JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Forensic face sketch construction and recognition

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Abstract: In Facial composite sketches are crucial in forensic investigations for identifying suspects, but traditional methods are slow and often yield limited results. Here, we present an application designed to revolutionize the process of creating and matching composite face sketches against legal authority databases. Our system utilizes cutting-edge deep learning techniques and cloud infrastructure, enabling users to generate sketches with a simple drag-and-drop interface, eliminating the need for skilled forensic artists. These sketches are then automatically compared with extensive databases, significantly enhancing the accuracy of criminal identification. We provide overview of the system's design, implementation, and evaluation, showcasing its efficacy in real-world forensic scenarios.

Index Terms - Forensic Face Sketch, Face Sketch Construction, Face Recognition, Criminal Identification, Deep Learning, 1 Machine Locking, Two Step Verification.

I. INTRODUCTION

In today's advanced world, conventional methods of creating face sketches for criminal identification on the basis of witness descriptions are often inefficient and time-consuming when for identifying and matching suspects from police databases. Despite previous attempts to automate this process, existing techniques have not yielded the desired level of accuracy.

To tend these shortcomings, we propose development of an innovative application tailored to the needs of legal agencies. Unlike previous solutions, our application tries to provide an approach to creating composite face sketches. In addition to offering a selection of predefined facial features, users will be provided the capability to upload manually drawn sketches directly onto the platform. This unique and unparalleled feature allows for greater customization and makes sure that the resulting sketches closely resemble hand-drawn renditions, facilitating ease of adoption by law enforcement personnel.

Furthermore, our application will support the uploading of previously created hand-drawn sketches, enabling law enforcement teams to utilize this platform for efficient suspect identification and recognition. Leveraging machine learning models and cloud services, the application will analyze both uploaded sketches and existing databases to suggest relevant facial features, thereby streamlining the sketch creation process and enhancing overall efficiency.

By combining the power of deep learning model with intuitive user interfaces, our application aims to revolutionize the field of face sketching in forensic, providing law with a valuable tool for swiftly and accurately identifying suspects in criminal investigations.

II. RELATED WORK

Many studies have explored Facial Reconstruction and Identification in Forensic Science using diverse methodologies. Dr. Charlie Frowd, alongside Yasmeen Bashir developed an application aimed at identifying and constructing facial components. Initially, the system was time-consuming and perplexing, akin to traditional methods. However, a shift to a novel approach ensued, wherein victims were presented with a selection of faces similar the culprit and tasked with choosing the most similar one. Subsequently, the system will amalgamate all chosen faces and automatically predict the culprit's facial composite. The results yielded promise, with 20 out of 24 composite faces correctly identified. Specifically, when aided by department personnel, the success rate was 21.3%, whereas it decreased to 17.1% when witnesses attempted to construct faces independently.

Xiaoou introduced a recognition approach for synthesizing photo-sketches using a Multi-scale Markov Model. The project involved synthesizing given sketches into photos or vice versa, followed by database search for relevant matches. This model segmented the face-sketch into patches and initially synthesized available photos into sketches. Subsequently, the model is trained to minimize the disparity between original photos and hand-drawn sketches, thus improving overall recognition efficiency.

Testing involved synthesizing photos into sketches and comparing them with manually drawn sketches of the same faces. The model is trained using 60% of the info and tested on the remaining 40%. While the results were impressive, they fell slightly short of expectations.

An alternative approach is proposed by Anil K for sketch-to-photo matching, employing SIFT Descriptors. This method calculated results based on the measured SIFT Descriptor distance between face photos in the DB and sketches. Initially, the algorithm converted face photos uses a linear-transformation inspired by Tang and Wang's model. Subsequently, the sketch was utilized to determine the SIFT description distance compared to face-photo, with additional measurement of distances between pictures in the DBs for improved accuracy. Experimental results indicated that the dataset used is familiar to those utilized by Tang in their experiment. Notably, the algorithm's enhancement involved measuring the descriptor, resulting in improved accuracy compared to the model proposed by Wang..

P. C. Yuen and C. H. Man presented a technique aimed at identifying human faces through sketches. Their method involved a multi-step process wherein sketches were transformed into mug shots, which are frontal-view photographs often used for identification. These mug shots were then subjected to comparison with faces stored in databases, utilizing various variables specified by face matching algorithms.

The prevailing challenge across all standard algorithms was the comparison of face-sketches with frontal-facing human photographs, facilitating easier mapping between drawn sketches and front-facing human images. However, difficulties arose when photographs or sketches depicted faces in different orientations, reducing the likelihood of successful mapping and matching with front-facing faces from the database.

Systems are introduced for composite face construction. However, most of these systems utilize facial features extracted from photos and selected by an operator on the basis of witness descriptions. These features are then compiled to create a human face. This process complicates both human and algorithmic recognition, as every facial feature is sourced from separate face photographs with varying dissimilarities. Consequently, the combination of these features makes it challenging to recognize the resulting composite face, particularly when matching it with a suspect's face.

Hence, the preceding methods were either inefficient, time-consuming, or overly complex. Our application, as described earlier, not only addresses the shortcomings of these approaches but also bridges the level between traditional hand-drawn face sketching and modern composite face sketching techniques. It achieves this by enabling users to feed hand drawn sketches and facial features, thereby providing a more seamless and adaptable solution.

III. OVERVIEW AND FEATURES

A. Security and Privacy

With security and privacy being paramount concerns for law agencies, the application is meticulously designed to safeguard user privacy and implement robust security measures.

a) Machine Locking: The application employs a Machine Locking technique to ensure its integrity and prevent unauthorized use on other systems once installed. This technique makes use of two locking parameters: a software-based parameter and a hardware-based parameter. The software-based parameter, known as HD ID, involves the volume serial of the hardisk with the operating system installed. The hardware-based parameter, known as NET ID or Hardware ID, utilizes the Media Access Control (MAC) address of the system.

b) Two Step Verification: Each authorized law enforcement user will be provided with an mail address for signing into the application. Users will need to enter a randomly generated code sent to their mobile device or desktop to authenticate their identity.

C) Centralized Usage: Once installed, the system hosting the application will be connected to a server within the legal department's campus. This server contains the DB and other essential features of the application. Consequently, the application will only be operable while connected to this server and will become inaccessible when disconnected.

B. Backward Compatibility

The main obstacle when moving to a new system is usually the difficulty of shifting from the old method to the new, which can waste time and resources. To tackle this issue, our application enables a safe transition by letting users upload hand-drawn sketches. These sketches are then analyzed using deep learning models and cloud technology to detect and identify criminals, simplifying the adoption process.

C. Face Sketch Construction using Drag and Drop

This application enables the construction of precise composite face sketches through the utilization of predefined facial feature sets provided as tools.

Fig. 1. Face shape

Fig. 2. Eyes sketch

Fig. 3. Ears

These facial features are available within the application to facilitate the creation of composite face sketches of suspects, aligning with the descriptions provided by eyewitnesses to legal and forensic departments.

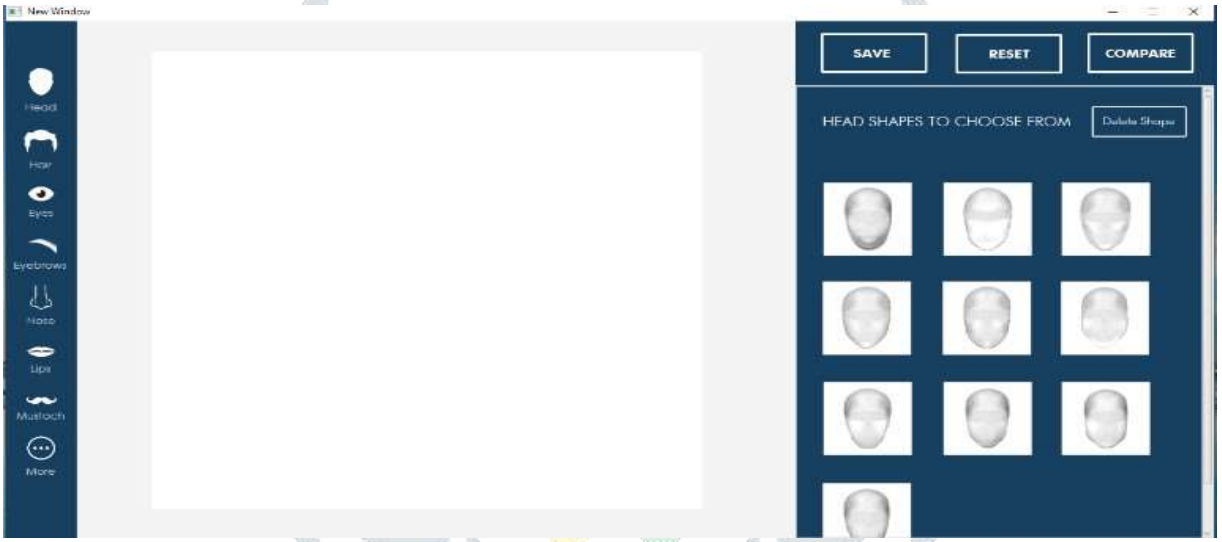

Fig. 4. Blank canvas

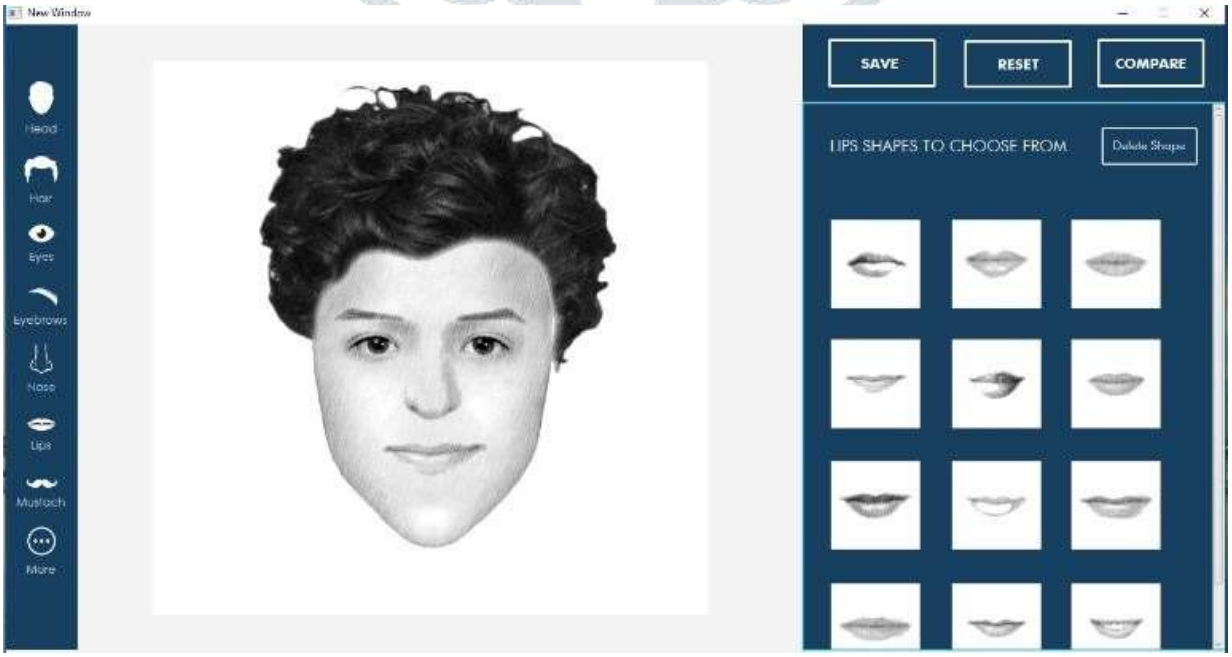

Fig. 5. Facial features been dragged to the canvas

D. System Flow

The Fig. 6 depicts the system's flow, beginning with the login section, which incorporates a two-step verification process. Subsequently, the application offers the option to utilize either a hand drawn sketch or create a composite face sketch using the drag-and-drop feature. Following this, both images undergo a feature extraction process, enabling the application to apply image processing algorithms. Finally, the sketch is matched with the database, and the system displays the familiarity ratio 3 between the sketch and the database photograph.

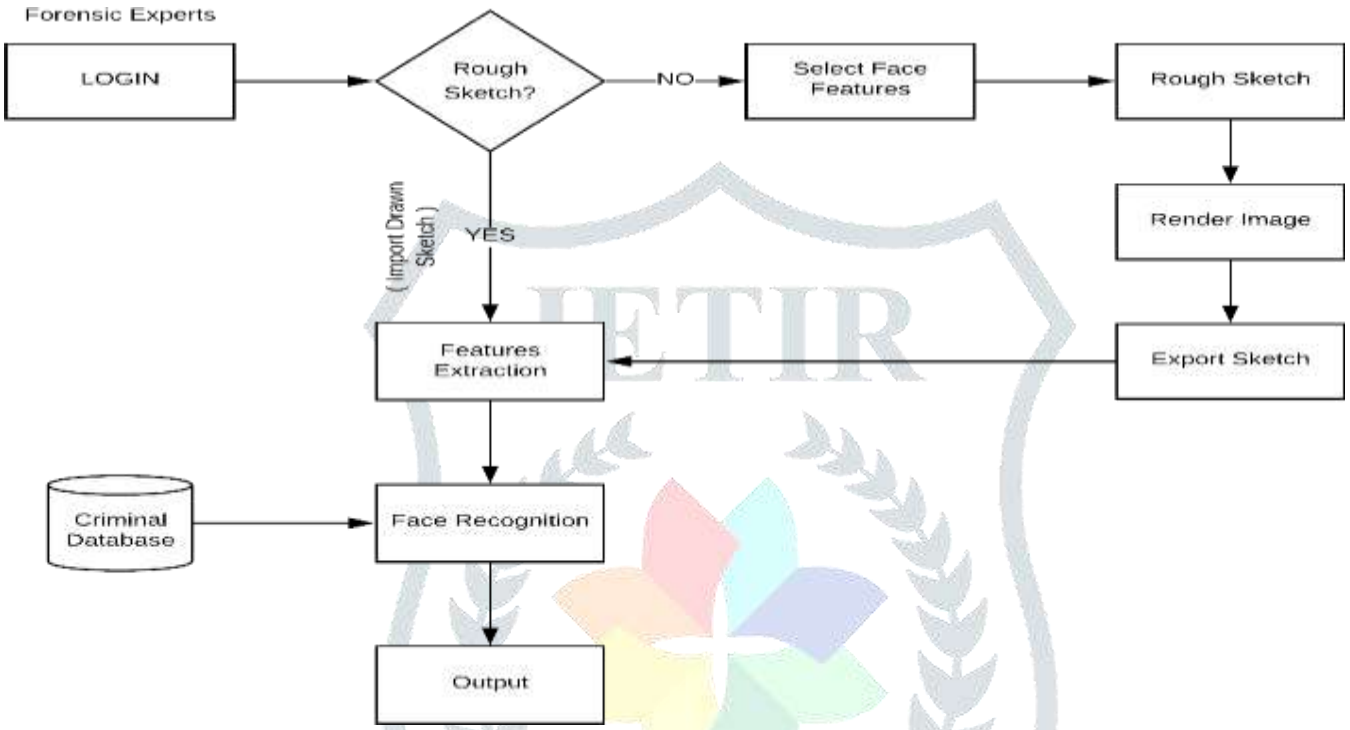

Fig. 6. Generic flow of the application

IMPLEMENTATION

In this application, Operations is performed in two stages.

A. Face Sketch Construction:

The flowchart outlines how individuals navigate the platform to produce precise face sketches on the basis of provided statements. The dashboard is deliberately designed for ease of use, ensuring even those without professional training can navigate it effortlessly. This method is saving time, but also decreases the department's resource requirements.

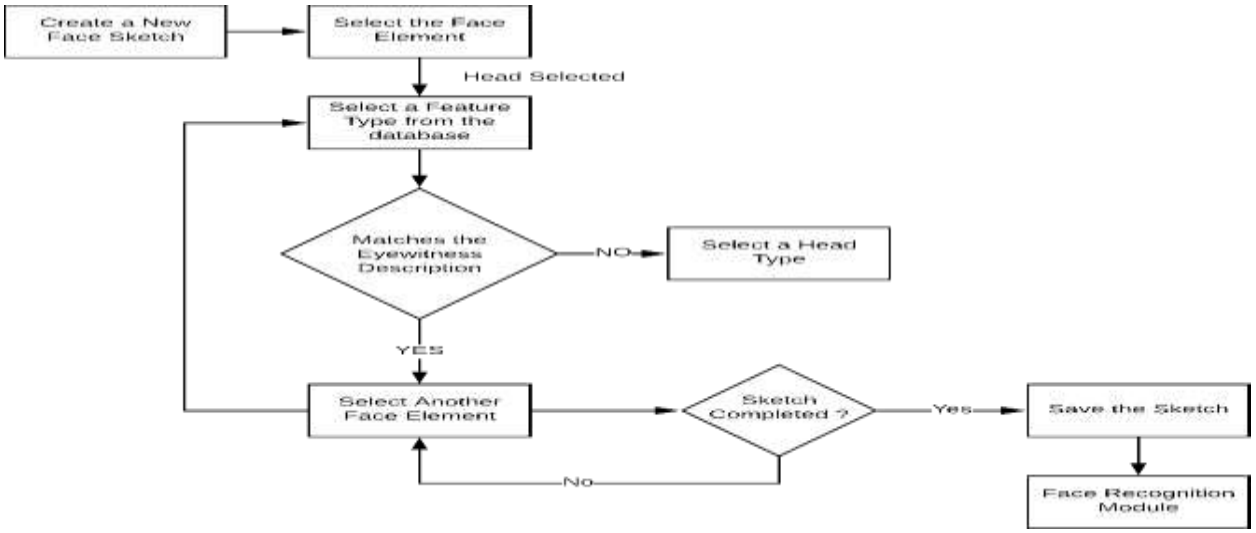

Fig. 7. Creating a sketch in this application

The dashboard comprises five main modules. The primary module, positioned in the center of the dashboard, is the Canvas. This Canvas serves as the workspace for housing the components and elements necessary for constructing the face sketch. Creating a face sketch can feel overwhelming when all the facial features are shown at once and in a random order. This complexity goes against the purpose of our system. To overcome this challenge, we've devised a plan to categorize facial elements like the head, nose, hair, and eyes. These categories are displayed on the left side of the canvas on the dashboard, making it easy for users to find and select different facial structures. Each category contains multiple elements, providing users with various options. In the future, our platform will use machine learning to predict similar facial elements or suggest elements for selection, once we have enough data to train the model and improve the platform further. When a user clicks on a specific face category, a new module on the right side of the canvas opens, allowing them to choose an element from the available options to build a face sketch based on the eyewitness's description. The selected elements are shown on the canvas and can be 2 1 moved and adjusted according to the eyewitness's description to create a more precise sketch. Each element has a predefined position and order on the canvas; for example, eye elements will always appear over the head element regardless of the selection sequence. The final module provides options to enhance the usability of the dashboard. For example, if a user picks the wrong element, they can correct it using the erase option found when selecting the face category from the left panel. Essential buttons, like the option to clear the canvas completely or save the created face sketch as a PNG file for future 3 reference, are located in the panel on the right. The saving location may vary, depending on the Law Enforcement Department's 1 preference, either on the host PC or on the server.

B. Face Sketch Recognition:

The flowchart demonstrates the user's journey within the platform to generate and recognize an precise face sketch based on the provided description. The dashboard is intentionally designed to be user-friendly, removing the need for professional training prior to use. This approach saves time and also conserves departmental resources that would otherwise be expended on training.

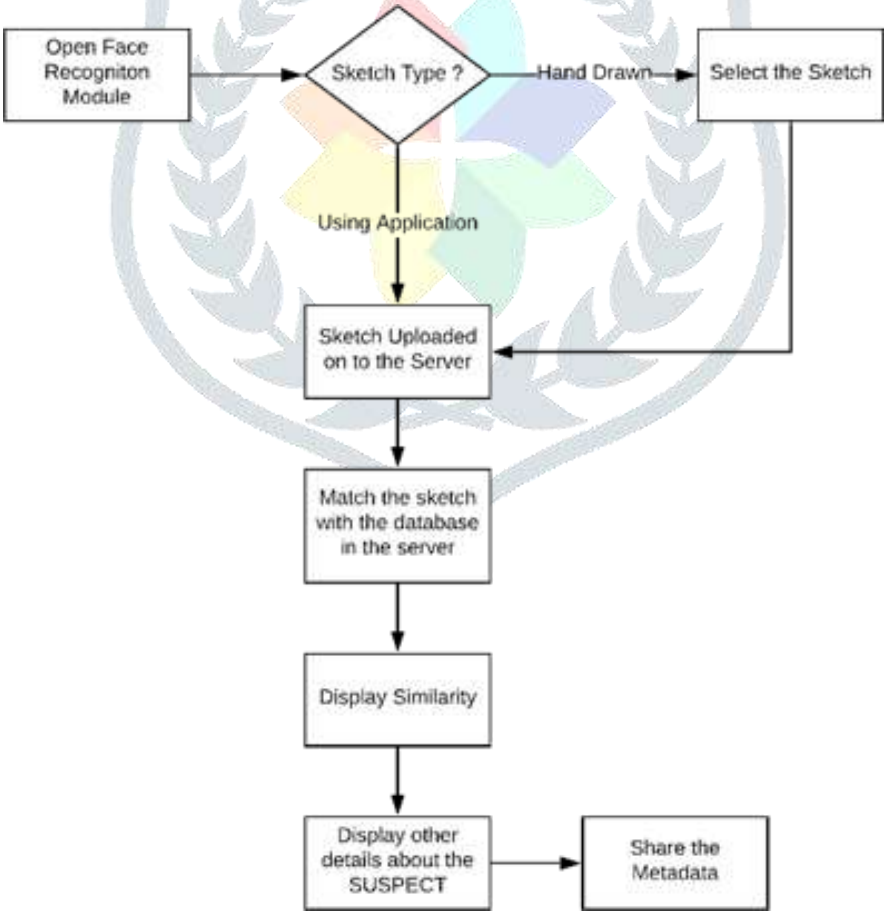

Fig. 8. Chart for Recognizing a sketch in this application

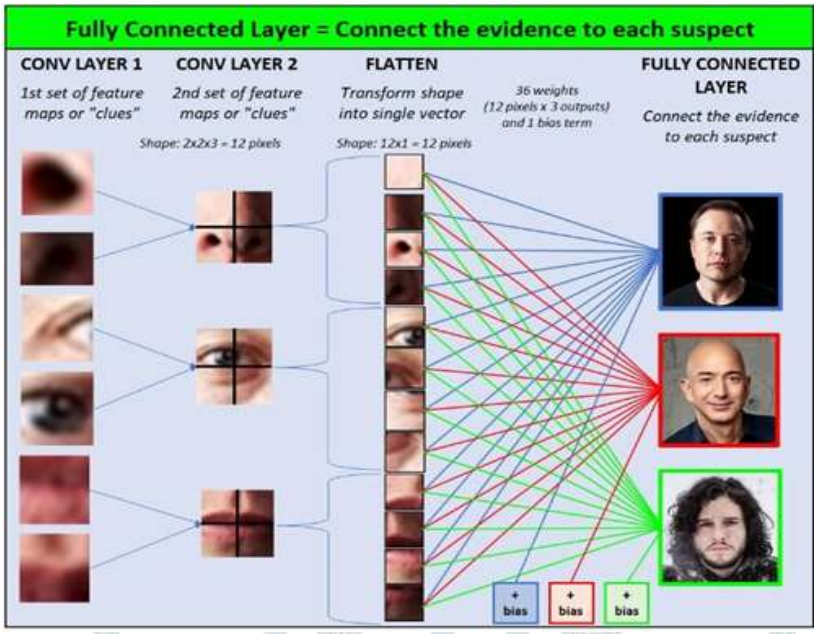

Fig. 9. Feature extraction

The depicted process initially involves preparing existing records within the legal authority to be compatible with our platform. This entails training this platform's algorithm to assign and recognize IDs to faces. The code establishes connection to the records, breaking down each face into finer features and assigning IDs to these many features of a photo.

Next, the module primarily designed to operate on the legal department's server for safety and security purposes is executed. Here, the user opens one of the sketches drawn using hands or the face sketches constructed on this platform, which is saved on the host's machine. Subsequently, the opened sketch is feeded to the legal department server, which houses the recognition module. This ensures the integrity and security of the process and data in the records, preventing meddling.

Once the facial sketch feeded to the aws server, the algorithm traces the sketch image to learn its features and maps them, as depicted in the figure below, to find match with them with the features of the pictures.

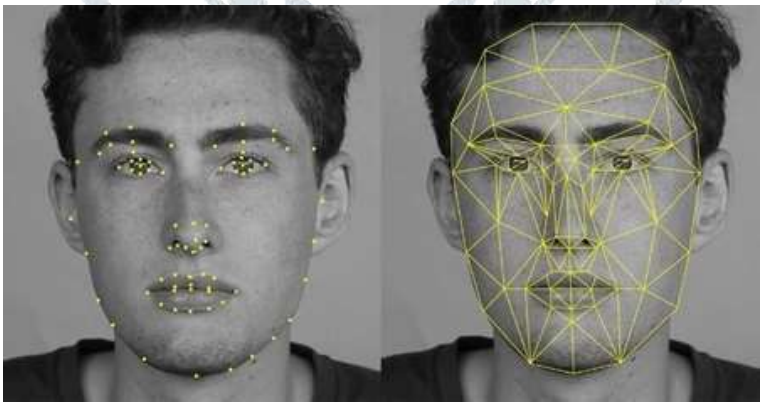

Fig. 10. Face Sketch mapped on this Platform

Upon mapping sketch and identifying a match in the records, the platform presents the matched face, similarity percentage and additional details of the individual from the records. This information is displayed in the figure below, showcasing the matched individual and their associated details.

Fig. 11. Face Sketch matched to the Database Record

RESULTS & CONCLUSION

This project is meticulously crafted, developed, and thoroughly tested, with a strong emphasis on real-world situations and prioritizing security, confidentiality, and precision at every stage—from the initial screen to the concluding data retrieval screen. The platform has demonstrated robust security measures, such as verifying Media Access Control Address upon loading to ensure alignment with user credentials in the database. Incorporating a dynamic OTP system has demonstrated its efficacy in preventing unauthorized access by generating unique codes for each login attempt, bolstering platform security. Regarding accuracy and speed, the platform has shown impressive performance in both Facial Reconstruction and Identification. It achieved an average accuracy rate exceeding 89% with a confidence level of 99.9% across various test cases, scenarios, and datasets, which is highly commendable in the field according to relevant studies. Additionally, the platform offers unique features not present in comparable studies, enhancing overall security and accuracy. These distinctive features differentiate the platform from others in the field, reinforcing its status as a standout solution in facial reconstruction and identification in the field of forensic science.

CONTRIBUTION TO SOCIETY AND DEVELOPMENT

The project's contributions to society and development are significant, as it enhances the capabilities of law enforcement agencies in combating crime and ensuring public safety. By streamlining the process of facial reconstruction and identification in the field of forensic science, the project facilitates more efficient and accurate identification of suspects, leading to faster resolution of criminal cases and increased apprehension of perpetrators. This, in turn, contributes to a safer and more secure society by deterring criminal activity and promoting justice. Furthermore, the project's emphasis on security and privacy ensures that sensitive data remains protected, maintaining public trust in law enforcement practices and upholding individuals' rights to privacy. By implementing robust security measures, the project fosters transparency and accountability in the use of technology for crime-fighting purposes, ultimately contributing to the development of ethical and responsible practices in law enforcement. Overall, the project's contributions extend beyond the realm of law enforcement, influencing societal development by promoting safety, justice, innovation, and ethical governance. Through its efforts to leverage technology for the betterment of society, the project exemplifies the potential for interdisciplinary collaboration and technological advancement to address complex social challenges and foster positive societal change.

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