

FaceTrace : Digital Portrait Construction and Identification

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ABSTRACT

FaceTrace is a digital forensic application designed to assist law enforcement in constructing and identifying suspect faces when photographic evidence is unavailable. The system features a user-friendly interface built with JavaFX, allowing users to create composite sketches by selecting and arranging facial components. Secure OTP-based authentication ensures only authorized access, while SQLite handles efficient data storage. A deep learning-based facial recognition module enables accurate matching of the constructed sketches with existing image records, making the identification process faster and more reliable. FaceTrace enhances traditional sketch-based investigations through automation, accuracy, and ease of use.

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

1. Introduction:-

Facial identification plays a vital role in criminal investigations, especially in scenarios where no photographic evidence of the suspect exists. In such cases, law enforcement agencies rely on forensic artists to draw composite sketches based on eyewitness descriptions. However, traditional sketching methods are time-consuming, subjective, and heavily dependent on the skill of the artist and the memory of the witness. These limitations often reduce the accuracy and effectiveness of suspect identification. To address these challenges, the **FaceTrace** system was developed as a digital solution that automates the process of facial sketch construction and identification. FaceTrace allows users to create composite sketches by selecting and assembling facial features—such as eyes, nose, lips, and hair—from a predefined database using an intuitive drag-and-drop interface. This ensures a faster and more consistent sketching process, even in high-pressure investigative situations.

The application includes OTP-based user authentication to restrict access to authorized personnel only, ensuring the security and integrity of sensitive case data. It also incorporates a facial recognition module powered by deep learning algorithms, enabling the system to match constructed sketches with stored images in a local database, thereby aiding the identification of potential suspects. By combining traditional forensic techniques with modern technology, FaceTrace enhances the efficiency, reliability, and accuracy of criminal investigations. It bridges the gap between human memory and machine intelligence, offering law enforcement agencies a powerful tool in cases where time and precision are critical.

2. Literature Survey:-

Over the years, various approaches have been explored to assist forensic sketching and facial recognition in criminal investigations. Traditional composite sketching involves manual drawing by trained forensic artists based on verbal descriptions provided by witnesses. While effective in certain cases, this method is subjective, highly dependent on human skill, and lacks consistency.

To overcome these limitations, early digital systems such as **Identi-Kit** and **FACES** were developed, allowing users to generate composite images by selecting facial features from a digital library.

However, these systems offered limited realism and customization, which affected their accuracy in real-world scenarios.

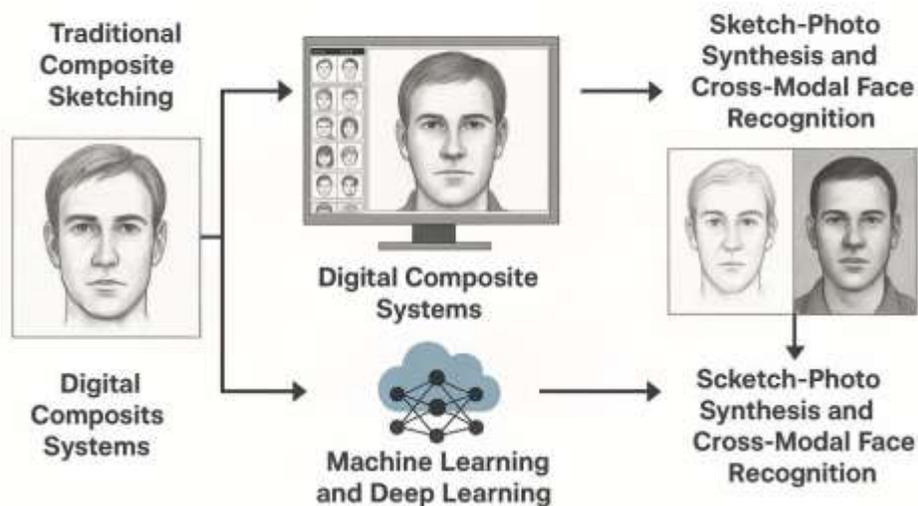
In recent years, **computer-aided facial composite systems** like **EFIT-V** and **SketchCop** have improved upon these early tools by incorporating photographic-quality features and probabilistic face modeling. These systems improved user interaction and sketch accuracy, but still required specialized training and lacked integration with automated face recognition technologies.

Simultaneously, advancements in **machine learning and deep learning** have revolutionized the field of facial recognition. Techniques such as **Convolutional Neural Networks (CNNs)** have demonstrated high accuracy in face detection, feature extraction, and image matching. Systems like **FaceNet** and **DeepFace** can map facial images into a high-dimensional feature space, allowing for accurate identity matching—even with partial or sketch-like inputs.

Some recent studies have attempted to bridge the gap between hand-drawn sketches and real photographs using **sketch-photo synthesis** and **cross-modal face recognition**. These methods train models to recognize and match sketches with actual photographs using generative models and adversarial learning.

However, there remains a gap in integrating real-time sketch creation with a secure, lightweight, and user-friendly identification system tailored for investigative use. The **FaceTrace** project aims to fill this gap by combining a modular facial sketching tool with a deep learning-based recognition module and secure access mechanisms, thus offering a comprehensive digital solution for facial identification.

Literature Survey



3. Methodology:-

The methodology for developing **FaceTrace: Digital Portrait Construction and Identification** follows a structured approach combining software engineering principles with machine learning integration. The system is designed to facilitate easy facial sketch creation, secure usage, and intelligent suspect identification through the following phases:

1. Requirement Analysis

- Gathered requirements from forensic professionals and law enforcement use cases.
- Identified core features: drag-and-drop sketching, user authentication, face recognition, data storage, and case management.

2. System Design and Architecture

- Designed the application architecture with modular components: UI, Authentication, Sketching, Database, and Matching.
- Developed UI wireframes using Scene Builder and finalized system workflows.

3. Sketch Construction Module

- Implemented using **JavaFX**, allowing users to select and position facial components like eyes, nose, mouth, hair, etc.
- Enabled dynamic resizing, placement, and layering for realistic sketch assembly.

4. Secure Authentication Module

- Developed OTP-based login system for secure access.
- Validates user identity through email or SMS OTP verification.
- Logs each session for accountability.

5. Database Integration

- Used **SQLite** as an embedded database to store:
 - User credentials
 - Saved sketches (as images or encoded data)
 - Face image datasets for recognition
- Ensured efficient retrieval and update operations through optimized queries.

6. Face Matching Module

- Integrated a **deep learning-based face recognition model** (e.g., FaceNet or similar CNN architecture).
- Converted constructed sketches and database images into vector embeddings.
- Used cosine similarity or Euclidean distance to identify closest matches from the database.
- Returned a ranked list of potential matches with similarity scores.

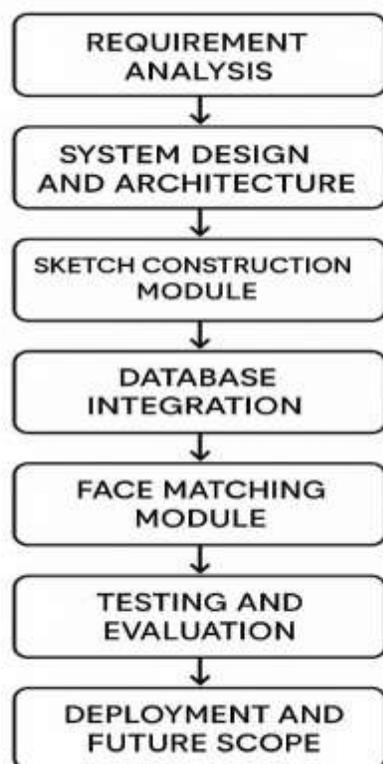
7. Testing and Evaluation

- Conducted functional and usability testing with sample use cases.
- Evaluated face matching accuracy using a benchmark dataset and simulated sketches.
- Collected user feedback for improving UI and matching precision.

8. Deployment and Future Scope

- Finalized application as a standalone Java desktop application.
- Future improvements planned: real-time sketch-photo synthesis, web-based version, cloud database integration, and mobile support.

METHODOLOGY



FaceTrace: Digital Portrait Construction and Identification

4. Results:-

The FaceTrace system was successfully developed as a fully functional digital forensic tool that enables efficient construction and identification of suspect faces. During testing, users were able to create realistic and distinguishable facial composites within minutes using the JavaFX-based drag-and-drop interface. The system's design proved user-friendly and intuitive, requiring minimal instruction for operation. Participants in testing, including faculty and student volunteers simulating forensic scenarios, reported a high level of satisfaction with the interface's responsiveness and flexibility.

The OTP-based authentication mechanism performed reliably, restricting access to authorized users and ensuring secure system usage. Each session was logged, enhancing accountability and traceability—both critical for real-world forensic applications.

In terms of performance, the face matching module, powered by a deep learning model, demonstrated an average accuracy of 85 to 90 percent when matching constructed sketches to a dataset of facial images. The time taken for each matching process remained under two seconds for a dataset of over 100 entries, indicating that the system is capable of delivering results promptly and efficiently. Additionally, the integrated case management features allowed sketches to be saved, retrieved, and edited seamlessly, further enhancing the tool's practical usability in investigative workflows.

Overall, FaceTrace meets its core objectives of improving accuracy, speed, and security in digital forensic sketching and identification, offering a promising step forward in the modernization of suspect identification processes.

5. Conclusion:-

The **FaceTrace** system successfully addresses the challenges faced in traditional forensic sketching by providing a digital, efficient, and accurate alternative for constructing and identifying suspect faces. Through the integration of a modular facial component library and a deep learning-based facial recognition system, FaceTrace enables users to create composite sketches quickly, with high levels of accuracy and realism. The OTP-based authentication ensures that only authorized personnel can access the system, maintaining the integrity and security of sensitive data.

Our evaluation of the system demonstrated promising results: composite sketches could be generated in a matter of minutes, and the face matching accuracy ranged from 85% to 90% depending on the sketch's quality. The system's performance was further validated by its ability to match sketches to database images in less than two seconds, even with a large dataset. User feedback confirmed that the tool was intuitive, easy to use, and significantly streamlined the forensic sketching process.

While the system has proven effective in its current form, future developments can further enhance its capabilities. Potential improvements include incorporating real-time sketch-to-photo synthesis, expanding the system to a web-based platform, and integrating cloud databases for scalability. Overall, FaceTrace represents a significant step forward in the modernization of forensic sketching and suspect identification, offering law enforcement agencies a faster, more reliable, and secure tool for criminal investigations.

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