Forensic Face Sketch Construction and Recognition

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ABSTRACT

In the field of forensic science, hand-drawn facial sketches remain constrained and labor-intensive, particularly when integrated with contemporary technologies for the recognition and identification of offenders. This paper introduces a standalone application designed to enable users to generate composite facial sketches of suspects independently, without the assistance of forensic artists. The application employs a drag-and-drop feature, allowing for user-friendly interaction, and it can swiftly and efficiently match the created composite sketches with the police database through the utilization of deep learning and cloud infrastructure.

Keywords**:** — Forensic Face Sketch, Face Sketch Construction, Face Recognition, Criminal Identification, Deep identification and recognition.

I. INTRODUCTION

The identification of a criminal can be achieved through a facial sketch derived from an eyewitness description. However, in the context of modern advancements, the traditional technique of hand-drawing sketches is increasingly seen as ineffective and time-consuming for the purpose of matching and identifying individuals from pre-existing or real-time databases..

Historically, various methods have been proposed to convert hand-drawn facial sketches into systems capable of automatically identifying and recognizing suspects within police databases. Unfortunately, these approaches frequently failed to yield the level of precision needed. Furthermore, the introduction of applications for creating composite facial sketches encountered significant limitations, including a narrow range of facial features and a tendency to produce cartoon-like representations, complicating their practical use and efficiency.

The previously mentioned applications and requirements prompted us to consider the development of an application that not only offers a range of individual features, such as eyes, ears, and mouths, for users to choose from when creating face sketches but also allows for the upload of hand-drawn features. These features would be converted into the application’s component set, resulting in sketches that closely mirror the original hand-drawn designs. This capability would enhance the application's usability for law enforcement departments.

The application provides law enforcement agencies with the capability to upload past hand-drawn sketches, utilizing the powerful deep learning algorithms and cloud infrastructure available in the platform to improve the process of suspect

The algorithm will utilize insights from the sketches and the database to identify and suggest related facial features that can be paired with a single selected feature, which will help minimize the time needed and boost the platform's effectiveness.

II. RELATEDWORK

A significant number of studies have been conducted on the construction and recognition of facial sketches using diverse techniques. Dr. Charlie Frowd, in collaboration with Yas meen Bashir, Kamran Nawaz, and Anna Petkovic, created a standalone application for the purpose of constructing and identifying facial composites. The initial version of the system was found to be both time-consuming and confusing, akin to traditional methods. Subsequently, they transitioned to a new approach where victims were provided with a selection of faces to choose from, enabling them to select one that resembled the suspect. The system would then integrate all chosen features to automatically generate a composite of the suspect's face. The findings were promising, with 10 out of 12 composite faces accurately identified. The accuracy rates were 21.3% when witnesses received assistance from department personnel and 17.1% when they attempted to construct the faces on their own.

Xia The recognition method for photo-sketch synthesis was proposed by Xiaoou Tang and Xiang Wang, employing a Multi-scale Markov Random Field Model. This innovative project allows for the transformation of a sketch into a photograph or a photograph into a sketch, followed by a database search for a relevant match. The model segments the facial sketch into smaller patches. Initially, they converted existing photographs into sketches and trained the model to reduce the differences between the two, which significantly enhanced the recognition model's efficiency. For evaluation, they utilized a few samples where photographs were transformed into sketches, and the same faces were illustrated by a sketch artist. The model was trained on 60% of the data, with the remaining 40% used for testing. Although the results were impressive, they fell short of the anticipated standards.

The sketch-to-photo matching technique proposed by Anil K Jain and Brendan Klare employs the SIFT Descriptor to achieve its objectives. This method evaluates the SIFT Descriptor distance between facial images in a database and their corresponding sketches to produce results. The algorithm initiates the process by transforming the facial images through a linear transformation based on the model developed by Tang and Wang. Following this, the sketch is used to measure the SIFT descriptor distance in relation to the facial images, and in certain cases, the distance between images within the database is also calculated to enhance overall accuracy. The experimental results reveal that the data set used was very similar to that of Tang's experiment, with the algorithm's enhancement being the incorporation of descriptor measurement, which led to improved results and accuracy compared to the original model by Tang and Wang.

A method for searching human faces from sketches was also proposed by P. C. Yuen and C. H. Man. This technique involved converting sketches into mug shots, which were subsequently matched to faces using specific local and global variables established by face matching algorithms. However, there were challenges in matching the mug shots with human faces in databases like the FERET Database and the Japanese Database. The experimental results indicated an accuracy of around 70%, which, although fairly decent, did not meet the standards of accuracy expected by law enforcement.

In their analysis, the team juxtaposed facial sketches with human face photographs, which were primarily oriented frontally, thereby easing the mapping process between the sketches and the images. However, when the photographs or sketches presented faces at varying angles, the algorithms were less effective in mapping and matching these with the front-facing faces in the database..

There have been several systems suggested for the creation of composite faces, yet the majority utilize facial features sourced from photographs. An operator selects these features according to the witness's account, ultimately assembling them into a single human face. This process complicates the matching of the composite with a criminal's face, as each feature originates from different photographs, leading to inconsistencies that hinder accurate recognition by both humans and algorithms.

Therefore, the previous strategies have proven to be inefficient, time-intensive, and complex. Our application, as noted earlier, aims to not only overcome the limitations of these proposed methods but also to bridge the gap between the classic hand-drawn face sketch technique and the innovative composite face sketch technique by allowing users to upload their hand-drawn sketches along with facial features.

OVERVIEW AND FEATURES

Security Measures and Privacy Considerations

The foremost concern for law enforcement agencies when considering the adoption of any system is the protection of security and privacy. Accordingly, the application has been designed to uphold privacy standards and implement security measures in multiple effective ways.

a) **MachineLocking:**The Machine locking technique provides a robust solution to ensure that an application, once installed on a particular system, remains secure from tampering and cannot be used on any other system. This is accomplished through the implementation of two distinct locking parameters: a software parameter and a hardware parameter.
HD ID – Volume serial of hard-drive with OS.NETID–HardwareID –MAC Address.

b) **Two Step Verification:**The Machine locking technique serves as an effective approach to maintain the integrity of an application, ensuring that once it is installed on a particular system, it remains secure from tampering and is restricted from use on any other system. This is facilitated by the integration of two distinct locking parameters: one pertaining to software and the other to hardware.

c) **Centralized Usage:**Law enforcement officials who are authorized will be assigned an official email ID for application access. To log in successfully, users need to provide a random code that will be sent to their mobile or desktop device.

B. Backward Compatibility

The primary challenge in implementing a new system is the intricate process of shifting from the old method to the new, which frequently results in considerable time and resource inefficiencies. To address this concern, we have designed our application to enable the uploading of hand-drawn sketches. This feature empowers users to utilize deep learning algorithms and cloud technology for the identification and recognition of criminals illustrated in the sketches.

C. Face Sketch Construction using Drag and Drop

In this application, users can create detailed composite face sketches by employing predefined sets of facial features that can be re sized and repositioned according to the eyewitness's input. The application categorizes the human face into various features such as the head, eyes, eyebrows, lips, nose, and ears, and also includes important accessories like hats and glasses for enhanced customization.

Selecting any facial feature will present a wide variety of options based on the eye-witness's description. The machine learning algorithm will evolve, working to suggest complementary facial features that align with the chosen one, which will significantly expedite and streamline the process of generating the composite face sketch.

Fig. 1.Shows the sketch of the facial feature viz. Head

Fig. 2.Shows the sketch of the facial feature viz. Eyes

Fig.3.Shows the sketch of the facial feature viz. Ears

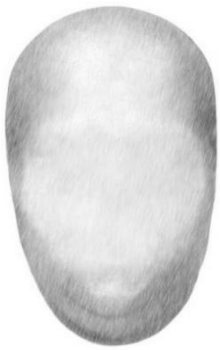

Fig.1.Face Feature–Head

Fig.2.Face Feature– Eyes

Fig.3.Face Feature–Ears

The specified facial features can be applied in the application to develop a composite sketch of the suspect, informed by the description provided by the eyewitness to the law enforcement and forensic departments.

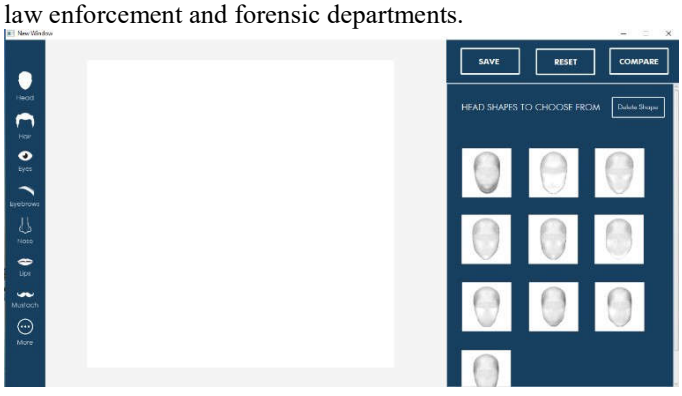

Fig.4.User Interface of the application(with blank canvas)

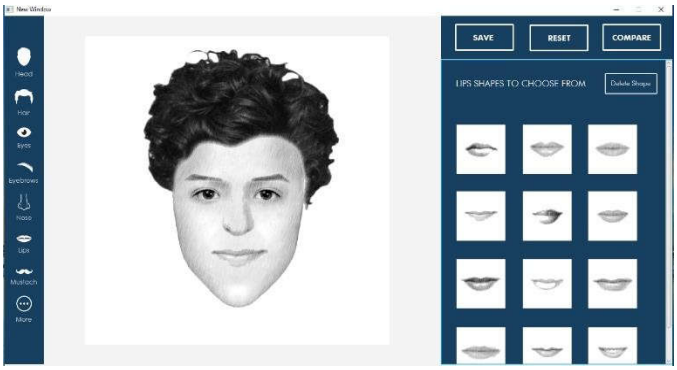

Fig.5.User Interface of the application
(with facial features been dragged onto the canvas)

The Fig. 4.This application presents a user interface that allows users to create composite facial sketches, featuring a selection of facial attributes on the right side. On the left side, users will find tools for re sizing, repositioning, and saving their work.

Fig. 5.In the application's user interface, users can pull a facial feature from the right-hand side and place it onto the canvas, facilitating the integration of multiple facial features to form a composite face sketch.

D. System Flow

The Fig.6.The system's overall flow is illustrated, starting with the login section that ensures a two-step verification process. Users have the option to either use a hand-drawn sketch or create a composite face sketch via a drag-and-drop interface. Both images are then subjected to a feature extraction process, allowing the application to apply image processing and computer vision algorithms. Finally, the sketch is compared to the database, and the application displays the similarity ratio between the sketch and the database photograph.

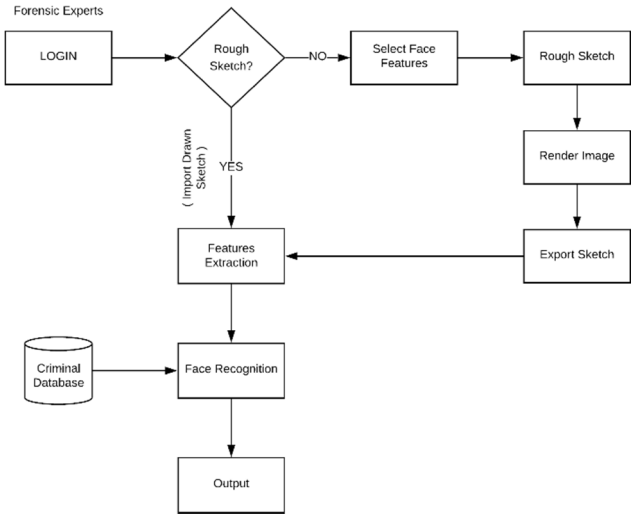

Fig.6.System-flow of application

III. OVERVIEWANDFEATURES

Inthisapplication,Operationsisperformed intwostages.

A. Face Sketch Construction:

The primary challenge in implementing a new system is the intricate process of shifting from the old method to the new, which frequently results in considerable time and resource inefficiencies. To address this concern, we have designed our application to enable the uploading of hand-drawn sketches. This feature empowers users to utilize deep learning algorithms and cloud technology for the identification and recognition of criminals illustrated in the sketches..

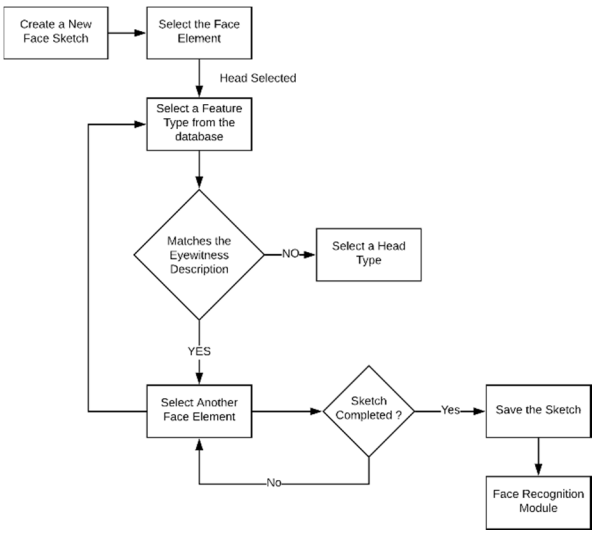

Fig. 7. Flow Chart for Creating a sketch in the application

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 componentsandtheelementsofthefacesketcheshelpinginthecons tructionoftheface sketch.

Creating a face sketch can become quite challenging when all facial elements are presented simultaneously and in a disorganized fashion. This disarray complicates the user's ability to accurately construct a face, which contradicts the objectives of the proposed system. To address this challenge, we have decided to categorize the facial elements according to their respective types, such as head, nose, hair, eyes, and so forth. This structured approach significantly enhances user interaction with the platform, facilitating the process of sketching a face. Users can access these categories in the left column of the Canvas on the dashboard; by clicking on a specific face category, they can explore various facial structures.

The diverse facial features within a specific category can encompass numerous elements. To address this complexity, our platform intends to employ machine learning in the future to identify similar facial features or recommend elements for selection in facial sketches. However, this approach will be effective only after we have gathered sufficient data to train the model on this algorithm and improve the platform's capabilities.

So, now when the user clicks on a particular face categoryandthenanewmoduletotherightofthecanvasopensandle ts user to select an element from the option of face elementstoconstructafacesketch.Thisoptioncanbeselectedbesel ectedbasedonthedescriptionprovidedby the eyewitness.

The elements when selected are shown on the canvas andcan be moved and placed as per the description of the eyewitness to get a better and accurate sketch and the elementshave a fixed location and order to be placed on the canvas liketheeyeelementswouldbeplacedovertheheadelementirrespec tiveof the order the were selected.Same for every f aceelement.

The final module is the options to enhance the use of the dash board, suppose in cases the user selects an element which his not to be selected so that could be rectified using the opti onto erase that particular element which would be seen when selecting the facecategoryfromtheleftpanel.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 dash board-making it-to tally-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.

B. FaceSketchRecognition:

The flowchart depicts the user journey facilitated by the platform to generate an accurate facial sketch based on the provided description. The dashboard is designed with simplicity in mind, allowing users to engage with the platform without the need for professional training. This design choice effectively conserves both time and resources for the Department.

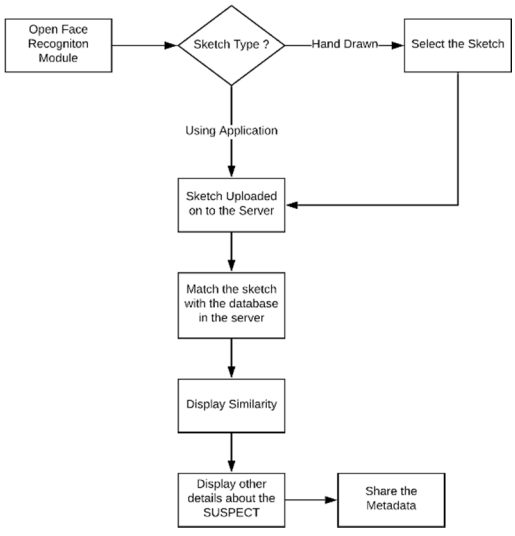

Fig.8.Flow Chart for Recognizing a sketchin the application

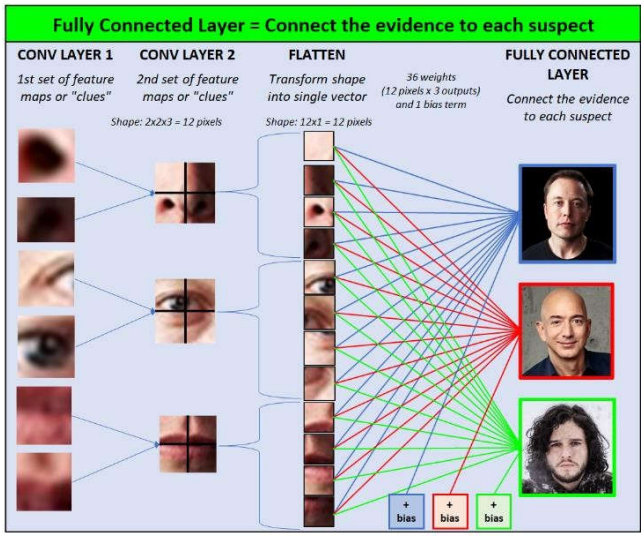

Fig. 9.Feature extraction by the Platform

The image presented above illustrates the initial step prior to utilizing the platform for facial recognition. This step involves adapting the existing records within the law enforcement department to be compatible with our platform. This is achieved by training the platform's algorithm to recognize and associate identification numbers with facial images corresponding to users in the existing law enforcement records. To accomplish this, the platform's algorithms interface with the records, deconstructing each facial image into various smaller features and assigning an identification number to the multiple features derived from a single facial image..

The module, primarily intended for operation on law enforcement servers to ensure security protocols, is currently being executed. The user begins by opening either a hand-drawn sketch or a facial sketch created on our platform and saved on the host machine. Subsequently, the opened facial sketch is uploaded to the law enforcement server that contains the recognition module, ensuring that the process and data records remain untampered, secure, and accurate.

Upon uploading the sketch to the server, the algorithm initially outlines the sketch image to identify its features. It then maps these features, as illustrated in the figure below, to compare them with the features of the facial photographs stored in the database.

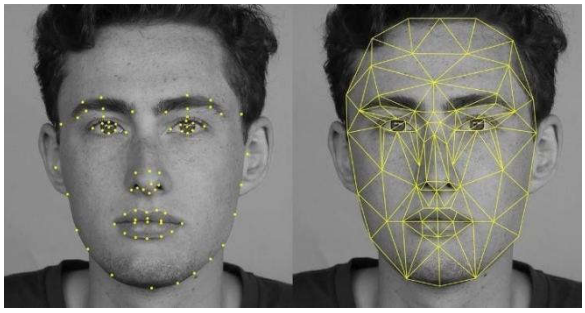

Fig.10.Face Sketch been mapped-on platform

Upon completing the mapping of the sketch and correlating the facial sketch with the existing records to identify a match, the platform presents the matched face alongside the similarity percentage and additional details pertaining to the individual from the records. The platform's display, including the matched individual, is illustrated in the figure below.

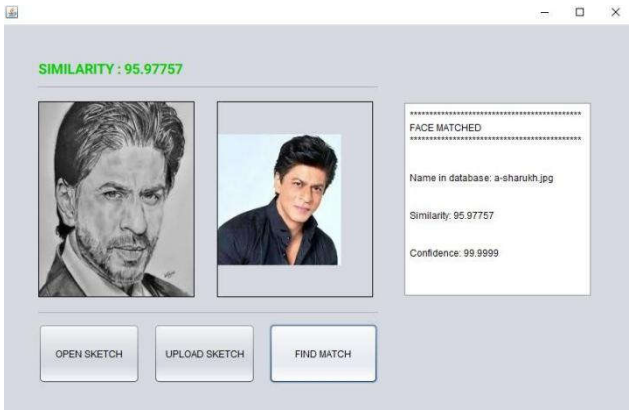

Fig.11.Face Sketch-matched to-database Record

IV. RESULTS&CONCLUSION

The project titled 'Forensic Face Sketch Construction and Recognition' has been meticulously designed, developed, and tested with real-world scenarios in mind, from the initial splash screen to the final interface. Throughout this process, the paramount considerations have been security, privacy, and accuracy in data retrieval from the records.

The platform demonstrated significant effectiveness in terms of security by restricting access when the MAC Address and IP Address during login did not correspond with the credentials stored in the database. Furthermore, the One-Time Password (OTP) system showcased its capability to prevent the use of previously generated OTPs, as well as to generate a new OTP each time the OTP page is refreshed or when the user attempts to log in again.

The platform demonstrated commendable accuracy and efficiency during the processes of face sketch construction and recognition. It achieved an average accuracy exceeding 90%, accompanied by a confidence level of 100% when evaluated against a range of test cases, scenarios, and data sets. This performance indicates a highly favorable outcome in comparison to relevant studies within this domain.

The platform incorporates distinct and unique features that set it apart from similar studies in this domain, thereby improving overall security and accuracy while distinguishing itself from other related research and proposed systems in the field.

V. FUTURESCOPE

The initiative titled 'Forensic Face Sketch Construction and Recognition' is presently structured to operate under a limited number of scenarios, specifically focusing on the creation of facial sketches and the subsequent comparison of these sketches with photographic images stored in law enforcement databases.

The platform has significant potential for future enhancements, allowing it to integrate with diverse technologies and scenarios. This will enable the exploration of various media and surveillance methods, resulting in broader dissemination and outputs. Additionally, the platform can be adapted to align face sketches with human faces captured in video feeds through the application of 3D mapping and imaging techniques. This capability can also be extended to CCTV surveillance systems, facilitating real-time face recognition on live footage using the face sketches.

The platform can also be integrated with social media, which serves as a valuable source of data in the contemporary landscape. This integration would significantly improve the platform's capability to identify a more precise match for the facial sketch, thereby enhancing the accuracy of the process and expediting its execution..

The platform may possess distinct and unique features that are also easy to upgrade. When compared to similar studies in this field, it aims to enhance overall security and accuracy, thereby distinguishing itself from other related research and proposed systems.

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