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Face Recognition & Criminal Identification (FRCI)

Bachelor of Science in Information Technology

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Certificate

We accept the work contained in the report titled "Face Recognition & Criminal Identification (FRCI)", written byMr. NAJAM UL ISLAM AND Mr. MOHSIN KHAN as a confirmation to the required standard for the partial fulfillment of the degree of Bachelor of Science in Information Technology.

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Abstract

Due to increasing number of theft crimes more and more people are concerned regarding their safety. We have seen huge trends of using safety cameras to ensure the safety and security. However, many times we've observed the culprits could not be caught even if the record/footages available and the authorities remain unable to identify the criminals. In cases when the criminals do get identified the process takes too much time which allows the culprits to flee the country. Face Recognition & Criminal Identification (FRCI) can be used to identify the credentials of the person in front of the camera in real-time. FRCI uses the Haar Cascade Classifier for face detection and Principal Component Analysis (PCA) for face recognition.

Acknowledgments

We feel so fortunate being able to study in Bahria University Islamabad as an Information Technology student, University offers us to think out of the box and explore. We have prestigious faculty which is always there to help and support.

We give a very special thanks to Ma'am Zubaria Inayat (Supervisor), for their inspiration and guidance during the completion of this project. A special thanks to those who provided help in our research material.

Thanks for the Encouragements!

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"You cannot control what happens to you, but you can control your attitude toward what happens to you, and in that, you will be mastering change rather than allowing it to master you."

Brian Tracy

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Acronyms and Abbreviations

FRCI	Face Recognition and Criminal Identification
PCA	Principal Component Analysis
USP	Unique Selling Proposition
UML	Unified Modeling Language
OpenCV	Open-Source Computer Vision Library
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICODE	Unique, Universal, and Uniform Character enCoding
XML	Extensible Markup Language

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Chapter 1

Introduction

1.1   Using Real Time Face Recognition for Criminal Identification

The security concerns of citizens arise a question that "Do we really need to make use of face detection and recognition for identifying criminals"? The answer to this question is very simple and straightforward, Yes, we do need it because just placing a camera won't do anything until and unless you are able to recognize the person in front of the camera. This would be helpful in one or two ways it can either stop the criminals from doing any illegal activity or immediately figure out who are involved in such activities. We will simply have the dataset of each, and every person authorized to enter specific premises and whenever he/she faces the camera it would show their credentials in real-time.

1.2   Project Background and Overview

Safety and security are the basic rights of every citizen of the state and observing increased number of criminal activities doesn't make life easier living in cities. We have to acknowledge the fact that just installing the security cameras isn't enough until they could identify the criminals.[1] Specially offices having sensitive information should be kept safe to avoid any sort of unprecedented criminal activities. However, we can enable these security cameras to identify if the person is authorized to enter any secure facility or not by showing their credentials (ID/Name) on run time to the security staff monitoring the cameras.

Almost every day we hear the news of criminal activities where the culprits were caught on footage, but they are never caught because we are unable to identify their identity. In cases like these we can have two different scenarios, we can either stop any such activity from happening when we observe a person entering an unauthorized location or have everyone in our dataset with their information to track them when any such incident happens.

Here we propose Face Recognition & Criminal Identification (FRCI) to overcome such incidents. FRCI will store the information (Name/ID) of the person authorized to enter a specific area. Whenever the authorized person comes in front of the camera it will detect the face using Haar Cascade Classifier and recognize the person from the dataset using Principal Component Analysis (PCA). This face detection and recognition would be on run time and show the person's Name/ID. If an unauthorized person tries to enter that area FRCI would detect the face and inform that this person is "unknown/unauthorized/intruder".
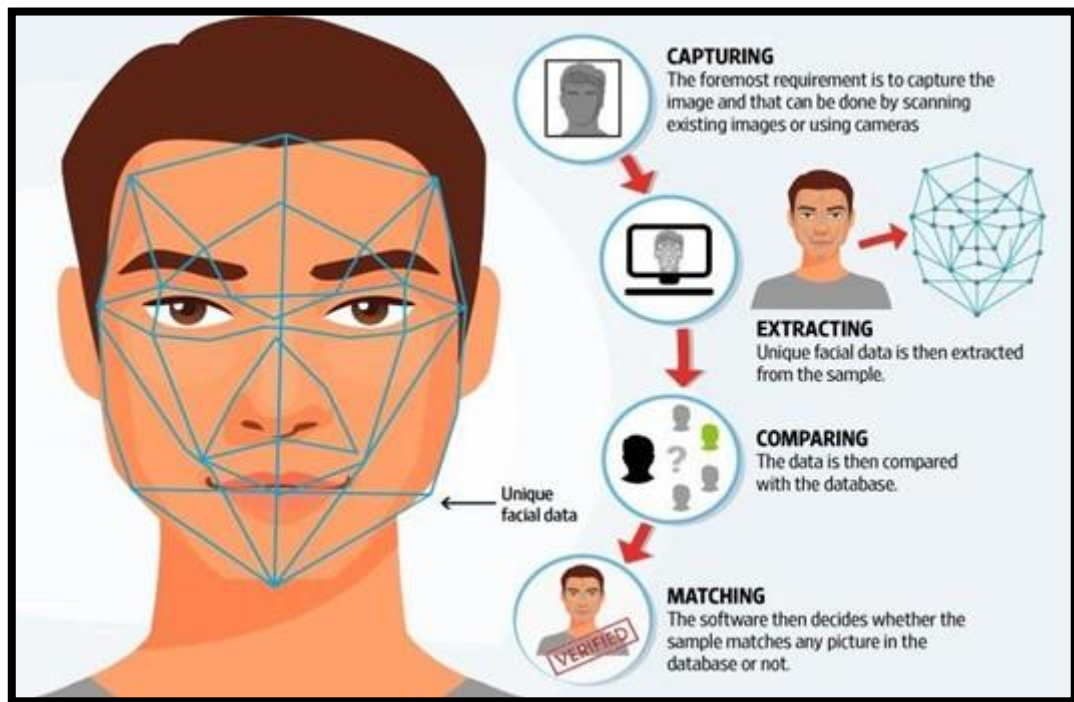
Figure 1.1: Steps Involved in Face Recognition

1.3   Problem Description

During the last few years, we have seen elevation in crime rates because in most cases the criminals were not identified. According to the reports shared with the media of transparency police was unable to trace the killers in at least 60% of the homicide investigations. The number of crimes reported by the bureau of statistics report show constant increase in 3 years. [2] The reason here is simple and straightforward, if the authorities are not able to trace more than half of the criminals then how can there be decrease in the crime ratio.[3]

The reason due to which they failed to track is because they were unable to identify them even if they had them on footage from the camera. In developed countries such face detection and recognition systems are being built on large scale while in counties like Pakistan we are still just focusing on placing cameras rather than using face recognition systems.

We observe whenever a crime is committed in most of the cases, they have the footages of crime scene and cameras placed everywhere. Still the news we get to hear is that some unknown people committed this crime. Then what is the point of placing cameras everywhere if we still can't figure out who is responsible and most of the crimes remain unsolved and cases are closed. It has become a common issue in Pakistan in the past few years even when the face of the culprits is not hidden. Some consider the low camera resolution to be the problem but that is not exactly the case every time. In this era of technological revolution data theft is a major problem, and there are two ways to cater such problems.

Either we can stop anything like this from happening or take immediate action after anything of this sort happens. In first scenario having 24/7 watch of the cameras as soon as any unauthorized person access the unauthorized premises they would know as his/her face would be marked red. In second scenario after the crime has been committed, they would immediately know the credentials of who did it rather than speculating about it. An application like Face Recognition & Criminal Identification (FRCI) is the solution to opt for in places where entry of only specified people is allowed. This application would be fairly simple to adopt in various environments. Users can easily operate by adding/deleting a person's record and then recognizing the person in front of the camera.

1.4   Project Objectives

Desktop application is the best way for the implementation of Face Recognition & Criminal Identification (FRCI). The already built systems are very complex and expensive being used at a much larger scale which requires you to have authorized access to use them. However, using FRCI which is very simple and easy to use and can be implemented in various sectors for security purposes. This can be enhanced by embedding this application with all the companies offering security cameras. It won't be costly while giving you competitive edge in the market.
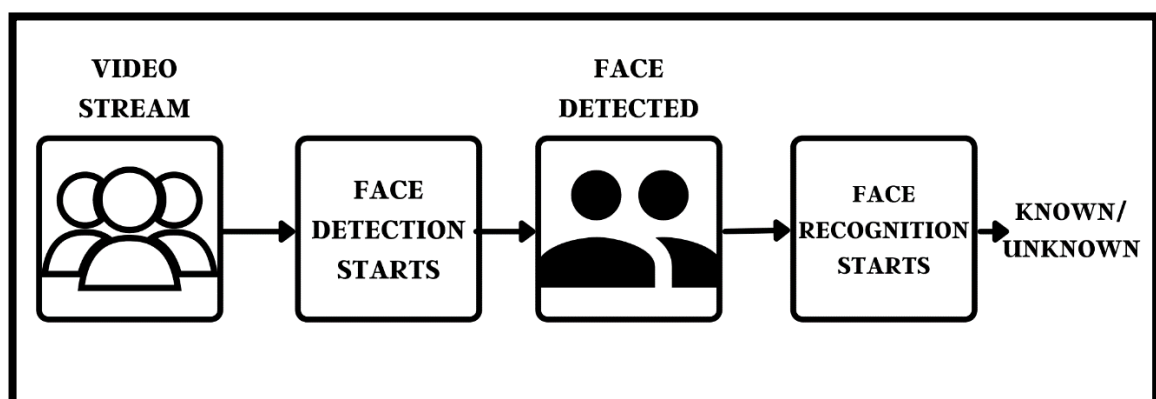

Figure 1.2: Simple Working Methodology

FRCI is of great value by enabling the criminal identification process as fast as it takes few seconds, hence saving time to take action. This project mainly targets the domain

of security by providing enhanced and worthy solution to a common problem faced in security sector. Time is critical when operating on security threats while having great precision is what makes it valuable.

1.5   List of Objectives

- Desktop application for face detection and identification
- Simplicity in its use
- Can be implemented in various security sectors
- Real time verification from live footage
- Maximum accuracy & precision in its results.
- Overcoming the present loopholes in available applications

1.6   Project Scope

Application of this project has a very vast scope considering the need of its use. Since security of any sensitive institution is integral when dealing with crime rates increasing every day. RFCI would be a major breakthrough in terms of response time by relevant authorities knowing the necessary information, helping find the culprits within no time.

This project brings value to the security systems which are based on cameras. Let us consider an office which holds information (sensitive to national security). An office like this would definitely be monitored 24/7 using cameras. We can deploy this project in this scenario by adding all the authorized personals to our dataset.

So, as anyone enters that office his/her name and designation would be visible on screen proving he is an authorized person. However, if someone who is not granted the access won't be the part of our dataset would easily be recognized as soon as he enters that office.

In case if there is a bank robbery, in most cases we do have a video tape of the robbers. However, they are still unaware of any whereabouts while using RFCI the video tape would show their name (and possibly some other info as well). Making it a piece of cake to locate them immediately.

This would work perfectly in collaboration with security systems, just like their system was evolved recently with biometric verification. Biometric verification was made necessary to each citizen, similarly we can make visual verification mandatory to create the dataset of all the citizens.

Chapter 2

Literature Review

The face recognition acts the same as biometric technology but the difference being that face is the focal point for searching the identity of person. Face recognition is evolved over the period of time.[4] Increase in utilization of face recognition has prevailed to be effective in improving the security in various sectors. Over the years several software's and applications have been launched using different aspects to maintain the high standards of security. However, these existing systems used different algorithm which were either not accurate or efficient enough.[5]

Recognizing a face is problematic when working with the artificial intelligence. This was used on Facebook to instantly identify the users appearing in the pictures with their profile pictures. We have seen several techniques for face recognition until now but still it is very crucial to choose which algorithm to be used. Here we are designing face recognition using Principal Component Analysis (PCA). Accuracy of PCA has been found to be more than ninety percent. [6]

Many applications are using face detection and the trend is increasing each year for computer vision and control systems. Face detection process detects the face by focusing on different attributes of an image. Face recognition is not an easy task if the subjected image is not clear correctly shaped etc. We propose using its preferred to use PCA for such applications due to its fast and accurate results.[7]

Traditionally face recognition systems recognize the face and display their names respective to their face. Without considering the fact that two or more people can have the same first and last name. The Face Recognition and Criminal Identification (FRCI) system would store person's Name along with their ID to distinguish and won't allow you to enter the same name for more than one person. This would avoid the serious issue of redundancy that is face in face recognition systems. Moreover, Face Recognition and Criminal Identification (FRCI) would update its data record without having to restart the application.

Mostly, the face recognition systems that are introduced detect faces from static images by comparing them with the images available in their dataset. Recently some applications have been developed which perform the operation of face recognition in real time but are not much accurate due to use of algorithms which are not efficient. [8] We are using Haar Cascade Classifier for face detection and Principal Component Analysis (PCA) for face recognition with the USP of real time face recognition with high accuracy by having dataset without redundant labels (names) and updating the application without restarting.

2.1   Recent Contributions

We have gathered the list applications that are already contributing to same domain are mentioned below:

2.1.1 Real Time Face Recognition

We already have some applications which are performing the same task, but they are not covering all the aspects. They are unable to fulfill the customers' needs and due to which they are not secure. Just like this app which can store multiple faces with the same name and this application cannot detect faces properly when you move your face or change the angle. Similarly, you cannot delete an existing person from your dataset.

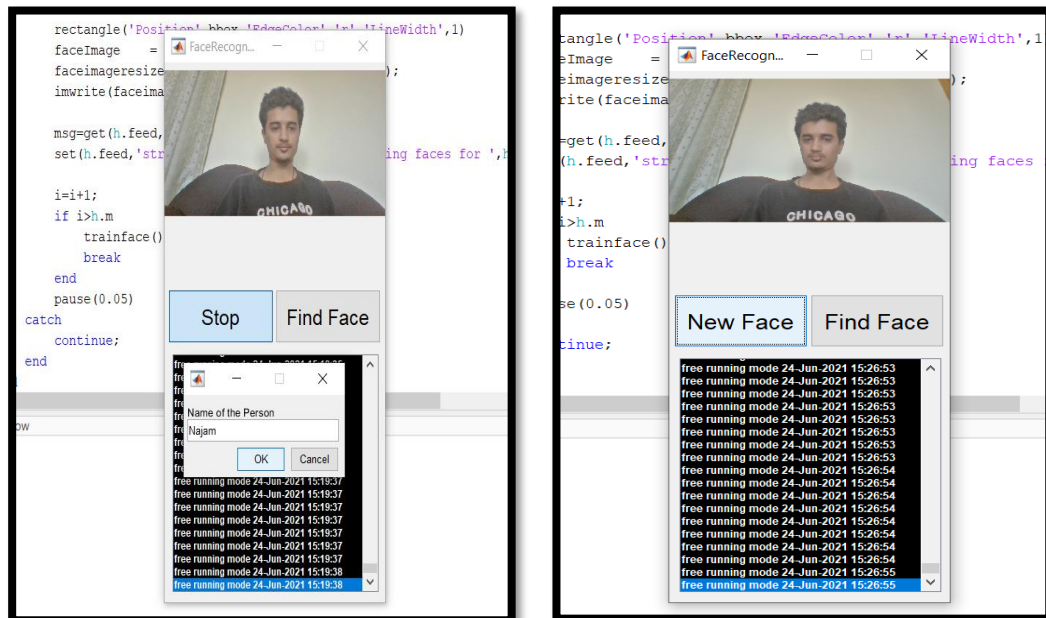Figure 2.1: Real Time Face Recognition

There are not many applications which provide real time face recognition as most of them recognize faces by selecting a static image. On the other hand, the systems which do provide real-time face recognition efficient enough to be reliable.

2.1.2 Face-Recognition-by-CNN

This is another application that performs face recognition by using Convolutional Neural

Network (CNN). This application is much better in terms of detecting faces but not in any other aspect. You have to run two different programs manually, firstly it would start a video stream and record your face and then the other one is meant for recognition.
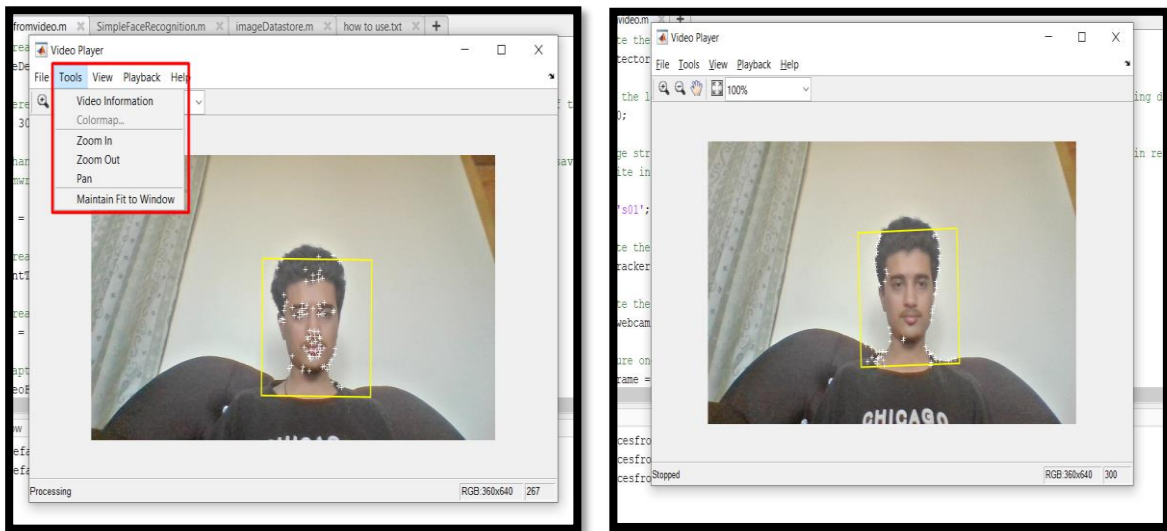
Figure 2.2: Face-Recognition-by-CNN

Another thing to note here is that this application is meant for only storing 3-person dataset. In case you want to add more persons, then you have to create new directories for and make amends in the code. It is not an easy task to understand how this works for naïve person as it doesn't have many functions.

2.1.3 Serg3ant's face detector and recognizer

This face detection and recognition application is better than the previous 2 but it has no accuracy at all as it show different names for the same time. Although the face was added only once. You can observe that in the figure 2.3 as well.
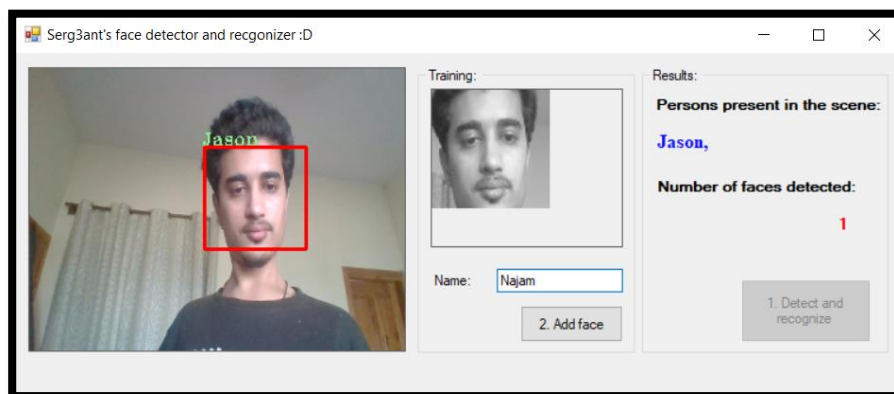
Figure 2.3: Serg3ant's face detector and recognizer

This application is not good enough for detecting multiple faces at the same time and it doesn't have the option to tell if the person is already present in the dataset or not. So, this will show the name of the closest match corresponding the unknown face.

2.2 Literature Review Table

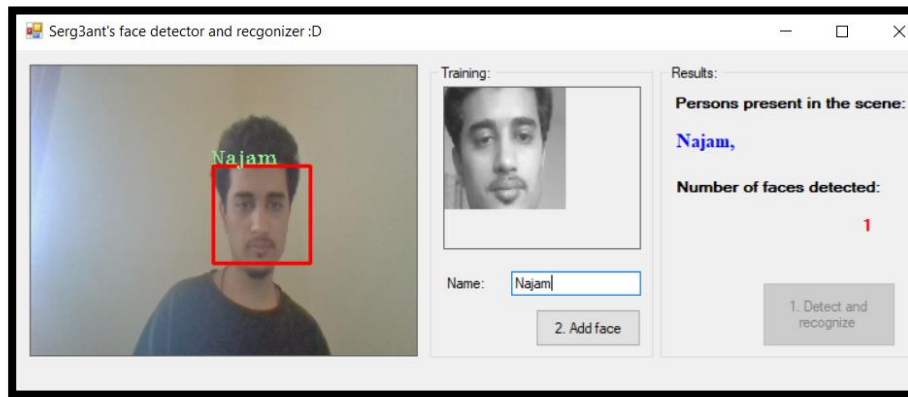| TITLE	BRIEF SUMMARY	DOP
A Review of Face Recognition Technology	The face recognition acts the same as biometric technology but the difference being that face is the focal point for searching the identity of person. Face recognition is evolved over the period of time. In primary algorithm phase PCA (principal component analysis) is used to recognize the pattern of different faces and considered mainstream technology. Now with the time passing we have observed different techniques like neural networks, adaboost, support vector machine and deep learning that provides aid in face recognition process.	21 July 2020
Real-time implementation of face recognition system	Face Recognition helps in recognizing the person's identity based on their facial features. This has now become necessity for the security systems to have access control. There are many methods which have already been presented but have low accuracy. However, this paper has used PCA (principal component analysis) and LDA (Linear Discriminant Analysis) to increase the performance of this system.	8 Feb 2018
Face Detection and Recognition Using OpenCV	The process of face detection and recognition has been very prevalent, especially in terms of real time face detection. There is different algorithm available for face detection and recognition. The best algorithm's available for face detection are Haarcascade, Eigenfaces, Fisher, Local Binary Patterns. When focusing on face detection PCA (Principal Component Analysis) is our choice for performing the process of recognition. Karhunen-Loeve is also effective algorithm for face detection but this paper focusses on using PCA.[9]	18-19 Oct. 2019

Real Time Attendance System Using Face Recognition Technique	We have been observing the increase in deployment of face detection and recognition systems around the globe due to one simple reason that it does not require any human effort or interaction in contrast with biometric verification. This paper focuses on integrating OpenCV algorithm for face recognition in addition to the usage of PCA for transforming images into eigen values and HaarCascade to detect the feature of the face.[10]	28-29 Feb. 2020
A Comparative Study of Face Recognition Algorithms under Facial Expression and Illumination	Different studies were performed on two different datasets of faces to contrast which face recognition algorithms work best under facial expression and illumination. Insights from the studies show that LBPH (Local Binary Pattern Histogram) algorithm is more accurate to illumination factors overall. However, LDA (Latent Dirichlet Allocation) has proved itself to be more accurate in terms of facial expression factors. The research shows that each algorithm should be tested against different datasets to have more precise results. Mean accuracy in descending order is like LBPH>LDA>PCA.[11]	17-20 Feb. 2019
A Survey on Face Recognition Algorithm	Biometric identification is used most cases for the purpose of identifying a person's identity. However, face recognition is the advanced version of identification technique emerging in the past few years. This is done by using different algorithms and most frequently used algorithms include PCA, KPCA, LDA, SVM, SIFT. PCA is one of the most used which works by reducing the dimensions of the image by compressing it. LDA is an appearance-based technique which also uses dimensionality reduction. SVM uses binary classifiers while SIFT is based on invariant features. Every algorithm is feasible depending on your requirements.[12]	3 Dec 2018
Comparison of face recognition algorithms	This paper is based on comparison between different face recognition algorithms which are considered accurate. The algorithms which were observed include K-nearest neighbors, Eigenfaces, PCA and naive bayes. As a conclusion K-nearest was the most successful after the Principal Component Analysis and Naive Bayes has worst performance results. [13]	15-18 May 2017
Feature extraction and face recognition algorithm	The process of face recognitions consists of 4 parts including: face detection, image processing, feature extraction and face recognition. In terms of feature extraction 2 methods were analyzed PCA and 2DPCA. After the experiment based on two observing recognition rate and recognition time it was concluded that we should choose PCA method instead of using 2DPCA.[14]	25 June 2018

Performance Analysis of Supervised Classifiers Using PCA Based Techniques on Breast Cancer	This paper was based on the recognition of tumorous. Different algorithms were tested to see the accuracy of the algorithms and the algorithms include PCA, K-nearest mean, Naive Bayes, Support Vector Machine among others. PCA showed the accuracy between 96.4% to 97.8% while SVM with sigmoid shows worse performance 83.5% accuracy in its results.[15]	21-22 Feb. 2019
Intrusion Detection System Using PCA with Random Forest Approach	Today we are facing several security threats due to increase in evolution of wireless communication and the intrusion detection system helps to find and detect the intruders in the system. We are creating the intrusion detection system using PCA and random forest classification. PCA will help in dimensionality reduction as it is more accurate in terms of accuracy compared to SCM, Naive Bayes and Decision Tree. The results show the accuracy rate of 96.78% with error rate of 0.21% for PCA. [16]	2-4 July 2020
Facial Recognition using Machine Learning Algorithms on Raspberry Pi	Face Recognition is another way of doing biometric identification and beneficial in many ways. We must use the appropriate algorithm with good accuracy percentage for the implementation of real time system. The two-system discussed in this paper for the implementation are Haar-Cascade method and HOG (Histogram of Oriented Gradients). The focal reason for the usage of Haar Cascade is that it works almost real time working with traditional CPU's because of its simple architecture. [17]	13-14 Dec. 2019
Face Recognition System Using Machine Learning Algorithm	Recognizing a face is problematic when working with the artificial intelligence. This was used on Facebook to instantly identify the users appearing in the pictures with their profile pictures. We have seen several techniques for face recognition until now but still it is very crucial to choose which algorithm to be used. Here we are designing face recognition using machine learning algorithm and PCA. Accuracy of PCA and linear discriminant analysis was 97% and 100%. [18]	10-12 June 2020
An Efficient Face Recognition Algorithm Based on Deep Learning for Unmanned Supermarket	In the past few years, we've experienced rapid increase in the usage of face recognition systems. In field of machine learning and deep learning face recognition algorithm like Convolutional Neural Network (CNN) is becoming popular. These applications have great untapped customer base like unmanned supermarket.	1-4 Aug. 2018

An Efficient and Compact Review of Face Recognition Techniques	Recognizing a face is a specified process done by using various algorithms developed and tested by researchers. Now, that we have seen so much advancement in research more and more applications are incorporating face recognition techniques. Few of the most popular and best served algorithms for face recognition include PCA (Principal Component Analysis), ANN (Artificial Neural Network), Support Vector Machine (SVM) etc. However, each algorithm provides different results in different situations. Each algorithm has its own pros and cons, but you should choose the algorithm based on your requirements.	22-23 Feb. 2020
An approach to face detection and recognition	Many applications are using face detection and the trend is increasing each year for computer vision and control systems. Face detection process detects the face by focusing on different attributes of an image. Face recognition is not an easy task if the subjected image is not clear correctly shaped etc. We propose using Viola Jones algorithm with PCA (Principal Component Analysis) due to its fast and accurate results.[19]	8 June 2017
Analysis of Face Detection and Recognition Algorithms Using Viola Jones Algorithm with PCA and LDA	Privacy is the primary concerns of most people these days. Many well reputed companies have failed to provide privacy and security to their customers. In order to solve such problem that is faced around the world face recognition seems to be the right option to opt for and to maintain the high standards we are using two most prominent algorithm PCA (Principal Component Analysis) and LDA.	11-12 May 2018
An Efficient Face Detection and Recognition Method for Surveillance	Automatic detection and recognition for face is the purpose of this discussion. In this paper we propose the method which detects the regions of the skin in the subjected image using coloring model HSV and YCbCr. Then we use PCA (Principal Component Analysis) for correct recognition of the face. It showed around 97.3% accuracy for images. [20]	18 Aug 2016
Research and Implementation of Face Detection, Tracking and Recognition Based on Video	Observing the continuous advancement in computer vision face recognition systems have played a major role. In this system camera captures the image or video stream focused to track the human face. In this paper OpenCV library was used with different algorithms like LBP, Eigenface, PCA and Fisherface. It was analyzed that use of each algorithm are different and every one of them have their advantages and disadvantages.[21]	11-12 Jan. 2020

Table 2.1: Literature Review Table

Chapter 3

Requirement Specifications

3.1 Overview

This chapter will entail the description of the requirements for Face Recognition and Criminal Identification (FRCI). As discussed before in chapter 2 there have been applications of face recognition that are launched before bud had certain shortcomings. Specifically, not a single system was feasible to be implemented for the security purposes as they did not have complete functionality like FRCI. The previous systems could store the same name for multiple faces and were not able to detect multiple faces in real time. FRCI would detect multiple faces in real time with great accuracy.

3.2 Existing System

Most of the systems that are already available offer face recognition from static images rather than performing face recognition in real time. Around 80% of the systems available recognize faces from images which is not feasible to make a high-end security system. The applications that do offer real-time face recognition are not efficient enough to encounter all security aspects and are not good in accuracy. Another defect of these systems is that they cannot detect multiple faces at the same time.

3.3 Proposed System

Face Recognition & Criminal Identification (FRCI) would detect the face in real-time and show the credentials of the person in front of the camera. This would increase the time for face detection. As soon as the face is detected (which hardly takes few seconds) the person's Name/ID would be displayed. If the person detected is not part of our dataset (not added in our dataset) then it would display red box around the detected face and Unknown/Intruder written on it.
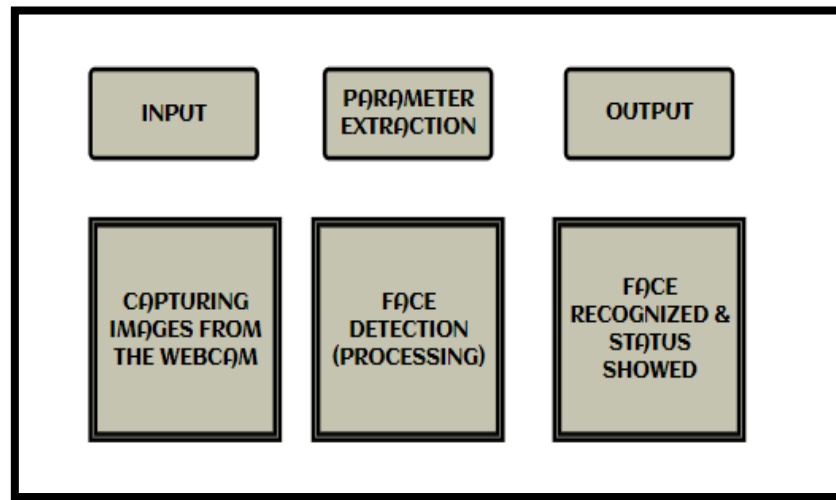
Figure 3.1: Proposed System

This system very simple to understand as it is only few steps process. First you have to click on capture button which will activate the camera. After that by clicking on detect face button the face of the person would be detected, and we can enter the Name/ID of that person. Then by adding the person it would capture few images and store in dataset. Once the person is added you can recognize the person in real-time.
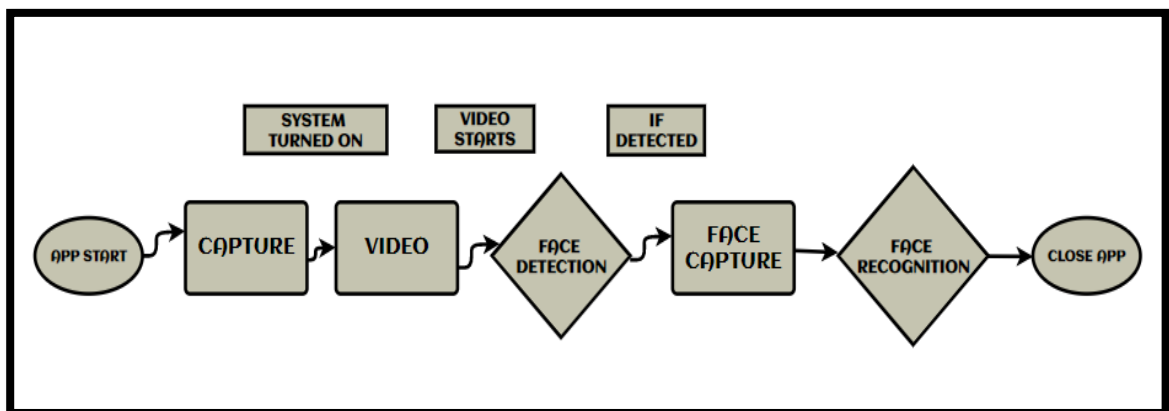
Figure 3.2: Methodology Diagram

3.4 Requirement Specifications

There are certain functional and non-functional requirements that should be met to make this project effective and efficient.

3.4.1   Functional Requirements

In terms of functional requirements, the system must have the support of .net applications and access to the webcam. The camera should be positioned in such angle that it could see the person from the front in order to detect the face. All the functional requirements are straightforward to make it work on most of the systems available.

3.4.1.1   List of Functional Requirements

- **Face Detection.**
The application must be able to detect face in real time.
- **Maintain Record**
Store the person's record in dataset successfully.
- **Avoid Data Redundancy**
Does not store the same name for more than one person.
- **Face Recognition In Real Time.**
Recognizes the faces in real time and shows credentials
- **Authentic Access Tracking**
Proactive measure can be taken to increase security

3.4.2 Non-Functional Requirements

The system should be reliable enough to implement and user-friendly. The face recognition should have a good percentage of accuracy and speed to yield good performance. The system should be very easy to understand and maintain according to the need of security purposes.

3.4.2.1   List of Non-Functional Requirements

- **Usability**
The project should be very easy to interact with when completed even for a naïve person when interacting with it the very first time.
- **Maintainability**
It should be very simple to manage any changes if required by the system to be implemented successfully.
- **Reliability**
When used in the designated environment it should be dependable enough to be implemented.
- **Scalability**
The project implementation scope can be elaborated easily by the support/collaboration and future work.

3.4.3 Use Case/ UML Diagram

In figure 3.2 is the general UML diagram of the FRCI system that we have proposed in which the user tends to navigate with the application by launching up the camera for detecting face.
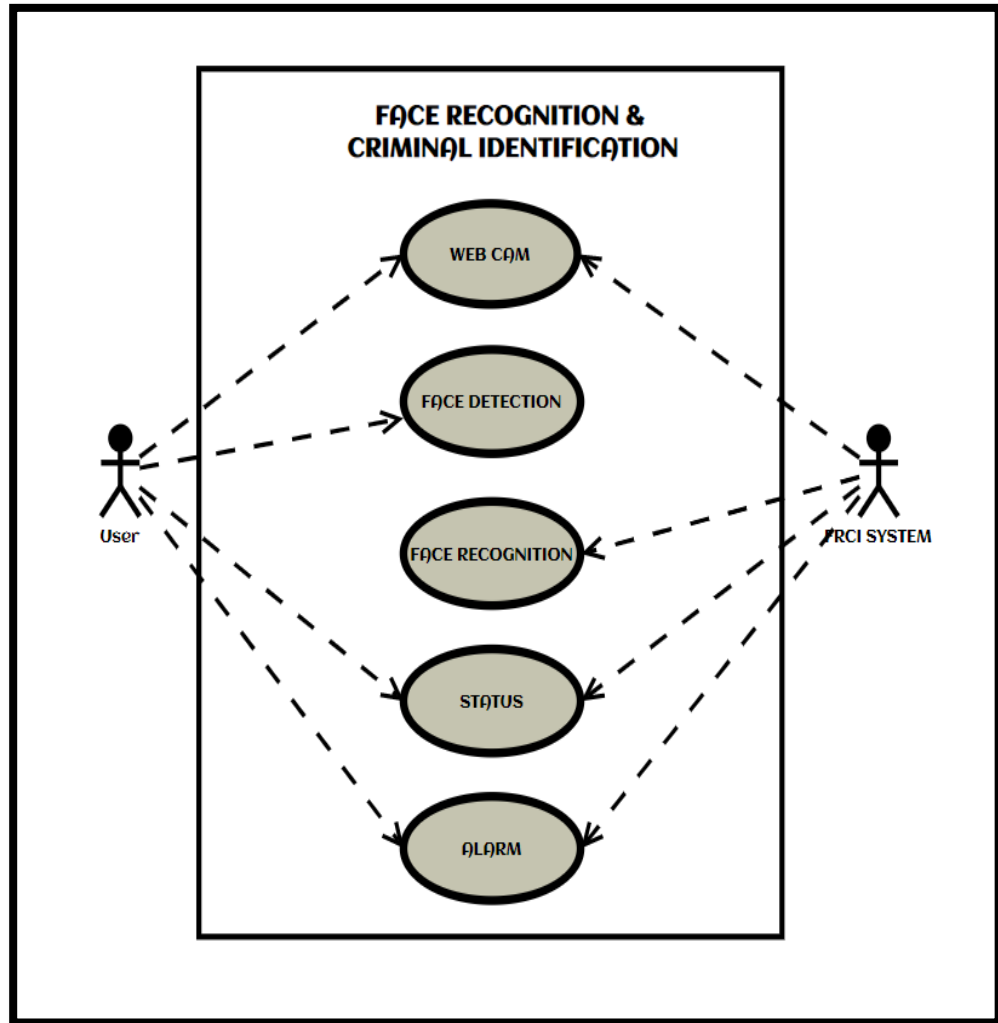
Figure 3.3: UML Diagram: Face Recognition & Criminal Identification

Once the camera is started you can start detecting the face of the person. Once the person in front of the camera is detected you will be able to see the status of his/her identify if that person is authorized or not for entering.

3.5 Use Cases

In the figure 3.3 we have a use case for the illustration of face detection and recognition in real time. In terms of recognition status would be shown (if recognized identity would be shown otherwise unknown).
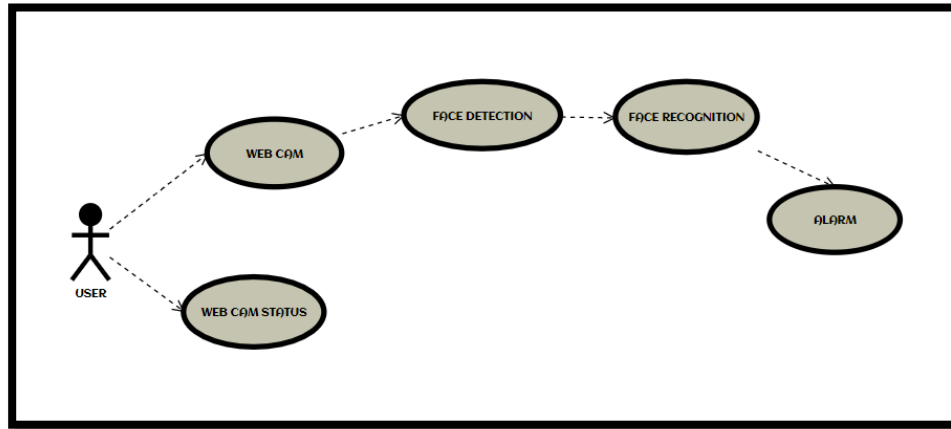
Figure 3.4: Use Case: Face Recognition

Once the person comes in front of the camera FRCI starts detecting the face for the recognition process starts. Then based on the dataset system will show the status unknown if the person is not authorized if the person is authorized then it would show their credentials.

3.5.1 Use Case (Face Detection)

This use case shows the pre- and post-condition for face detection process to happen successfully. For face detection process if the pre-condition is not satisfied the post-condition won't be met. In this use case camera should be turned on and available in working condition.

User case ID	FRCI01
Title	Face Detection
Description	This use case is made for the face recognition Parameters
Primary Actor	Person Entering the premises
Pre-Condition	Camera Should be turned ON
Post-Condition	Recognition of the person's status by showing his/her identity.

Table 3.1: Use Case: Face Recognition

3.5.2 Use Case (Face Recognition)

The second use case is of face recognition and the pre-condition requires that the face detection is already done. If the pre-condition is satisfied, then the recognition process would go smoothly, and it would show the status after the recognition process is done in real time.

User case ID	FRCI02
Title	Face Recognition
Description	This use case is made for displaying the status of recognition, which help the authorities to check if the person is authorized to access or not.
Primary Actor	Person Entering the premises
Pre-Condition	Face detection should already be done to proceed for face recognition.
Post-Condition	Known/Unknown status will be displayed corresponding to the face detected.

Table 3.2: Use Case: Face Recognition

Chapter 4

Design

4.1   System Architecture

Face Recognition and Criminal Identification (FRCI) begins with detecting the face of the person in front of the camera. When face of the person is detected successfully using Haar Cascade Classifier algorithm. Then face recognition algorithm starts working and it would start the face recognition process. Once the person faces the camera as shown in figure 4.1. If the system is unable to recognize then it would instantly show that the person is unknown. However, if the recognition is successful then it would show their authorization by displaying their identity.
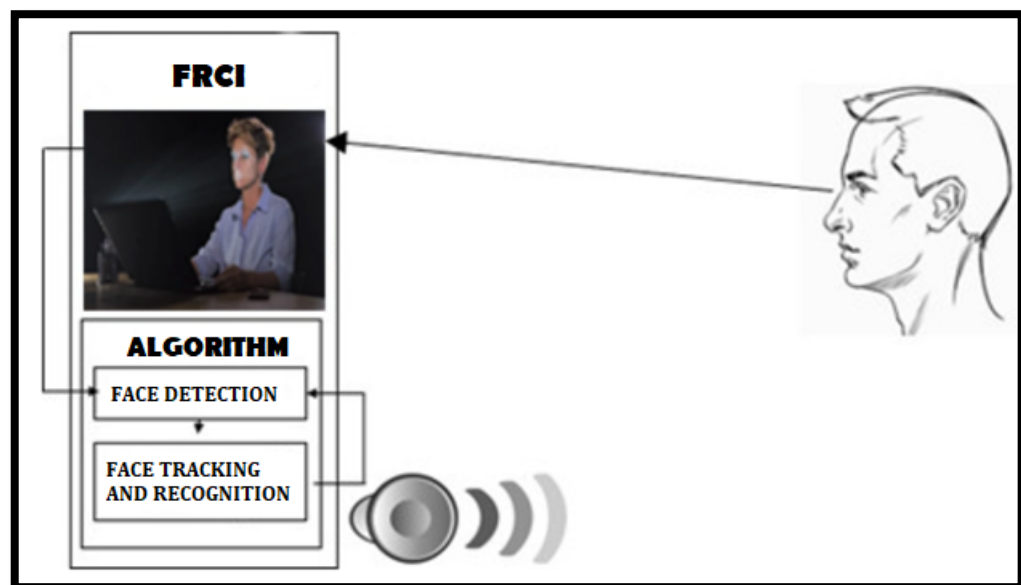
Figure 4.1: System Architecture Diagram

4.2   Design Constraints

4.2.1 Software Constraints
The system will require the support for .Net 4.5.2 or above.

4.2.2 Hardware Constraints

The system should have the following hardware constraints:

• Good webcam quality for better face detection and recognition.
• Logical placement of the camera.

4.2.3 Development Environment Constraints

4.2.3.1   .Net Framework

Most of the applications, especially security systems are built as .net applications due to its simplicity and ease of use along with ease of implementation. It has been the best architecture so far in terms of simplicity in user interface and high performance. Using .Net framework is highly secure to deliver safe applications with vast language support. This is scalable and stable with very fast loading time at any instant. We can reuse components and code with various system tasks.

4.3   Design Methodology

The design methodology of FRCI application is summarized in the figure 4.2 which shows how the interaction would occur with the application. The context of the person in front of the camera with FRCI GUI and how face recognition methodology will be processed accordingly.
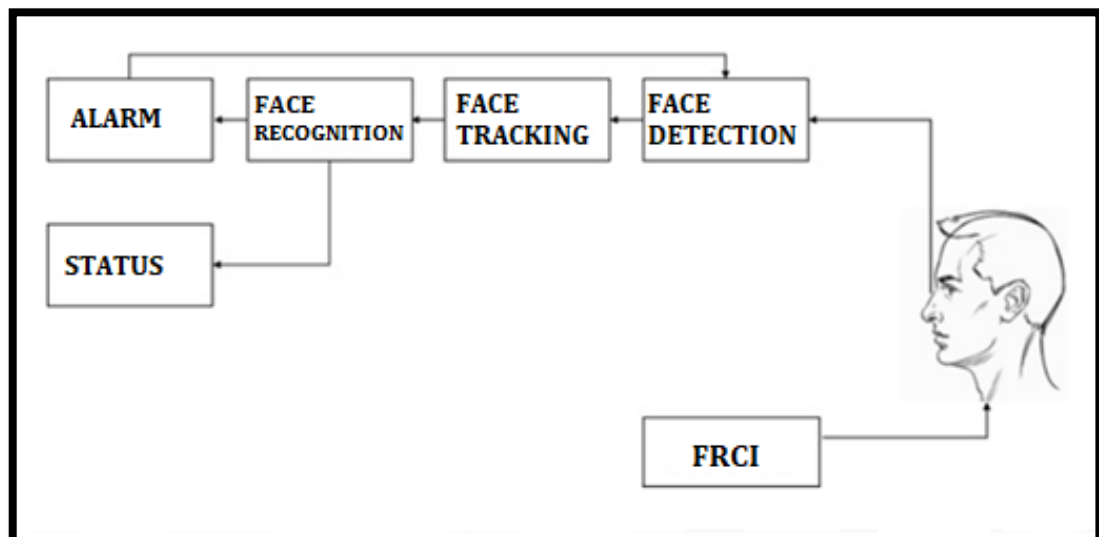
Figure 4.2: Design Methodology

4.4   High Level Design

You can see the high-level design of Face Recognition and Criminal Identification (FRCI) mentioned infigure 4.3 which demonstrates the overall interaction of the system.
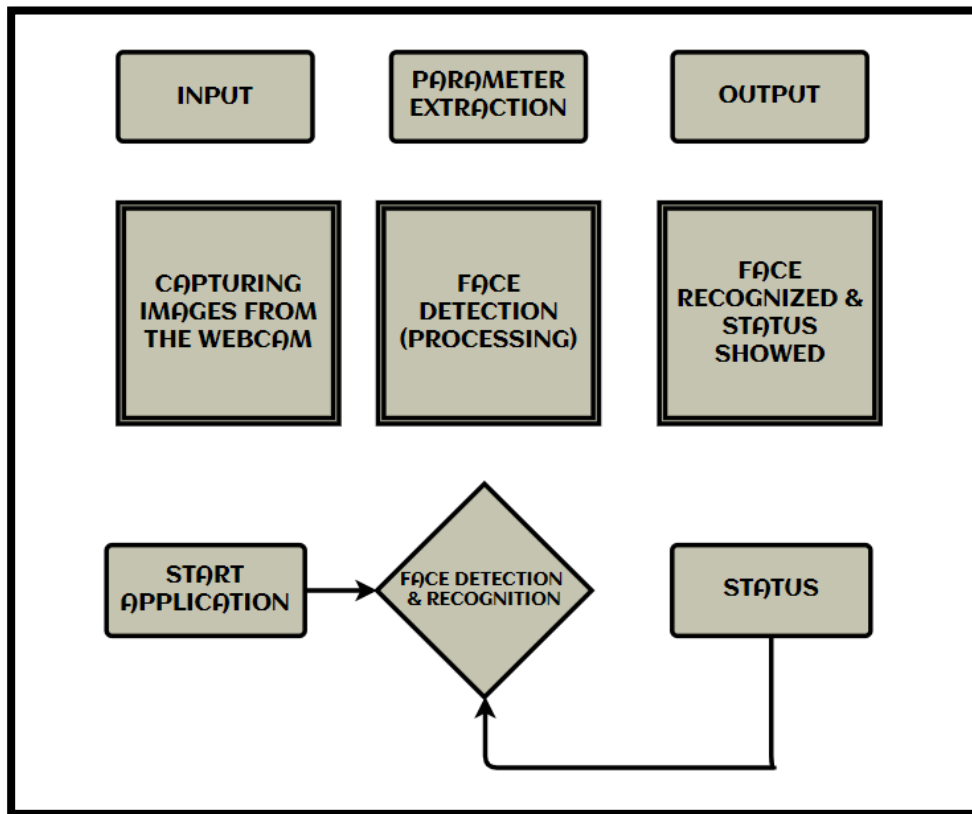
Figure 4.3: High Level Design

The HLD of system depicts the abstract interaction of application with the person in front of the camera. The person's image is taken as input from the camera for the parametric extraction. When the parameters are extracted then then FRCI would be able to recognize the face and show the status.

4.5 Low Level Design

The detailed diagram for the Face Recognition and Criminal Identification (FRCI) includes the comprehensive processing of the system works. We have summarized the low-level design of our system in figure 4.4 mentioned below.
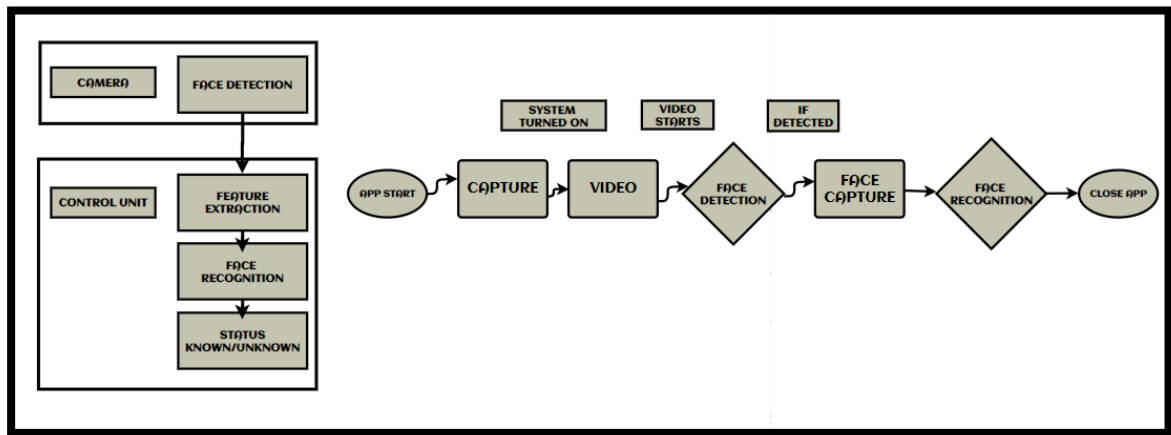
Figure 4.4: Low Level Design

4.6   Flow Chart Diagram for Face Detection

We have created flowchart diagram for face detection and face recognition separately for better understanding of the workflow of FRCI. In figure 4.5 you can see the step-by-step process of how face is detected.
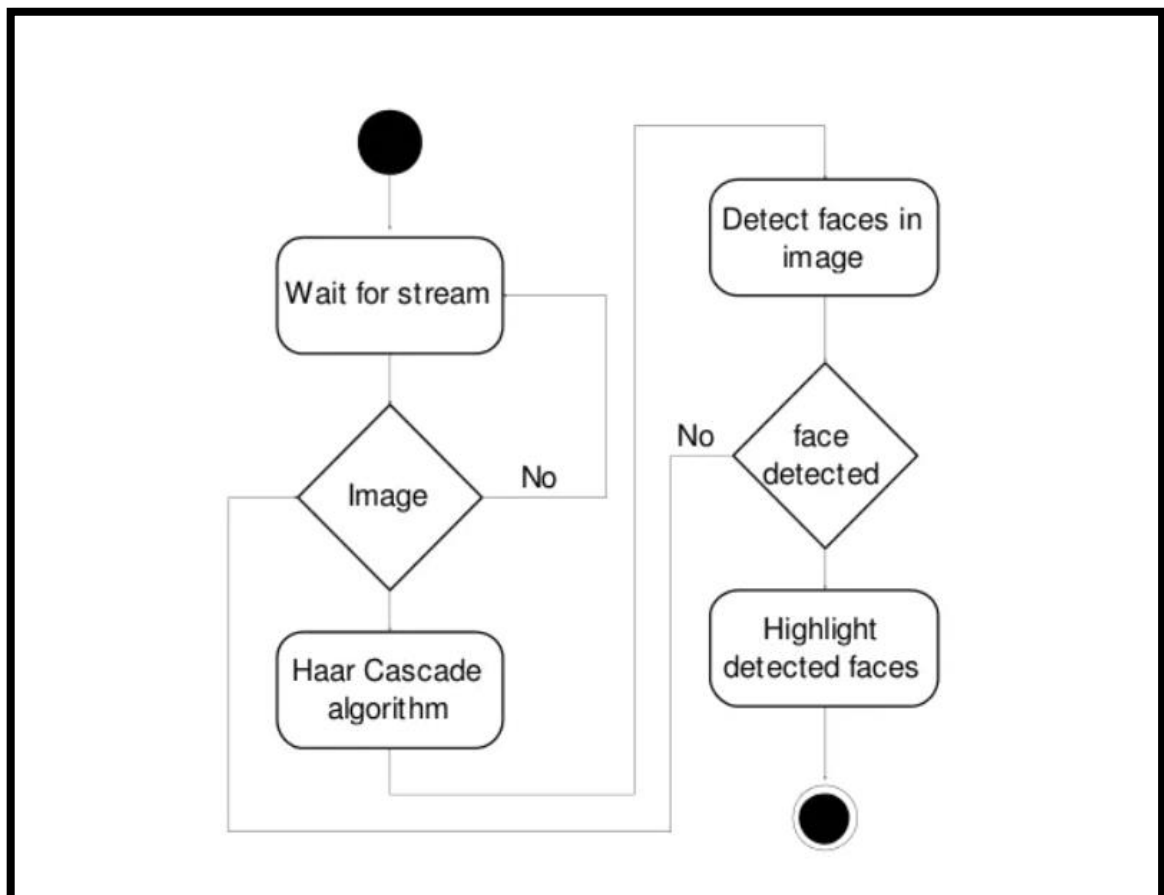
Figure 4.5: Flowchart Diagram of Face Detection

4.7   Flow Chart Diagram for Face Recognition

In the figure below you can see the complete workflow of how Face Recognition and Criminal Identification process happens in a systematic order and the steps involved.

Figure 4.6: Flowchart Diagram of Face Recognition

4.8   Block Diagram

The figure 4.5 depicts the block diagram of the project which shows the blocks of Face Recognition and Criminal Identification (FRCI). This gives the systematic representation of the main blocks of our project and the manner in which they interact.
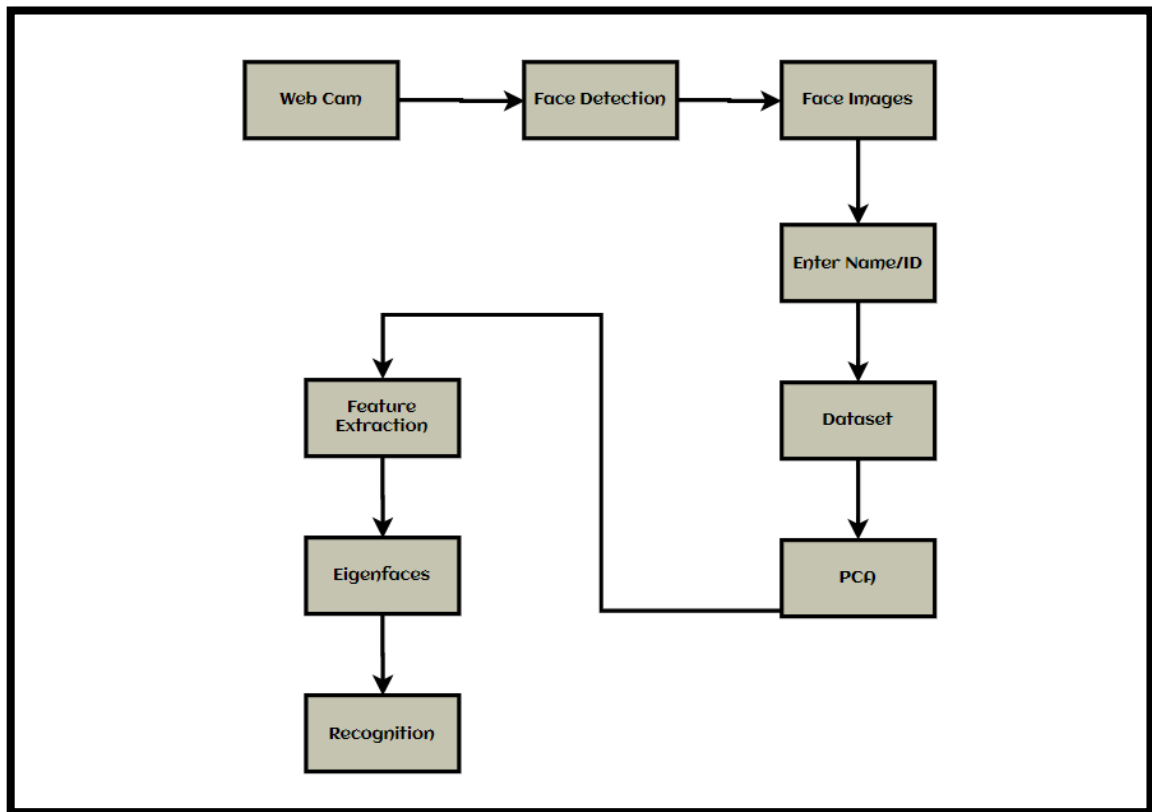
Figure 4.7: Block Diagram

4.9   Sequence Diagram

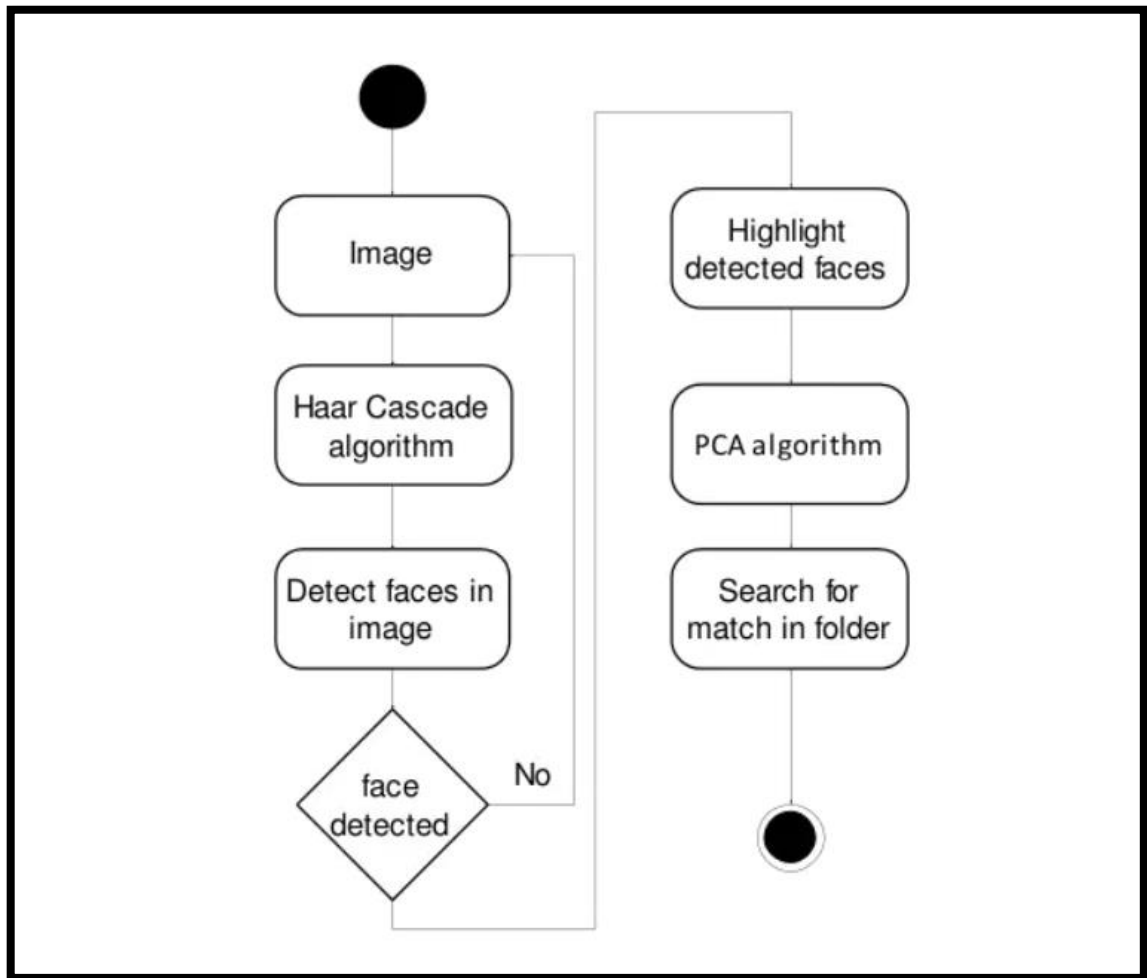We have created the sequence diagram of Face Recognition and Criminal Identification (FRCI) for the process of creating the dataset when we enter a new record/person/credentials to our dataset. The process starts by accessing the camera and then detecting the face, after face detection is done features are extracted from the detected image (face). After face detection is completed, we have to enter the credentials corresponding to which we identify the person in our data set. Then finally the data (images along with credentials) is stored in the dataset.
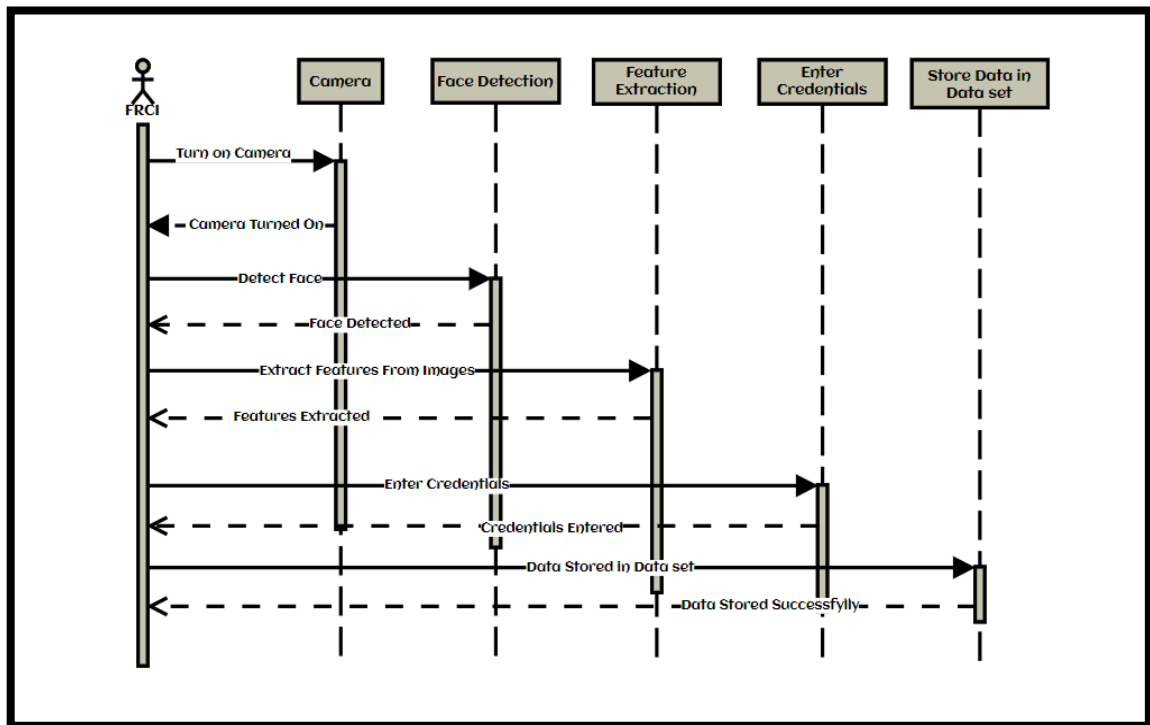
Figure 4.8: Sequence Diagram (Storing in Data set)

4.10 Summary

The Design chapter of this thesis includes the holistic illustration of the system either in the form of diagrams or structural/architectural representation. These representations clarify the internal working and overall structure of the system.

Chapter 5

System Implementation

Face Recognition and Criminal Identification is implemented using image processing techniques followed by two different algorithms Principal Component Analysis and Haar cascade classifier algorithm. These two algorithms are used for face detection and recognition.

5.1   System Architecture

The System is divided into two components, based on the system features:

- Face Detection using Haar cascade classifier.
- Face Recognition using Principal Component Analysis (PCA).

Figure 5.1: Architecture Diagram: Face Recognition & Criminal Identification

5.2   Tools and Techniques

Implemented Technologies in FRCI are:

- .Net Framework 4.5.2 or above.

- OpenCV Library.

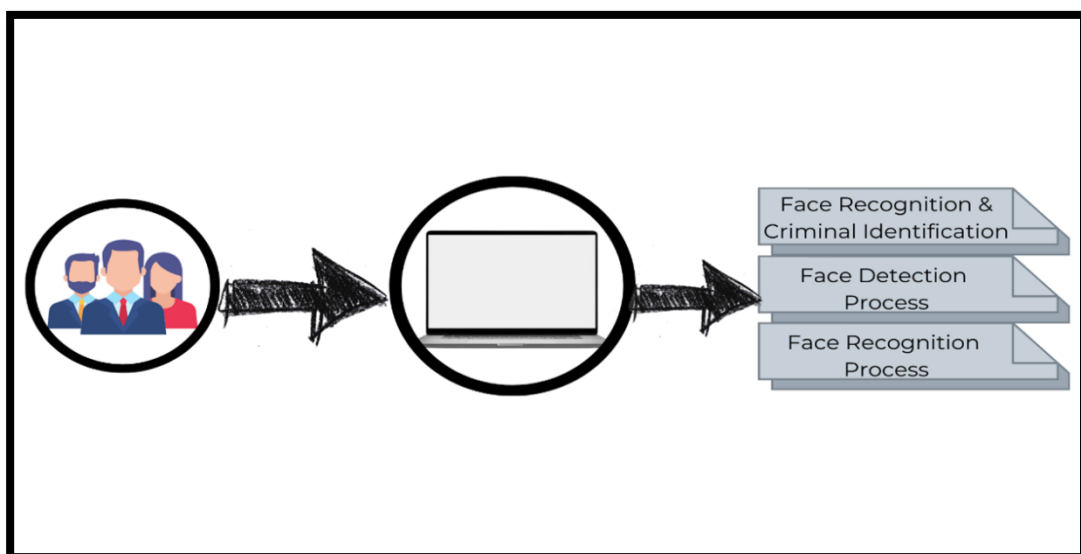- Language (.Net C#).

- Interface is designed through C# .Net.

5.3   Algorithms Used

FRCI uses two algorithms for the implementation purposes these are as follows:

5.4   Haar Cascade Classifier

Haar cascade classifier algorithm uses four step processes for the detection of face in video or image. These steps include Haar features, integral images, Adaboost and Cascading. These features are detected using cascade file save with the extension of .xml used to compare the images that the system wants to detect.[22]

The .xml file is created using several of thousands of images containing the image sample you want to detect that are stored as database for the comparison purposes. Then through comparison system will ensure whether face is detected or not.

5.5   Principal Component Analysis (PCA)

Principal Component Analysis (PCA) algorithm is best suitable for the face recognition purposes. PCA is a technique used for the dimensionality reduction. It used Eigenvectors and Eigenvalues for reducing the dimensionality and create a small feature space.

When we create a set of eigenvectors   from the training dataset of human face recognition that collection of eigenvectors is named as eigenface. It extracts the main components of the facial features that are detected and try to eliminate as much as possible to speed up the recognition process. Facial recognition using PCA consists of series of steps:

5.5.1 Initialization process

The Initialization process involves the following operations:

    I.   Acquire the initial set of face images called as training set.
   II.   Calculate the Eigenfaces from the training set, keeping only the highest

eigenvalues. These M images define the face space. As new faces are experienced, the eigenfaces can be updated or recalculated.

III. Calculate distribution in this M-dimensional space for each known person by projecting his or her face images onto this face-space.

5.5.2 Recognition process

Having initialized the system, the next process involves the steps:

I. Calculate a set of weights based on the input image and the M eigenfaces by projecting the input image onto each of the Eigenfaces.

II. Determine if the image is a face at all (known or unknown) by checking to see if the image is sufficiently close to a "free space".

III. If it is a face, then classify the weight pattern as either a known person or as unknown.

IV. Update the eigenfaces or weights as either a known or unknown, if the same unknown person face is seen several times then calculate the characteristic weight Face Recognition Using Principal Component Analysis Method pattern and incorporate into known faces. The last step is not usually a requirement of every system and hence the steps are left optional and can be implemented as when the there is a requirement. [23]

5.6 Summary

The chapter 5 of the thesis contains system implementation of Face Recognition and Criminal Identification (FRCI). This shows that how system implements all the functionalities through different tools and Algorithms.

Chapter 6

System Testing and Evaluation

System testing of Face Recognition & Criminal Identification is to analyze, verify and evaluate system compliance with the requirements given. System testing is abstract term referred to as the Holistic testing of the whole system that every functionality works according to system goals or not. The Face Recognition and Criminal Identification application structure works perfectly according to the specified requirements before system will be deployed into market.

6.1   Unit Testing

Unit testing is referred to as the testing of single component. Face Recognition & Criminal Identification (FRCI) consists of three major components Face detection, Face recognition, and Status showing. Each single component contributes perfectlywithout any error.

6.2   Integration Testing

Previously mentioned in the Diagram of System Architecture that each component is dependent on the previous one. Hence, integration of each component along with the other is critical for FRCI. This phase of testing clearly identifies and analyze project minor mistakes either in code or in GUI Design. The result of this phase shows system is well integrated both with respect to coding and design. This will enhance the smooth and easy flow of data among different parts of system.

6.3   User Acceptance Testing

The system is tested with the intended user to analyze the performance of the system in Real time basis in similar environment. Face Recognition and Criminal Identification is tested in an office to check the feedback of the user. The application works exactly as the user expected with good accuracy and precision.

6.4   GUI Testing

Interface of Face Recognition & Criminal Identification (FRCI) is designed user friendly. To make it convenient for the users to navigate through all the essential processes of application easily without any hassle.

6.5   User Interaction

In the figure 6.1 we can see the interface of the Face Recognition and Criminal Identification FRCI application which has the capture button which will access the camera. We also have other functionalities which will be discussed in the following figures.
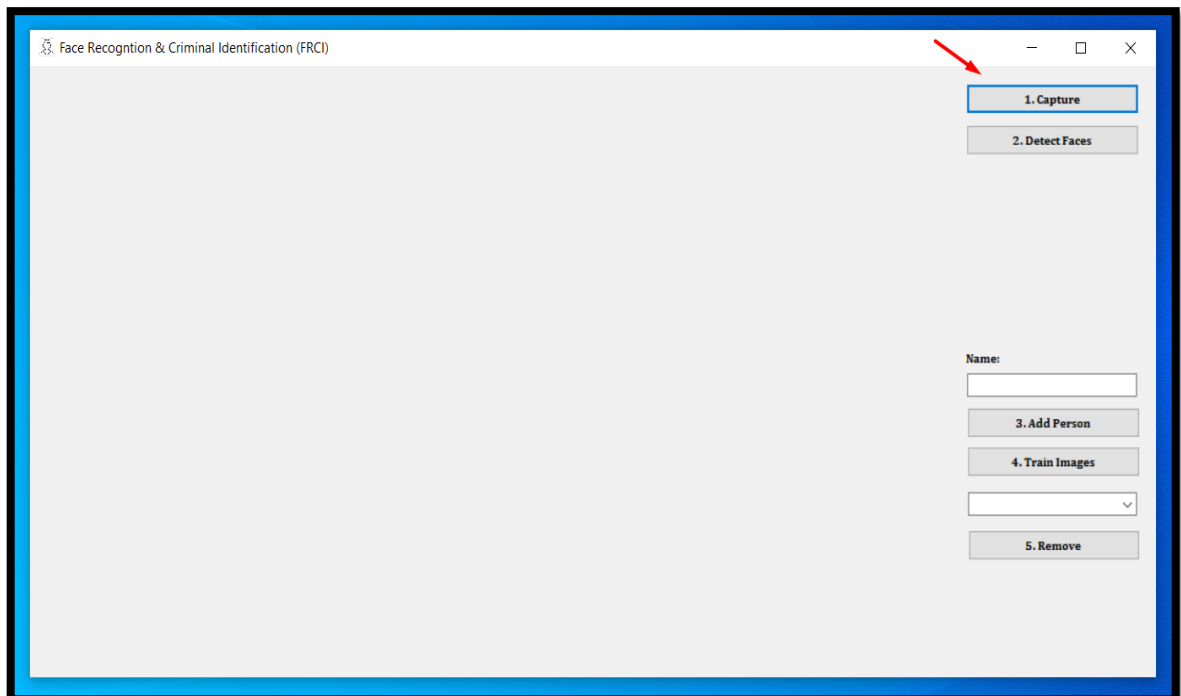
Figure 6.1: External Interface for FRCI

In Figure 6.2 attached below we can see that after the capture button was pressed the camera has been accessed and has started the live view from the camera.
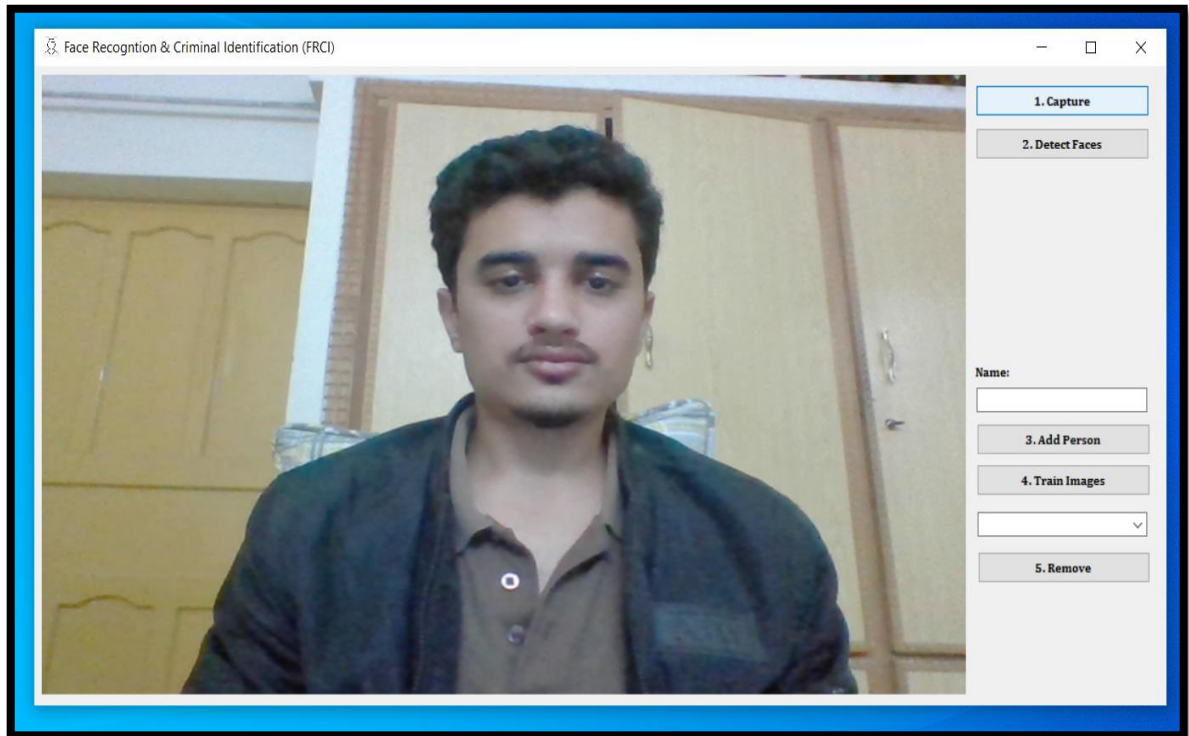
Figure 6.2: FRCI Camera capturing footage

Once the camera has been turned on now after the user clicks on the Detect Face button it will start capturing the face and you'll be seeing the captured image of the face in the picture box on the right corner.

Figure 6.3: FRCI Camera Detecting Face Interface
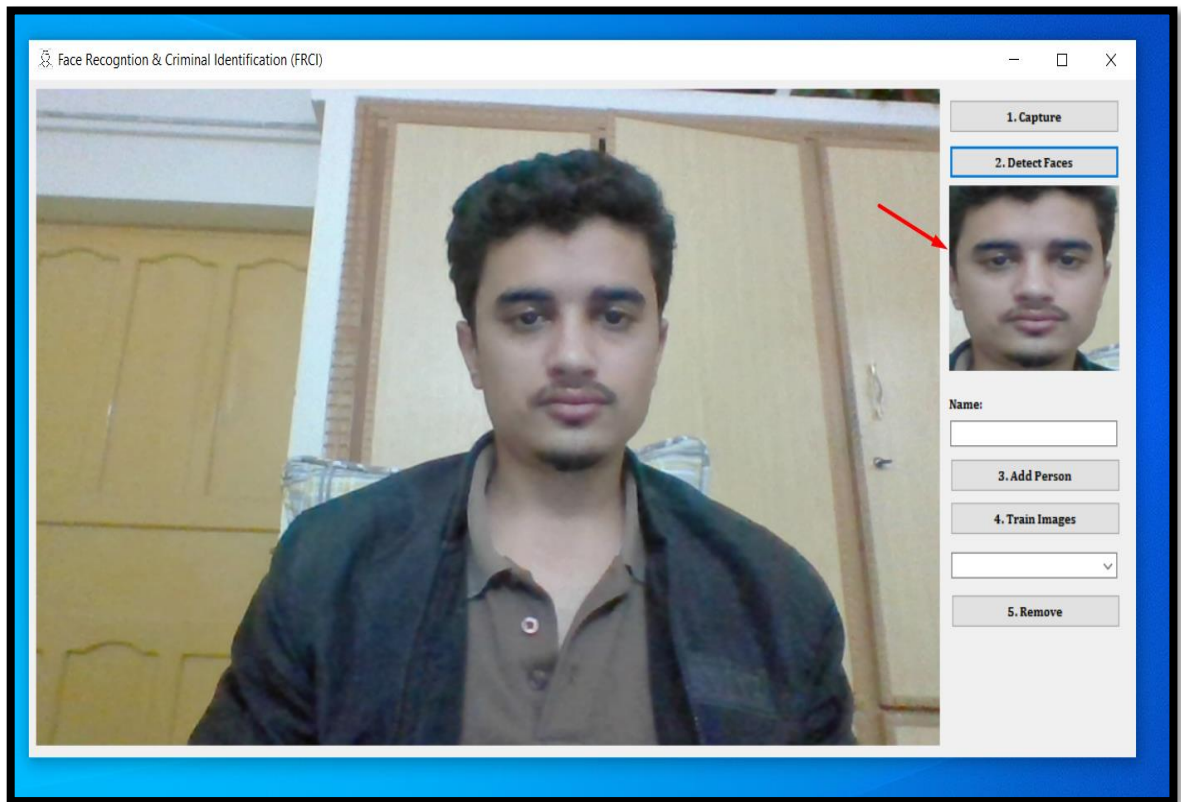
Figure 6.4: FRCI Face Detected

Now that the face has been successfully detected and the captured face is displayed, in order to insert the person's record/credentials in the dataset we have to write them in the textbox and then press the add person button to proceed.
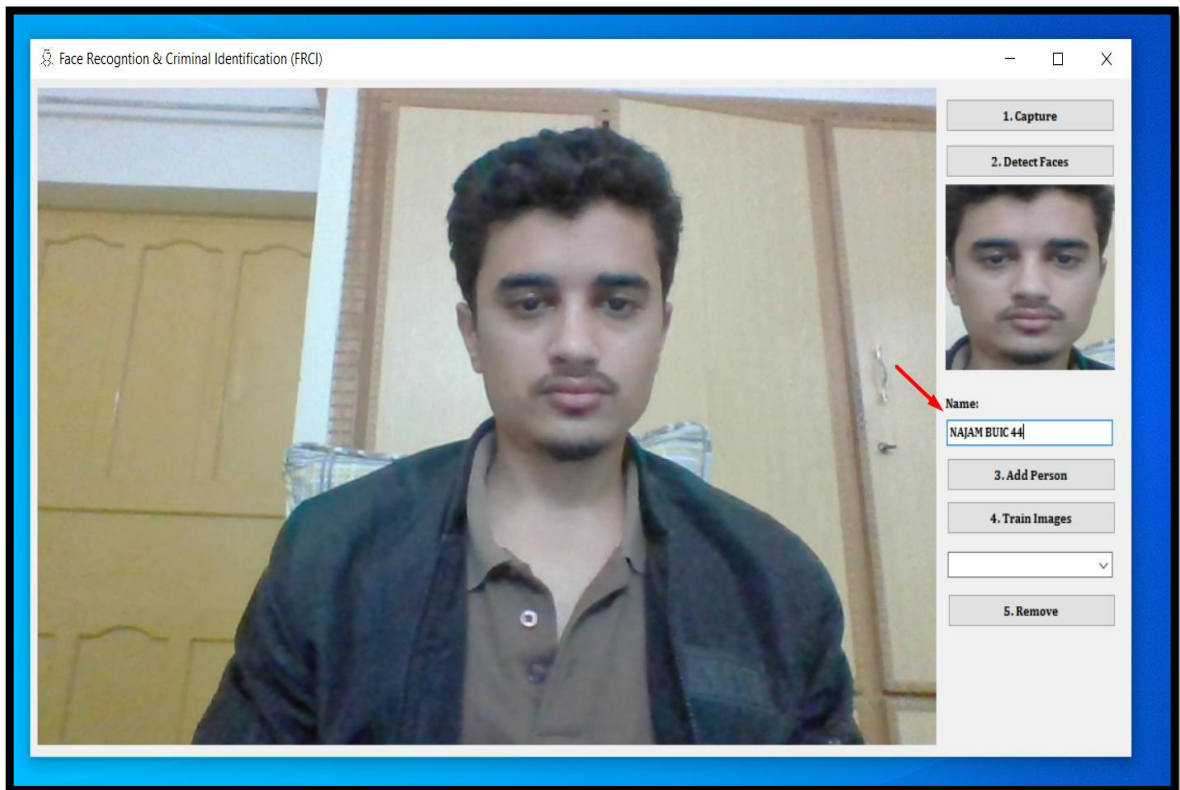
Figure 6.5: FRCI Entering Credentials
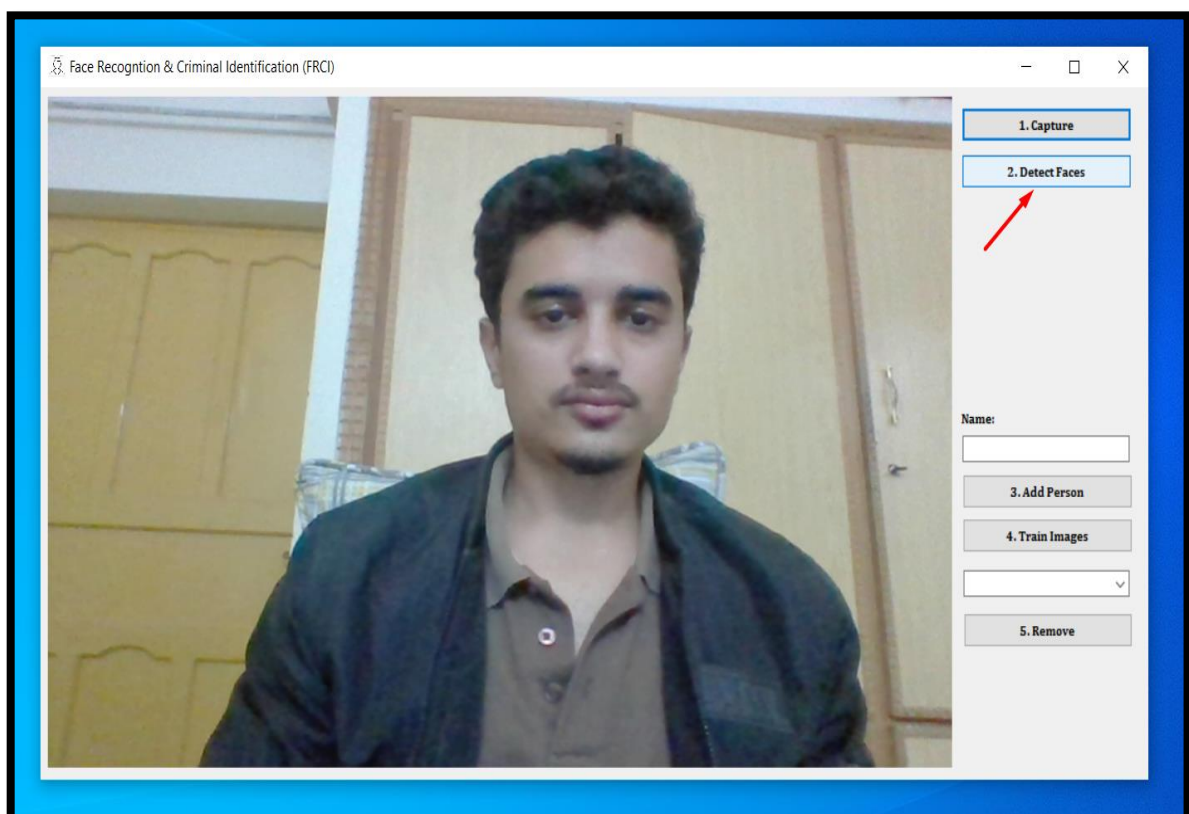
Finally, dialog box will be displayed showing the message whether your process has been successful or not and then we can move to the recognition process. In the figure 6.6 you can see that the face has been recognized and the credentials are shown corresponding to the face highlighted in a green colored box which will turn red if the face is not recognized and show the status as unknown to the user.
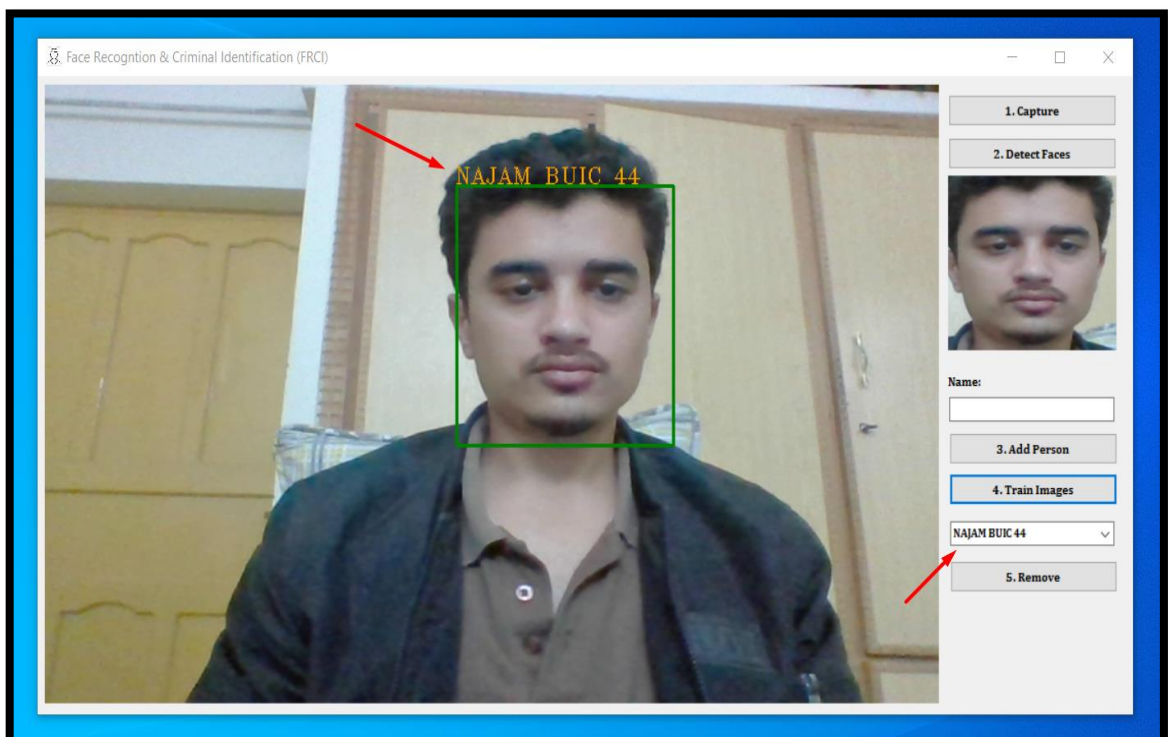
Figure 6.6: FRCI Recognizing Face

6.6   Usability Testing

The FRCI interfaces is designed by keeping the user's priority up front to make it simple and easy to interact for the user. We have avoided the use of very bright and dark colors and used colors which would make it look professional and pleasant for the eye. The application is fast, efficient and reliable.

We have used black, white and grey colors to keep our design tidy while keeping the color scheme professionally acceptable. Utilizing such colors would be more preferable as we don't the users to have an unpleasant experience.
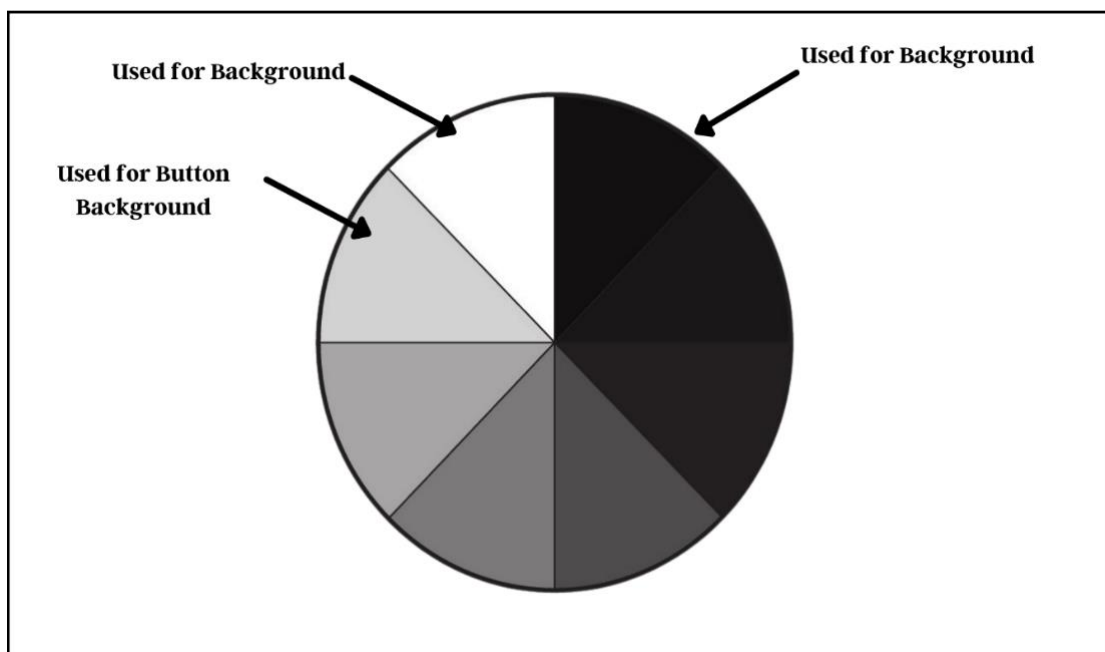
Figure 6.7: Color Selection: DSMD Application

In Usability testing the system is tested according to the user ease of use. Keeping the user ease while navigation attract the user.

6.5.1   Test Case 1 (App Run)

The test case App Run is done to tracking whether application is running properly as it is intended to be without any problems or bugs.

Test Case ID	TC-ID-01
Description	Test is for to verify the application is running properly or not

Application		Laptop/PC	
Requirements		N/A	
Initial Condition		Save the project files in a laptop and check if it requires any initial setup and if not then the app is running successfully by opening the exe file.	
Steps	Full/Reg	Tasks and Expected Outcomes	
1.		Open Up the FRCI Application	
2.		Verify and Check whether application is running properly or not.	Pass/Fail

Table 6.1 Test Case 1 (App Run)

6.5.2   Test Case 2 (App Navigation)

The test case App Run is done for tracking the navigation of application whether application is navigating the user properly for purpose of user ease and reliability.

Test Case ID	TC-ID-02
Description	Test is for to verify the application is properly navigating or not according to the set requirement.
Application	Laptop/PC
Requirements	N/A
Initial Condition	Run the application

Steps	Full/Reg	Tasks and Expected Outcomes	
1.		Run the FRCI application	
2.		Properly Verify and validate every course of action while navigating	Pass/Fail

Table 6.2 Test Case 2 (App Navigation)

6.5.3   Test Case 3 (Face Detection & Recognition)

The test case face detection & recognition is done for the purpose of validating whether face detection and recognition is done on real time without any problems.

Test Case ID		TC-ID-03	
Description		Test the Application Face detection and Recognition Functionality as required.	
Application		Laptop/PC	
Requirements		N/A	
Initial Condition		Working Camera	
Steps	Full/Reg	Tasks and Expected Outcomes	
1.		Check if the camera is working properly.	

2.		Verify and Check whether face detection is done properly with better accuracy. After face detection check the face recognition along with status given.	Pass/Fail

Table 6.3 Test Case 3 (Face Detection & Recognition)

6.5.4 Summary

This section of thesis contains different test cases to evaluate the application is running as it is intended to be. We have also done comparative testing in earlier chapters to check and validate whether the application functionalities are running properly or not comparative to other applications.

Chapter 7

Conclusions

In this modern era of technology people are involving themselves more towards the security by placing the cameras while there is still increase in crimes because cameras cannot identify the person. To overcome this problem there should be an application which not only detects the face but also recognizes the identify. The system focus is to implement the concept on desktop application to keep the comfort and safety in view (Concern).

4.1 Project Conclusion

In times like these where no justice is served to those who commit the crime whether its data theft or something else just because of the reason that the authorities are not aware of the person's identity FRCI would be a step in the right direction. Instead of just relying on the cameras to do all the work and placing cameras everywhere we should think ahead of how this could be a more effective measure for the safety and security.

The concern for security must be catered in a proactive measure rather than a reactive approach specially when its about the sensitive data or information which could be crucial for a business or an organization. This has been a big flaw in our security systems that whenever such unfortunate incident happens its often regarded as "unknown people" committed a crime.

4.2   My System:

In order to tackle such problems and eliminate all the security risks and concerns FRCI would be a major breakthrough which would be solving multiple issues at the same time. Face Recognition and Criminal Identification (FRCI) would reveal the identity of the person facing the camera in real-time if her/she is present in our dataset or in other words if they are authorized to access that specific premises otherwise it would be very obvious to stop an unauthorized access from happening.

4.3 Future Work

In future the scope of this project can be enhanced by the collaboration of the national

institutions if we include the data of all the citizens and create their dataset at the time of issuing the identity card. This way everyone would be part of the dataset and the authorities will have the access to identify the criminals participating in any sort of criminal activities all across the country.

4.4 Strong Dataset:

By implementing this system on large scale this project can be used as a reactive method as well. In situations where the authorities won't be able to stop the crime from happening, they can use the reactive approach which won't take more than a minute to get the identity of the culprits, rather than just sitting and waiting for the lab results to find the identity you can simply get their credentials and use that information to track them within no time.

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