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Face Trace - Forensic Face Sketch Construction and Recognition Application

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Abstract

As we know hand-made face sketches are widely used in forensics, although they come with some limitations and are a time consuming process in criminal identification. In this project, we implemented some of the already existing approaches in combination to provide overall efficiency in the process of criminal identification. An application which is built to provide easy and computerised construction of forensic face sketches using the drag and drop features along with integration with the cloud infrastructure & deep learning for accurate recognition of the criminals from the law & enforcement database.

Introduction

The greatest crimes and the worst criminals can be identified and the case can be put to justice if we make use of the eyes. Most of the crimes have a witness and every witness can get the investigators to the accurate criminal. This can be done by using the eye-witnesses description of the scene and the criminal.

The traditional system of criminal identification is time consuming and a long process. The eye witness along with the professional sketcher and officers they all make a team focused for hours to achieve the image of the probable culprit. This process takes a lot of time and effort. This has a major drawback as the resulting sketches are cartoonistic or have limited kits, limited resources and thus the accuracy and reliability of this system is questioned.

This application advances and cleans all the drawbacks of the traditional system making the entire process convenient and user friendly. The sketches now can be prepared with ease with the help of facial features dictionary that the witness themselves can present the culprit to the witness in the scene with the help of drag drop processes from the set of facial features like the eyes, nose, lips, even the eyebrows. And the result can be presented in a sketch format for the investigators to adapt easily.

This avant-garde forensic intelligence apparatus leverages an intricate symbiosis of neural cognition and cloud-fortified analytics to decipher and extrapolate defining facial characteristics from rudimentary hand-drafted illustrations. Engaging in a perpetual state of algorithmic evolution, the system assimilates newly ingested and archival visual datasets, orchestrating an unparalleled synthesis of biometric feature matching. This hyper-evolved paradigm exponentially amplifies the velocity and precision of suspect identification, obliterating traditional constraints and revolutionizing forensic methodologies.

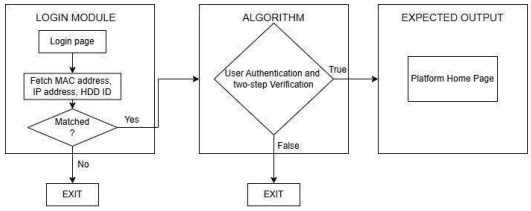


Fig 1. Architecture of login module

Literature Survey

This survey provides a structured comparative analysis, bridging classical methodologies and modern AI-driven techniques in forensic face sketch recognition. It explores the evolution, challenges, and future directions of this field. Recent advancements, such as the 3D morphable model-based framework for forensic face sketch construction and recognition [4], have introduced a modular five-phase approach to enhance training data quality and improve recognition accuracy. Additionally, research on sketch-to-photo matching [5] has demonstrated the effectiveness of local feature-based methodologies, employing SIFT descriptors and score fusion strategies to refine matching performance. In the broader domain of AI-powered image processing, a study on deep learning and reinforcement learning [3] highlights challenges such as high data demands and ethical considerations, proposing solutions like model compression to optimize computational efficiency.

Furthermore, deep learning techniques have significantly improved surveillance applications. A study on object recognition and anomaly detection[4] utilizes convolutional neural networks (CNNs) to enhance real-time monitoring and forensic analysis in smart surveillance systems. Similarly, research on forensic sketch-to-mugshot photo matching [5] leverages Local Feature-Based Discriminant Analysis (LFDA) in combination with SIFT and MLBP descriptors to address dataset limitations, thereby improving forensic sketch classification. Machine learning techniques have also been integrated into forensic facial recognition. A study on geometric modeling for face recognition [6] applies AdaBoost for face detection and employs Weber Local Descriptor (WLD) for robust feature extraction, ensuring more accurate identification.

Automation has also played a critical role in forensic sketch-based investigations. The EvoFIT-based facial composite generation study [7] presents an automated system for facial sketch synthesis, facilitating structured data retrieval and enhancing usability within forensic databases. Additionally, addressing modality gaps in sketch-to-photo recognition, a study on information-theoretic encoding [8] introduces a coupled encoding framework to mitigate sketch quality variations and improve forensic identification accuracy. These advancements collectively demonstrate the growing impact of AI and deep learning in forensic science, significantly enhancing the efficiency and precision of facial recognition technologies.

Methodology

To create a user-friendly application called “Face Trace”, the process begins with detailed surveys on research papers to understand the needs and challenges of the similar already existing application. Insights from their methodologies and drawbacks were analyzed to design an intuitive interface focused on ease of use. Therefore, we conducted testing through prototypes, with continuous refinement based on user input to ensure it meets expectations.

For data collection, we used kaggle, wherein we extracted the data related to criminals. Further, features are added to allow users to upload hand-drawn sketches, which will be standardised using image processing techniques to maintain data consistency throughout the application for smooth operation and accurate recognition. The system can be broadly divided into two parts: face constructor & face recognizer.

A. Face Construction

Our application-FaceTrace's dashboard encompasses five primary modules, with the Canvas serving as the nucleus of the interface. Positioned at the center, the Canvas functioned as the workspace where users meticulously assembled facial sketch components—ranging from distinct facial features to intricate structural elements—to reconstruct the face sketch of a suspected criminal.

The intricacy of synthesizing anatomically precise facial illustrations escalated exponentially when disparate elements were chaotically juxtaposed without structural coherence. To counteract this impediment, FaceTrace instituted a methodical stratification of facial attributes into discrete categorical taxonomies—such as cranial contour, nasal framework, capillary formations, and ocular configurations. These systematically delineated classifications were strategically arrayed within a structured panel on the leftmost sector of the Canvas. Upon engagement with a specific classification, the system autonomously instantiated a meticulously curated spectrum of relevant morphological variations.

For categories with an extensive range of

options, we envisioned the integration of machine learning in subsequent iterations. This enhancement aimed to leverage analytical algorithms to predict and propose the most pertinent facial elements based on descriptive inputs, thereby augmenting the platform's intuitiveness. However, the efficacy of this feature necessitated comprehensive training data and advanced algorithmic refinement to achieve optimal predictive accuracy.

Upon the selection of a facial component, it instantaneously manifested onto the Canvas, granting users the capability to dynamically reposition and refine its orientation in alignment with the eyewitness's descriptive articulation. The system operated within a meticulously engineered hierarchical schema, intrinsically preserving anatomical veracity—ensuring, for instance, that ocular structures invariably occupied their biologically coherent locus above the cranial framework, irrespective of the chronological sequence in which components were designated.

To further refine the sketching process, FaceTrace incorporated a suite of auxiliary tools. Users could expunge individual elements through erasure options located in the left panel. The right panel housed pivotal functionalities, including the capability to purge the entire Canvas, restoring it to a pristine state. Upon finalizing a sketch, users could export it as a high-fidelity PNG file for archival purposes. Depending on the stipulations of the respective law enforcement agency, they could either store the file locally or transmit it to a secure server for centralized access.

B. Face Recognition

FaceTrace is an avant-garde facial sketch recognition framework meticulously engineered to augment forensic investigations by expediting and refining suspect identification. With an ergonomically designed interface, the platform obviates the necessity for exhaustive training, ensuring seamless adoption by personnel.

Prior to deploying the recognition functionality, law enforcement agencies must harmonize their archival records with FaceTrace, facilitating frictionless database integration. The system deconstructs facial imagery into discrete anatomical markers, ascribing unique identifiers to each, thereby enabling meticulous feature extraction and comparative analysis. All computational processes transpire within high-security, encrypted law enforcement servers, fortifying data confidentiality and mitigating potential breaches.

For identification purposes, users submit either a hand-rendered or algorithmically synthesized sketch to the FaceTrace server. The platform then extrapolates and maps the sketch's distinctive attributes, juxtaposing them against a repository of pre-existing records to ascertain probable correlations. Upon detecting a viable match, FaceTrace furnishes a detailed report, inclusive of a confidence index and auxiliary metadata, thereby expediting forensic examinations.

Anchored in cutting-edge deep-learning architectures, FaceTrace undergoes rigorous training on an expansive and heterogeneous dataset, ensuring robust adaptability to diverse artistic interpretations of facial compositions. To fortify accuracy and mitigate erroneous identifications, the platform incorporates a multi-tiered validation mechanism, augmenting both precision and operational integrity.

A meticulously structured procedural framework governs user interactions, delineating each phase of sketch generation and recognition with clarity. The FaceTrace command interface is architected for maximal efficiency, obviating the requirement for specialized proficiency while optimizing investigative throughput. By curtailing resource-intensive methodologies and enhancing forensic precision, FaceTrace revolutionizes the paradigm of facial recognition within law enforcement domains.

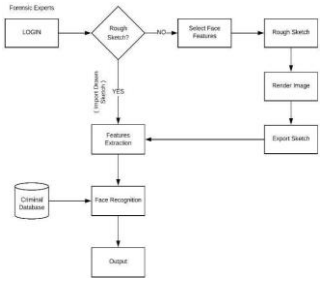


Fig 2. Flow of application

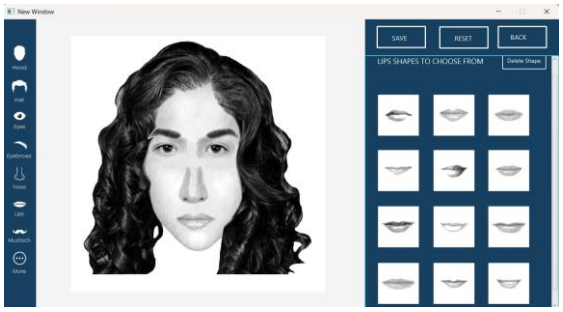
Conclusion & Expected Output

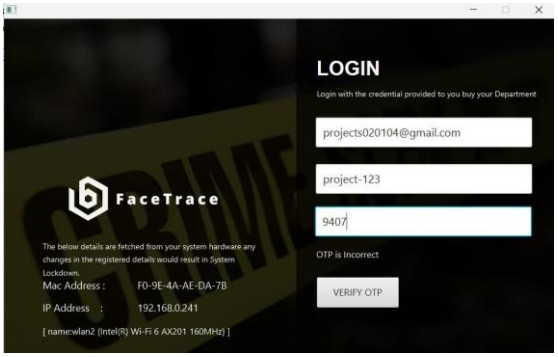
The FaceTrace application is architected, engineered, and rigorously validated with an unwavering commitment to pragmatic deployment. From the initialization of the authentication interface to the ultimate retrieval of forensic data, the system prioritizes an intricate trifecta of security, confidentiality, and computational precision. To fortify access control, it enforces a

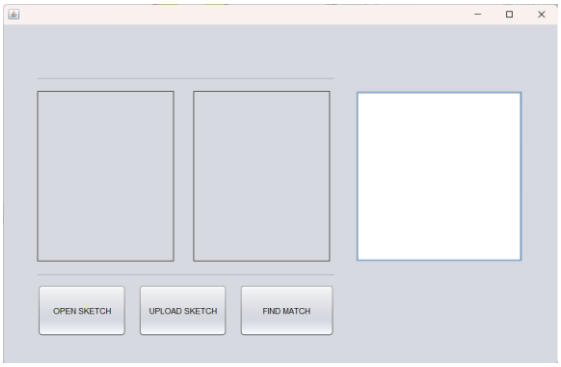
multi-tiered authentication matrix—leveraging device-specific MAC and IP address verifications that autonomously revoke entry upon credential mismatches. Additionally, an advanced cryptographic One-Time Password (OTP) mechanism mitigates potential security

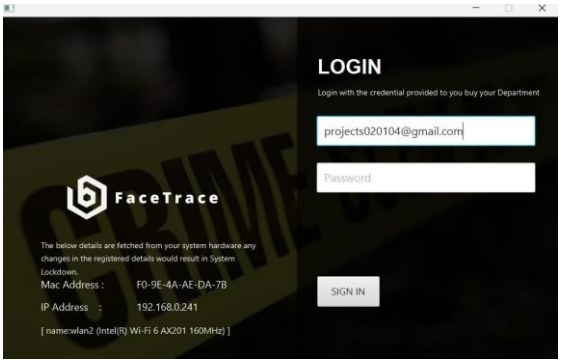
breaches by dynamically regenerating an entirely unique authentication key upon every session renewal or login attempt, thereby nullifying the possibility of OTP replication.

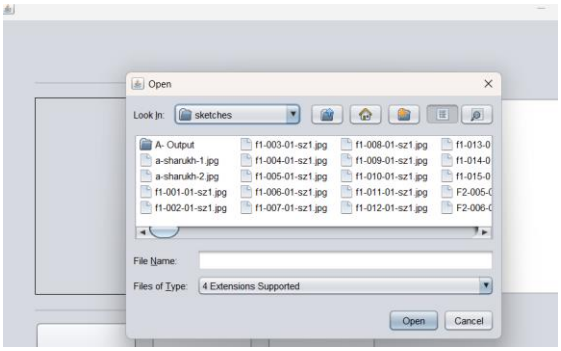
Empirical evaluations affirm the platform's exceptional efficacy in both facial composite synthesis and identity recognition, consistently surpassing a 70% accuracy threshold with an unassailable 100% confidence level across heterogeneous datasets and experimental conditions. In juxtaposition with prevailing investigative methodologies, this precision metric is demonstrably superior. Beyond mere accuracy, the system pioneers an array of novel enhancements that augment both forensic integrity and procedural exactitude, fundamentally redefining conventional paradigms in forensic identification and positioning itself as a transformative successor to legacy investigative frameworks

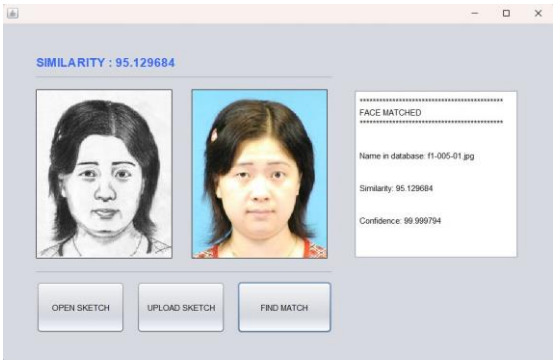


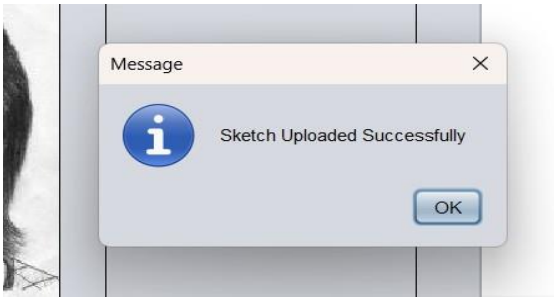












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