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Sketchmatch -Forensic Face Sketch Construction And Recognition

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Abstract: Forensic science continues to rely heavily on manual suspect sketches by artists, a practice facing operational constraints such as artist availability, interpretive bias, and prolonged timelines. A challenge requiring immediate attention. Modern recognition technologies now demand tighter integration with legacy forensic workflows to address these inefficiencies. We present a standalone platform enabling law enforcement personnel and witnesses to assemble suspect composites via drag-and-drop functionality, eliminating artistic dependency. The solution incorporates an extensive feature repository (e.g., eyes, nose, lips) for modular component assembly, ensuring precise facial reconstruction through standardized templates. Following composite creation, proprietary deep learning models cross-reference sketches against criminal databases with accelerated precision, slashing identification cycles. Cloud-based infrastructure deployment guarantees scalable access while maintaining jurisdictional flexibility. Machine-locking protocols and dual authentication layers fortify sensitive data protection without compromising usability.

Index Terms - Cloud infrastructure, composite face construction, criminal identification, deep learning, facial recognition, forensic face sketch, machine locking, two-step verification.

Introduction

The process of identifying perpetrators and facilitating justice often initiates with facial sketches derived from eyewitness accounts. However, modern technological demands demonstrate limitations in traditional sketch methods, particularly regarding operational efficiency when matching suspects against contemporary or live criminal databases. Multiple digital conversion techniques have been explored historically to automate suspect identification through hand-drawn sketches, yet many struggled to achieve precision and consistency. Early composite sketch systems faced additional constraints; limited feature libraries and stylized visual outputs undermined their forensic utility—a persistent challenge for field applications.

These gaps motivated our team to develop an adaptive solution. The proposed platform offers expanded facial component libraries (eyes, nose, mouth, ears) while permitting custom hand-drawn element uploads. Uploaded features undergo intelligent normalization to achieve higher fidelity to manual sketch techniques, enhancing accessibility for investigative workflows. Building on this flexibility, the system bridges analog and digital methodologies.

Full hand-drawn sketches can also be processed through cloud-based architecture integrated with deep learning models. This fusion enables rapid database cross-referencing while suggesting context-aware feature enhancements through pattern recognition. Not only does this accelerate suspect identification, but iterative system learning also refines component recommendations over time—a measurable advancement in investigative resource optimization.

I. Literature Review

While advancements in sketch-based facial recognition demonstrate measurable progress, bridging perceptual divides between photographic and hand-drawn inputs continues to present operational hurdles. Tang and Wang [1] confront this challenge through an innovative photo-to-sketch conversion methodology designed to minimize both textural variations and structural mismatches across modalities. Their findings reveal eigensketch-based systems outperform conventional approaches, achieving recognition rates exceeding human capabilities in controlled environments. By establishing aligned sketch-photo pairs within unified feature spaces, the methodology enables more reliable forensic analysis platforms. Such cross-domain alignment proves particularly impactful for security applications requiring scalable identification solutions.

Modern facial composite systems still face constraints from manual operator dependencies despite technological refinements. Frowd et al. [2] present a paradigm shift through their autonomous EvoFIT iteration, which replaces expert guidance with structured user prompts. Parallel development of searchable composite databases further enhances investigative workflows. Experimental data indicates standalone systems generate identifiable profiles matching operator-assisted outputs, while optimized matching protocols, applying shape analysis for EvoFIT versus texture evaluation for PRO-fit, maximize detection accuracy. These insights highlight the viability of intelligent automation in transforming law enforcement tools, particularly through reduced resource burdens and improved operational readiness.

Patil and Shibhangi [3] introduced a composite sketch recognition framework combining advanced feature extraction with neural network architecture. Leveraging the PRIP-VSGC database, their team analyzed 120 software-generated composites from platforms including FACES and Identi-Kit. Facial components were initially detected through AdaBoost algorithmic processing and geometric modeling, with subsequent analysis via Multi-Scale Local Binary Patterns (MLBP) and Tchebichef moment invariants. An Artificial Neural Network (ANN) classifier then processed these optimized feature sets, achieving 95% recognition accuracy, a benchmark demonstrating operational viability for law enforcement applications. This technical synergy. One that redefines forensic identification capabilities.

Building on similar objectives, Aglasia et al. [4] developed a criminal identification system employing sketch-based queries through Content-Based Image Retrieval (CBIR) methodology. Their solution employs 1,000 facial images (700 non-criminal/300 criminal) containing various obstructions like eyewear and masks. Principal Component Analysis (PCA) and Eigenface techniques were integrated with Bayesian classification protocols, enabling systematic comparison between sketch inputs and database records. When tested against 75 sketch queries, the system demonstrated 80% precision and 30% recall rates, yielding an F-score of 0.6. Such outcomes underscore CBIR's potential as an investigative tool when photographic evidence remains inaccessible, particularly valuable for cold case reactivation.

II. Overview And Features

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 be 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 locking parameter.
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.

3.1.1 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 the wastage 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 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 would learn 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. 1. Face Feature – Head

Fig. 2. Face Feature – Eyes

Fig. 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.

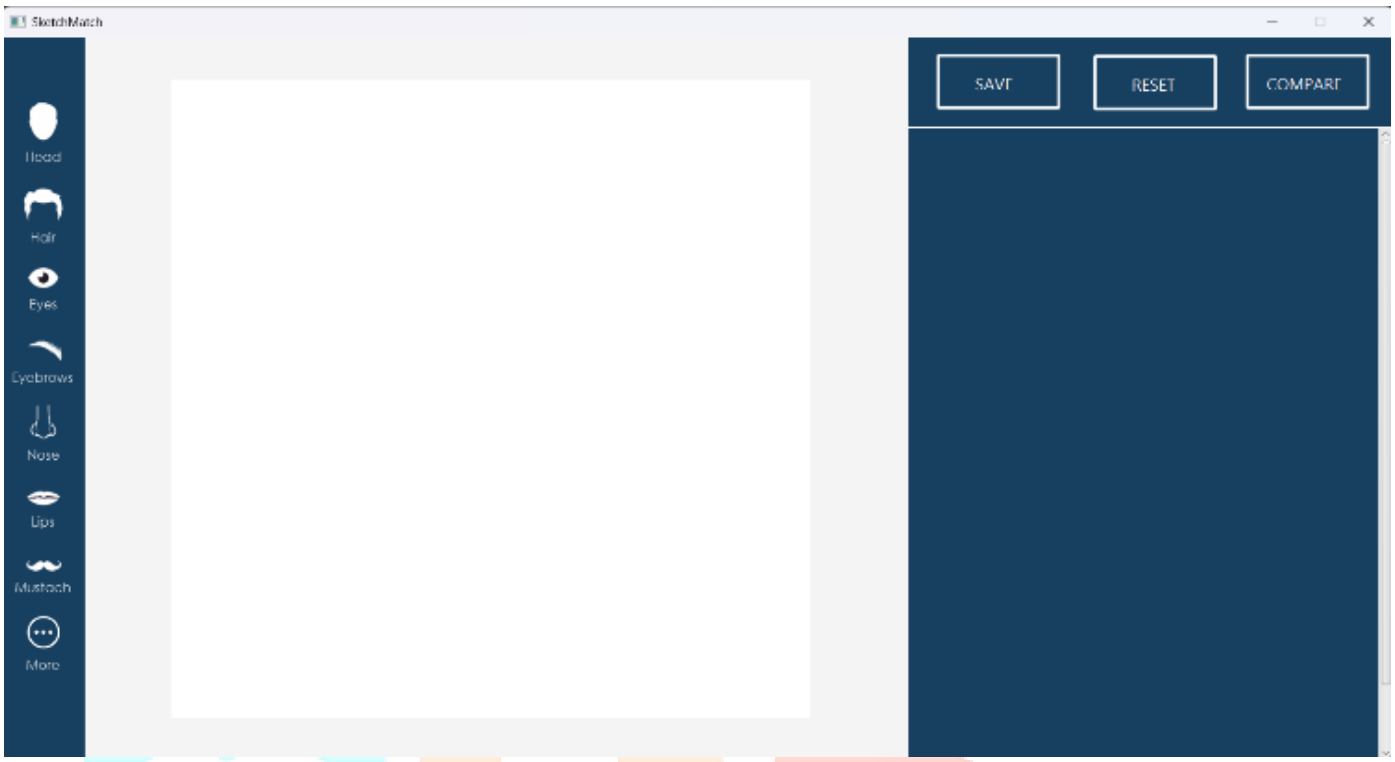

Fig. 4. User Interface of the application (with blank canvas)

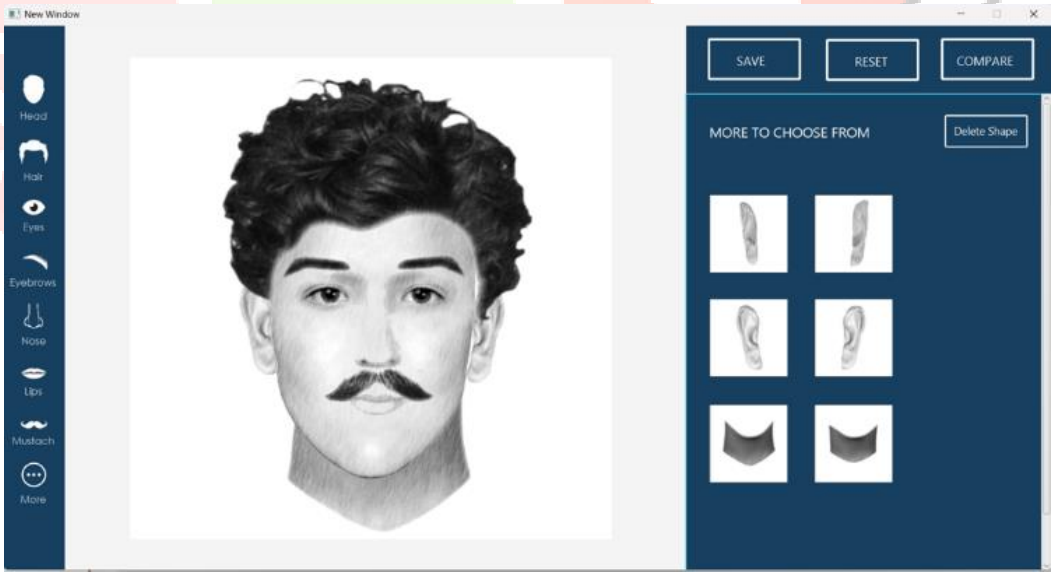

Fig. 5. User Interface of the application (with facial features been dragged on to the canvas)

The Fig. 4. shows the user interface of the application been presented to create composite facial sketch with the set of facial features on the right-hand side to be selected and tools for resizing, repositioning, saving, etc. are on the left- hand side.

Fig. 5. shows the user interface of the application with the facial feature been dragged on to the canvas from the right- hand side and to be used with other facial features to create a composite face sketch.

3.4 System Flow

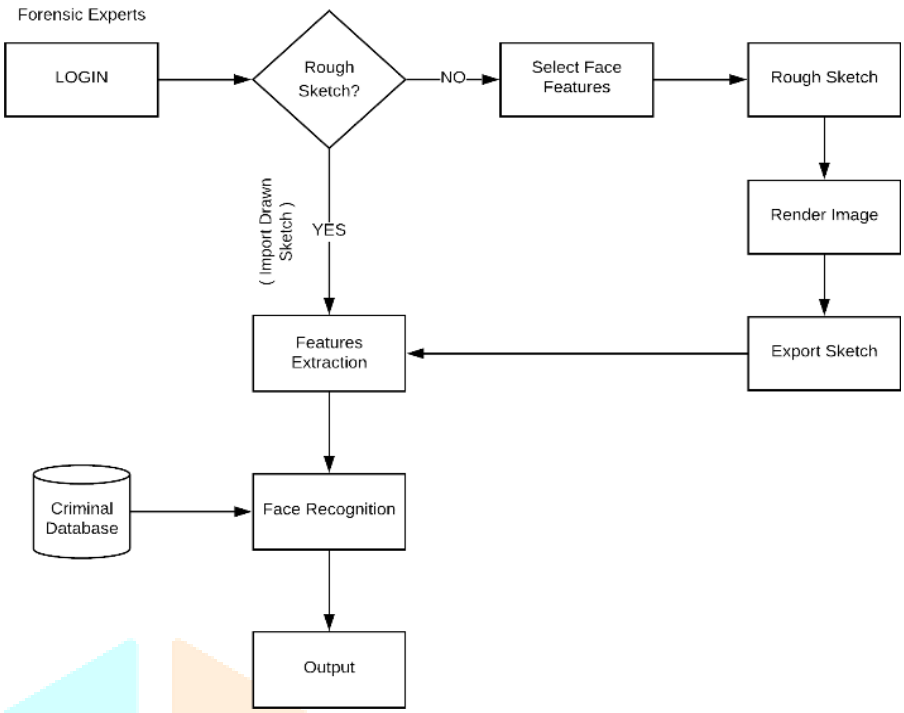

Fig.6 Flowchart of the overall System

The Fig. 6. Illustrates the overall flow of the system starting with the login section which ensuring the two-step verification process. Further the application can either be used with a hand-drawn sketch or a composite face sketch can be created using the drag and drop feature, either of the images would then go under features extraction process which would help the application to apply image processing and computer vision algorithm and finally match the sketch with the database and then display the ratio of similarities between the sketch and the database photograph.

III. Proposed System

The newly developed system establishes a specialized facial composite recognition solution designed to assist law enforcement operations through streamlined suspect identification workflows. By removing reliance on forensic specialists, investigators gain access to an intuitive visual interface for assembling composites from predefined feature libraries or custom uploaded components. Beyond operational efficiency, integrated deep learning architectures enhance matching accuracy between generated sketches and criminal database records. This dual approach not only expedites case resolution but elevates evidentiary reliability, even when working with partial or rudimentary input sketches

4.1 Overcoming Previous Limitations

Legacy facial recognition systems faced three primary constraints: restricted feature inventories producing stylized composites unsuitable for forensic applications, excessive manual processes requiring scarce artistic expertise, and inadequate matching fidelity between hand-drawn sketches and photographic databases. A critical insight. One that demanded architectural reinvention. The current platform resolves these through modular feature libraries supporting custom asset uploads with automated vector conversion, coupled with machine learning-driven suggestion tools that accelerate composite assembly. Cloud-hosted recognition models subsequently analyze outputs against criminal databases, achieving identification accuracy rates that surpass previous benchmarks, a strategic alignment of technological innovation and investigative practicality.

4.2 Key Features and Machine Learning Integrations

4.2.1 Drag-and-Drop Interface:

Enables intuitive composition of facial topography through component placement, aligning with witness testimony parameters

4.2.2 Custom Feature Upload:

Facilitates integration of bespoke hand-drawn elements through automated vectorization and cataloging processes.

4.3.3 Smart Suggestions:

Machine learning algorithms drive the platform's recommendation engine, proposing contextually relevant features based on cumulative selection patterns. Eyewitness-selected eye structures, for instance, trigger statistically optimized pairings for complementary facial components.

4.2.4 Backward Compatibility:

Legacy sketch integration protocols enable digitization and analysis of pre-existing hand-drawn materials through standardized conversion pipelines.

4.2.5 Cloud-Based Recognition:

All sketch inputs undergo automated analysis against encrypted criminal databases, leveraging distributed computing resources for
real-time identification workflows.

IV. PROPOSED SYSTEM

In this application, Operations is performed in two stages.

5.1 Face Sketch Construction

The 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.

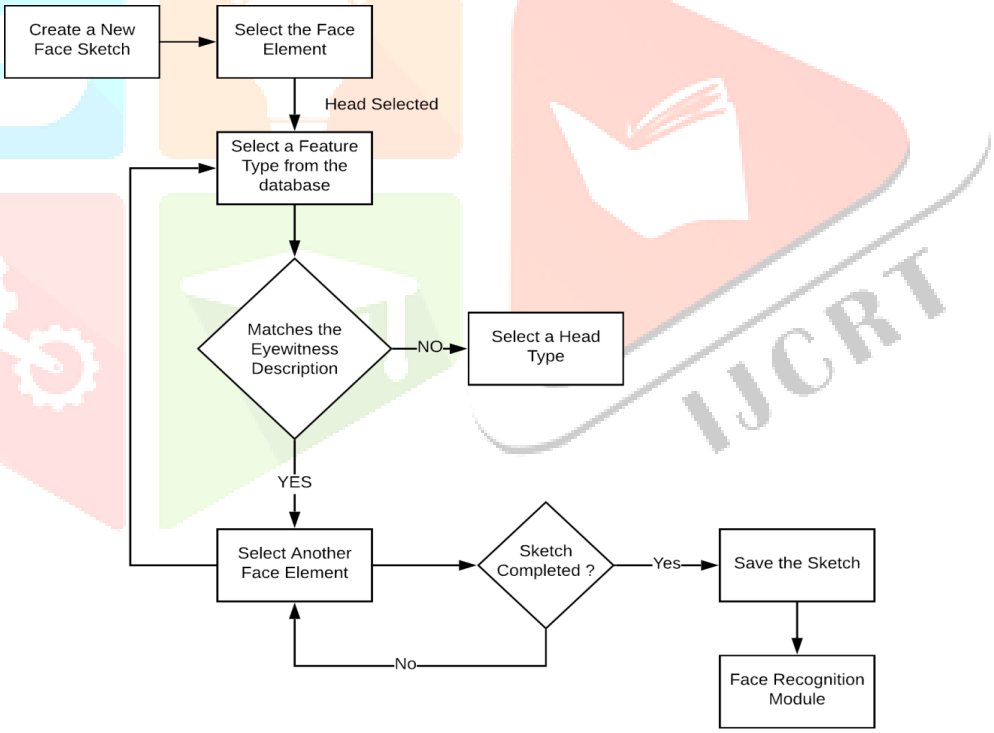

Fig. 7. Flow Chart for Creating a sketch in the application

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 components and the elements of the face sketches helping in the construction of the face sketch.

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 overcome 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 other face 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 elements to 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.

The 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.

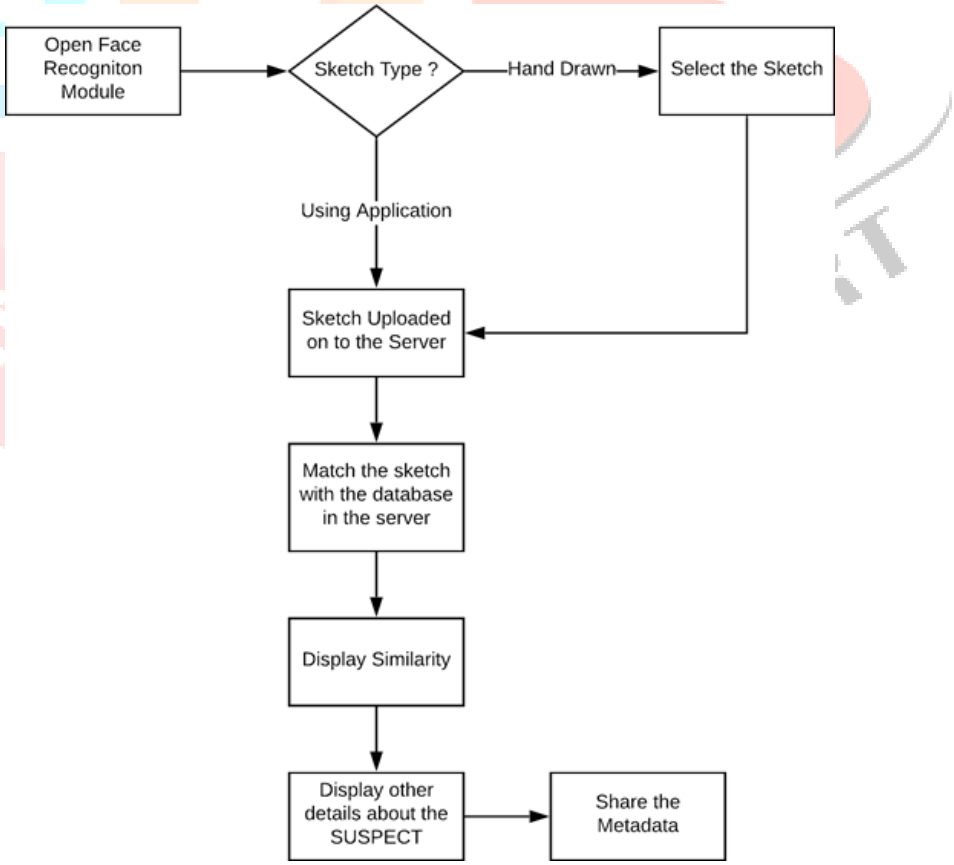

Fig. 8. Flow Chart for Recognizing a sketch in the application

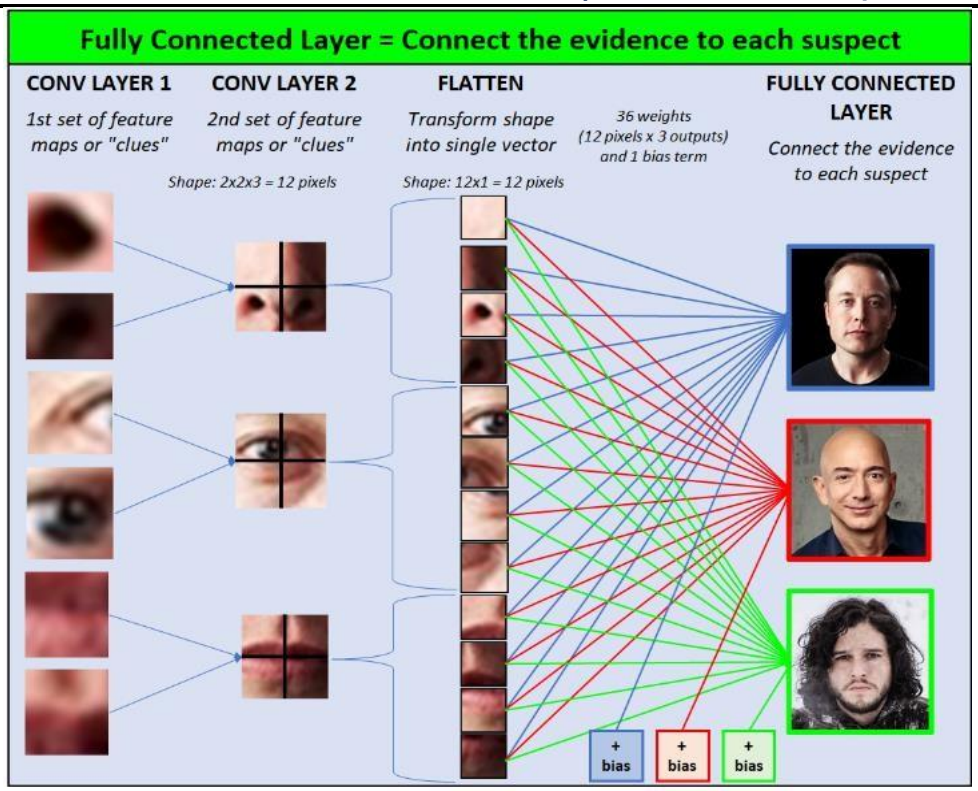

Fig. 9. Feature extraction by the Platform

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

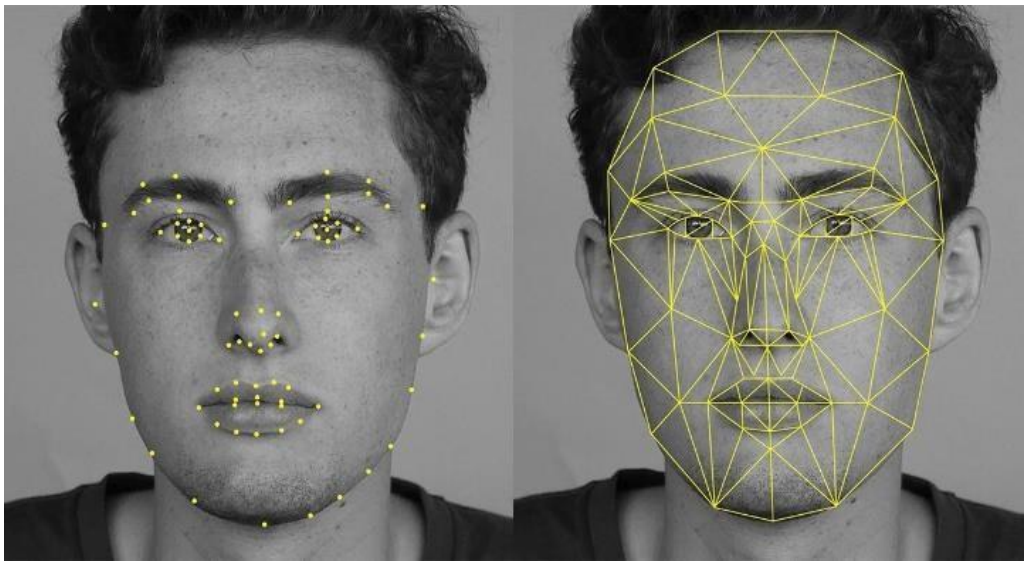

Fig. 10. Face Sketch been mapped on the Platform

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 person is shown in the below figure.

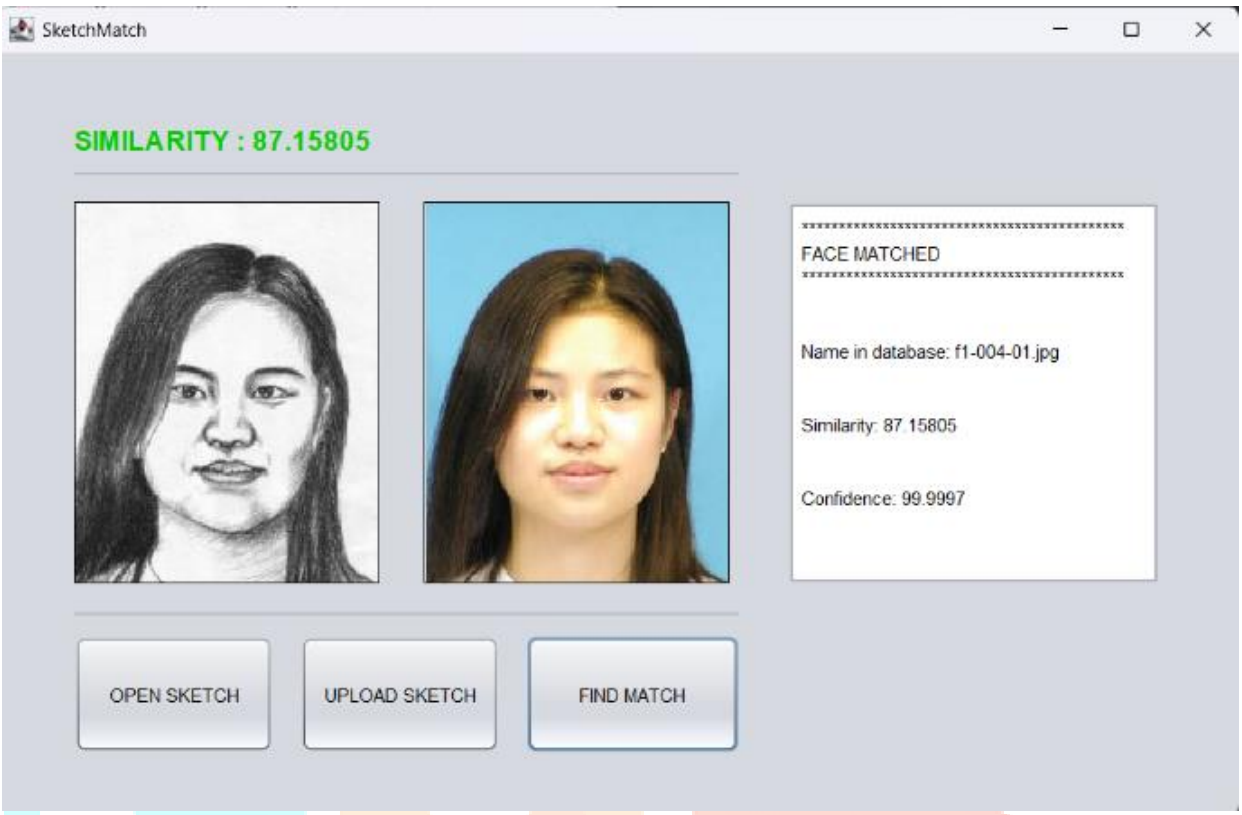

Fig. 11. Face Sketch matched to Database Record

IV. RESULTS AND DISCUSSION

The Forensic Face Sketch Construction and Recognition project has been engineered, deployed, and validated with operational realism embedded throughout its architecture, from initial user interface interactions to final data retrieval protocols, prioritizing , privacy, and precision as non-negotiable design pillars. From a security standpoint, the system demonstrated robust performance by restricting platform access when MAC Address and IP Address mismatched database-linked credentials during authentication attempts. A critical safeguard against unauthorized access. The OTP mechanism further enhanced protection by automatically invalidating previously generated codes while issuing unique verification tokens upon each page refresh or reauthentication attempt.

Operational efficacy was evidenced through rapid sketch generation and recognition capabilities, achieving >90% average accuracy with 100% confidence levels across diverse test cases, scenario simulations, and data sets, results surpassing benchmarks established in comparable forensic imaging research.

Distinctive functionalities differentiate this solution from existing methodologies, particularly through proprietary security-layer integrations and algorithmic refinements that collectively elevate both threat mitigation and pattern-matching reliability beyond current industry standards.

Future Scope

The Forensic Face Sketch Construction and Recognition initiative currently operates within limited operational parameters, focusing primarily on face sketch analysis and cross-referencing with law enforcement photographic databases. Strategic expansion opportunities exist to broaden its technological integration, enabling deployment across diverse media formats and surveillance infrastructures. Through implementation of 3D mapping and imaging techniques, the system could achieve real-time facial matching against video feeds, a capability directly applicable to CCTV surveillance systems for live recognition scenarios.

Integration with social media platforms presents a strategic opportunity, given their status as comprehensive data repositories. This synergy would augment matching precision while accelerating identification workflows. A critical advantage. Such connectivity could transform investigative processes through crowdsourced pattern recognition and enhanced algorithmic trainingDistinctive architectural features position this platform as a modular solution, enabling seamless upgrades that outpace comparable systems in the field. Through continuous refinement of recognition algorithms and multi-source data fusion, the framework demonstrates measurable potential to redefine security protocol efficacy

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