FORENSIC FACE SKETCH CONSTRUCTION AND RECOGNITION

A PROJECT REPORT

Submitted by

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IN

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VEL TECH HIGH TECH

Dr. RANGARAJAN Dr. SAKUNTHALA ENGINEERING COLLEGE
An Autonomous Institution

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The report of the project work submitted by the above students in partialfulfilment for the award of degree, Bachelor of Technology/Engineering in Information Technology for the viva voce examination held at Vel TechHigh Tech Dr.RangarajanDr. Sakunthala Engineering College on _ _____has been evaluated and confirmed to be reports of the work done by the above students.

INTERNAL EXAMINER **EXTERNAL EXAMINER**

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ABSTRACT

A criminal can be easily identified and brought to justice using a face sketch drawn based on the description been provided by the eye-witness, however in this world of modernization the traditional way of hand drawing a sketchis not found to be that effective and time saving when used for matching andidentifying from the already available database or real-time databases. During the past there were several techniques been proposed to convert hand-drawn face sketches and use them to automatically identify and recognize the suspect from the police database, but these techniques could not provide the desired precise results. Application to create a composite face sketches were even introduced which too had various limitations like limited facial features kit, cartoonistic feel to the created suspect face which made it much harder to use these applications and get the desired results and efficiency. The above applications and needs motivated us into thinking of creating an application which would not just provide a set of individual features like eyes, ears, mouth, etc. to be selected to create a face sketch but also would allow user to upload hand-drawn individual features on the platform which would then be converted in to the applications component set. This in turn would make the created sketch much more similar to the hand-drawn sketch and would be much easier for the law enforcement departments to adapt the application. Our application would even allow the law enforcement team to upload a previous handdrawn sketch in order to use the platform to identify and recognize the suspect using the much more efficient deep learning algorithm and cloud infrastructure provided by the application. The machine learning algorithm would learn from the sketches and the database in order to suggest the user all the relatable facial features that could be used with a single selected feature in order the decrease the time frame and increase the efficiency of the platform.

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

A criminal can be easily identified and brought to justice using a face sketch drawn based on the description been provided by the eye-witness, however in this world of modernization the traditional way of hand drawing a sketch is not found to be that effective and time saving when used for matching and identifying from the already available database or real-time databases.

During the past there were several techniques been proposed to convert hand-drawn face sketches and use them to automatically identify and recognize the suspect from the police database, but these techniques could not provide the desired precise results. Application to create a composite face sketches were even introduced which too had various limitations like limited facial features kit, cartoonistic feel to the created suspect face which made it much harder to use these applications and get the desired results and efficiency.

The above applications and needs motivated us into thinking of creating an application which would not just provide a set of individual features like eyes, ears, mouth, etc. to be selected to create a face sketch but also would allow user to upload hand-drawn individual features on the platform which would then be converted in to the applications component set. This in turn would make the created sketch much more similar to the hand-drawn sketch and would be much easier for the law enforcement departments to adapt the application.

Our application would even allow the law enforcement team to upload a previous hand- drawn sketch in order to use the platform to identify and recognize the suspect using the much more efficient deep learning algorithm and

cloud infrastructure provided by the application.

The machine learning algorithm would learn from the sketches and the database in orderto suggest the user all the relatable facial features that could be used with a single selected feature in order the decrease the time frame and increase the efficiency of the platform.

1.1 Overview:

This is a standalone application, allowing user to construct accurate composite face sketch using the predefined facial feature sets provided as tools that can be resized and repositioned as per requirement/described by the eye-witness.

Moreover, the constructed composite face sketch can then be matched with the law enforcement departments database using deep learning and the speed and efficiency of cloud infrastructure to identify and verify the criminal. The same process can even be done with the hand-drawn sketch making the application backward compatible with traditional approaches.

1.2 Problem Statement:

In this modern age, the overall crime rate is increasing day-by-day and to cope up withthis the law enforcement departments too should find ways that would speed up the overall process and help them in bringing one to justice. One such way can be using face recognition technology for identifying and verifying the criminal.

The traditional approach here is to use the hand-drawn face sketches drawn by forensic sketch artist to identify the criminal, modernizing this would mean using the hand-drawn sketch and then matching them with the law enforcement departments database to identify the criminal. Using this approach

would result in the various limitations with latest technologies and even would be time consuming as there are very few forensic sketch artists available when comparedto the increasing crime ratio.

Thus, there is a need for creating an application which would not just provide a set of individual features like eyes, ears, mouth, etc. to be selected to create a face sketch that would help in finding the criminal much faster and efficiently.

CHAPTER 2

LITERATURE SURVEY

2.1 LITERATURE REVIEW – I

TITLE: Constructing and identifying the facial composites

AUTHOR: Dr. Charlie Frowd, Yasmeen Bashir, Kamran Nawaz and Anna Petkovic

PUBLISHER: IEEE

YEAR: 2021

CONTEXT:

There are lot of studies on face sketch construction and recognition using various approaches. Dr. Charlie Frowd along with Yasmeen Bashir, Kamran Nawaz and Anna Petkovic designed a standalone application for constructing and identifying the facial composites, the initial system was found to be time consuming and confusing as the traditional method, later switching to a new approach in which the victim was given option of faces and was made to selected similar face resembling the suspect and at the end the system would combine all the selected face and try to predict automatically the criminal's facial composite. The Results where promising and 10 out of 12 composite faces where named correctly out of which the results 21.3% when the witness was helped by the department person to construct the faces and 17.1% when the witness tried constructing faces by themselves.

Bringing a criminal to justice is a labour intensive process. In the current paper, we explored ways of reducing police time when constructing and identifying facial composites. In the former, we designed and evaluated a standalone version of the

EvoFIT composite system. This was found to perform similarly to the full system that normally requires several hours of a police officer's time. In the latter, we built a small database of composites that could be used to search for matching identities. It was found that pixel intensity (texture) information was valuable for composites produced from a traditional feature-based system, but feature shape information for composites produced from the recognition-based EvoFIT. The results show promise for the automated construction and identification of facial composites.

2.2 LITERATURE REVIEW – II

TITLE: Face Photo-Sketch Synthesis and Recognition

AUTHOR: Xiaogang Wang and Xiaoou Tang

PUBLISHER: IEEE

YEAR: 2021

CONTEXT:

Xiaoou Tang and Xiaogang Wang proposed a recognition method of photo-sketch synthesized using a Multiscale Markov Random Field Model the project could synthesis a give sketch into photo or a given photo in to sketch and then search the database for a relevant match for this the model divided the face sketch in to patches. In this they first synthesized the available photos in to sketch and then trained the model making the model to decrease the difference between photos and sketch this enhanced the overall efficiency of the recognition model. For testing this they took few samples in which the photos where synthesized in to sketch and the same faces where drawn from sketch artist and then the model was trained from 60% data and remaining 40% data for testing the model. The overall results where impressive but not up to the mark as expected.

In this paper, we propose a novel face photo-sketch synthesis and recognition

method using a multiscale Markov Random Fields (MRF) model. Our system has three components: 1) given a face photo, synthesizing a sketch drawing; 2) given a face sketch drawing, synthesizing a photo; and 3) searching for face photos in the database based on a query sketch drawn by an artist. It has useful applications for both digital entertainment and law enforcement. We assume that faces to be studied are in a frontal pose, with normal lighting and neutral expression, and have no occlusions. To synthesize sketch/photo images, the face region is divided into overlapping patches for learning. The size of the patches decides the scale of local face structures to be learned. From a training set which contains photo-sketch pairs, the joint photo-sketch model is learned at multiple scales using a multiscale MRF model. By transforming a face photo to a sketch (or transforming a sketch to a photo), the difference between photos and sketches is significantly reduced, thus allowing effective matching between the two in face sketch recognition. After the photo-sketch transformation, in principle, most of the proposed face photo recognition approaches can be applied to face sketch recognition in a straightforward way.

2.3 LITERATURE REVIEW – III

TITLE: Human face image searching system using sketches

AUTHOR: P. Yuen and C. Man

PUBLISHER: IEEE

YEAR: 2021

CONTEXT:

This paper reports a human face image searching system using sketches. A two-phase method, namely, sketch-to-mug-shot matching and human face image searching using relevance feedback, is designed and developed. In the sketch-to-mug-shot matching phase, we have developed a facial feature matching algorithm

using local and global features. A point distribution model is employed to represent local facial features while the global feature consists of a set of the geometrical relationship between facial features. It is found that the performance of the sketch-to-mug-shot matching is good if the sketch image looks like the mug shot image in the database. However, in some situations, it is hard to construct a sketch that looks like the photograph. To overcome this limitation, this paper makes use of the concept of ldquohuman-in-the-looprdquo and proposes a human face image searching algorithm using relevance feedback in the second phase. Positive and negative samples will be collected from the user. A feedback algorithm that employs subspace linear discriminant analysis for online learning of the optimal projection for face representation is then designed and developed. The proposed system has been evaluated using the FERET database and a Japanese database with hundreds of individuals. The results are encouraging.

2.4 LITERATURE REVIEW – IV

TITLE: Matching composite sketches to face photos: A component based approach

AUTHOR: H. Han, B. Klare, K. Bonnen, and A. Jain

PUBLISHER: IEEE

YEAR: 2021

CONTEXT:

The problem of automatically matching composite sketches to facial photographs is addressed in this paper. Previous research on sketch recognition focused on matching sketches drawn by professional artists who either looked directly at the subjects (viewed sketches) or used a verbal description of the subject's appearance as provided by an eyewitness (forensic sketches). Unlike sketches hand drawn by artists, composite sketches are synthesized using one of the several facial composite software systems available to law enforcement agencies. We propose a component-based representation

(CBR) approach to measure the similarity between a composite sketch and mugshot photograph. Specifically, we first automatically detect facial landmarks in composite sketches and face photos using an active shape model (ASM). Features are then extracted for each facial component using multiscale local binary patterns (MLBPs), and per component similarity is calculated. Finally, the similarity scores obtained from individual facial components are fused together, yielding a similarity score between a composite sketch and a face photo. Matching performance is further improved by filtering the large gallery of mugshot images using gender information. Experimental results on matching 123 composite sketches against two galleries with 10,123 and 1,316 mugshots show that the proposed method achieves promising performance (rank-100 accuracies of 77.2% and 89.4%, respectively) compared to a leading commercial face recognition system (rank-100 accuracies of 22.8% and 52.0%) and densely sampled MLBP on holistic faces (rank-100 accuracies of 27.6% and 10.6%). We believe our prototype system will be of great value to law enforcement agencies in apprehending suspects in a timely fashion.

CHAPTER 3

SYSTEM ANALYSIS

3.1 Security and Privacy

The major concern of the law enforcement department before adapting any system is security and privacy. Keeping this in mind the application is designed to protect the privacy and carry out the security measures in the following ways.

3.1.1 Machine Locking:

The Machine locking technique would ensure that the application once installed on a system could not be tampered and could not been operated on any other system, for which the application uses two locking parameters i.e. one software and one hardware lockingparameter.

HD ID – Volume serial of hard-drive with OS.
NET ID – Hardware ID – MAC Address.

3.1.2 Two Step Verification:

Every law enforcement authorized user would be given an official E-Mail ID which would use to login on to the application, thus using this step would require the user to enter a random code been shared with them on their mobile/desktop in order to complete the logging process.

3.1.3 Centralized Usage:

The system which has the application been installed would be connected to a centralized server of the law enforcement department campus containing the database and the other important feature set of the application, thus the

application could not be operated once disconnected from the server.

3.2 Backward Compatibility

The major drawback in adapting any new system is the complication been involved in completing migrating from the previous technique to the new technique, Hence resulting in thewastage of time resources.

To overcome this issue, we have designed our application in such a way that even the hand-drawn sketches can be uploaded and the user can use the deep learning algorithms and cloud infrastructure to identify and recognize the criminal using the hand-drawn sketch.

3.3 Face Sketch Construction using Drag and Drop

In this application, accurate composite face sketch can be constructed using the predefined facial feature sets provided as tools allowing to be resized and repositioned as per requirement/described by the eye-witness.

Here, the human face is be categorized into various facial features such as head, eyes, eyebrow, lips, nose, ears, etc. and some important wearable components such as hats, specs, etc. too are been available in the application for use.

Every facial feature when selected would open a wide range of options to choose from based on the requirement/description of the eye-witness. The machine learning algorithm wouldlearn and in future try to suggest all the facial features which could suit the single selected feature and would try to help in completing the composite face sketch much sooner and much efficiently.

Fig. 3.3.1. Shows the sketch of the facial feature viz. Head Fig. 3.3.2. Shows the sketch of the

facial feature viz. Eyes Fig. 3.3.3. Shows the sketch of the facial feature viz. Ears

To overcome this issue, we have designed our application in such a way that even the hand-drawn sketches can be uploaded and the user can use the deep learning algorithms and cloud infrastructure to identify and recognize the criminal using the hand-drawn sketch.

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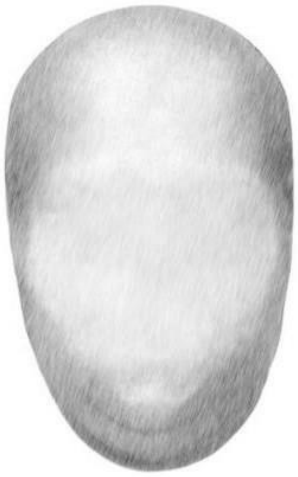

Fig. 3.3.1. Face Feature – Head

Fig. 3.3.2. Face Feature – Eyes

Fig. 3.3.3. Face Feature – Ears

Such are the facial features which can be used in the application to create the composite face sketch of the suspect based on the description been provided by the eye-witness to the law enforcement and forensic department.

3.4 System Specification:

3.4.1 Hardware Specification

This application is been designed to run on the minimum possible configuration ofhardware.

Client/ Node Machine:

- Processor: Intel Dual Core CPU and above
- RAM: 1 GB and above
- Hard Disk: 250GB and above

Server Machine:

- Processor: Intel Core i3 CPU and above
- RAM: 4 GB and above
- Hard Disk: 1 TB and above

3.4.2 Software Specification

This application is been designed to run as a desktop application with part of the datasaved on server for security purpose.

Client/ Node Machine:

- Operating System: Windows 7 and above
- Framework: Java JDK
- Cloud: Amazon Web Services CLI

Server Machine:

- Operating System: Windows Desktop OS or Windows Server Edition
- Framework: Java JDK
- Cloud: Amazon Web Services CLI
- Database: SQLite

CHAPTER 4

DESIGN AND IMPLEMENTATION

4.1 System Flow:

Our Application would be majorly used by the Law Enforcement Departments in orderto reduce the overall time required to bring the criminal to justice and even to enhance the workforce and speed up the system by keeping accuracy in mind. So, keeping this scenario in mind the platform is designed to be as simple as possible in order to make sure that a user can create a sketch in the application without a formal training.

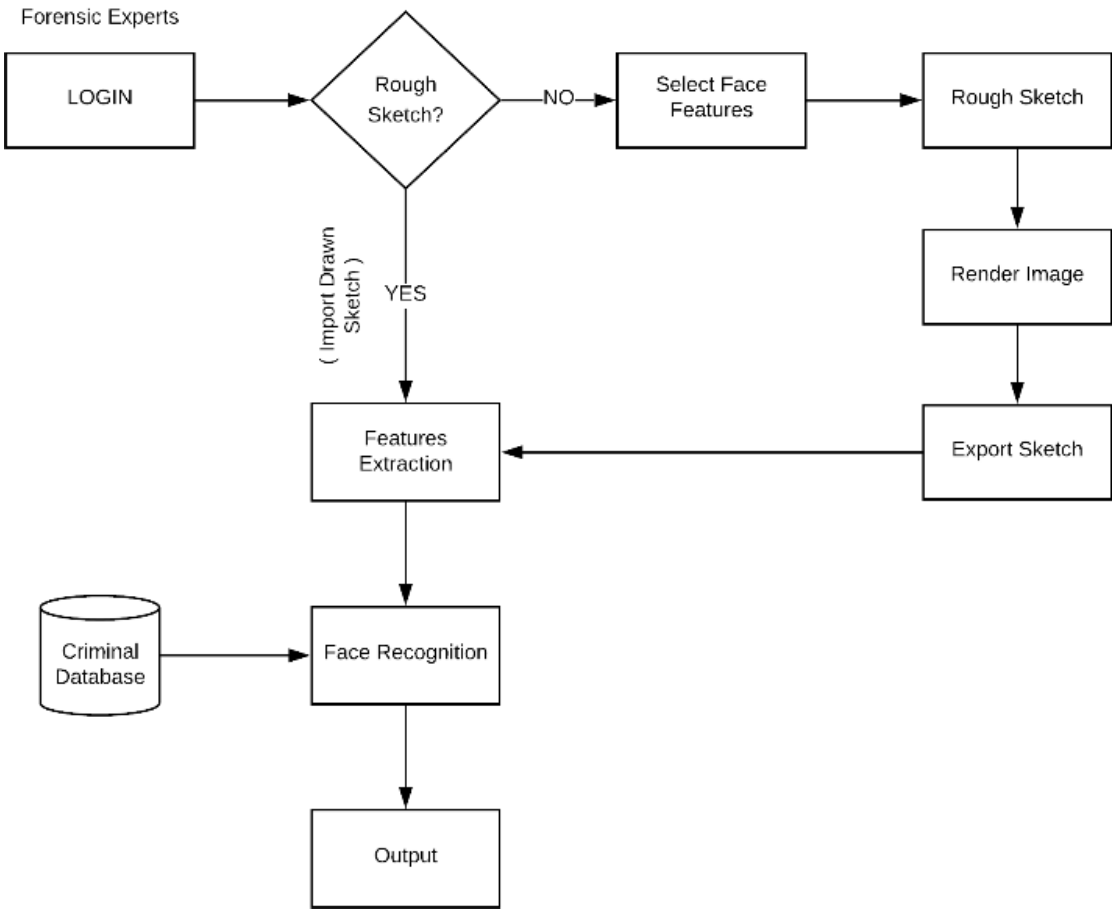

Fig 4.1.1 System Flow Chart of the Application

The above flowchart represents the overall flow of the system starting with the login page to the actual results been displayed after the sketch is been matched by the records in the database.

The privacy and security are been kept in mind from the very first stage itself starting with the login page itself, the login page consists of two parts. At the start the login page fetches the Mac Address along with IP Address and HDD ID which is then been matched with the data been collected while installing the platform in the host machine and if the data does not match the platform would lock itself and won't allow the user to move further and use any feature of the platform. This would make sure that the platform could not be accessed when the host machine is been tampered or the hard-disk is been tampered to be used in other machine making it more secure and much more reliable than any other platform currently available.

Moving further the second part consist of authenticating the user which consist of making sure that the user accessing the platform can have total privacy and security with the data and their credentials, for this we made use of Two Step Verification where in the user when enters his/her credential on to the platform the platform checks the authenticity of the user after which the platform mails an OTP to the registered email id making sure that no one other than the verified user can access the platform even if they have the login credentials. The OTP is been generated real-time for every login.

After the secure login on to the platform and moving further the platform uses something called as Backward Compatibility, this feature is been introduced in order to make a smooth transition from the current technique on to the new platform. The current technique been the use of hand drawn sketch been drawn by an expert forensic artist with years of experience and then the sketch been used by the law enforcement department to be showed on to various platforms in

order to create a sense of awareness in people in order to find someone to recognize the suspect. So backward compatibility allows the law enforcement department to upload those hand drawn sketches on to the platform in order to use our face recognition module and match the suspect sketch with the large record and reducing the overall time and the efforts used in the previous age-old technique.

If the law enforcement department doesn't have a hand drawn sketch and the law enforce department would wish to use the platform for creating a face sketch using our platform,they can access the canvas where they would find a wide range of facial elements in the database. The elements can be easily selected to create a described face sketch of the suspect and use the feature like drag and drop in order to arrange the elements according to the eye witnesses description. The platform is designed in such a way that one can use the platform without a prior professional training and knowledge of sketching. The user thus can select the main face category he/she wishes to select and would then prompt with a variety of option underthat particular face category and then can select one feature based on the description provided by the suspect. The platform even would allow the user to change a selected feature to be replaced by any other feature if it does not match the description even after selection.

The selected face categories would be placed one another to create a complete face sketch and can be moved on using the mouse for placing that face feature on to another spot based on the description been provided by the eye witness. This canvas can then be saved as JPG format image in order to further use the image in possible medium other than out platform like sharing on social media or for printing purpose.

Once the sketch is created the platform gives access to the face prediction module, where in the database of all the criminals until now in been saved on the data centers for maintaininga level of security and for this purpose the sketch too

is been uploaded to the data center first and then the prediction is been performed on the cloud for security purpose. Our platform uses deep learning alongside with Amazon Web Services (AWS) in order to give the best and accurate result so as to bring the criminal to justice.

The prediction module divides the screen in to four parts, first the sketch to be predicted is been uploaded to the data centers for security purposes and the second part is the match found in the database followed with the third part which is the accuracy been shown in the predicted/match images and lastly the forth part is called the meta which can be customized in order to show the data about the match as per need and then can be exported and shared with other if required.

4.2 Face Sketch Construction Module:

As mentioned earlier, security and accuracy are the key features been focused while developing our platform for the law enforcement department. So, this module of the project mainly focuses on creating a face sketch based on the description been provided by the Eye Witness to the Law enforcement department.

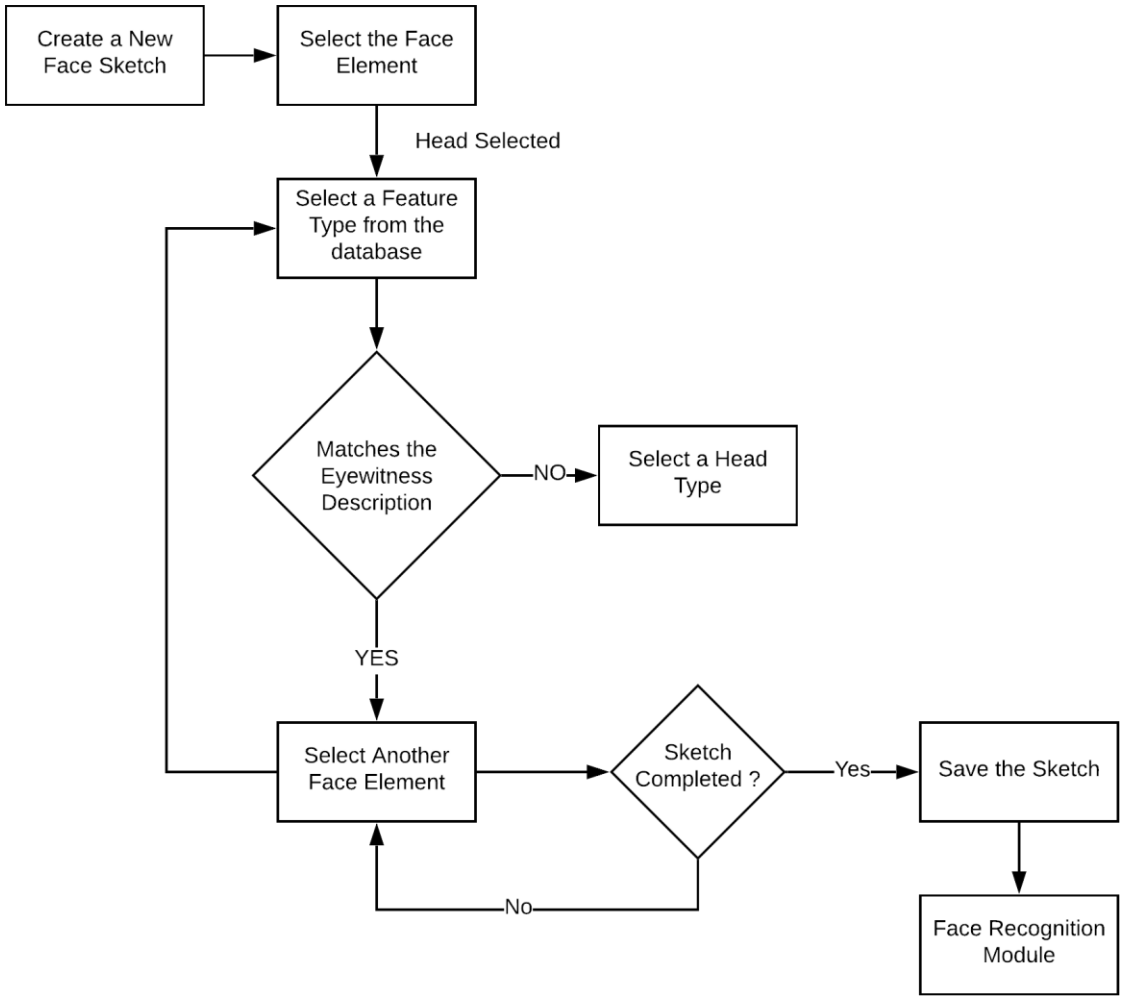

Fig 4.2.1 Flow Chart for Creating a sketch in the application

The above flowchart illustrates the users flow been followed by the platform to provide an construct accurate face sketch based on the description, the dashboard is designed simple in order to encourage no professional training to go through before using this platform already saving the timeframe which would have been taken a lot time and resources of the Department Keeping it simple thus ensures that the user doesn't have to be a professional sketch artist from the forensic department rather any one from the law enforcement department using the descriptions narrated by the eye witness or in some cases the eye witness too can take control of the platform but that would not be recommended as it can tamper the security protocols.

Moving further the dashboard consists of Five main modules, First the important module is the Canvas been shown at the middle of the dashboard which would house the face sketch components and the elements of the face sketches helping in the construction of the facesketch.

Creating the face sketch would be a complicated thing if all the face elements are given all together and in an unordered manner making the process difficult for the user and complicated to construct an accurate face which would be against the agenda aimed in the proposed system. So, to over come this issue we planned on ordering the face elements based on the face category it belongs to like head, nose, hair, eyes, etc. making it much easier for the user to interact with the platform and construct the face sketch. This is available in the column in the left on Canvas on the dashboard click on a face category allows user to get various otherface structure.

Coming to the various face elements in a particular face category we could have multiple and n number of elements for a single category, so to solve this our platform would use machine learning in future to predict the similar face elements or predict an suggest the elements to be selected in the face sketch but this would only work once we have appropriate data to train the model on this algorithm and work to enhance the platform.

So, now when the user clicks on a particular face category and then a new module to the right of the canvas opens and lets user to select an element from the option of face elementsto construct a face sketch. This option can be selected be selected based on the description provided by the eye witness.

The elements when selected are shown on the canvas and can be moved and placed as per the description of the eye witness to get a better and accurate sketch and the elements have a fixed location and order to be placed on the canvas like the eye elements would be placed over the head element irrespective

of the order the were selected. Same for every face element.

The final module is the options to enhance the use of the dashboard, suppose in cases the user selects an element which is not to be selected so that could be rectified using the option to erase that particular element which would be seen when selecting the face category from the left panel. The major important buttons are placed in the panel on the right which has a button to completely erase anything on the canvas of the dashboard making it totally blank.

Then we have a button to save the constructed face sketch, saving the face sketch as a PNG file for better future access. This could be any location on the host pc or on the server depending on the Law Enforcement Department.

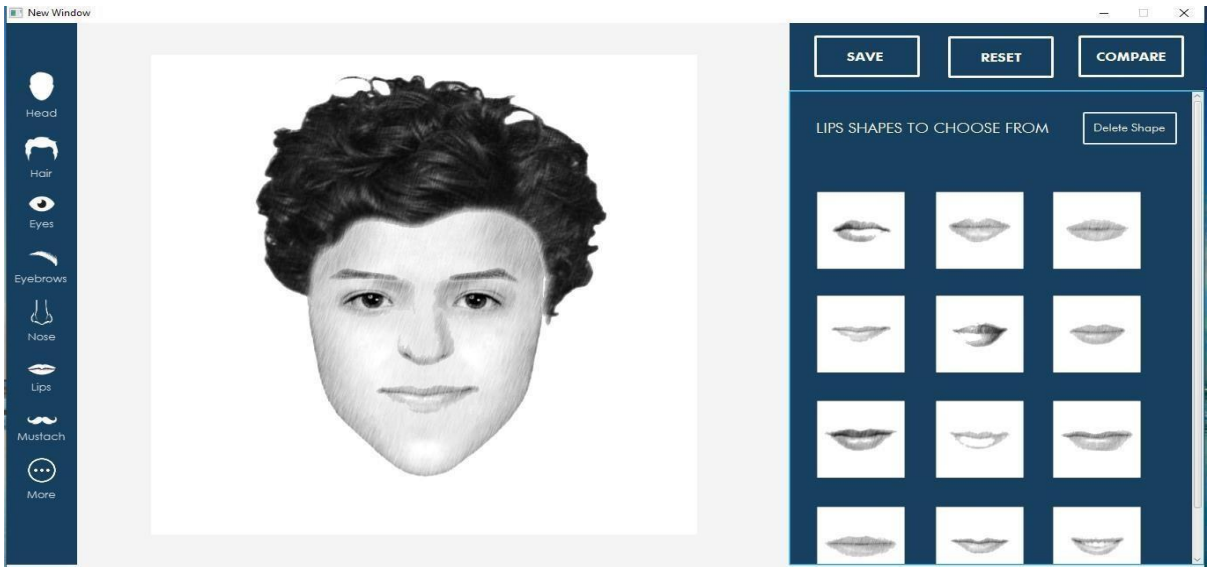

Fig 4.2.2. A Complete Face Sketch in Dashboard

(The Complete Face Sketch been displayed on the Dashboard Canvas

4.3 Face Sketch Recognition Module:

As mentioned earlier, security and accuracy are the key features been focused while developing our platform for the law enforcement department. So, this module of the project mainly focuses on recognizing a face sketch in the Law enforcement department face photo records with accuracy and confidence

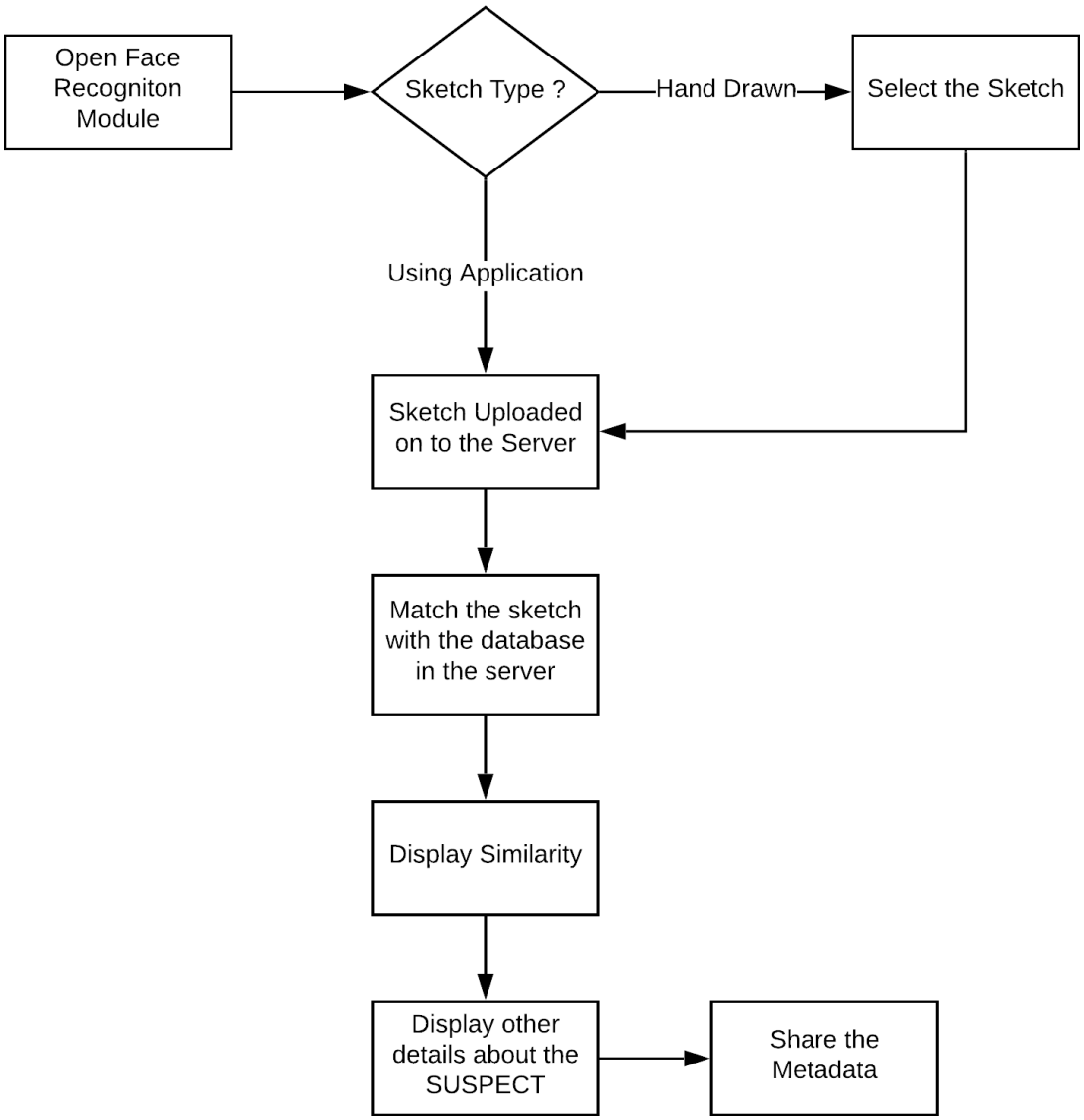

Fig 4.3.1 Flow Chart for Recognizing a sketch in the application

The above flowchart illustrates the users flow been followed by the

platform to provide an recognize accurate face sketch based on the description, the dashboard is designed simple in order to encourage no professional training to go through before using this platform already saving the timeframe which would have been taken a lot time and resources of the Department.

Keeping it simple thus ensures that the user doesn't have to be a professional sketch artist from the forensic department rather any one from the law enforcement department using the descriptions narrated by the eye witness or in some cases the eye witness too can take control of the platform but that would not be recommended as it can tamper the security protocols.

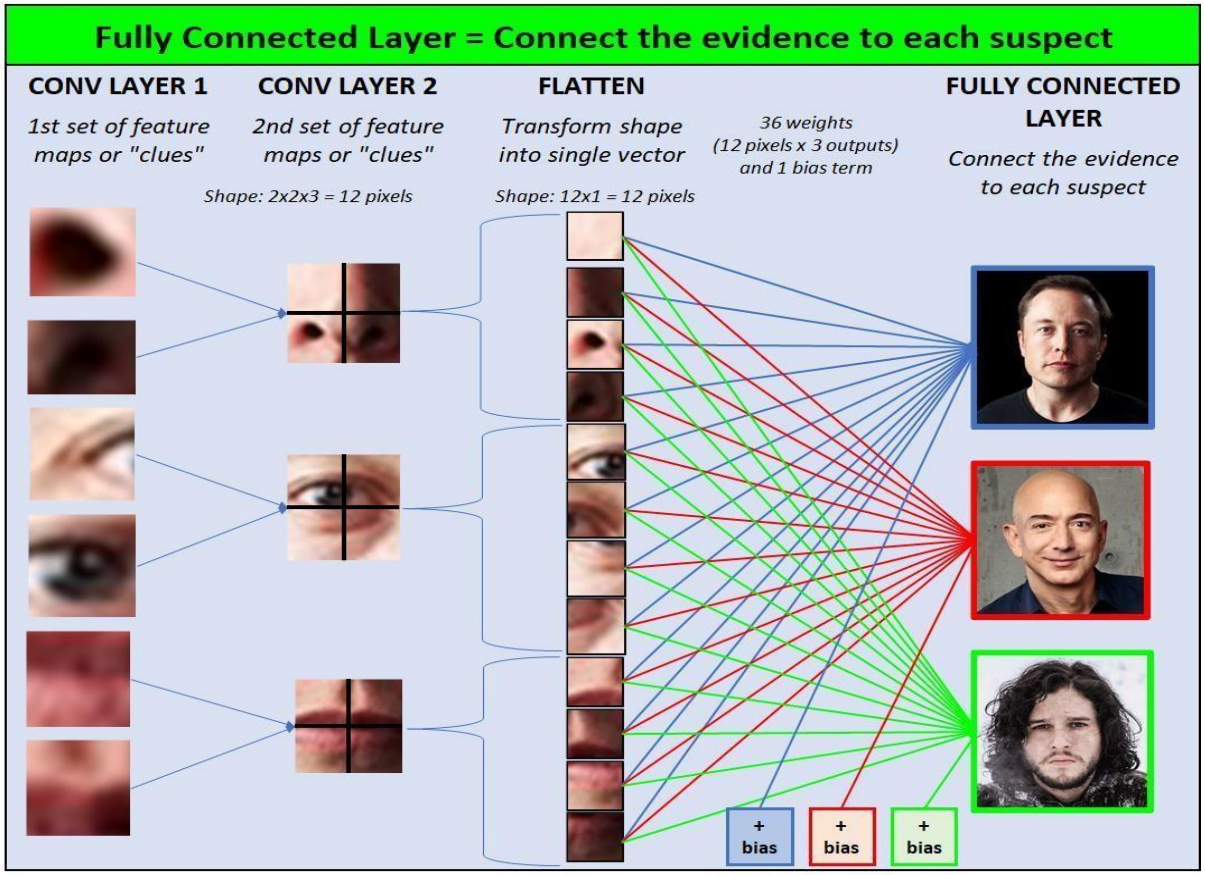

Fig 4.3.2 Feature extraction by the Platform

The above image demonstrates the first part before using the platform to recognize faces is making the existing records in with the law enforcement department suitable for our platform by training and making the platforms algorithm recognize and assign IDs to the face photo to the user in the existing records in with the law enforcement department. For this the platforms algorithms gets connected to the records and breaks each face photo in to various smaller feature and assign an ID to the multiple features generated for a single face photo.

Now, the Module which is majorly designed to be run on the Law enforcements server for security protocols, is been executed where in the user first opens either the hand drawn sketch or the face sketch constructed on our platform saved in the host machine, after which the opened face sketch is been uploaded to the Law enforcements server housing the recognition module so that the process or the data of the record are not tampered and are secure and accurate.

Once the sketch is uploaded on to the server the algorithm first traces the sketch image in order to learn the features in the sketch and map the features as shown in the below figure in order to match those with the features of the face photos in the records.

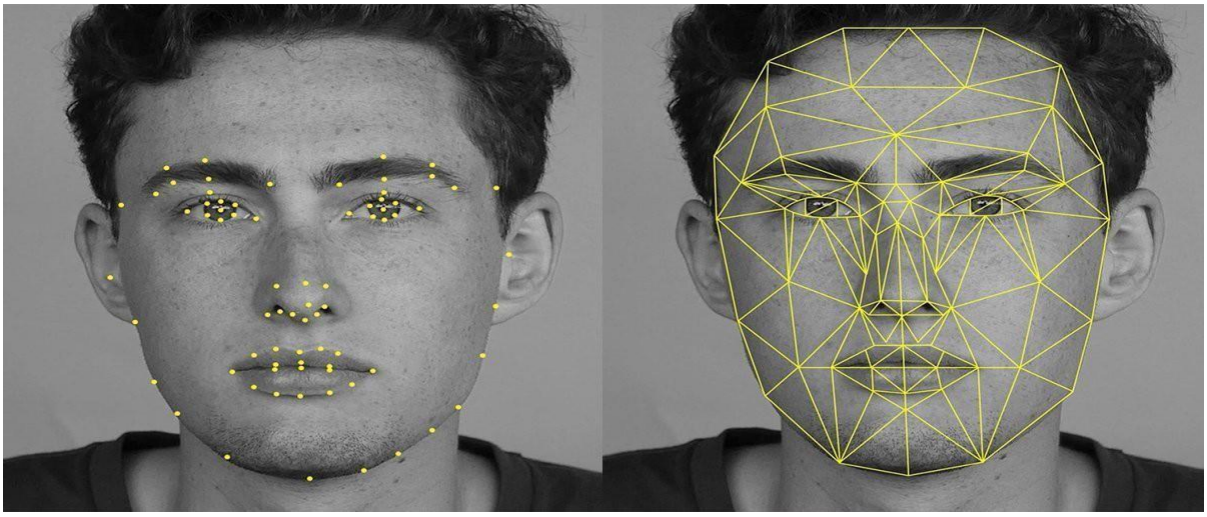

Fig 4.3.3 Face Sketch been mapped on the Platform

After mapping the sketch and matching the face sketch with the records and finding a match the platform displays the matched face along with the similarity percentage and other details of the person from the records. The platform displaying all this and the matched personis shown in the below figure.

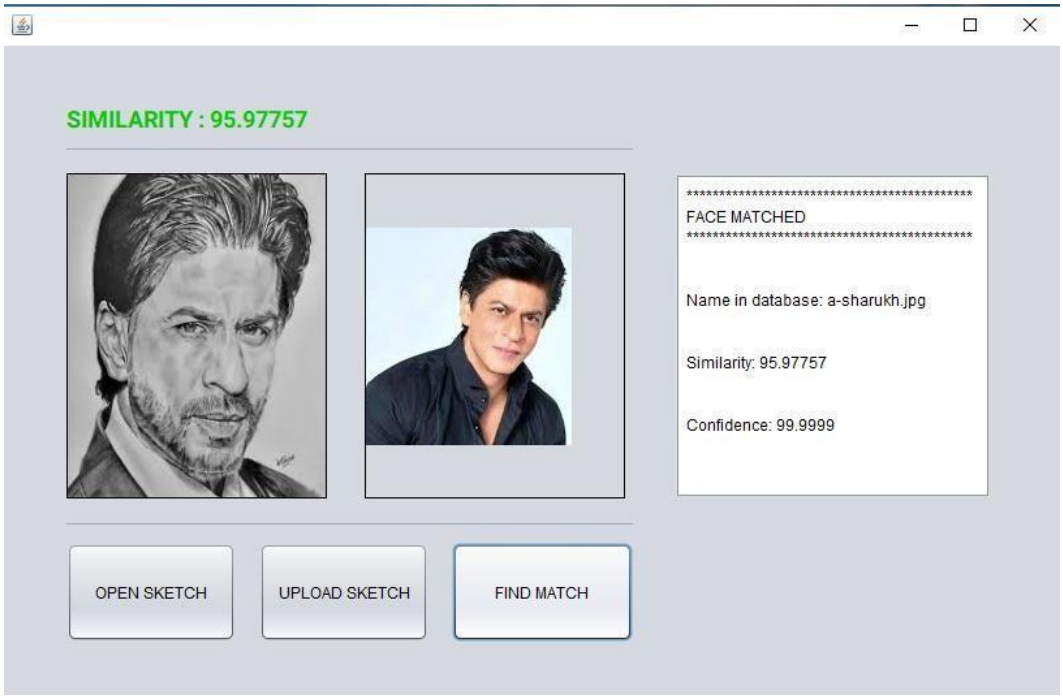

Fig 4.3.4. Face Sketch matched to Database Record

(The Face Sketch when Matched with the Record shows the Further Details)

CHAPTER 5

TECHNOLOGY STACK

Our platform was designed and developed using various technology stack in order to provide the law enforcement department with state-of-the-art security features and accuracy which in turn provide the law enforcement department with a better crime solving rate and efficiency.

5.1 MACHINE LOCKING:

The Machine locking technique would ensure that the application once installed on a system could not be tampered and could not been operated on any other system, for which the application uses two locking parameters i.e. one software and one hardware locking parameter.

HD ID – Volume serial of hard-drive
with OS. NET ID – Hardware ID –
MAC Address.

5.2 OTP (ONE TIME PASSWORD):

Every law enforcement authorized user would be given an official E-Mail ID which would use to login on to the application, thus using this step would require the user to enter a random code been shared with them on their mobile/desktop in order to complete the logging process.

A one-time password (OTP) is an automatically generated numeric or alphanumeric string of characters that authenticates the user for a single transaction or login session.

An OTP is more secure than a static password, especially a user-created password, which can be weak and/or reused across multiple accounts. OTPs may replace authentication login information or may be used in addition to it in order to add another layer of security.

In OTP-based authentication methods, the user's OTP app and the authentication server rely on shared secrets. Values for one-time passwords are generated using the Hashed Message Authentication Code (HMAC) algorithm and a moving factor, such as time-based information(TOTP) or an event counter (HOTP). The OTP values have minute or second timestamps for greater security. The one-time password can be delivered to a user through several channels, including an SMS-based text message, an email or a dedicated application on the endpoint.

Security professionals have long been concerned that SMS message spoofing and man- in-the-middle (MITM) attacks can be used to break 2FA systems that rely on one-time passwords. However, the U.S. National Institute of Standards and Technology (NIST) announced plans to deprecate the use of SMS for 2FA and one-time passwords, as the method is vulnerable to an assortment of attacks that could compromise those passwords and codes. Asa result, enterprises considering deployment of one-time passwords should explore other delivery methods—besides--SMS.

5.3 JAVA:

Java is a programming language and computing platform first released by Sun Microsystems in 1995. There are lots of applications and websites that will not work unless you have Java installed, and more are created every day. Java is fast, secure, and reliable. From laptops to datacenters, game consoles to scientific supercomputers, cell phones to the Internet, Java is everywhere!

- Java offers higher cross- functionality and portability as programs written in one platform can run across desktops, mobiles, embedded systems.
- Java is free, simple, object-oriented, distributed, supports multithreading and offers multimedia and network support.
- Java is a mature language, therefore more stable and predictable. The Java Class Library enables cross-platform development.
- Being highly popular at enterprise, embedded and network level, Java has a large active user community and support available.

  Unlike C and C++, Java programs are compiled independent of platform in bytecode language which allows the same program to run on any machine that has a JVM installed.

- Java has powerful development tools like Eclipse SDK and NetBeans which have debugging capability and offer integrated development environment.
- Increasing language diversity, evidenced by compatibility of Java with Scala, Groovy, JRuby, and Clojure.
- Relatively seamless forward compatibility from one version to the next

In conclusion, almost 20 years after its inception, Java continues to deliver

considerable value to the world of software development. Java 8, in fact, offers new features such as a scalable and flexible platform for the Internet of Things, less boilerplate code, new date and time library and API, refreshed graphics toolkit, integration with JavaScript, and others.

5.4 JAVAFX:

JavaFX is a set of graphics and media packages that enables developers to design, create, test, debug, and deploy rich client applications that operate consistently across diverse platforms.

Written as a Java API, JavaFX application code can reference APIs from any Java library. For example, JavaFX applications can use Java API libraries to access native system capabilities and connect to server-based middleware applications.

The look and feel of JavaFX applications can be customized. Cascading Style Sheets (CSS) separate appearance and style from implementation so that developers can concentrate on coding. Graphic designers can easily customize the appearance and style of the application through the CSS. If you have a web design background, or if you would like to separate the user interface (UI) and the back-end logic, then you can develop the presentation aspects of the UI in the FXML scripting language and use Java code for the application logic. If you prefer to design UIs without writing code, then use JavaFX Scene Builder. As you design the UI, Scene Builder creates FXML markup that can be ported to an Integrated Development Environment (IDE) so that developers can add the business logic.

JavaFX 2.2 and later releases have the following features:

- Java APIs. JavaFX is a Java library that consists of classes and interfaces that are writtenin native Java code. The APIs are designed to be a friendly alternative to Java Virtual Machine (Java VM) languages, such as JRuby and Scala.
- FXML and Scene Builder. FXML is an XML-based declarative markup language for constructing a JavaFX application user interface. A designer can code in FXML or useJavaFX Scene Builder to interactively design the graphical user interface (GUI). Scene Builder generates FXML markup that can be ported to an IDE where a developer can add the business logic.
- WebView. A web component that uses WebKitHTML technology to make it possible to embed web pages within a JavaFX application. JavaScript running in WebView can call Java APIs, and Java APIs can call JavaScript running in WebView.
- Swing interoperability. Existing Swing applications can be updated with new JavaFX features, such as rich graphics media playback and embedded Web content.
- Built-in UI controls and CSS. JavaFX provides all the major UI controls required to develop a full-featured application. Components can be skinned with standard Web technologies such as CSS
- Canvas API. The Canvas API enables drawing directly within an area of the JavaFX scene that consists of one graphical element (node).
- Multitouch Support. JavaFX provides support for multitouch operations, based on the capabilities of the underlying platform.
- Hardware-accelerated graphics pipeline. JavaFX graphics are based on the graphics rendering pipeline (Prism). JavaFX offers smooth graphics that render quickly through Prism when it is used with a supported graphics card or graphics processing unit (GPU). If a system does not feature one of the recommended GPUs supported by JavaFX, then Prism defaults to the

Java 2D software stack.

- High-performance media engine. The media pipeline supports the playback of web multimedia content. It provides a stable, low-latency media framework that is based onthe GStreamer multimedia framework.
- Self-contained application deployment model. Self-contained application packageshave all of the application resources and a private copy of the Java and JavaFX runtimes.They are distributed as native installable packages and provide the same installation and launch experience as native applications for that operating system. See the Deploying JavaFX Applications document.

  With JavaFX, you can build many types of applications. Typically, they are network-aware applications that are deployed across multiple platforms and display information in a high- performance modern user interface that features audio, video, graphics, and animation.

5.5 AWS (AMAZON WEB SERVICES):

Amazon Web Services (AWS) is a subsidiary of Amazon that provides on-demand cloud computing platforms and APIs to individuals, companies, and governments, on a metered pay-as-you-go basis. In aggregate, these cloud computing web services provide a set of primitive abstract technical infrastructure and distributed computing building blocks and tools. One of these services is Amazon Elastic Compute Cloud (EC2), which allows users to have at their disposal a virtual cluster of computers, available all the time, through the Internet. AWS's version of virtual computers emulates most of the attributes of a real computer, including hardware central processing units (CPUs) and graphics processing units (GPUs) for processing; local/RAM memory; hard-disk/SSD storage; a choice of operating systems; networking; and pre-loaded application software such as web servers, databases, and customer relationship management (CRM).

The AWS technology is implemented at server farms throughout the world, and maintained by the Amazon subsidiary. Fees are based on a combination of usage (known as a "Pay-as-you-go" model), the hardware/OS/software/networking features chosen by the subscriber, required availability, redundancy, security, and service options. Subscribers can pay for a single virtual AWS computer, a dedicated physical computer, or clusters of either. As part of the subscription agreement, Amazon provides security for subscribers' systems. AWS operates from many global geographical regions including 6 in North America.

In 2020, AWS comprised more than 212 services including computing, storage, networking, database, analytics, application services, deployment, management, mobile, developer tools, and tools for the Internet of Things. The most popular include EC2 and Amazon Simple Storage Service (Amazon S3). Most services are not exposed directly to end users, but instead offer functionality through APIs for developers to use in their applications. Amazon Web Services' offerings are accessed over HTTP, using the REST architectural style and SOAP protocol for older APIs and exclusively JSON for newer ones.

Amazon markets AWS to subscribers as a way of obtaining large scale computing capacity more quickly and cheaply than building an actual physical server farm. All services are billed based on usage, but each service measures usage in varying ways. As of 2017, AWS owns a dominant 34% of all cloud (IaaS, PaaS) while the next three competitors Microsoft, Google, and IBM have 11%, 8%, 6% respectively according to Synergy Group.

5.6 CENTRALIZED COMPUTING (AWS FOR NOW):

Centralized computing is computing done at a central location, using terminals that are attached to a central computer. The computer itself may control all the peripherals directly (if they are physically connected to the central computer), or they may be attached via a terminal server. Alternatively, if the terminals have the capability, they may be able to connect to the central computer over the network. The terminals may be text terminals or thin clients, for example.

It offers greater security over decentralized systems because all of the processing is controlled in a central location. In addition, if one terminal breaks down, the user can simply go to another terminal and log in again, and all of their files will still be accessible. Depending on the system, they may even be able to resume their session from the point they were at before, as if nothing had happened.

This type of arrangement does have some disadvantages. The central computer performs the computing functions and controls the remote terminals. This type of system relies totally on the central computer. Should the central computer crash, the entire system will "go down" (i.e. will be unavailable).

Another disadvantage is that central computing relies heavily on the quality of administration and resources provided to its users. Should the central computer be inadequately supported by any means (e.g. size of home directories, problems regarding administration), then your usage will suffer greatly. The reverse situation, however, (i.e., a system supported better than your needs) is one of the key advantages to centralized computing.

5.7 DEEP LEARNING FOR FACE RECOGNITION:

Face recognition is the problem of identifying and verifying people in a photograph by their face. It is a task that is trivially performed by humans, even under varying light and when faces are changed by age or obstructed with accessories and facial hair. Nevertheless, it is remained a challenging computer vision problem for decades until recently.

Deep learning methods are able to leverage very large datasets of faces and learn rich and compact representations of faces, allowing modern models to first perform as-well and later to outperform the face recognition capabilities of humans. Generally, we refer to this as the problem of automatic "face recognition" and it may apply to both still photographs or faces in streams of video.

Humans can perform this task very easily. We can find the faces in an image and comment as to who the people are, if they are known. We can do this very well, such as when the people have aged, are wearing sunglasses, have different colored hair, are looking in different directions, and so on. We can do this so well that we find faces where there aren't any, such as in clouds. Nevertheless, this remains a hard problem to perform automatically with software, even after 60 or more years of research. Until perhaps very recently.

All facial recognition and detection systems require the use face datasets for training and testing purposes. In particular, the accuracy of CNNs is highly dependent on large training datasets. For example, the development of very large datasets such as ImageNet, which contains over 14 million images, has allowed the development of accurate deep learning object detection systems.

More specifically, face detection and recognition datasets developed alongside benchmarks such as the MegaFace Challenge, the Face Detection Dataset and Benchmark (FDDB) dataset and the Labeled Faces in the Wild (LFW) dataset provide a means to test and rank face detection, verification and recognition systems using real-life, highly challenging images in unconstrained settings. Notable and widely used datasets are listed in Table, along with information regarding their intended usage, size and the number of identities they contain.

Upon analysis of the results attained by face verification and identification algorithms tested on small datasets such as the LFW dataset, one may be led to believe there remains little scope for improvement. This is far from true: when tested on millions of images, algorithms achieving impressive results on smaller testing sets produce far from ideal accuracies. The MegaFace Challenge was created in response to the saturation of small datasets and benchmarks, providing a large-scale public database and benchmark which requires all algorithms to be trained on the same data and tested on millions of images, allowing fair comparison of algorithms without the bias of private dataset usage. This addresses the problemof lack of reproducibility of results caused by the usage of private databases for training by state-of-the-art CNN methods. Although a shortage of cross-age identity sets is one limitation of the MegaFace dataset, results thus far have indicated there is ample scope for algorithm improvement, with the highest identification and verification accuracies attained by the state-of-the-art method ArcFace reaching 82.55%, and 98.33% respectively. Similarly, the MS- Celeb-1M database was created to provide both training and testing data, to enable the comparison of face recognition techniques by use of a fixed benchmark. However, despite the benefits conferred by their size, both MegaFace and MS-Celeb-1M are disadvantaged by annotation issues and long

tail distributions.

Face detection is a fundamental step in facial recognition and verification. It also extends to a broad range of other applications including facial expression recognition, face tracking for surveillance purposes, digital tagging on social media platforms and consumer applications in digital technologies, such as auto-focusing ability in phone cameras. This survey will examine facial detection methods as applied to facial recognition and verification.

Historically, the greatest obstacle faced by face detection algorithms was the ability to achieve high accuracy in uncontrolled conditions. Consequently, their usability in real life applications was limited. However, since the development of the Viola Jones boosting based face detection method, face detection in real life settings has become commonplace. Significantprogress has since been made by researchers in this area due to the development of powerful feature extraction techniques including Scale Invariant Feature Transform (SIFT), Histograms of oriented Gradients (HoGs), Local Binary Patterns (LBPs) and methods such as Integral Channel Features (ICF).

For a recent and comprehensive review of these traditional face detection methodologies, readers are referred to. This review will alternatively focus on more recently proposed deep learning methods, which were developed in response to the limitations of HoG and Haar wavelet features in capturing salient facial information under unconstrained conditions which include large variations in resolution, illumination, pose, expression, and color. Essentially, it is the limitations of these feature representations which have thus far limited the ability of classifiers to perform to the best of their ability.

Lately, key improvements have been made with the development of deep dual pathway methods, and other confidence map-based solutions, such as and Traditional model-based fiducial point methodologies include Active Shape Model (ASM), which suffers from low accuracy, partially rectified by the work of, Active Appearance Model (AAM), and Constrained Local Models (CLM). CLMs are generally outperformed by cascaded regression, models due to the latter's inherent inability to mode the complex variation of local feature appearances.

It must be noted however, that highly effective methods based on CLMs have been developed. For example, is based on CLMs but takes advantage of the neural network architecture, proposing a Convolutional Experts Network (CEN) and Convolutional Experts Constrained Local Model (CE-CLM) which uses CLM as local detector, achieving very competitive results particularly on profile images.

Subsequent to feature extraction, facial recognition is performed. Recognition can be categorized as either verification or identification. Modern face recognition systems using DCNNs involve deep feature extraction, and lastly, similarity comparison. More specifically, verification involves comparison of one-to-one similarity between a probe image and a gallery of a known identity, whilst identification determines one to many similarities to determine the identity of the probe.

Both these processes require robust feature representation, and a discriminative classification model or similarity measure. Traditional methods used for feature representation include LBP, HoGs, and Fisher Vector. Relevant metric learning methods include cosine metric learning, Mahalanobis metric

learning, and one-shot similarity kernel. Others include large margin nearest neighbor, Joint Bayesian and attribute-based classifiers. These methods are thoroughly reviewed by. Thus, for the sake of relevance and context, we have only included a brief overview of the role these methods play in modern face recognition and have chosen to focus on the most recently developed state of the art methodologies, which largely rely on DCNNs.

The modern CNN framework was designed in 1990 by when they developed a system known as LeNet-5 to classify handwritten digits by recognizing visual patterns from image pixels without the need for preprocessing first presented a neural network used for upright, frontal, grayscale face detection, which although primitive by today's standards, compared in accuracy with state-of-the-art methods at the time.

Since then, research has accelerated significantly, leading to the development of highly sophisticated DCCNs capable of detection, recognition and verification with accuracy approaches that of humans.

Although the development of CNNs was impeded by lack of computing power, recent hardware advances have allowed rapid improvement and a significant increase in CNN depth, and consequently, accuracy. One outstanding feature is an increase in depth, and width to allow for improved feature representation by improving non-linearity. However, this leads to issues such as reduction in efficiency and overfitting.

This section will explore the various methods which have aimed to address these problems in the context of facial recognition, through an examination of general improvements in DCCN architecture and loss functions. CCNs are generally more suitable to object recognition than standard feedforward neural networks of similar size due to the use of fewer connections

and parameters which facilitates training and efficiency, with only slight reduction in performance. CNNs were designed specifically for classification of 2D images due to their invariance to translation, rotation and scaling. A CNN is comprised of a set of layers, including convolutional layers, which are a collection of filters with values known as weights, non-linear scalar operator layers, and down sampling layers, such as pooling. Activation values are the output of individual layers which are used as input in the next layer.

The use of CNNs in facial recognition tasks is comprised of two essential steps; namely, training and inference. Training is a global optimization process which involves learning of parameters via observation of huge datasets. Inference essentially involves the deployment of a trained CNN to classify observed data. The training process involves minimization of the loss function to establish the most appropriate parameters, and determination of the number of layers required, the task performed by each layer, and networking between layers, where each layer is defined by weights, which control computation. CNN face recognition systems can be distinguished in three ways; the training data used to train the model, the network architecture and settings, and the loss function design.

DCNN's have the capacity to learn highly discriminative and invariant feature representations, if trained with very large datasets. Training is achieved using an activation function, loss function and optimization algorithm. The role of the loss function is to determine the error in the prediction.

Different loss functions will output different error values for an identical prediction, and thus determine to a large extent the performance of the network. Loss function type depends on the type of problem, e.g. regression or classification.

Minimization of the error is achieved using back propagation of the error to a previous layer, whereby the weights and bias are modified. Weights are learned and modified using an optimization function, such as stochastic gradient descent, which calculates the gradient of the loss function with respect to weights, then modifies weights to reduce the gradient of the loss function.

CHAPTER 6

APPLICATION DESIGN

6.1 Screenshots:

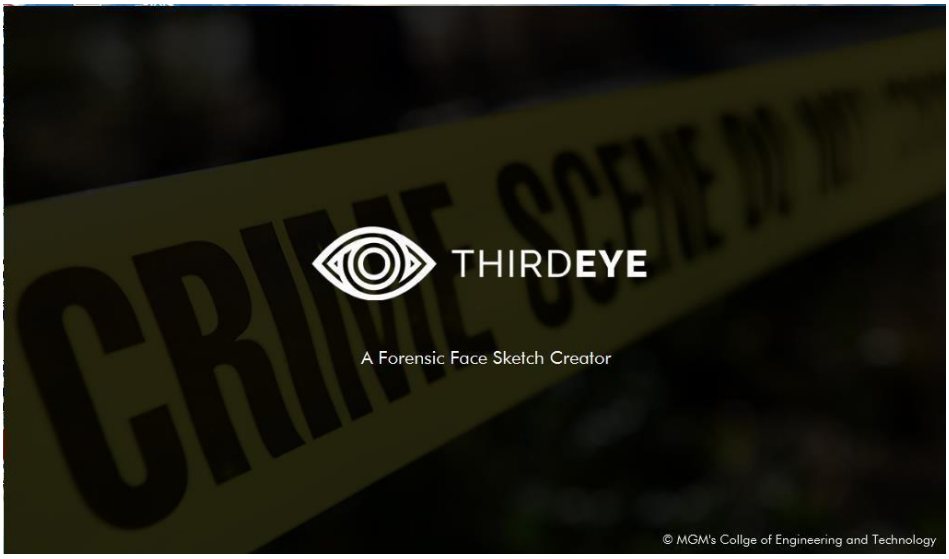

Fig 6.1.1. Splash Screen for our Standalone Desktop Application
(Fetching MAC Address and IP Address to match with Data in Database)

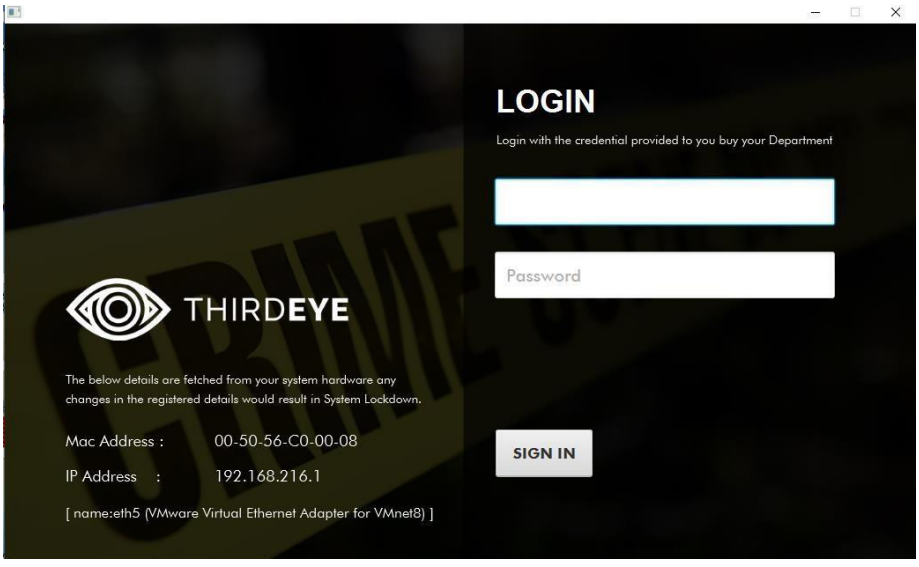

Fig 6.1.2. Login Screen of our Standalone Desktop Application
(Would only be displayed if the MAC Address and IP Address match with the database)

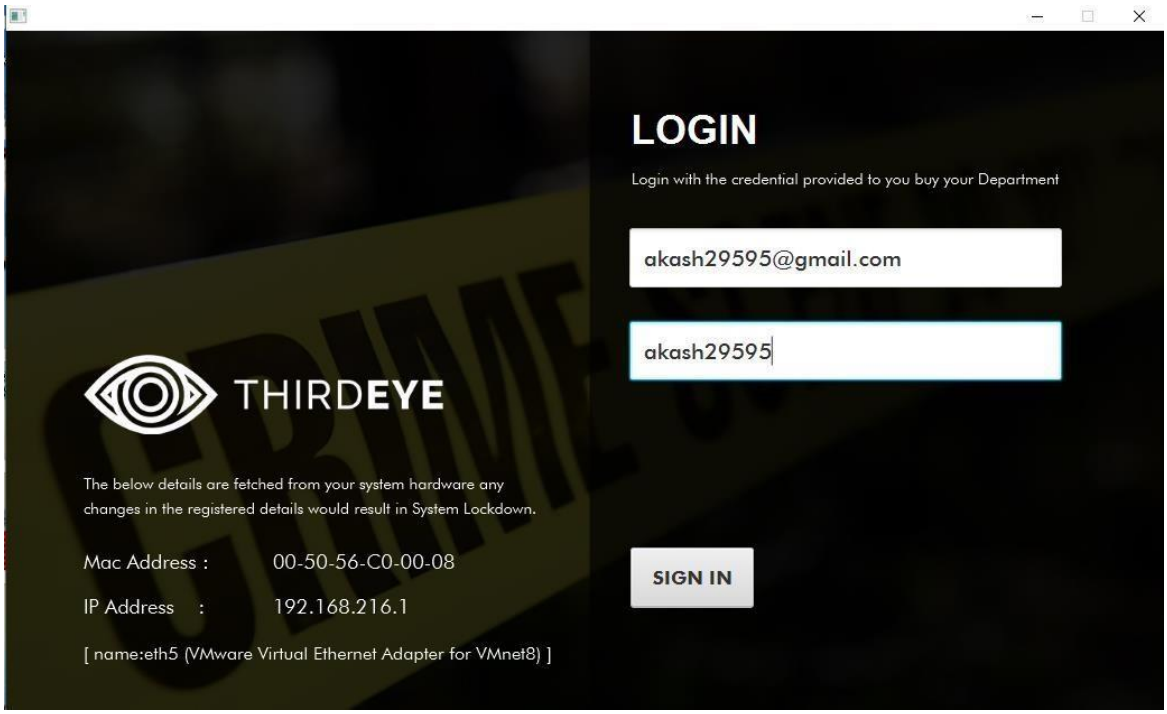

Fig 6.1.3. OTP sent on Registered Mail ID if the Credentials Match

(OTP will be sent only to registered email id only after the login credentials are valid)

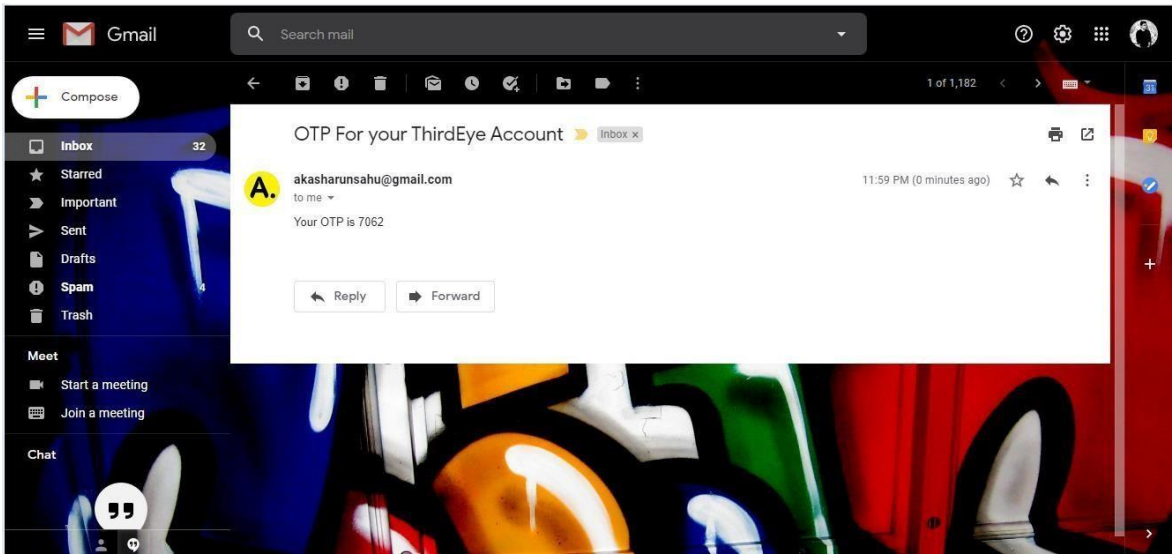

Fig 6.1.4. OTP sent on Registered Mail ID

(OTP will be sent only to registered email id only after the login credentials are valid)

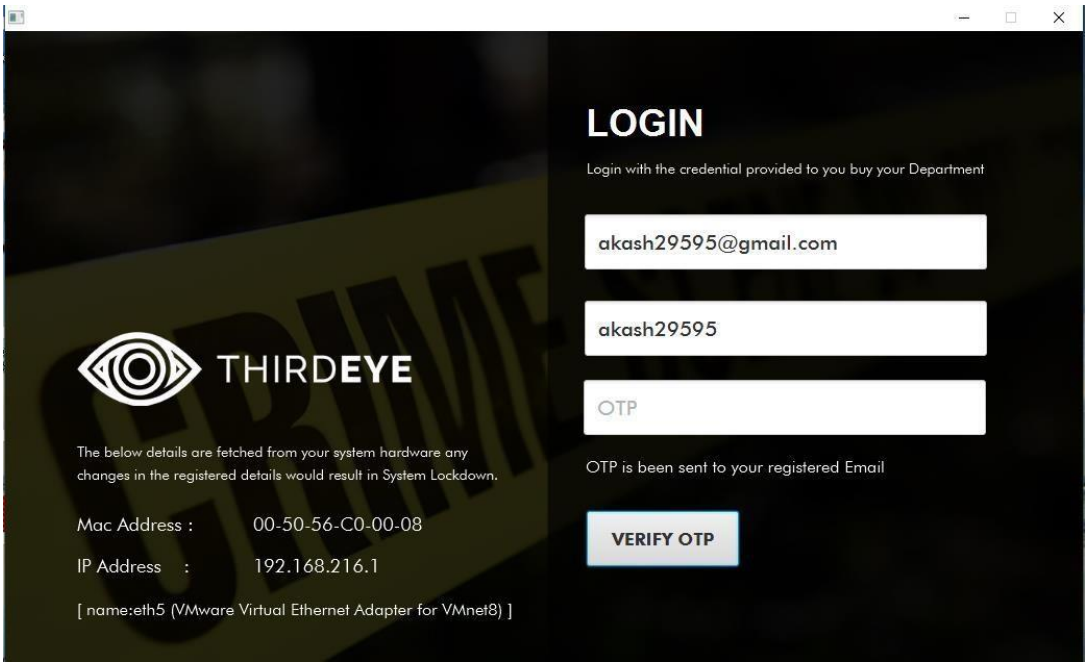

Fig 6.1.5. Enter OTP sent on Registered Mail ID

(OTP will be sent only to registered email id only after the login credentials are valid)

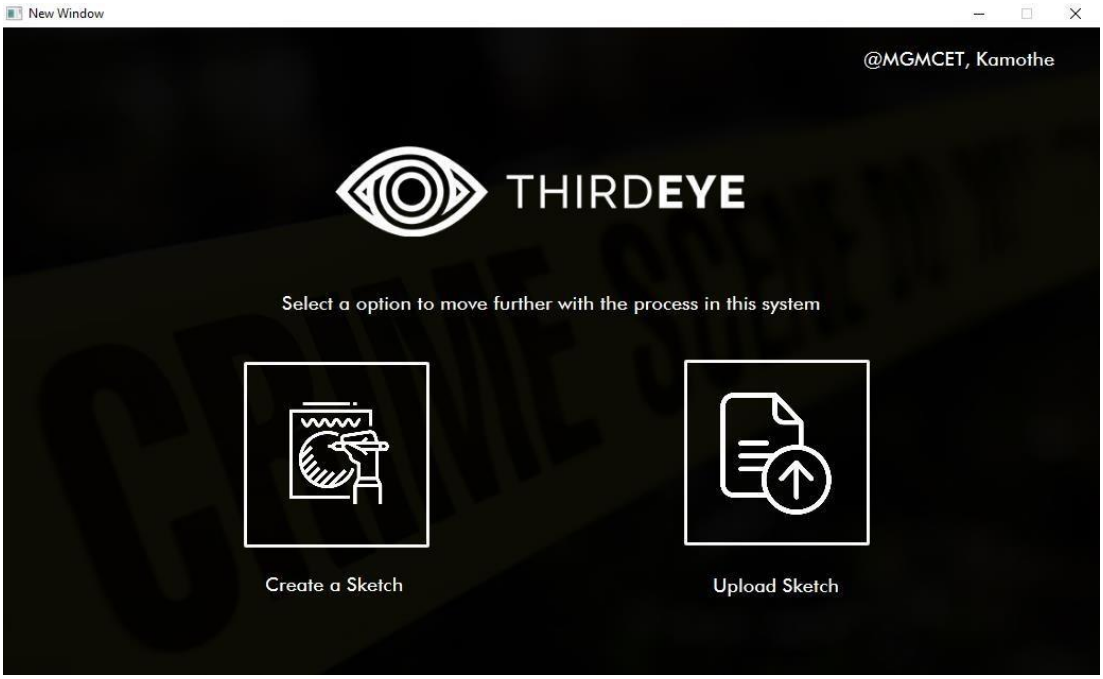

Fig 6.1.6. Option Selection Screen

(Select the option to work on Creating a Sketch or Matching a Sketch)

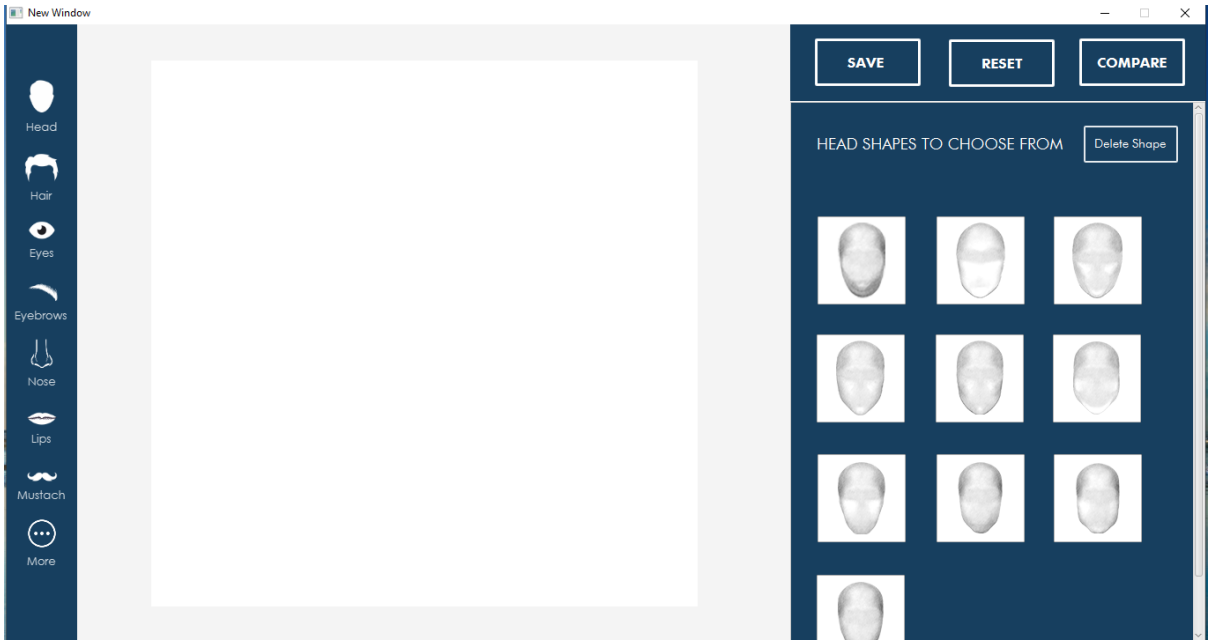

Fig 6.1.7. Dashboard to Create a Facial Sketch

(Dashboard with the Head Element Selected showing the various head shapes)

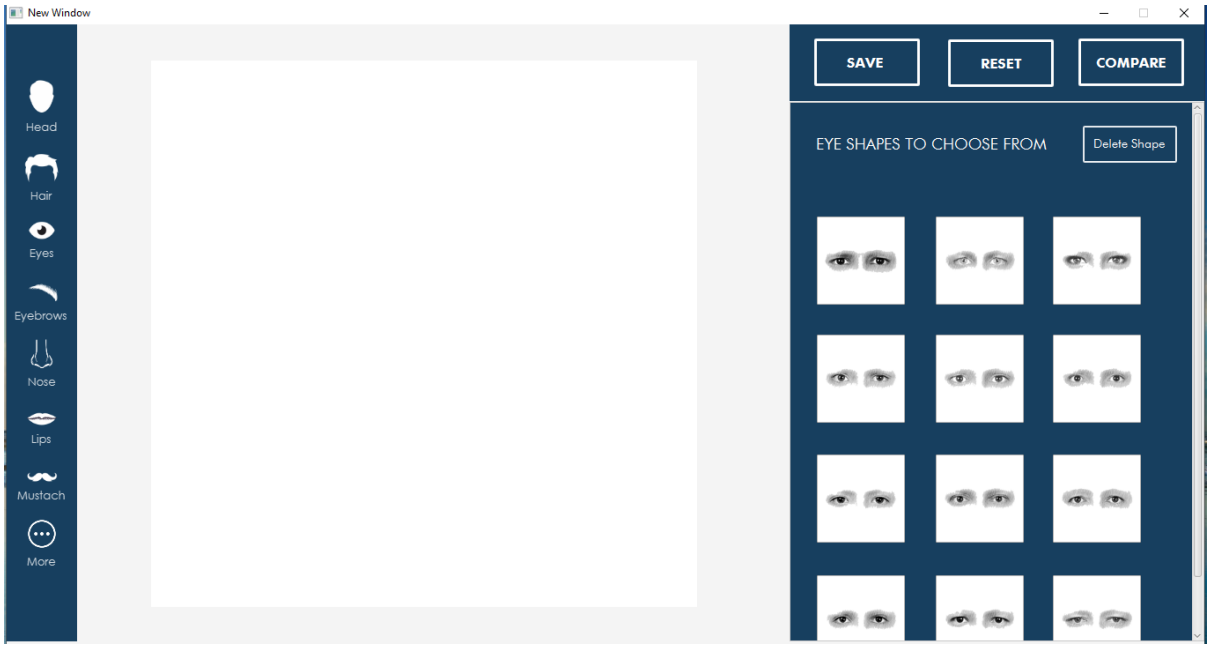

Fig 6.1.8. Dashboard to Create a Facial Sketch

(Dashboard with the Eyes Element Selected showing the various Eyes shapes)

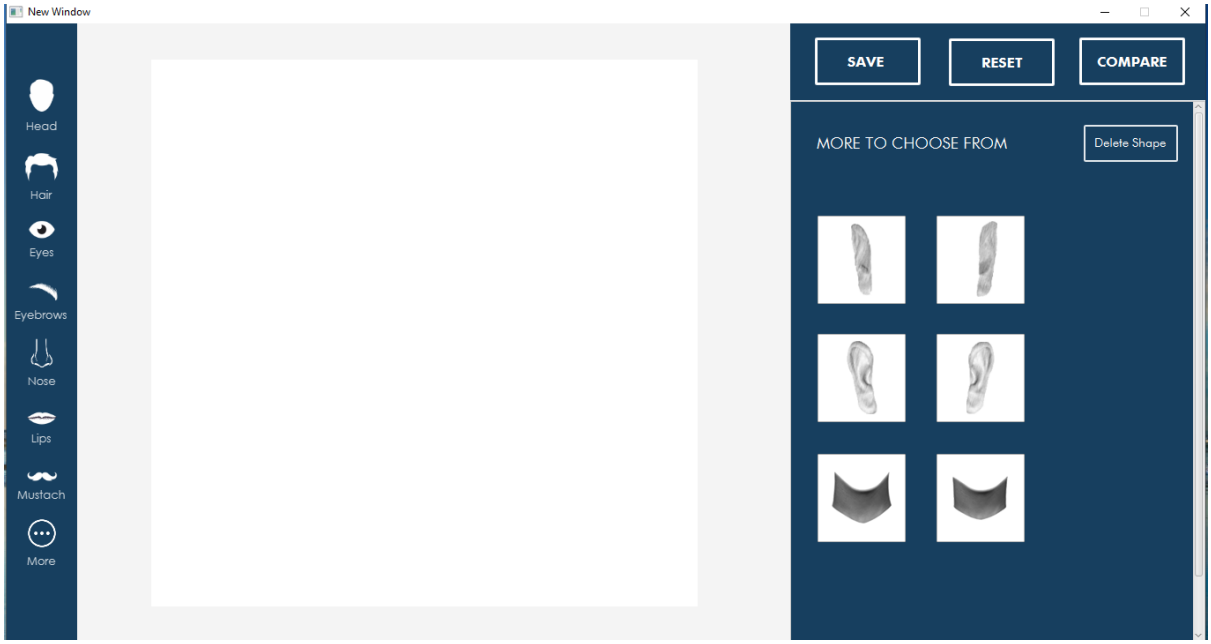

Fig 6.1.9. Dashboard to Create a Facial Sketch

(Dashboard with the More Element Selected showing the various more shapes)

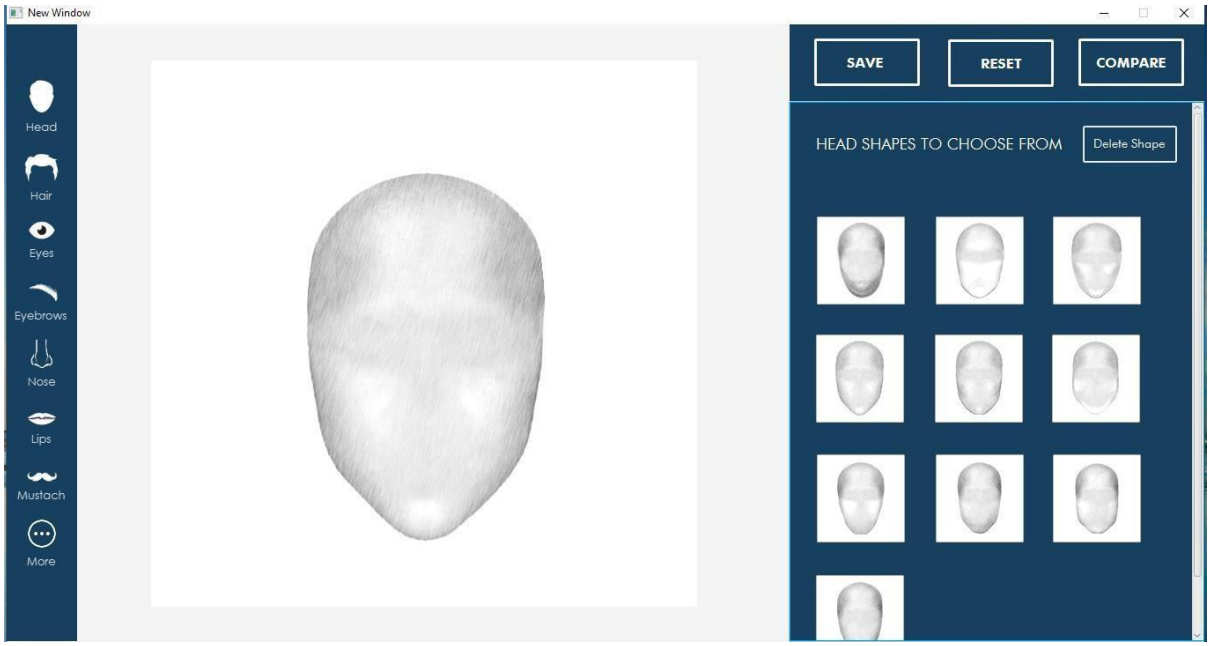

Fig 6.1.10. A Head Shape selected in Dashboard

(The Head Shape selected is been displayed on the Dashboard Canvas)

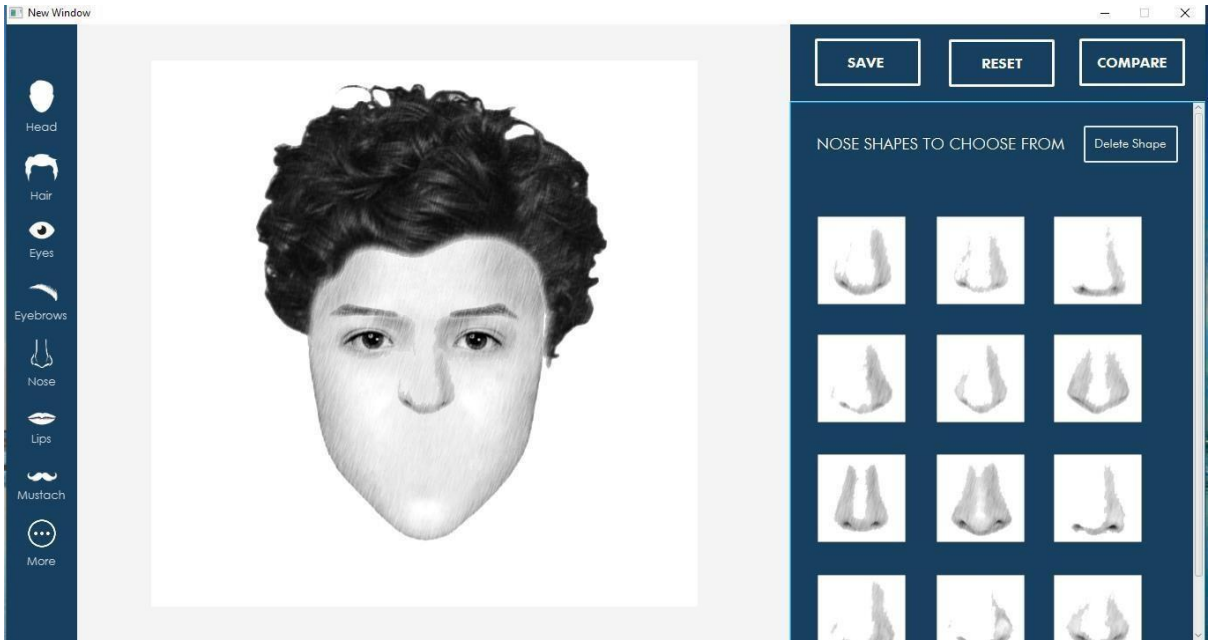

Fig 6.1.11. Other Shape too selected in Dashboard

(The Shapes selected too are been displayed on the Dashboard Canvas)

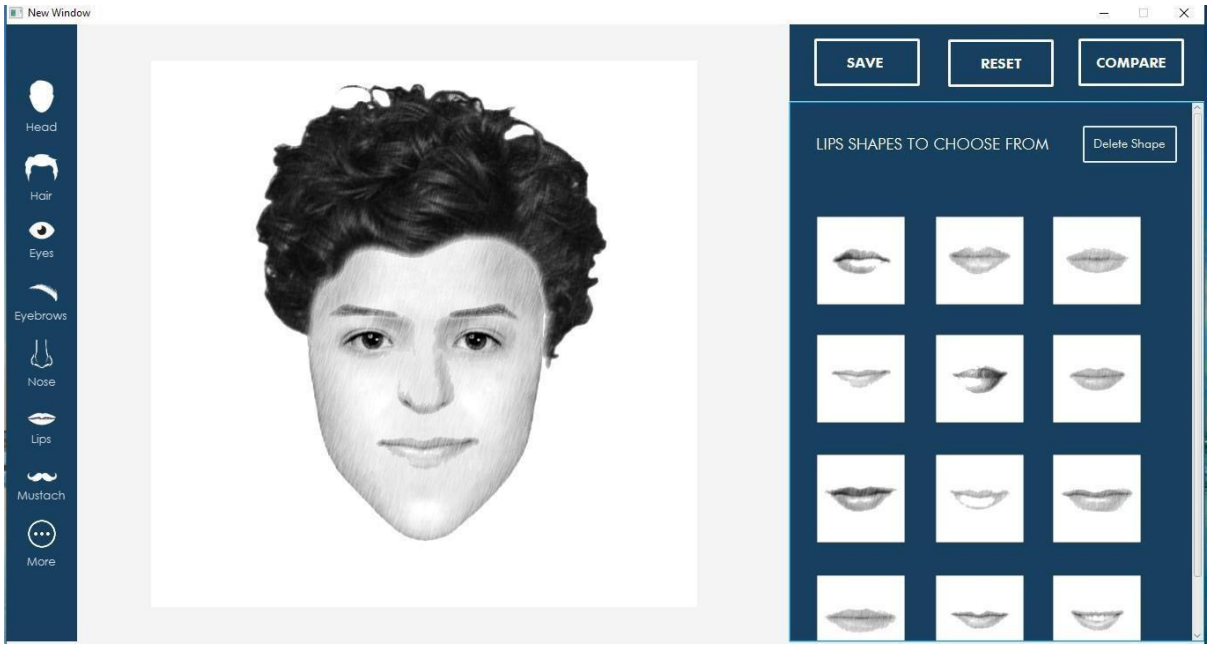

Fig 6.1.12. A Complete Face Sketch in Dashboard

(The Complete Face Sketch been displayed on the Dashboard Canvas)

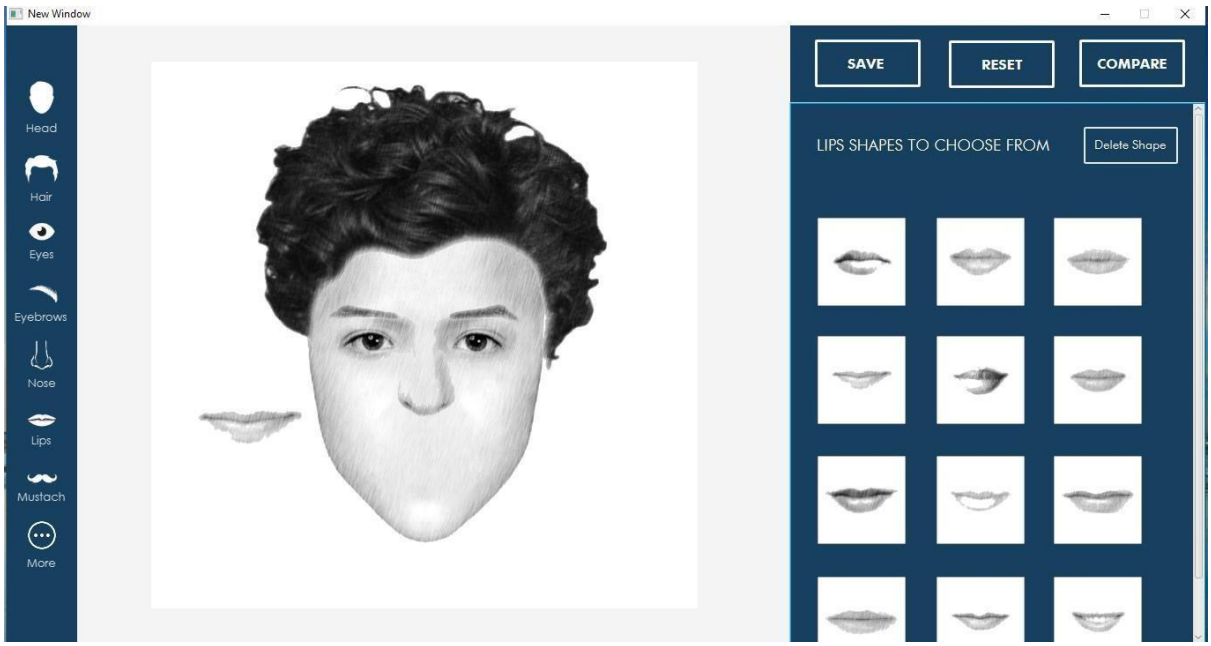

Fig 6.1.13. Shape selected in Dashboard can be Moved using Mouse

(Shape selected is moved freely on the Dashboard Canvas to adjust as per description)

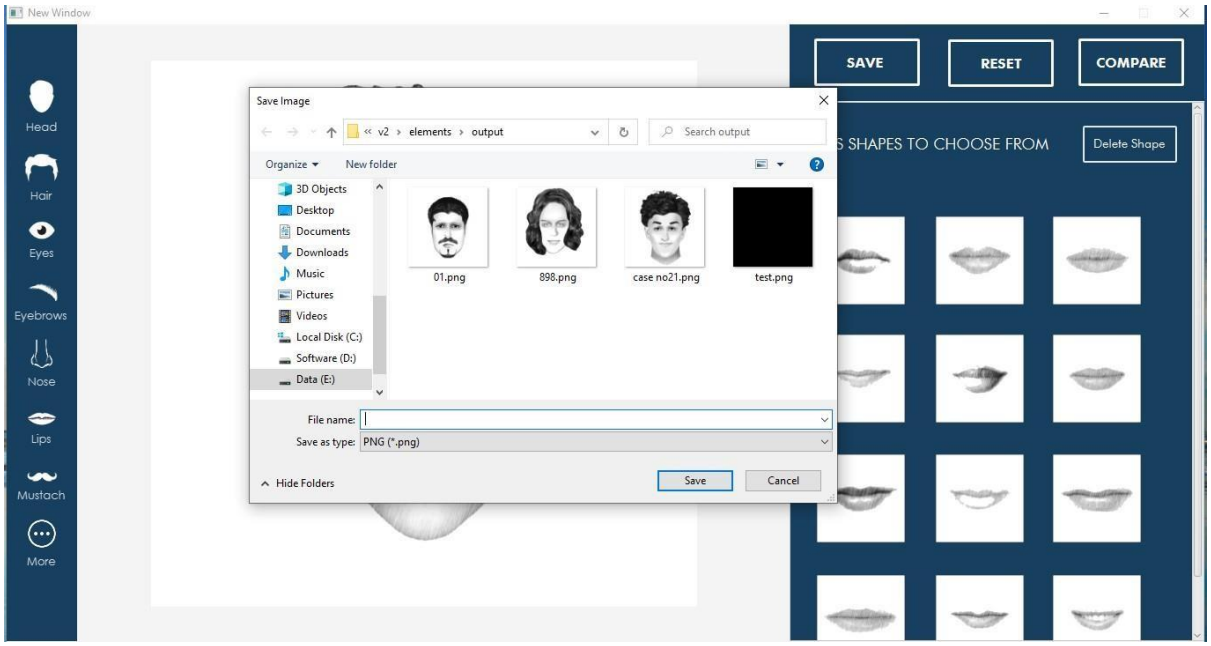

Fig 6.1.14. The Face Sketch can now be Saved as File

(The Face Sketch on the Dashboard Canvas can be Saved as PNG file)

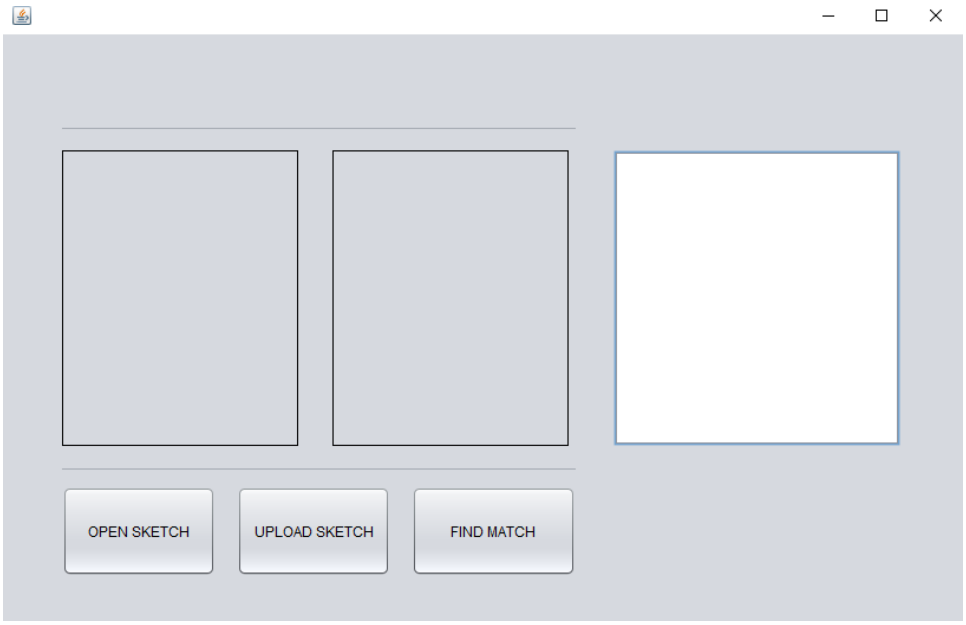

Fig 6.1.15. Dashboard to Recognize Face in Database

(The Face Sketch is now matched with the Database Record)

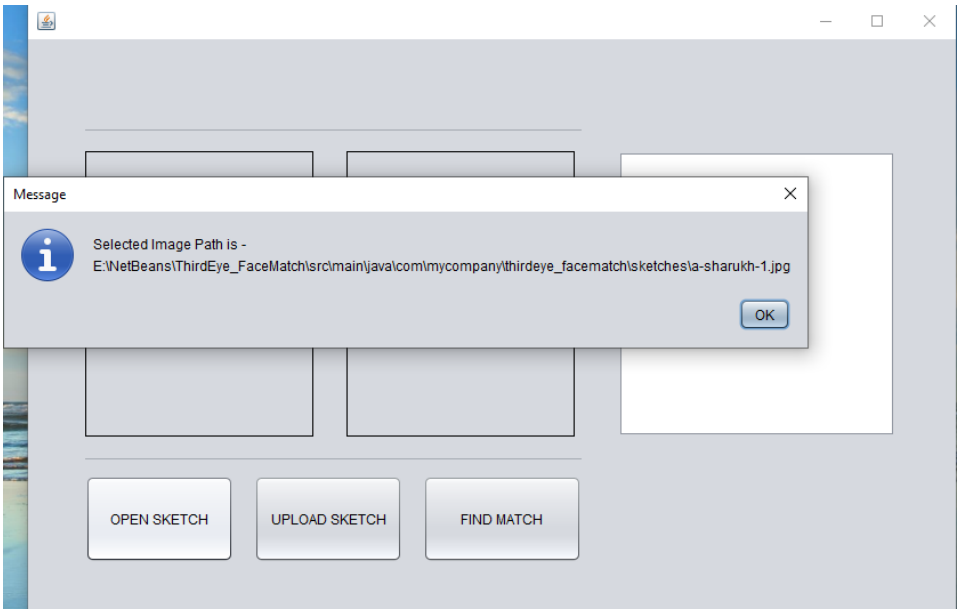

Fig 6.1.16. Select and Open a Face Sketch

(The Face Sketch to be match has to be Selected and Open on the Platform)

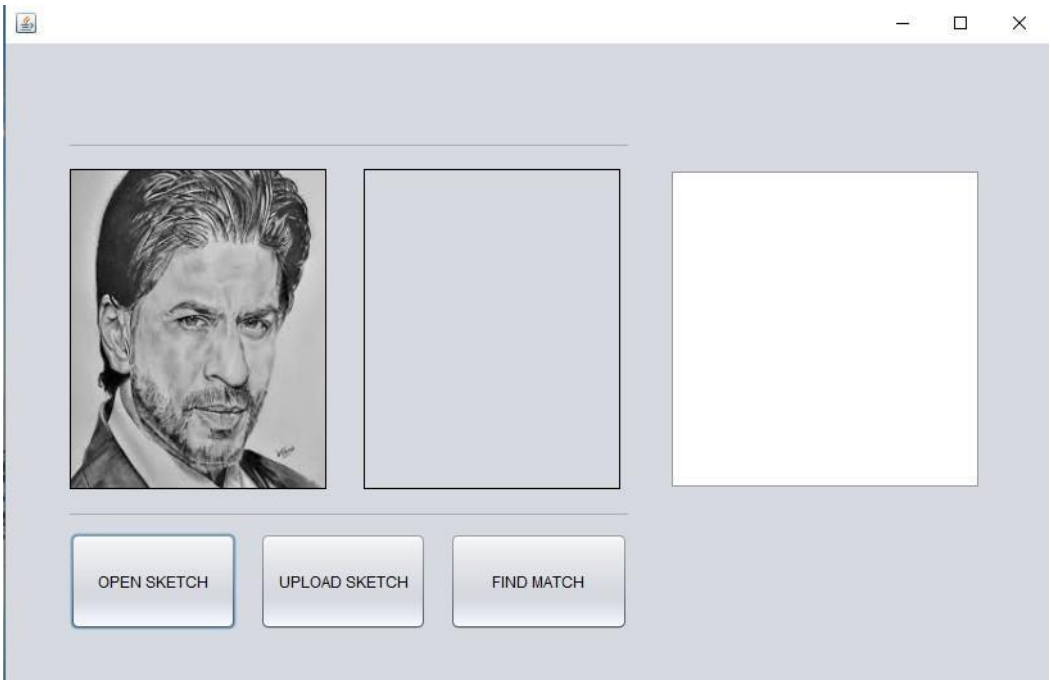

Fig 6.1.17. Opened Face Sketch

(The Face Sketch to be match has to be Opened on the Platform)

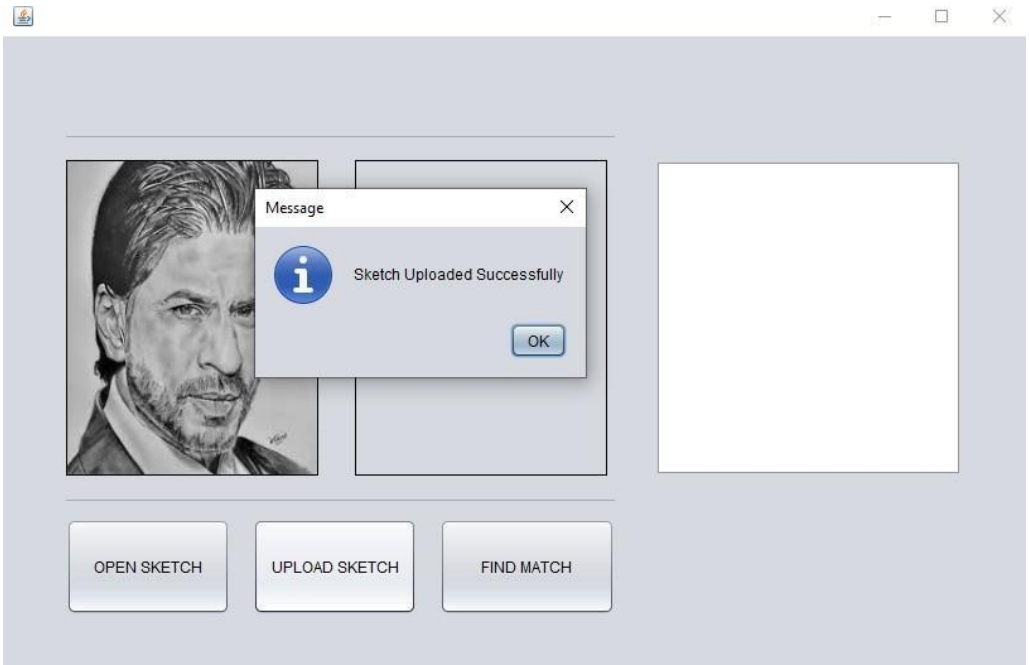

Fig 6.1.18. Face Sketch uploaded to the Server

(The Face Sketch is uploaded to the Server for better Security)

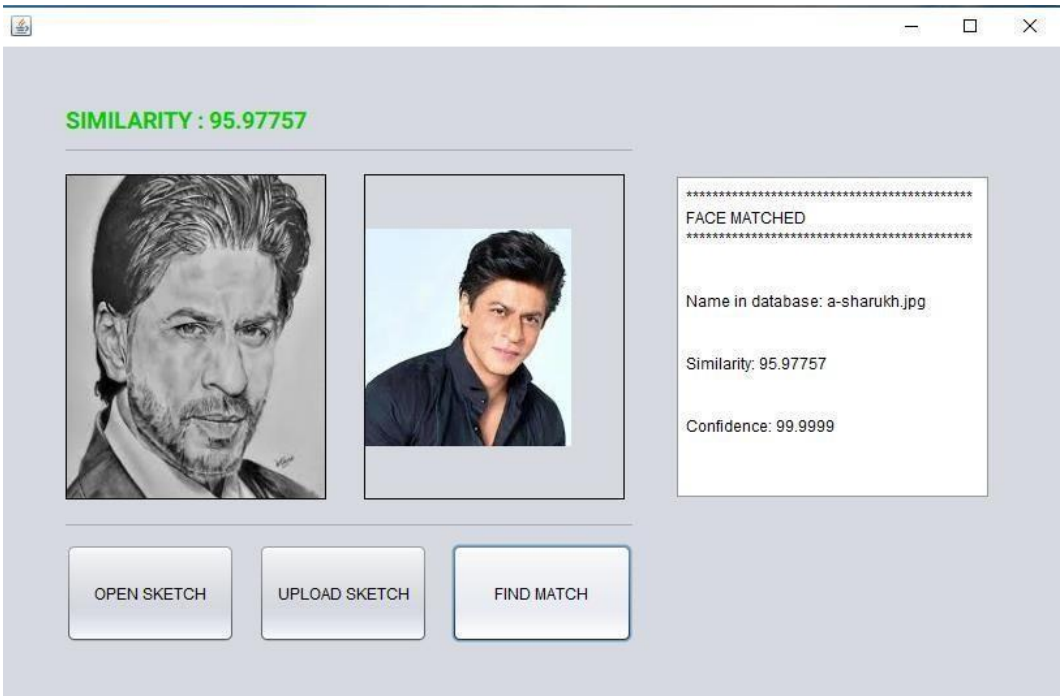

Fig 6.1.19. Face Sketch matched to Database Record

(The Face Sketch when Matched with the Record shows the Further Details)

Fig 6.1.20. Face Sketch not matched to Database Record

(The Face Sketch when not Matched with the Record shows Error)

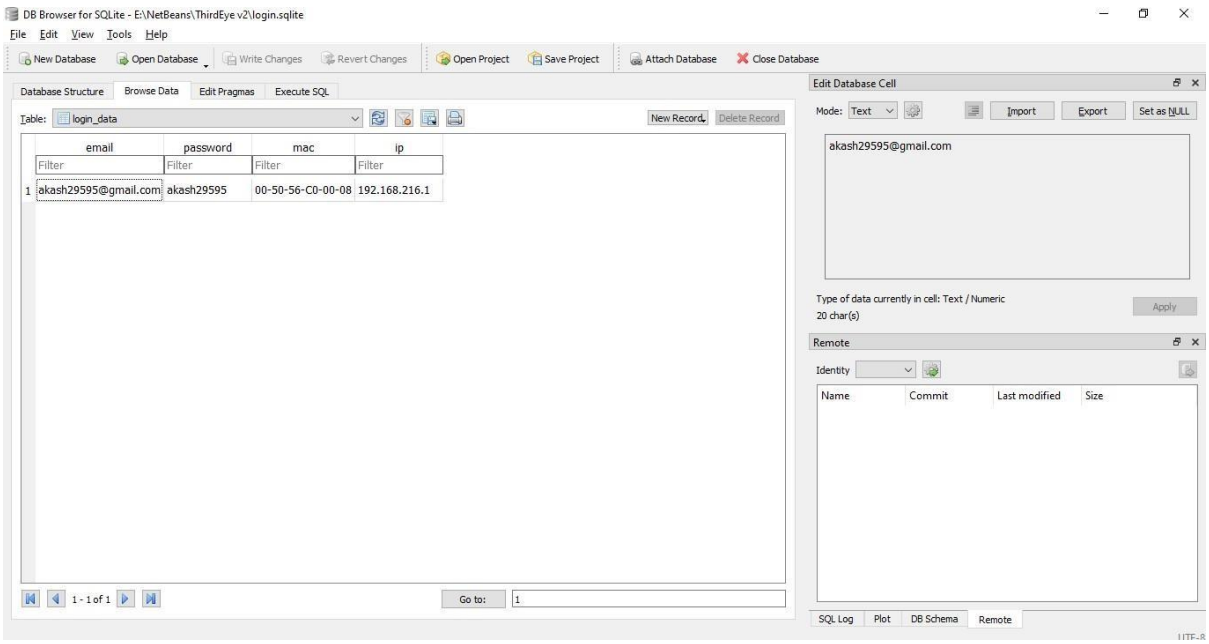

Fig 6.1.21. Database with User Credentials

(The User Credentials Management Dashboard)

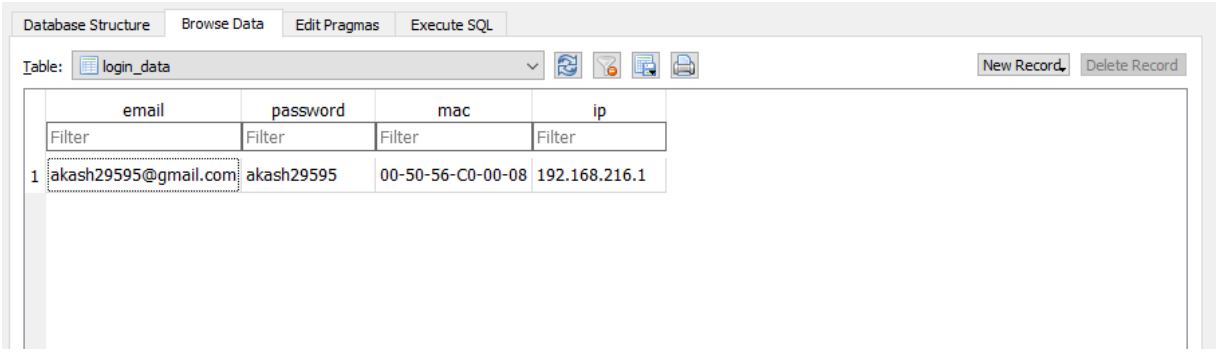

Fig 6.1.22. User Credentials and MAC Address and IP Address

(MAC Address and IP Address are saved in the Database while the first boot or load)

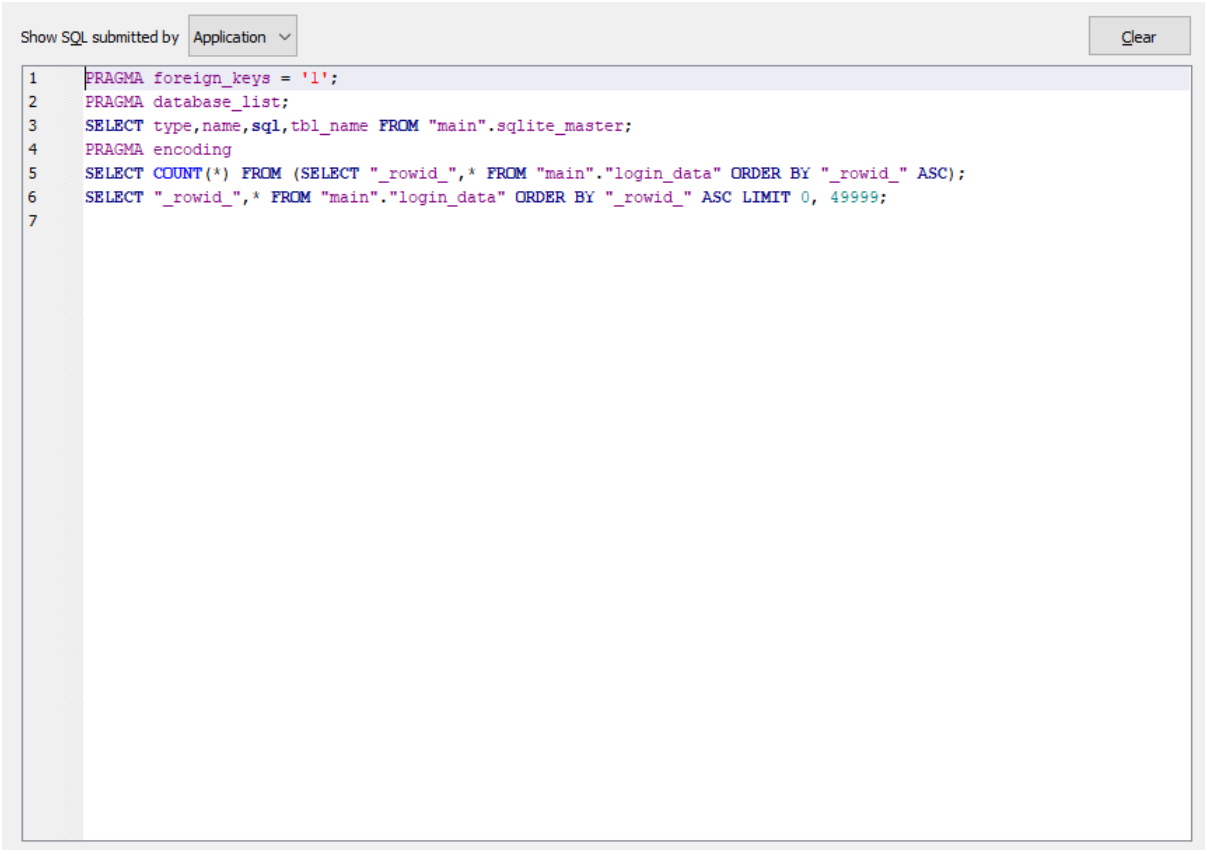

Fig 6.1.23. Database User Credentials Schema

(The User Credentials Schema)

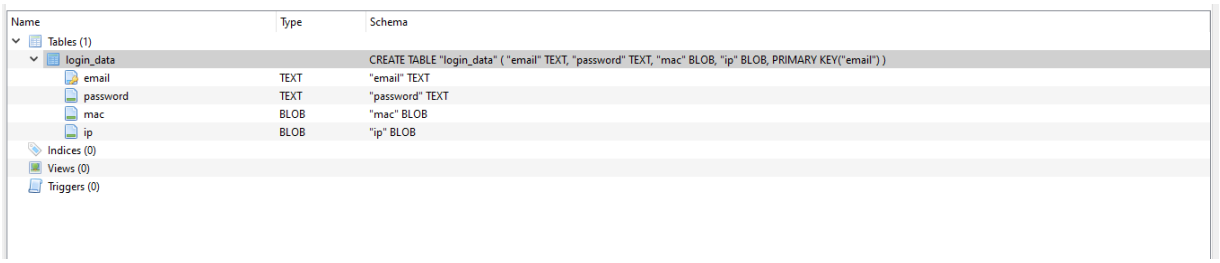

Fig 6.1.24. Database Schema

(The User Credentials Schema)

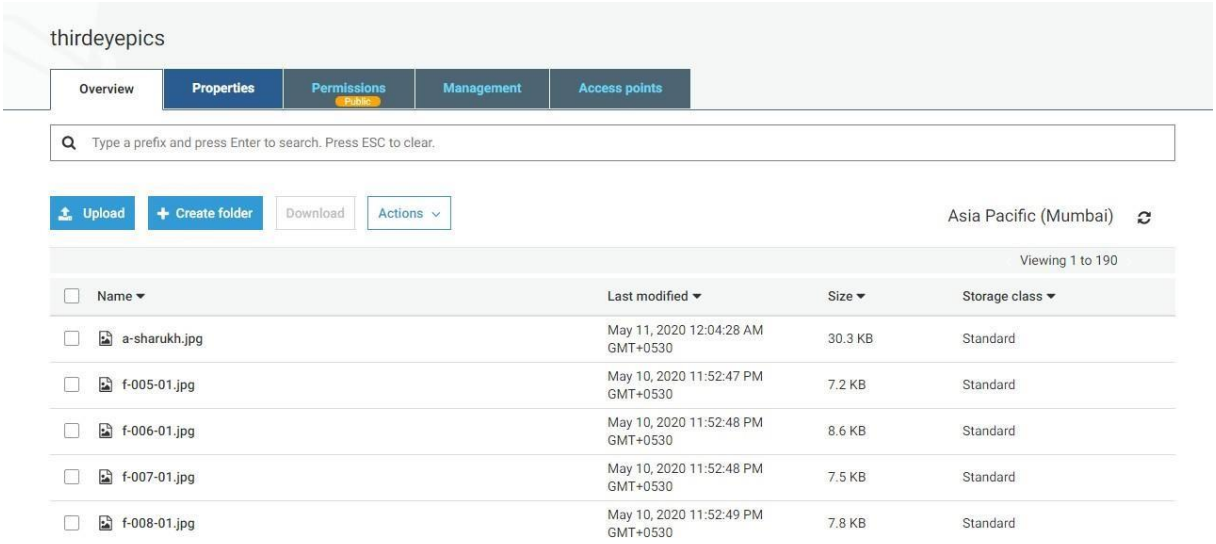

Fig 6.1.25. Police Record with Face Images

(Face Images Stored in the Server)

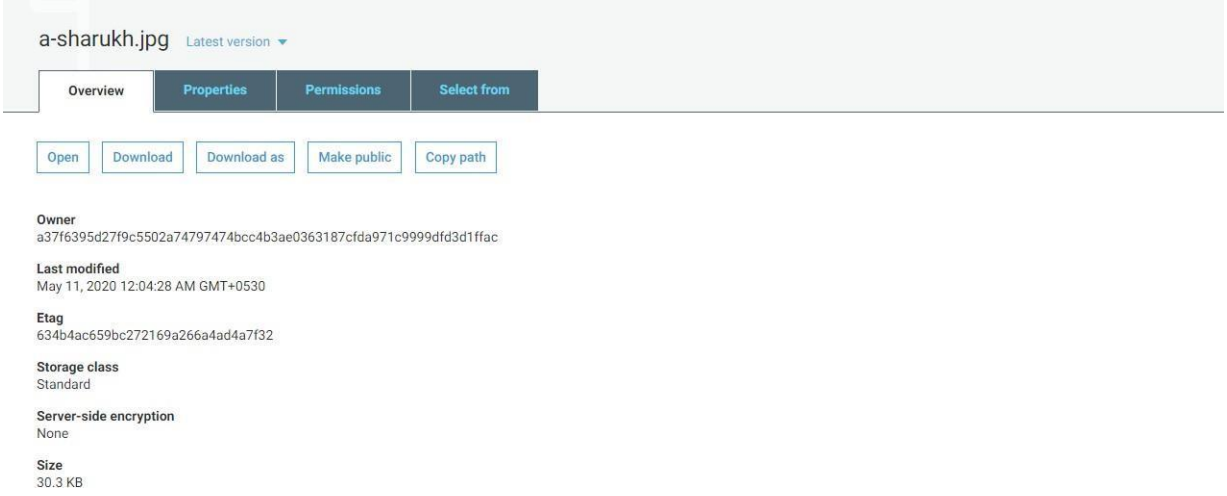

Fig 6.1.26. Police Record with Face Images Details

(Face Images Details Stored in the Server)

CHAPTER 7

RESULTS AND CONCLUSION

The Project ‘Forensic Face Sketch Construction and Recognition’ is been designed, developed and finally tested keeping the real-world scenarios from the very first splash screen to the final screen to fetch data from the records keeping security, privacy and accuracy as the key factor in every scenario.

The platform displayed a tremendous result on Security point of view by blocking the platform use if the MAC Address and IP Address on load didn’t match the credentials associated with the user in the database and later the OTP system proved its ability to restrict the use of previously generated OTP and even generating the new OTP every time the OTP page is reloaded or the user tries to relog in the platform.

The platform even showed good accuracy and speed while face sketch construction and recognition process, provided an average accuracy of more than 90% with a confidence level of 100% when tested with various test cases, test scenario and data sets, which means a very good rate according to related studies on this field.

The platform even has features which are different and unique too when compared to related studies on this field, enhancing the overall security and accuracy by standing out among all the related studies and proposed systems in this field.

CHAPTER 8

FUTURE SCOPE

The Project ‘Forensic Face Sketch Construction and Recognition’ is currently designed to work on very few scenarios like on face sketches and matching those sketches with the facephotos in the law enforcement records.

The platform can be much enhanced in the future to work with various technologies andscenarios enabling it to explore various media and surveillances medium and get a much widerspread and outputs, The platform can be modified to match the Face sketch with the human faces from the video feeds by using the 3D mapping and imaging techniques and same can be implemented to the CCTV surveillances to perform face recognition on the Live CCTV footage using the Face Sketch.

The platform can further be connected to social media has social media platforms acts has a rich source for data in today’s world, this technique of connecting this platform with the social media platform would enhance the ability of the platform to find a much more accurate match for the face sketch and making the process much more accurate and speeding up the process.

In all the platform could have features which could be different and unique too and easy to upgrade, when compared to related studies on this field, enhancing the overall security and accuracy by standing out among all the related studies and proposed systems in this field.

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