue and X is Eigen vector.

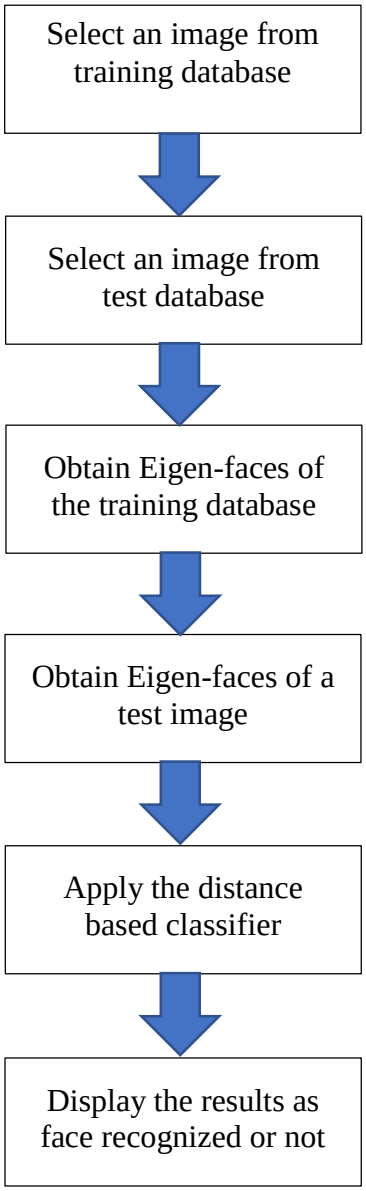


Fig 2.2: Flowchart of Eigen Faces [18]

Around 500 images of different individuals were taken for testing the algorithm and the system identifies around 485 images which is equivalent to accuracy of 96 % which is good but this system fails while dealing with occluded face image.

Table 2. Recognition of Faces Carried Out Using Eigen-faces

Total Images	Successful Recognition	Success Rate
500	485	96%

Note*: The values are taken from the paper [11]

In this paper a model was proposed in prior to face recognition with Eigen faces [11]. The major problem of face recognition is the elimination of features which are not important while recognition of faces. In face recognition using Eigen faces [11] the PCA was used to eliminate or remove the unwanted features and the image obtained after elimination of these features results in Eigen faces which has Eigen-vector with its corresponding eigenvalues and the Eigen vector with maximum eigenvalue gives more information about the variation in images.
There have been cases when PCA could not yield desirable results so a new theory was proposed and that is LDA along with PCA. LDA is used to find the subspace of a set of images, the resulting vectors defining that particular space are known as Fisher faces [12].

The steps which we follow in face recognition using fisher faces [12] are as follows:

- Design System- The system is planned or drafted to examine images by matching the images gathered to the results obtained from the feature extraction of the images.
- Image Processing Process [1] – It consists of following processes
    1. Data Retrieval Process
    2. Image Processing Process
    3. Feature Generation Process

Face recognition system [3] using this algorithm was able to recognize images with around 93% of accuracy that 93 images out of 100 images was recognized accurately and this system is also immune to buzz or clamoured images but the difficulty with such an algorithm arises in case of partial occlusion and when an individual has clicked images in varying pose.

Chen Dong [13] propose the colour model and radial function networks to examine the users face detection, then he used integral projection and Hough round Transform [13] for the detection of the eyes. This method has basically two leads or benefits, first is the use of integral projection function which can achieve boorish or rude positioning of the eyes of human and to be integrated with Hough round Transform to determine the location of eyes with exact accuracy. The second benefit of using this method is that it determines the eyes accurately since the eye of human is examined as a whole, so it may detect the human eye in lesser times and hence improving the chances of occurrence of wrong outputs in detection. The algorithm worked well while the recognition of the frontal faces but wasn't accurate enough while facing the images with occlusion. After going through the research paper we came across a conclusion

that the algorithm used in the implementation is shown with the help of the following flow chart:

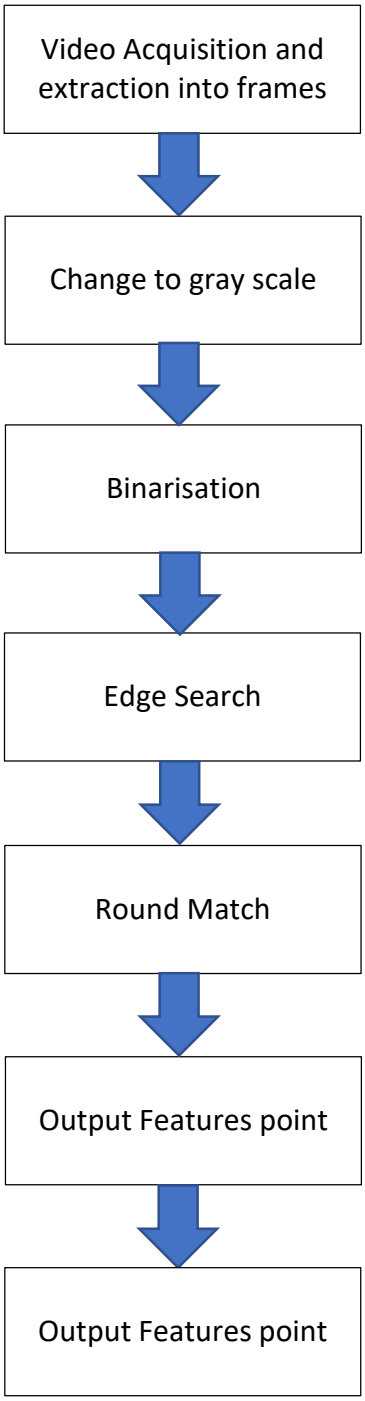


Fig 2.3: Flowchart of Eigen-Faces [13]

This method has basically two leads or benefits, first is the use of integral projection function which can achieve boorish or rude positioning of the eyes of human and to be integrated with Hough round Transform to determine the location of eyes with exact accuracy.

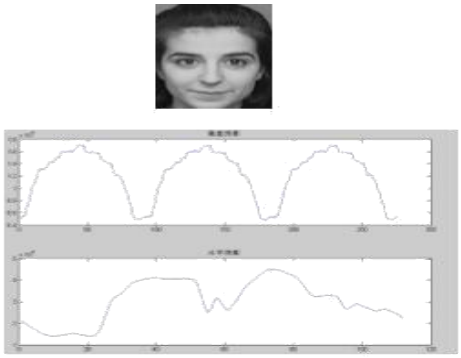


Fig 2.4: Vertical and Horizontal curve [14]

The captured video is pre-processed and a neural network is applied to detect the face area. Once the face is detected, the Integral projection method is applied to obtain the location of the human eye as shown above. After this, the Hough transform [14] method is applied to detect the eye state.

Fig 2.5: Detection of eye state [14]

Good results are obtained while testing in case of still images, with glasses and also with quick positioning speed.

2.2 COMPARATIVE ANALYSIS OF VARIOUS FACE DETECTION ALGORITHMS

Table-3: Comparative Analysis of various face detection algorithms

Algorithms	Description	Advantages	Disadvantages
Eigen Faces[11]	Uses PCA to extract the features of the face and classify them resulting a set of vectors called Eigen face. When a new input image is given, a system compares it with the saved Eigen	It is an efficient algorithm when it comes to processing time and it also requires less memory as compared to others.	This algorithm is sensitive to lightning conditions and it finds difficulty with poses and expressions.

	faces and hence can detect the face.		
Fisher Faces[12]	It is similar to Eigen faces but uses LDA instead of PCA as LDA is better than PCA when applied on various number of images. No. of components and threshold is different from Eigen faces.	It is efficient with facial expressions as it uses LDA instead of PCA and is invariant to change in illumination .	The processing time of fisher face algorithm is more as compared to other algorithm and even the larger storage is required as compared to other algorithms.
Local Gabor Binary Pattern[10,16]	It is simple but efficient to detect faces and identify textures and it could find value of pixel of image by thresholding the neighbour of each pixel and returning the result as binary number and the threshold value in LGBP is lower as compared to Eigen and fisher face algorithm.	It is an efficient algorithm as it is invariant to illumination intensity and no. of components and threshold required for detection is somewhat lower as compared to above mentioned algorithms.	It is not efficient when it comes to deal with occluded Images and it does not gives an accurate results while dealing images with varying pose.
Viola- Jones[9]	It is the most efficient algorithm while dealing with partial occlusions and uses adaptive boosting algo.to remove the irrelevant features that are not required in the detection of face. Apart from these it even uses cascading	It is rapid or faster in detecting faces from dataset consisting of images with faces and non – faces. The accuracy of detection rate is better as compared to above mentioned algorithms and also it is efficient	It is an effective algorithm while dealing with partial occlusion but it has a disadvantage too and that is it is ineffective in cases of an image with turned faces as well as images with turned faces.

	classifiers which makes it faster as compared to other.	in detecting faces with partial occlusions.	

2.3 METHODOLOGY

In the beginning, face recognition was considered as a 2D pattern recognition problem. Face Recognition is an interesting yet challenging problem which has attracted many researchers from various backgrounds like pattern analysis, computer vision, psychology, computer graphics, image processing, etc. Since now the 3D modelling and recognition of images has taken into the account which has led to two fundamental problems of face detection techniques. The first problem is occlusion problem and the second is pose problem. After going through various research papers we have decided to use knowledge based algorithms to overcome these problems.

Knowledge Based: Knowledge based [19] methods are basically the rule based methods. Based on the previous information and rules deduced, the detection of human face is made. Here, different features are recognized on account of their relative positions and distances from each other and symmetry in play. However, this method is deemed not too easy. The Methodology used in the implementation of our system is discussed in further chapters.

2.4 CONCLUSION

In this chapter we read various research papers on the algorithms which are associated with face recognition and in the end we compare the various algorithms along with their advantages and disadvantages in tabular form.

CHAPTER-3
SYSTEM DESIGN

In this chapter we would be talking about the steps that we are going to take while developing our system. After going through different research papers we planned to go for a non-intrusive method for designing our system. As we know that there are various face detection and recognition methods available we opt to go for the knowledge based techniques for developing our system and we have gone for such a method because it is more reliable and applicable under different circumstances.

We proposed a system which is based on the following two steps:

1. Face Detection
2. Face Recognition

Face detection is the process of identifying faces from set of faces and non faces or objects. Face detection is the technology which is used in various areas and variety of applications that identifies human faces in digital image. For face detection system we need to extract the important features from the human face and are storing it in NumPy array. There are various techniques available for extracting features from the human face and these are mentioned below.

3.1 FEATURE EXTRACTION TECHNIQUE

For the face extraction techniques to be applied, firstly the face is cropped from the obtained frame or in other words the current frame is displayed so that there is no extra processing is done in terms of the background also.

Now for the extraction of the face from the frame, there are several methods that can be applied like the skin color method, template matching method, feature based method, knowledge based method etc.

Skin color detection method is one of the widely used methods as it proves to be reliable in the face detection. In this method, all the pixels which are in skin color are detected and thus using that information it becomes quiet easy discovering the parts of the video frame wherein there might be a face or humans specifically.

The Feature based method actually detects human face based on the recognition of features that are purely human like the eyes, nose, lips, mouth and then a model is created and based on

the inter dependence of these features, the presence of a face is understood that is the system identifies whether a face is present or not.

Knowledge based methods are basically the rule based methods. Based on the previous stored information the rules are deduced and then the detection of a human face is made. Here the different features are recognized on account of their relative positions and distances from each other and the symmetry in play. However, this method is deemed not too easy as different states of the face may create an issue in getting the accurate results that is there might be a case in which the eyes of a particular face is closed or a particular human is wearing sunglasses, so in these cases it might give false results.

Template matching method requires the storage of the face under consideration in different poses and then comparing these to the incoming input images. Wherever a match is made, inferences are drawn. However, this method also tends to be a bit cumbersome as the images for comparing need to be stored and then used whenever necessary.

We chose Knowledge based approach for extracting features because it is regarded to be the most suitable and reliable approach related to the detection of faces.

3.2 ALGORITHM USED FOR DETECTION: VIOLA JONES

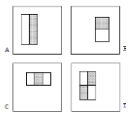
The Viola-Jones algorithm is the first object detection framework to provide competitive detection rates in the real-time proposed by Paul Viola and Michael Jones in 2001. Although it can be trained to detect a variety of object classes but was motivated primarily by the problem of face detection.

3.2.1 Feature Extraction

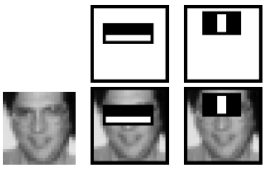
For the face extraction [4] techniques to be applied, firstly the face is cropped from the obtained frame or in other words the current frame being displayed so that extra processing is not done in terms of the background also. Now for the extraction of the face from the frame, there are several methods that can be applied like the skin color method, feature based method, template matching method, knowledge based methods etc.

Viola- Jones [9] proposed together algorithms to design a system which is robust while dealing with occluded faces. Basically Viola-Jones Algorithm Consists of four parts and these are Haar Features, Integral Image, AdaBoost and Cascading.

In Viola-Jones algorithm we try to design a system in which we give an input as set of faces and non faces and once the training is done the system is able to identify the faces from images that is we try to understand a computer what a face and non-face is. Once a computer is trained it will extract some features and all this will be stored in a file that is we have a trained dataset with all the features and whenever we have a new image we refer to data in the file and try to classify image as face and non-face.

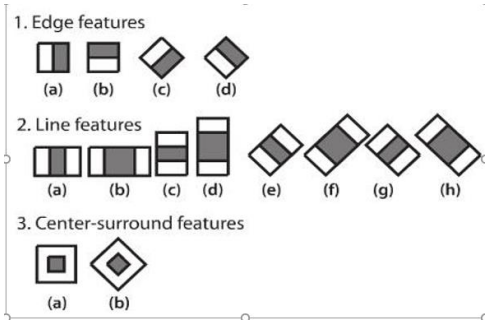


A: Four types of Haar features



B: Haar features applied on the image

Haar Features (A) are somewhat similar to convolution kernels which are generally used to detect a presence of particular feature in an image. Every single feature results in single value which is deliberated by subtracting total of pixels occurring under white rectangles (B) from the total of pixel occurring under black rectangles (B).



C: Haar Feature [20]

D: Simple and Binarised Image [20]

Fig 3.1: Feature Extraction using Viola-Jones

Now we can see in the above picture (C) that the Haar features [20] are applied as mentioned in the procedure and each of the features are slid on the image and wherever the threshold is exceeded the Haar features are found to match. The image (D) shows difference between simple and binarised image.

Viola-Jones uses 24*24 window [20] to start evaluating the features that are mentioned above in the given image and if we consider all possible parameters of Haar features we can end up with 160,000+features in this window which is another issue.

Fig 3.2: Haar Features On Sliding Window [20,9]

It is quite a problem to evaluate these many features so we try to eliminate redundant features that is the features which are not of greater importance and this is done using AdaBoost [15,8] which eliminates the redundant features and we are left with around 7000 features which are of greater significance.

Fig 3.3: Relevant and irrelevant features [22]

It is also a time consuming process to sum up all the pixels of black rectangle and white rectangle separately so viola-jones came up with an idea of Integral Image which is a trick to make calculations faster while dealing with pixels under black and white rectangles separately. In calculating an area of a particular patch we do not need to sum up all the pixels and we can calculate its area but just considering the corner pixels.

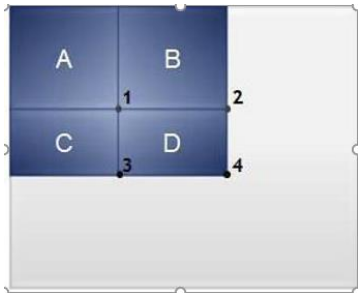


Fig 3.4: The Values Being Considered for Calculation [23]

Suppose we have to find the sum of pixels in block D then it is given as

$$D = 1+4-(2+3)$$
$$= A+(A+B+C+D)-(A+C+A+B) = D$$

After the identification of Relevant or significant features AdaBoost [8] gives weight to these features and linear combination of all these features is used to decide whether it is a face or not.

Weak Classifier [9] is something which performs better than random guessing that is if we give it an input of around 100 faces it would perfectly determine faces in around 50-60 images. We take a combination of these features with their corresponding weights to make a strong classifier or detector. The output of these weak classifier is either 1 or 0. It gives output 1 when it performs well that is it has perfectly determined the features otherwise it gives 0.

Cascading [9] We have to examine around 25,000 features that we get after the removal of irrelevant features by AdaBoost [8] but to examine these many features is yet again a time consuming process. So we divide the features in cascading structures that is 10 features in first cascade and next 20-30 features in another cascade and so on. So when an input image is given and it passes the first stage it may be a face and is passed on to next stage and so on but if an image cannot pass the first 10 features of first stage we need not to look further and in this way we could analyze the image in much less time. With the help of cascade-classifiers we could quickly identify images as faces and non-faces as cascade classifiers would pass on an input image to next classifier only once an input image matches all the features that are present in a present classifier. We need to carry out some numerical experiments to build an optimal cascade classifier.

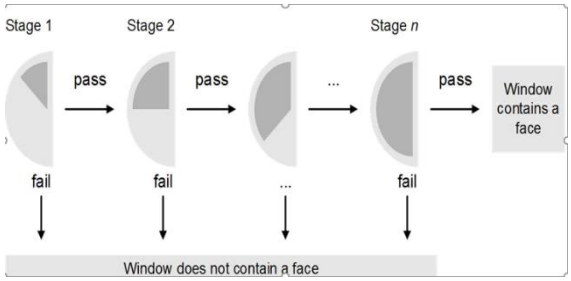


Fig 3.5 Cascade of Classifiers [22]

The entire process which we followed while using a viola-jones has been discussed above and the processes have been shown in the flowchart below.

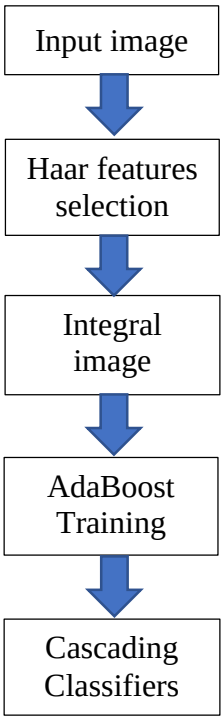


Fig 3.6: Flowchart of Viola-Jones [9]

Viola-Jones is easier to implement and is best in dealing with partial occlusions and also it uses adaptive boosting algorithm as well to eliminate the features that are not of greater importance in recognition of faces.

3.2.2 Feature Detection

The following are the steps in the method features extraction in this project:

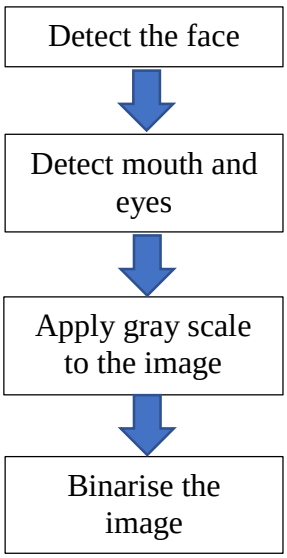


Fig 3.7: Flowchart-Detection System [9]

Applying the above mentioned Viola Jones algorithm, the face is detected on the frame and then cropped out as shown below

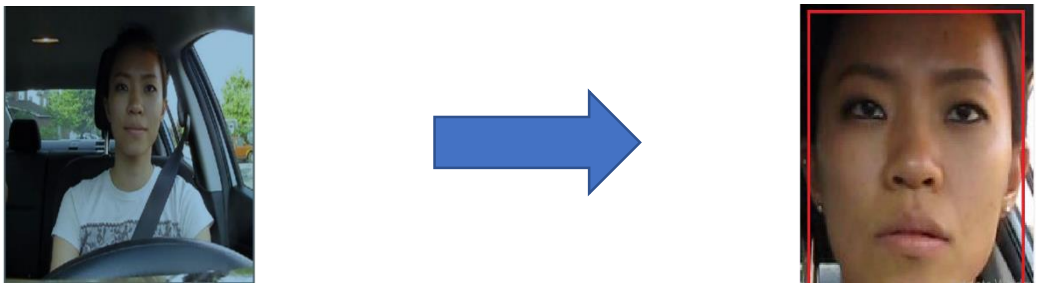


Fig 3.8: Face detected from the image [9]

Eye and Mouth Detection - From the output of the face detection step, the eyes and mouth are cropped out again using the Viola Jones algorithm. After that the cropped images are changed to gray scale and then binarised. [9]

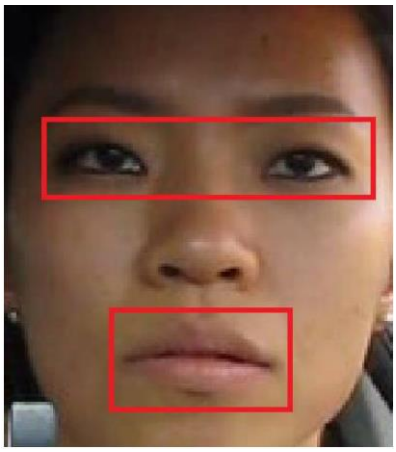


Fig 3.9: Eye and mouth detected [9]

Gray Scale - The output image obtained from the previous step is changed to gray scale so that the complexities which are involved in the processing of the RGB colors and then storing the values is reduced with colors ranging between 0 to 255 levels of from black to white. Once the output image is changed to the gray scale, then it is binarised.

Binarisation - In the step of binarisation the image is binarised so that the complexities are reduced to the intensity levels of 0 and 1, that is white and black.

Eyes Detection - From the output of the face detection step, again the eyes are cropped out using the Viola Jones algorithm. Once the eyes are cropped out, they are changed to the gray scale and then binarised.

Fig 3.10: Eyes Detected Cropped and Binarised [9]

Mouth Detection - Similarly the mouth is detected too and the cropped image of the mouth is first changed to the gray scale image and then binarised to be used for processing further because for the further stages of edge detection, value of the image to be counted in one and zero is important.

Fig 3.11: Mouth is detected and cropped and binarised [9]

3.3 FACE RECOGNITION SYSTEM

Face Recognition System is basically matching the features of the new input image with the existing dataset of images. Face recognition is used in variety of areas or domain and are proved to be beneficial in areas where security is the supreme concern but the recognition system fails drastically in certain conditions for example the recognition system fails while dealing with faces with occlusion or when there is variation in illumination or when the person is making an irrelevant pose.

We used different algorithm to build up a recognition system and later we compare these algorithms over the recognition of frontal face images and over the images where the relevant features of a face are blocked under different illumination condition.

3.3.1 Algorithms Used

1. Local Gabor Binary Pattern

The authors proposed an algorithm that is a combination of LBP [10] operators and Gabor wavelets [10]. Earlier works were based on face recognition using Eigen faces and fisher faces. We generally use facial points as features descriptors or indicators for facial expression. Feature based methods generally use properties between features of face image such as chin, mouth, nose etc. to perform recognition but the algorithms are not satisfactory enough when it

comes to variations due to aging and other factors in human images and rather class variations due to similarity between individuals and these variations can be local as well as global such as wrinkles appearing at the corner of the mouth and lightning.

To achieve robustness, we need to design a system that could withstand these variations. Facial recognition with LBP examines both the local and global variables by developing concatenated histograms. The features that are extracted from LBP [10] is invariant or unchangeable to illumination as LBP is unchangeable to monotonic grey-scale changes. Hence Gabor based face recognition is efficient in describing local image features.

What we do in LGBP [10] is that we first obtain multiresolution images by folding or twisting face image with multiscale and multi-oriented Gabor filters [10]. Then we use the LBP operator on multiresolution images to obtain LGBP images. Finally, we extract the local histograms from LGBP images and these histograms are summed up into a single histogram to represent an original image that we have in our database.

LBP OPERATOR [10]: It is an important operator which is used to identify the expressions that are relevant in facial recognition. It looks at nine pixels at a time that is it takes a block of 3*3 pixels and is particularly interested in the center pixel and 8 corresponding pixels are surrounding it with their corresponding intensity values. Local Binary Pattern is now going to convert set of 3*3 pixel to a single value and it will do this by comparing the value of center pixel and the surrounding pixels. If the value of neighboring pixel is greater than or equal to the center pixel we assign it a value as one and if the value of neighboring pixel is less than the value of center pixel we assign it a value as zero. The string of binary number will be entered as the decimal value to train our system. The nice thing of LBP is that it is illumination invariant that is if we change the lightning at the scene the values would go up but the relative difference between the center pixel as well as surrounding pixel will still remain the same so our binary pattern will remain the same irrespective of illumination variant then we have to compute the histogram over the cell of frequency of each number occurring greater or smaller than the intensity value of center pixel.

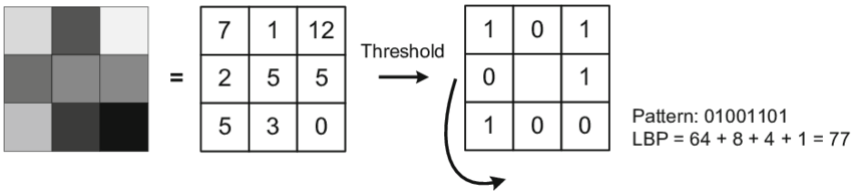


Fig 3.12: Applying LBP Operator on the image. [10]

Extracting Histograms: After applying LBP operator on the image a new image is generated and we use this image for extracting histograms. We could generally use Grid X and Grid Y for dividing the image into multiple grids.

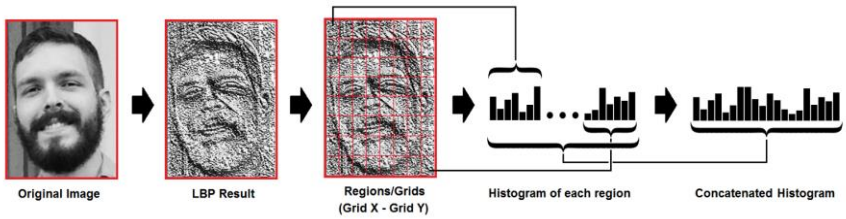


Fig 3.13: Extracting Histograms After the Division of Image. [10]

KLD based LGBP: If an image is completely occluded then the value of its corresponding histogram should be kept zero otherwise the weight should be kept unchanged and if the face is not visible entirely or if there is partial occlusion then the weight should be decreased accordingly. So we need to calculate the occlusion probability since it is the solution to occlusion as the distribution of the normal region is similar whereas the distribution of occluded region is not same as the normal one. So, if the region is not fully visible or if there are chances of partial occlusion then its histogram must be different from the results delivered from the histogram of the same region in images in which occlusion is not there. KLD is used to estimate the probability of occlusion to occur.

Fig 3.14: Partially Occluded faces. [10]

We have chosen LGBP along with Viola-Jones [9] because LGBP is invariant to illumination that is even in case of unfavorable conditions like lighting the system would be good enough to recognize the faces. So with the implementation of both viola- jones along with LGBP would help us to recognize faces at faster rate and with more accuracy.

2. KNN-Algorithm

KNN or K-Nearest Neighbor is the machine learning algorithm which basically makes prediction on the basis of past data provided or available. In this algorithm the system is trained by providing images of different individuals and then the new image is predicted by the system on the basis of previous data provided. Actually KNN [24] is based on the principle of matching features of new image with the existing image so we can say that we can use KNN algorithm for classification. KNN basically stores all the available cases and compares the new cases based on the previous one. K is basically a parameter that refers to the maximum number of neighbors that need to be incorporated in the voting process. It is non parametric algorithm that is it does not make any assumptions over the distribution of the data. The algorithm revolves around the criteria of choosing K and the process of choosing K is known as parameter tuning [9]. If we choose a value of K in KNN too low, then it gets too noisy and would have a greater impact on the outcome or result and if we choose the K value too large it gets computationally expensive. So the appropriate method of choosing K is to take the square root of n where n is the total number of data points and we try to avoid to take even value to K by adding one or subtracting one from the result obtained after the square root of n to prevent confusion between the two different classes. We basically use KNN [24] on datasets that are labeled and doesn't have too much noise I mean we prefer using KNN on smaller datasets as it is a lazy learner that is it doesn't learn a discriminative function from training set so if we have a very complex data or very large amount of it we must avoid using KNN but we do can take a small sample out of a large data and get an idea of what it looks like using KNN and for smaller data, KNN works well. In KNN we actually try to classify new data on the basis of the previously trained data using Euclidean Distance. According to Euclidean Distance [24] formula the distance between two points with coordinates (x, y) and (a, b) is given by Sqrt[(x-a)^2+(y-b)^2]. The Euclidean Distance of the new data point is calculated from its closest neighbors and then we find the common classification of these entries and that is the classification we give to new sample. So KNN algorithm is used once the system is trained to detect the faces from dataset of images consisting both faces and non faces that is we basically use KNN for the recognition purpose

that is we provide a new data to the system to recognize the data provided on the basis of results of previous stored data.

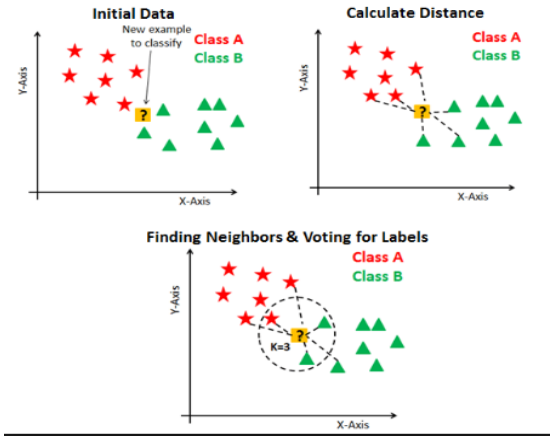


Fig 3.15: KNN Algorithm [24]

3.4 TEST PLAN

This topic presents the implementation details for the proposed system developed for the recognition of occluded faces is discussed here. The software used in the implementation of this, its versions, packages, etc. are described as follows:

3.4.1 Requirements:

Platform: Windows 7 or above/Mac OS 10 or above

Software Used: Python/PyCharm/Anaconda

Version: 3.7.0 or above

Minimum Requirements**:** 2 Mega-Pixel Camera

Intel-HD Graphics

3.4.2 Implementation Details:

The implementation is done in six stages:

1) Input Image: The first stage of the project deals with the images that is we provide different images to the system in various illumination conditions without occlusion and we use these images to train the system so that the system could get to know what face is that is we train our system to understand difference between faces and non faces [9].
2) Feature Detection: In computer vision and image processing feature detection includes methods for computing abstractions of image information and making

local decisions at every image point whether there is an image feature of a given type at that point or not.

3) Integral Image: The Integral Image is used as a quick and effective way of calculating the sum of values (pixel values) in a given image – or a rectangular subset of a grid (the given image) [9]. It can also, or is mainly, used for calculating the average intensity within a given image.
4) AdaBoost Training [20]: It can be used in conjunction with many other types of learning algorithms to improve performance. The output of the other learning algorithms ('weak learners') is combined into a weighted sum that represents the final output of the boosted classifier.
5) Cascading Classifiers [20]: With the help of cascade - classifiers we could quickly identify images as faces and non-faces as cascade classifiers would pass on an input image to next classifier only once an input image matches all the features that are present in a present classifier. We need to carry out some numerical experiments to build an optimal cascade classifier.

   Once the system is good enough to make difference between faces and non faces we use this training data for our recognition system that is when we provide the new image with occlusion to a system the system matches the relevant features of image with occlusion with the previous images or training dataset.
6) K-Nearest Neighbour [24]: We used KNN algorithm for building up our recognition system in which we use the concept of Euclidean distance that is we calculate the Euclidean distance of new data point from all its neighbour and the system makes the comparison on the basis of the distance of new point from previously stored data. *We used the code of KNN from Git-hub [https://github.com/prashant0598/Face-Recognition/blob/master/README.md] which is MIT licensed.*

3.5 CONCLUSION

In this chapter we discussed our proposed system in detail and how the entire procedure associated with facial recognition is carried out. We also discussed the algorithms implemented in different phases of face recognition and the steps which we are going to follow while building our system.

CHAPTER-4

PERFORMANCE ANALYSIS

4.1 EARLIER SYSTEMS

The earlier developed systems were good enough in extracting relevant features required for detection of faces and was working well to detect faces from non-faces and objects but failed in the recognition process that is the earlier systems were not able to recognize the authentic person when a new input is given to the system to match the new input image from previously trained data and failed miserably when we had to recognize faces with partial occlusion.

4.2 METHODOLOGY USED

In the beginning, face recognition was considered as a 2D pattern recognition problem. Face Recognition is an interesting yet challenging problem which has attracted many researchers from various backgrounds like pattern analysis, computer vision, psychology, computer graphics, image processing, etc. Since now the 3D modelling and recognition of images has taken into the account which has led to two fundamental problems of face detection techniques. The first problem is occlusion problem and the second is pose problem along with illumination. This project is implemented in two phases that is Detection and Recognition.

4.2.1 Feature Extraction

For detection system we need to provide an input image to the system so that the system could understand the differences between a face and non-face or in simpler words we can say that we use these images to train our system so that our system is well aware about the faces. For detection system we need to extract the relevant features of face that is nose, mouth and eyes and there are various techniques available to extract important features of the face like template based, knowledge based, feature based etc. and we used Knowledge based methods which are basically the rule based methods. Based on the previous information and rules deduced, the detection of human face is made. Here, different features are recognized on account of their relative positions and distances from each other and symmetry in play. However, this method is deemed not too easy. After the features are extracted using knowledge based techniques the manipulations are done in image by getting the outlines of each person's eyes, nose and mouth and we store these features of a particular person in array. We implemented the above work via viola-jones algorithm.

4.2.2 Recognition

For Recognition system we provide a new image and the system makes predictions about the new image on the basis of the stored data. The system matches the relevant features of the new image with the extracted features of the images that were used earlier for training our system. We used a machine learning algorithm for building up our system. Machine learning is basically based on learning from available data such as available search trends, available sales record pictures and images, sounds, text etc. then the system learns with the help of these data records and creates a model. Later on this model is tested and is refined using test data. We used K nearest neighbour system for implementing our recognition system. KNN is the machine learning algorithm which basically makes prediction on the basis of past data provided or available. In this algorithm the system is trained by providing images of different individuals and then the new image is predicted by the system on the basis of previous data provided. We basically use the concept of Euclidean distance in KNN and the distance of new data points is calculated from all the previous and closest data points neighbours and then we find the common classification of these entries and that is the classification we give to new sample.

4.2.3 Dataset

We have created our own dataset by clicking eight images of our five close friends and we used these images to train our system. The images which we used for the training of our system are taken in a good lightning conditions and all the images are free from occlusion that is all relevant features of the face are visible but while testing our system we used images of same five friends with occlusion that is some features of face were blocked or hidden and system was able to achieve some level of accuracy while dealing with occluded images.

Priyank Dhairya Sourav Ruhela Rishi

Fig 4.1: Sample images of dataset

4.3 DIFFERENCE BETWEEN EARLIER SYSTEM AND IMPLEMENTED SYSTEM

Earlier Systems were not good enough to give accurate results while dealing with faces with partial occlusion. The proposed system gives somewhat feasible result while dealing with faces with partial occlusion. The proposed system is based on a machine learning algorithm and works well on smaller datasets. Earlier proposed systems were sensitive to lightning conditions which is still a problem that is the recognition system works efficiently well in better lightning conditions when compared to recognition rates of images collected in poor lightning conditions.

4.4 RESULTS AND DISCUSSION

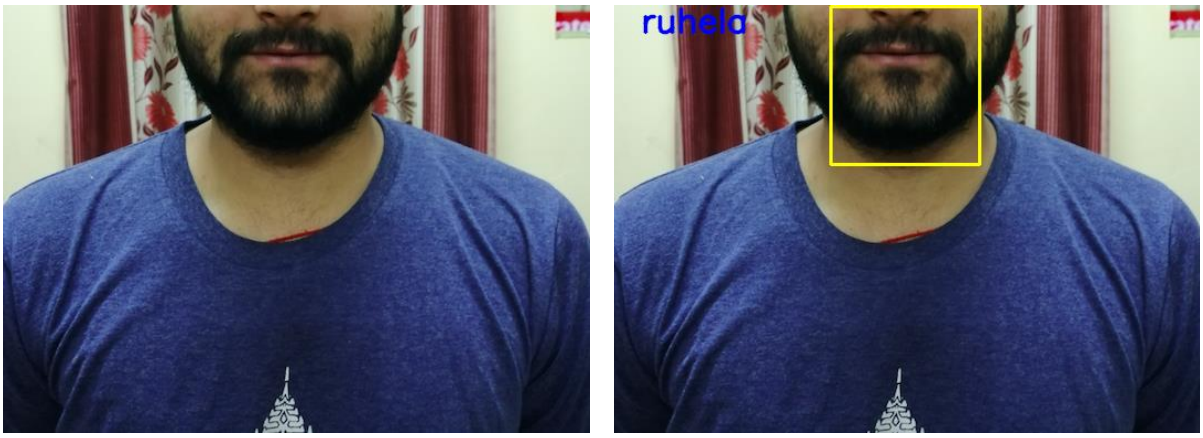


Fig 4.2: Screenshot from implemented model

The input image was provided and the system could accurately recognize the authentic person by detecting mouth as a relevant feature in case of occlusion. The viola- jones algorithm extracts the relevant feature and the K nearest neighbour algorithm matches the extracted features with new input image provided.

Fig 4.3: Screenshot from implemented model

The Input image is provided and the system could accurately determine the correct person by matching the left eye of the person in the input image with previously trained data.

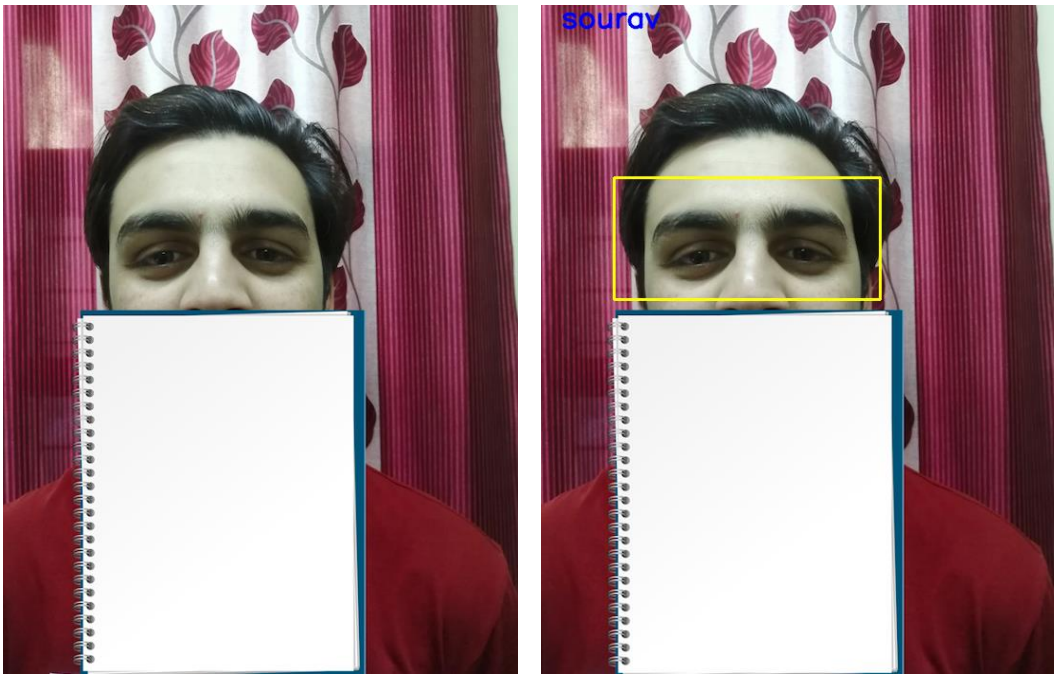


Fig 4.4: Screenshot from implemented model

The new input image is provided and the system could accurately determine the person correctly by using eye pair as the relevant features.

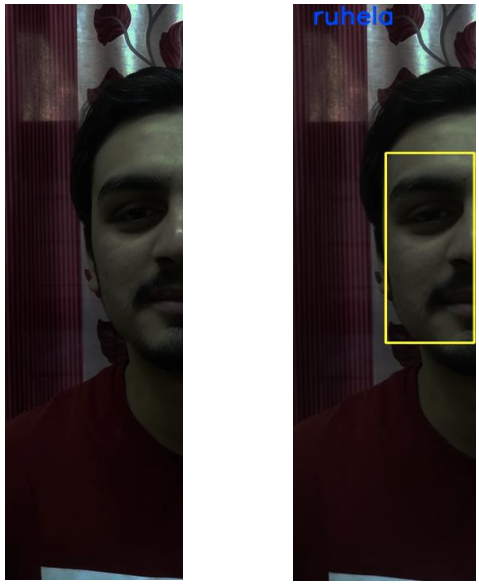


Fig 4.5: Screenshot from implemented model

The system was unable to detect the person accurately when new input image is provided to it as the image was taken in the bad lightning so the first problem associated with the system is illumination variation that is system recognizes the person accurately if the images are clicked in proper lightning conditions.

Fig 4.6: Screenshot from implemented model

The could recognize accurately the right person by matching the right eye with previously stored data so the system has achieved some accuracy while dealing with images with varying pose.

Fig 4.7: Screenshot from implemented model

The system failed to achieve results when an upside image was provided to the system for recognition purpose.

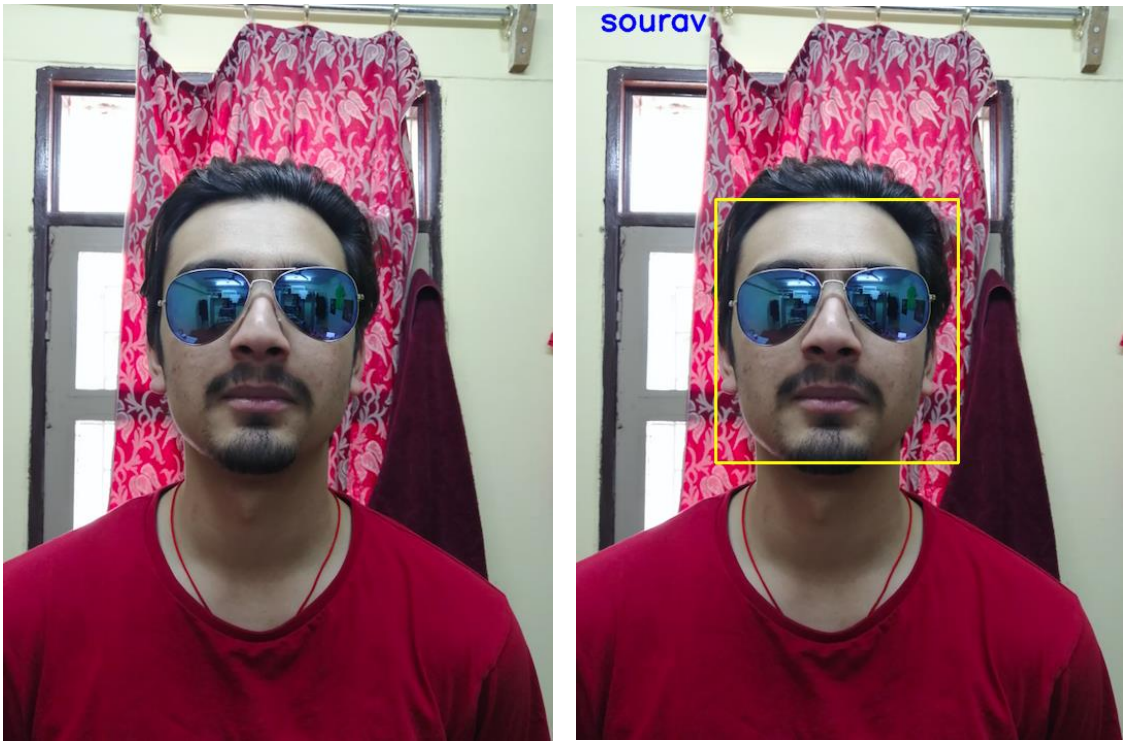


Fig 4.8: Screenshot from the implemented model

The system could accurately recognize the right person when we tested an image of a person wearing sunglasses as the system could extract mouth as a relevant feature.

Fig 4.9 Screenshot from the implemented model

The system could accurately determine the right person while we tried to test an image of a person wearing scarf because the system was able to extract the eye pair as a relevant feature and matches it with the previously trained data.

Factors Affecting Recognition Rates:

1) Expression types: Facial expressions are basically of six types and these are referred to as happy, fear, disgust, sad, anger and surprise and It can be concluded after going through various research papers that the type of emotion expressed effects the accuracy of the recognition system.
2) Expression intensity: The recognition accuracy rate is directly related to the intensity of emotional expressions. In general, the individuals were recognized more accurately when the expressions were more intense and less accurately when the expressions were subtle expressions.
3) Illumination effects: Illumination problems can be regarded as the most difficult problem to solve when it comes to face recognition. The system recognises more accurately when the images are taken in proper lightning conditions as compared to those taken in bad lightning conditions.

4) Image resolutions: After going through various literature studies it can be concluded that face recognition applications fail to achieve high accuracy rate when the size of the image is reduced.

4.5 CONCLUSION

In this chapter we discussed the methodology used along with the performance analysis of our implemented system and after going through the results we concluded the chapter with the factors affecting the face recognition system. After going through various research papers and implementing the system we saw that the normal face recognition rates of various algorithm was good but failed to give accurate results while dealing with faces with occlusion. The recognition rates of Eigen-faces were around 96% but it failed to recognize faces with occlusion and is sensitive to lightning conditions and faced problem with poses and expression. The face recognition using fisher faces showed somewhat similar results the only difference between above discussed algorithm and fisher faces is that the first one uses PCA and the other one uses LDA as the main component for feature extraction but it needs more processing time and the recognition rate is around 93%. The LGBP algorithm showed better results to detect faces covered with scarf and the recognition rate was around 95% but didn't showed better results with sunglasses and the recognition rate was just around 70% and LGBP was invariant to lightning conditions too but showed problem to recognize faces with varying poses. All the above mentioned algorithm showed better results in facial recognition but they all faced problems to recognize face accurately with occlusion. The algorithm which we implemented for detection system is viola-jones and for recognition purpose we used KNN algorithm the recognition rate of normal faces is around 97% but while dealing with faces with occlusion the rate decreases down to 70% and the higher recognition rates can be achieved using deep learning which is a future work related to this project.

CHAPTER-5
CONCLUSION AND FUTURE WORKS

5.1 OVERVIEW

In this last chapter of our report we would like to conclude our work and discuss the work we are going to implement in near future. So far we have we have read different research papers which actually discussed the various recognition techniques which has implemented so far.
We even did the comparative analysis of different face recognition algorithms with their pros and cons which helped us to choose an effective algorithm which could withstand while dealing images with partial occlusion. We even discussed about our system on which we are going to carry out the testing procedure. The project aims at a simple but an effective way of detection avoiding unnecessary complexities that may hamper to real life implementation. We even discussed about the robustness of various algorithms with their memory requirements and their processing time. In the entire project work we were focused on extracting features from images and after studying various research papers we decided to develop a traditional, simple yet an effective algorithm for partially occluded images. We can arrive to this point after the end of this report that higher detection rates are possible. After going through various research papers and implementing the system we saw that the normal face recognition rates of various algorithm was good but failed to give accurate results while dealing with faces with occlusion. The recognition rates of Eigen-faces was around 96% but it failed to recognize faces with occlusion and is sensitive to lightning conditions and faced problem with poses and expression. The face recognition using fisher faces showed somewhat similar results the only difference between above discussed algorithm and fisher faces is that the first one uses PCA and the other one uses LDA as the main component for feature extraction but it needs more processing time and the recognition rate is around is 93% . The LGBP algorithm showed better results to detect faces covered with scarf and the recognition rate was around 95% but didn't showed better results with sunglasses and the recognition rate was just around 70% and LGBP was invariant to lightning conditions too but showed problem to recognize faces with varying poses. All the above mentioned algorithm showed better results in facial recognition but they all faced problems to recognize face accurately with occlusion. The algorithm which we implemented for detection system is viola-jones and for recognition purpose we used KNN algorithm the recognition rate of normal faces is around 97% but while dealing with faces with occlusion the

rate decreases down to 70% and the higher recognition rates can be achieved using deep learning which is a future work related to this project.

The facial expression recognition system presented in this research work contributes a resilient face recognition model based on the mapping of behavioral characteristics with the physiological biometric characteristics.

The physiological characteristics of the human face with relevance to various expressions such as happiness, sadness, fear, anger, surprise and disgust are associated with geometrical structures which restored as base matching template for the recognition system.

5.2 FUTURE SCOPE

Methods to apply multi-view angle for face detection could be applied so that the drawback of only frontal face detection can be overcome.

As of now the project only considers cases where the images are captured during broad daylight and further work may be done to consider cases of night too.
We would be implementing the face recognition system which is based on convoluted neural networks or an algorithm which is based on deep learning rather than machine learning algorithm and the results can be compared.

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APPENDIX

LETTER OF PERMISSION

I hereby release and grant permission to **Yash** and **Akshit**, the irrevocable right to use any photographs of me taken by them, in all forms and in all manners, including composite or distorted representations, for their final year project as it is the major requirement of their project. I have read this release and consent and I am fully familiar with its contents.

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