Forensic Face Sketch Construction and Recognition

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Abstract- In forensic science, traditional hand-drawn face sketches have proven to be both time-consuming and limited in their effectiveness, particularly when integrated with modern recognition and identification technologies. In this paper, we introduce a standalone application designed to empower users to create composite face sketches of suspects independently, without the need for professional forensic artists. This user-friendly application employs a drag-and-drop interface, allowing for intuitive design. Furthermore, it leverages advanced deep learning algorithms and cloud infrastructure to automatically match the generated composite sketches against police databases, significantly enhancing the speed and efficiency of the identification process.

Keywords: — Forensic Face Sketch, Face Sketch Construction, Face Recognition, Criminal Identification, Deep Learning, Machine Locking, Two-Step Verification.

1. Introduction

Face sketches created from eyewitness descriptions can significantly aid in identifying and apprehending criminals. However, in our modern era, traditional hand-drawn sketches have proven to be less effective and time-efficient when matching and identifying suspects from existing or real-time databases.

Historically, various techniques have been proposed to convert hand-drawn sketches into formats suitable for automatic identification and recognition within police databases. Unfortunately, these methods have often fallen short of delivering the precise results needed. While applications for creating composite face sketches have emerged, they typically come with limitations, such as a restricted set of facial features and a cartoonish aesthetic that complicates their practical use in law enforcement.

These challenges inspired us to develop an innovative application that not only offers a comprehensive selection of individual facial features such as eyes, ears, and mouths but also allows users to upload their hand-drawn features. This functionality enables the application to convert these uploaded elements into its component set, resulting in sketches that closely resemble the original hand-drawn artwork. This approach aims to enhance usability and acceptance among law enforcement agencies.

Additionally, our application facilitates the upload of previous hand-drawn sketches, enabling law enforcement teams to leverage advanced deep learning algorithms and cloud infrastructure for more efficient suspect identification and recognition. The machine learning algorithms will analyse both the uploaded sketches and the existing database, suggesting relevant facial features that can be combined with any selected

feature. This capability is designed to reduce the time required for sketch creation while simultaneously increasing the overall efficiency of the identification process.

2. Literature Survey

Numerous studies have explored face sketch construction and recognition through various approaches. One significant effort by Dr. Charlie Frowd and collaborators, including Yasmeen Bashir, Kamran Nawaz, and Anna Petkovic, led to the development of a standalone application for creating and identifying facial composites. Initially, the system was time-consuming and confusing, mirroring traditional methods. However, it evolved to allow victims to select features from a range of faces, which the system would then combine to automatically generate a composite of the suspect. The results were promising, with 10 out of 12 composites correctly identified, achieving accuracy rates of 21.3% with assistance and 17.1% independently. In another study, Xiaoou Tang and Xiaogang Wang proposed a photo-sketch synthesis method using a Multiscale Markov Random Field Model, which converted sketches into photos and vice versa by dividing the face sketch into patches. They trained the model to minimize differences between photos and sketches, enhancing recognition efficiency. Although the results were impressive, they did not meet the expected benchmarks for accuracy.

Anil K. Jain and Brendan Klare proposed a sketch-to-photo matching method utilizing the SIFT (Scale-Invariant Feature Transform) descriptor, which measured the SIFT descriptor distances between face photos in the database and corresponding sketches. The algorithm first applied a linear transformation to the face photos based on the model proposed by Tang and Wang and then used the sketch to measure the SIFT descriptor distance in comparison to the face photos. Additionally, distances between images in the database were evaluated to enhance accuracy. The experimental results indicated that the dataset used was similar to that of Tang's study, and incorporating descriptor measurements improved results and accuracy.

Meanwhile, P. C. Yuen and C. H. Man developed a method for searching human faces using sketches by converting them into mug shots and matching these to faces using various local and global variables defined by face matching algorithms. However, challenges arose in matching mug shots with human faces in databases like the FERET and Japanese databases. Their method achieved an accuracy of approximately 70%, which, while decent, still fell short of the accuracy required by law enforcement agencies.

3. System Analysis

3.1 Security and Privacy

A primary concern for law enforcement agencies when considering the adoption of any system is security and privacy. With this in mind, our application has been designed with robust measures to safeguard user privacy and ensure security in the following ways:

3.1.1 Machine Locking

The machine locking technique ensures that the application, once installed on a specific system, cannot be tampered with or operated on any other device. This is achieved through two locking parameters: a software locking parameter and a hardware locking parameter.

- **HD ID:** This refers to the volume serial number of the hard drive containing the operating system.
- **NET ID:** This is the hardware identifier, specifically the MAC address.

3.1.2 Two-Step Verification

Each authorized law enforcement user will be assigned an official email address to log into the application. This process includes a two-step verification mechanism, requiring users to enter a randomly generated code sent to their mobile device or desktop. This additional layer of security ensures that only authorized personnel can access the application.

3.1.3 Centralized Usage

The system on which the application is installed will be connected to a centralized server located within the law enforcement department's campus. This server will host the database and other critical features of the application. As a result, the application cannot be operated if it becomes disconnected from the server, further enhancing security and control over its usage.

3.2 Backward Compatibility

One of the significant challenges in adopting a new system is the complexity involved in migrating from existing techniques to new ones, which can lead to wasted time and resources. To address this issue, we have designed our application to support backward compatibility, allowing users to upload hand-drawn sketches. This feature enables users to leverage deep learning algorithms and cloud infrastructure to identify and recognize criminals based on these hand-drawn sketches.

3.3 Face Sketch Construction Using Drag and Drop

Our application facilitates the construction of accurate composite face sketches through a user-friendly drag-and-drop interface. Users can select from predefined facial feature sets, which can be resized and repositioned according to the descriptions provided by eyewitnesses.

The human face is categorized into various features, including the head, eyes, eyebrows, lips, nose, ears, and additional wearable components such as hats and glasses. When a facial feature is selected, a wide range of options becomes available, allowing users to choose based on the specific requirements or descriptions given by the eyewitness.

Furthermore, the machine learning algorithm continuously learns from user interactions and will eventually suggest relevant facial features that complement the selected feature. This capability aims to expedite the process of completing the composite face sketch, enhancing both speed and efficiency.

4. Block Diagram

4.1 System Flow

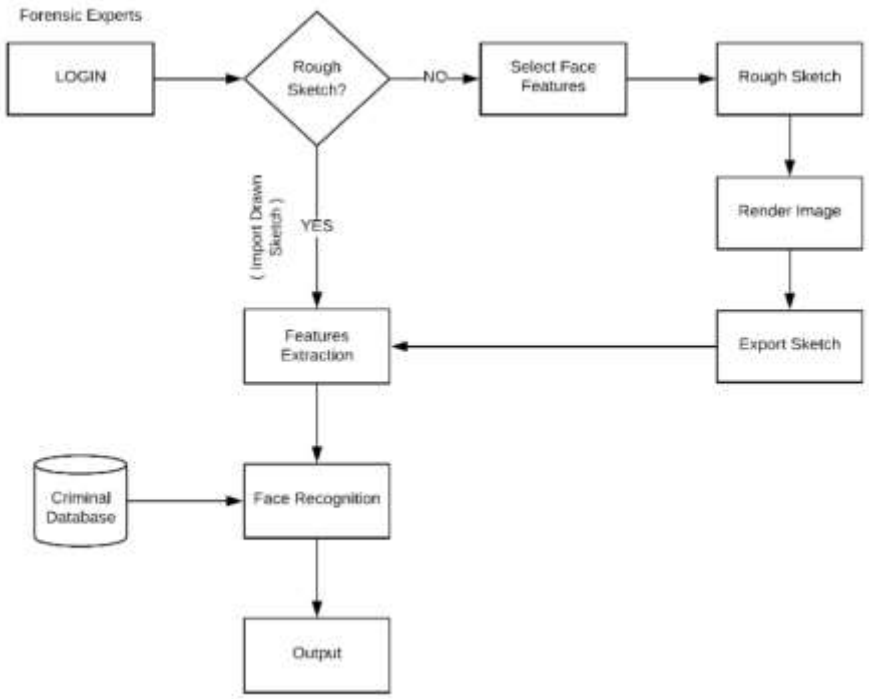

Fig. 1. System Flow Chart of the Application

This flowchart illustrates the overall flow of the system, beginning with the login section, which incorporates a two-step verification process to ensure security. Once logged in, users can either upload a hand-drawn sketch or create a composite face sketch using the drag-and-drop feature.

Regardless of the method chosen, the uploaded image undergoes a feature extraction process, enabling the application to apply image processing and computer vision algorithms. Finally, the system matches the sketch against the database and displays the similarity ratio between the sketch and the photographs in the database.

4.2 Face Sketch Construction Module

The flowchart illustrates the user journey within the platform, detailing the steps taken to construct an accurate face sketch based on eyewitness descriptions. The dashboard is designed to be user-friendly, eliminating the need for professional training before using the platform. This streamlined approach not only enhances usability but also saves valuable time and resources for the department that would otherwise be spent on training and familiarization.

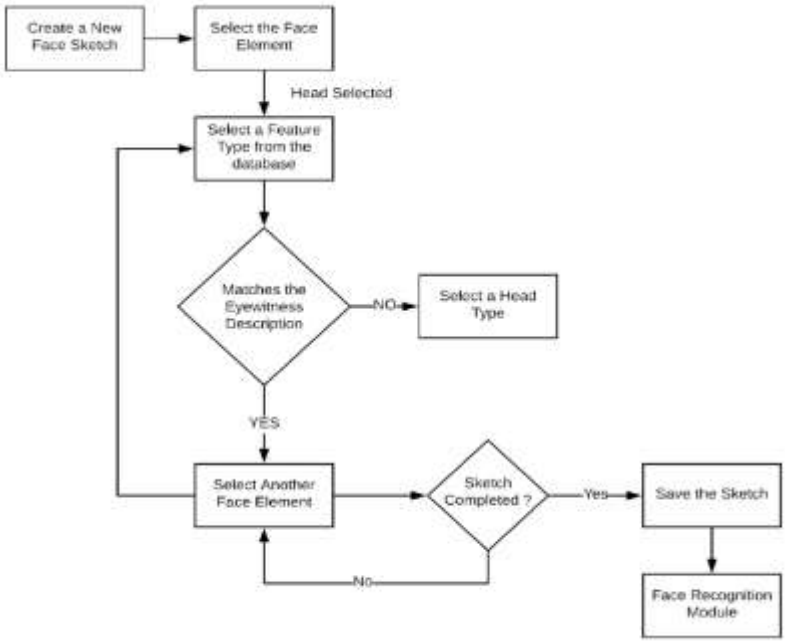

Fig. 2. Flow Chart for Creating a sketch in the application

4.3 Face Sketch Recognition Module

The flowchart illustrates the user flow within the platform, outlining the steps taken to recognize an accurate face sketch based on eyewitness descriptions. The dashboard is designed to be simple and intuitive, allowing users to navigate the platform without the need for professional training. This user-friendly design not only facilitates ease of use but also saves valuable time and resources for the department that would otherwise be spent on training and onboarding.

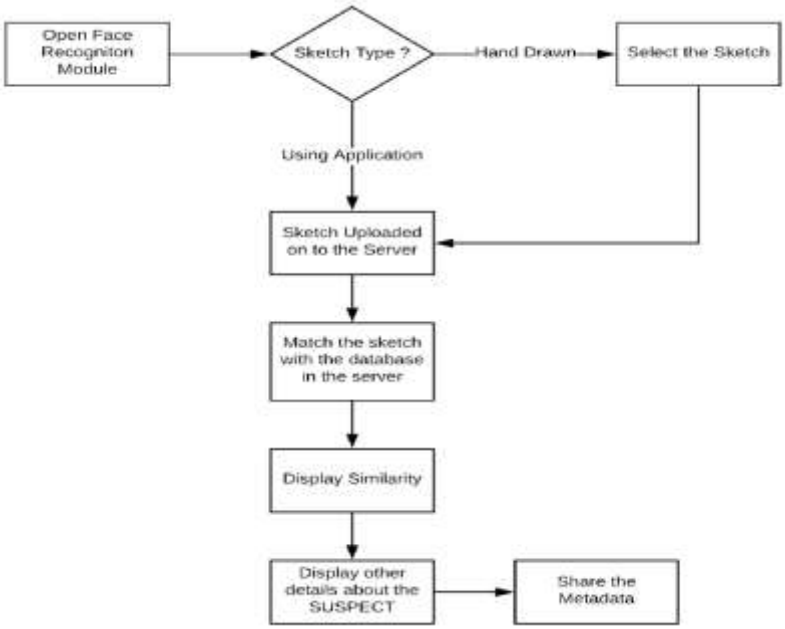

Fig. 3. Flow Chart for Recognizing a sketch in the application

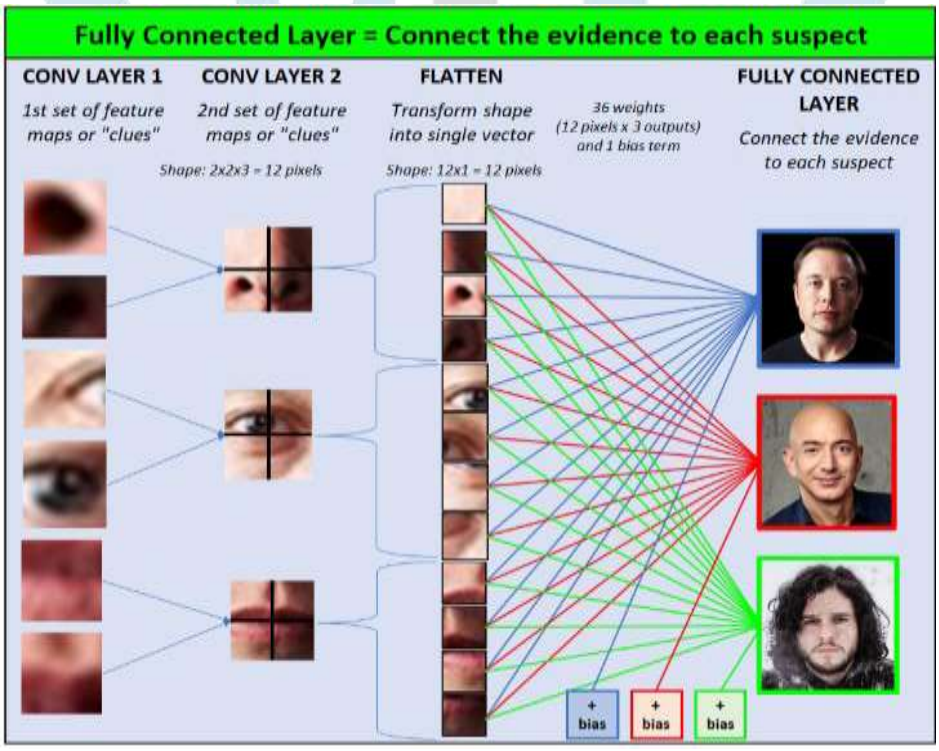

Fig. 4. Feature extraction by the Platform

The above image illustrates the initial step in using the platform to recognize faces, which involves preparing existing records within the law enforcement department for compatibility with our system. This process includes training the platform's algorithms to recognize and assign IDs to facial features extracted from the existing face photos. The algorithms connect to the records, breaking each photo into smaller features and assigning unique IDs to them. The module, primarily designed to run on the law enforcement server for security purposes, is executed when the user uploads either a hand-drawn sketch or a face sketch

created on our platform. This upload occurs on the server to ensure that the data remains secure and tamper-proof. Once the sketch is uploaded, the algorithm traces the image to identify its features and maps them for comparison with the features of the face photos in the records.

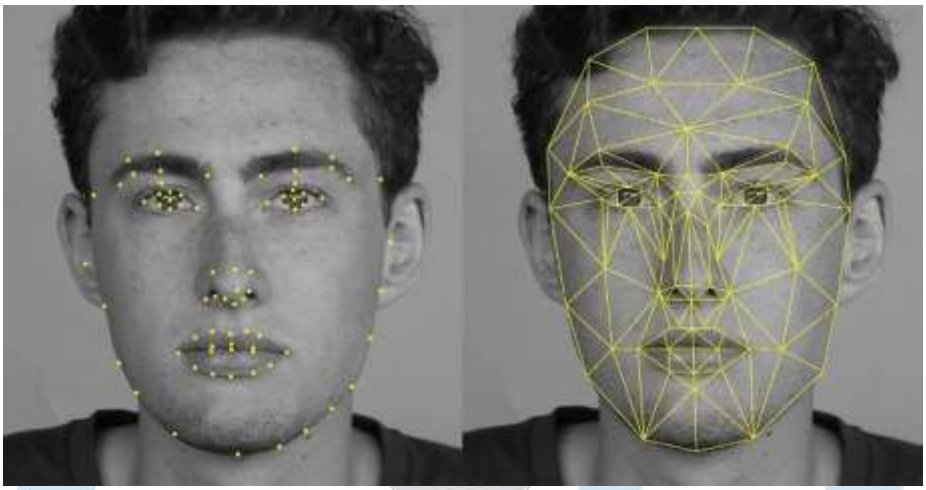

Fig. 5. Face Sketch been mapped on the Platform

After mapping the sketch and matching it with the records, the platform displays the identified face along with the similarity percentage and additional details about the individual from the records. This information, including the matched person's profile, is illustrated in the figure below.

Fig. 6. Face Sketch matched to Database Record

5. Future Scope

The paper "Forensic Face Sketch Construction and Recognition" is currently designed to operate within a limited scope, focusing primarily on matching face sketches with photographs in law enforcement records. However, there is significant potential for future enhancements that could expand its capabilities across various technologies and scenarios. For instance, the platform could be adapted to match face sketches with human faces in video feeds using 3D mapping and imaging techniques, enabling real-time face recognition from live CCTV footage. Additionally, integrating the platform with social media could leverage

the vast data available on these platforms, improving the accuracy and speed of face sketch matching. Overall, the platform has the potential to incorporate unique features that facilitate easy upgrades, thereby enhancing its security and accuracy and distinguishing it from other studies and proposed systems in the field.

6. Result and Conclusion

The paper "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 data retrieval interface. Throughout the process, security, privacy, and accuracy have been prioritized at every stage.

From a security perspective, the platform demonstrated robust measures by blocking access if the MAC address and IP address did not match the credentials associated with the user in the database. Additionally, the one-time password (OTP) system effectively restricted the use of previously generated OTPs, generating a new OTP each time the OTP page is reloaded or the user attempts to log in again.

In terms of performance, the platform exhibited impressive accuracy and speed during the face sketch construction and recognition processes, achieving an average accuracy of over 90% with a confidence level of 100% across various test cases, scenarios, and datasets. This performance is commendable compared to related studies in the field.

Moreover, the platform incorporates unique features that differentiate it from other studies and proposed systems, further enhancing its overall security and accuracy. This distinctiveness positions it as a standout solution in the realm of forensic face sketch construction and recognition.

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