

The Detective Vision: Forensic Face Sketch Construction and Recognition

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Abstract: In forensic science, it is seen that hand-drawn face sketches are still very limited and time consuming when it comes to using them with the latest technologies used for recognition and identification of criminals. In this paper, we present a standalone application which would allow users to create composite face sketch of the suspect without the help of forensic artists using drag and drop feature in the application and can automatically match the drawn composite face sketch with the police database much faster and efficiently using deep learning and cloud infrastructure.

Key Words: Forensic Face Sketch, Face Sketch Construction, Face Recognition, Criminal Identification, Deep Learning, Machine Learning, Two Step Verification.

I. 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 sketch were even introduced which too had various limitations like limited facial features kit, cartoonist 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 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 order to suggest the user all the relatable facial features that could be used with a single selected feature in order to decrease the time frame and increase the efficiency of the platform.

II. LITERATURE SURVEY

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 were promising and 10 out of 12 composite faces were 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.

Xiaoou Tang and Xiaogang Wang proposed a recognition method of photo-sketch synthesized using a multi-scale 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 were impressive but not up to the mark as expected.

Another proposed method was sketch to photo matching proposed by Anil K Jain and Brendan Klare which used SIFT Descriptor, the method proposed displayed result based on the measured SIFT Descriptor distance between the face photos in the database and the sketches. The algorithm first converts the face photos using linear transformation which was based on Tang and Wang proposed model and then the sketch was used to measure the SIFT descriptor distance compared to the face photo and in some cases distance between images in the databases too were measured for better accuracy. The experimental result shows that the data-set used were very similar to the those used by Tang in their experiment and the addition in the algorithm was the measurement of the descriptor which gave a better result and accuracy from the model proposed by Tang and Wang.

P. C. Yuen and C. H. Man too proposed a method to search human faces using sketches, this method converted sketches to mug shots and then matched those mugshots to faces using some local and global variables been declared by the face matching algorithms. However, in some cases the mugshots were hard to be matched with the human faces in the databases like FERET Database and Japanese Database. The proposed method showed an accuracy of about 70% in the experimental results, which was fair decent but still lacked the accuracy needed by the law enforcement department.

The common issue with all the proposed algorithm where that they compared the face sketches with human face which were usually front facing making it easier to be mapped both in drawn sketch and human face photograph, but when a photograph or sketch collected had their faces in different direction the algorithms were less likely to map it and match with a face from the database which is front facing.

There is even system been proposed for composite face construction but most system used facial features which were been taken from photographs and then been selected by the operator as per described by the witness and at last complied to form a single human face making it much more complicated for human as well as any algorithm to match it with a criminal face as every facial feature was been taken from the separate face photograph having various dissimilarity and when combined together made it harder to recognize.

Thus, all the previous approaches proved either inefficient or time consuming and complicated. Our application as mentioned above would not only overcome the limitations of the mentioned proposed techniques but

It would like to the gap between the traditional hand-drawn face sketch technique and new modernized composite face sketch technique by letting user to upload the hand-drawn face sketches and facial features.

III. METHODOLOGY AND SYSTEM DESIGN

The project's other objectives include improving facial feature recognition accuracy, enabling users to manipulate facial features in the sketch to refine and adjust the likeness of the generated composite, providing an easy-to-use interface, enabling export of the composite face sketch in a variety of formats, ensuring the system can be easily adapted to new facial feature sets and databases, and enhancing security by implementing secure authentication and authorization mechanisms.

- The first part of the project relies on the objective that is to make an application using different technology stacks such as Java and JavaFX etc so that with the help of drag and drop features a Face sketch can be drawn.
- The second part of the project contributes to the objective that sketches made through the application and also previously made sketches can be matched through Face Recognition by matching them to the database present.
- The technique may even be applied to a hand-drawn drawing, allowing the platform to be compatible with more conventional methods.
- Then create a standard marking system to check that database matching with sketches made by the application and also by the forensic artist as well.

Problem Statement:

In this modern age, the overall crime rate is increasing day-by-day and to cope up with this 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 compared to 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

System Design:

Our application would be majorly used by the Law Enforcement Departments in order to 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.

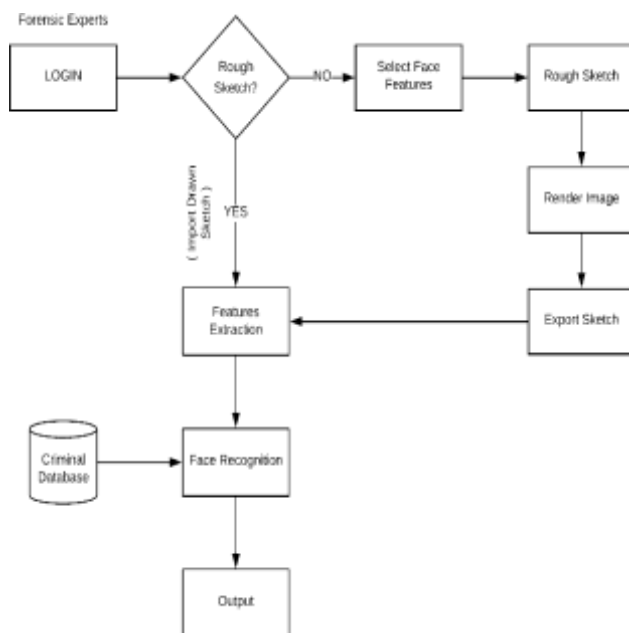


Fig. 1. Flow Chart for Creating a sketch in the application

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 the Secure Authentication Module ensures that only authorized personnel can access the application. The system verifies the device identity using User login parameters such as Login ID as Email ID and Password.

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 witness's 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 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 centres for maintaining a level of security and for this purpose the

sketch too is been uploaded to the data centre 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 centres 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.

IV. TECHNOLOGY USED:

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.

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 data centres, 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

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.

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; 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.

DEEP LEARNING FOR FACE RECOGNITION:

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 coloured 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.

V. IMPLEMENTATION:

The implementation of the proposed system is divided into three major modules: Secure Authentication (Login) Module, Face Sketch Construction Module, and Face Recognition Module.



Fig. 2. User Interface of the application (Login Page)



Fig. 3. User Interface of the application

The Secure Authentication Module ensures that only authorized personnel can access the application. The system verifies the device identity using User login parameters such as Login ID and Password.



Fig. 4. User Interface of the application (With facial features been dragged on to the canvas)

The Face Sketch Construction Module provides a user-friendly drag-and-drop interface developed using JavaFX. Users can create a facial composite by selecting facial components such as eyes, nose, mouth, ears, hair, and eyebrows from the available feature database. The selected features can be resized and repositioned according to eyewitness descriptions. The final sketch can be saved in image format for further processing.



Fig. 5. Command Line Interface of the application (Similarity Matching)

The Face Recognition Module performs matching between the generated sketch and the criminal database. The sketch image is uploaded to the cloud infrastructure hosted on AWS. A deep learning-based recognition model extracts facial embeddings from both the sketch and stored criminal images. Similarity matching is then performed to identify the most relevant candidates from the database. The results are displayed along with matching confidence scores and suspect information.

The complete system is implemented using Java, JavaFX, AWS cloud services, and deep learning techniques to provide a secure, scalable, and efficient forensic investigation platform.

VI. PROPOSED SOLUTION APPROACH:

The proposed solution aims to automate the traditional forensic face sketching process and improve the efficiency of criminal identification.

The workflow begins with secure user authentication. After successful verification, the user can either upload an existing hand-drawn sketch or create a new sketch using the drag-and-drop facial composite interface. The generated sketch is then pre-processed to normalize image dimensions and improve feature extraction.

The processed sketch is transmitted to the cloud server where the deep learning model performs feature extraction. The extracted facial features are compared against the criminal image database using similarity matching algorithms. The system ranks the matched records according to confidence scores and returns the most probable matches to the user.

VII. 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 face photos in the law enforcement records.

The platform can be much enhanced in the future to work with various technologies and scenarios enabling it to explore various media and surveillances medium and get a much wider spread 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.

VIII. RESULT 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.

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