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AI-Driven Forensic Face Sketching and 3D Model Reconstruction for Criminal Identification

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Abstract
In the realm of modern law enforcement and criminal investigation, the use of artificial intelligence in forensic sketching represents a milestone. This project showcases an AI-Powered Forensic Face Sketch and Recognition System intended to aid in suspect identification from eyewitness accounts. The system utilizes a multi-phase method that starts with natural language understanding (NLP) to analyze speech or written descriptions and translate them into rough sketches where these sketches are enhanced to produce realistic facial images. Additionally, the system includes facial recognition systems to compare the created faces against a criminal registry and initiate real-time alerts. This blended solution not only improves the accuracy and speed of suspect identification but provides a significant forensic tool. This also accepts voice or text, extracts feature, creates 2D and 3D face models, and compares them with criminal records contributing to a more comprehensive and interactive profiling system.

Keywords: *2D and 3D Face Modelling; Criminal Database Matching; Facial Recognition; Forensic Face Sketching AI; Natural Language Processing (NLP).*

1. Introduction
In contemporary criminal investigations, eyewitness identification still plays a paramount role in identifying suspects. Forensic artists have classically been tasked with transforming verbal descriptions into hand-drawn sketches that are then utilized to assist law enforcement agencies. Such manual processes, however, are usually hampered by human prejudice, uneven accuracy, and dependence on the memory of the eyewitness. With the swift advancement of Artificial Intelligence (AI), Natural Language Processing (NLP), and computer vision, new methods have been developed that automate this task to enhance efficiency and reliability. Deep generative models like Generative Adversarial Networks (GANs) have been shown in recent research to be used for sketch-to-photo translation and realistic face synthesis. In parallel, NLP advances have made it possible to accurately extract semantic features from eyewitness reports to enable a pipelined process of transforming natural language into visual representations. While current works emphasize either sketch creation or photo matching, there is still a lack of creating an end-to-end, multimodal forensic tool that can take eyewitness input, create 2D sketches and 3D models, and conduct real-time suspect identification. The goal of this work is to create an AI-based forensic face sketch and recognition system that translates eyewitness descriptions into visual suspects and compares them with criminal records. The novelty of the research is in the integration of NLP-based feature extraction, GAN-based sketching, 3D reconstruction, and face recognition, which constitutes an end-to-end system designed specifically for forensic purposes. This cutting-edge integration supports quicker, scalable, and more effective suspect identification, thus solving key challenges that confront law enforcement [1].

1.1. Background
Facial recognition has emerged as a pivotal security and law enforcement technology that responds to the growing need for precise and automated identification technologies. Forensic sketches drawn by artists are usually inaccurate because human memory and perception are subjective in nature. Even more, manual techniques take time and cannot

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be scaled when dealing with large suspect databases. Current studies indicate that the incorporation of Artificial Intelligence (AI) technologies, including machine learning, computer vision, and natural language processing, can increase the accuracy of forensic sketches through minimizing reliance on human effort and optimizing consistency. Such advancements form the basis for AI-driven systems that fill the gap between descriptive input and the self-executing identification of suspects [2].

1.2. Scope

The present study limits its scope to the design and implementation of an AI-based forensic face sketch and recognition system that works on eyewitness descriptions. The suggested model focuses on three key operations: (1) mapping natural language inputs into structured features, (2) producing realistic and accurate sketches or photorealistic faces through deep learning processes like GANs, and (3) recognition by comparing generated faces with criminal records. The research also seeks to deliver real-time application potential for forensic use by police and 2D to 3D Cnversion while being practical yet not sacrificing computational efficiency [3].

2. Method

The proposed system is designed to transform eyewitness descriptions—provided via text or voice—into accurate visual representations of suspects and match them against a criminal database. The methodology involves the following key stages:

- **Input Acquisition-** Eyewitnesses provide suspect descriptions through either voice or text. Voice inputs are transcribed using an Automatic Speech Recognition (ASR) system, ensuring consistent downstream processing.
- **Natural Language Processing (NLP) and Feature extraction-** The transcribed or written description is analyzed using a transformer-based NLP model to extract facial attributes such as gender, age, skin tone, hair type, eye color, and distinguishing features (e.g., scars, beard).
- **Face Sketch Generation-** The extracted attributes are used as conditional inputs to a trained Generative Adversarial Network (GAN), which synthesizes a 2D facial sketch that visually aligns with the described features.
- **3D Face Reconstruction-** The 2D sketch generated is passed through a 3D reconstruction model to create a 3D facial model. This step adds depth and structure, improving matching accuracy [4].
- **Face matching against Criminal Database-** The 2D sketch or 3D model is embedded using a face recognition model like Arc Face or FaceNet and then compared with embeddings in a pre-compiled criminal image database. Similarity scores are computed to identify potential matches.
- **Real-Time Alert Generation-** If a high-confidence match is found, the system automatically sends an alert to law enforcement personnel, including the generated images and associated metadata. Optional GPS tagging can be enabled if the eyewitness is using a mobile device [5].

2.1. Tables

Table 1 Key Technologies Used

Step	Models
Input Processing	NLP (BERT, GPT) [a]
Sketch Generation	GANs (StyleGAN2, PR-GAN) [b]
Reconstruction	3D Models (PRNet, DECA) [c]
Matching	Arc Face, FaceNet [d]
Alerts	REST APIs[e]

- [a] - BERT and GPT are widely used NLP models for text-to-image tasks.
- [b] - StyleGAN2 and PR-GAN are advanced GAN architectures for sketch generation.
- [c] - PRNet and DECA enable accurate 3D facial reconstruction.
- [d] - Arc Face and FaceNet are robust deep-learning models for face recognition.
- [e] - REST APIs are used for integration and alerting mechanisms.

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2.2. Figures

This flowchart illustrates a system for generating and identifying facial sketches, likely for forensic use. It starts with two inputs: a hand-drawn sketch or a parametric model created from feature descriptions. Both inputs are processed to extract and unify key facial features. From this point, the system can either synthesize a photorealistic 2D image or a 3D facial model. These synthesized images are then matched against a facial database to identify a person. The process concludes with the final output and visualization of the results Shown in Figure 1.

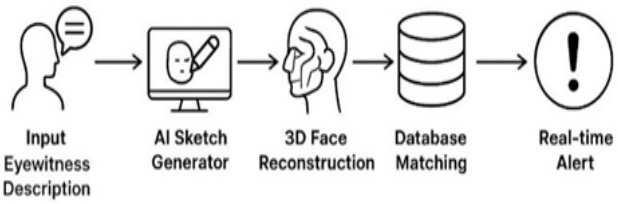

Figure 1 System Architecture

This flowchart depicts a system where the first stage involves text description of the individual that is converted into a feature-based representation. The next stage involves sketch creation, where an eyewitness works iteratively with an operator to build a composite image by selecting individual facial elements from a database. A loop allows them to refine the selections against the eyewitness's description until the sketch is completed. Once satisfied, the composite sketch is saved, and the recognition process is initiated Shown in Figure 2 and 3.

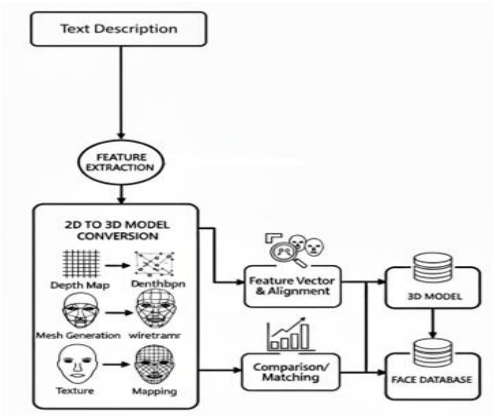

Figure 2 System flow of the Application

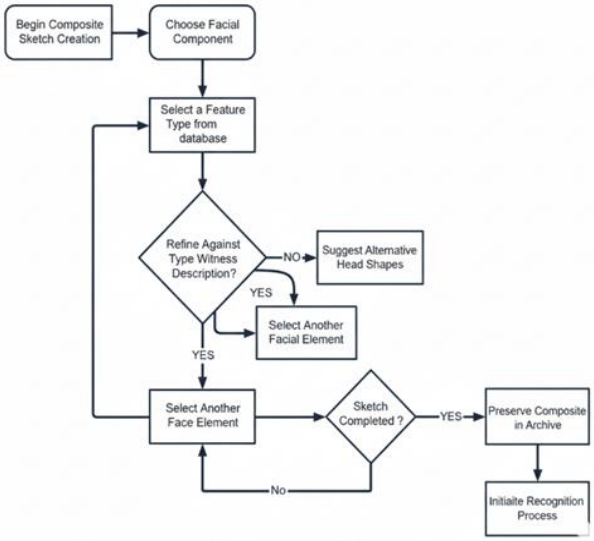

Figure 3 Face Construction Architecture

3. Results and Discussion

3.1. Expected Result

The envisioned AI-based forensic face sketch and recognition system is expected to effectively pick facial features from text and voice eyewitness accounts and produce natural 2D sketches. The sketches, when translated into 3D face models, are expected to enhance matching accuracy against a criminal database, with the 3D models offering superior spatial information than 2D sketches. The system is also anticipated to provide near real-time notifications of high confidence matches, with images and metadata, providing law enforcement with a useful and scalable means of suspect identification Shown in Figure 4.

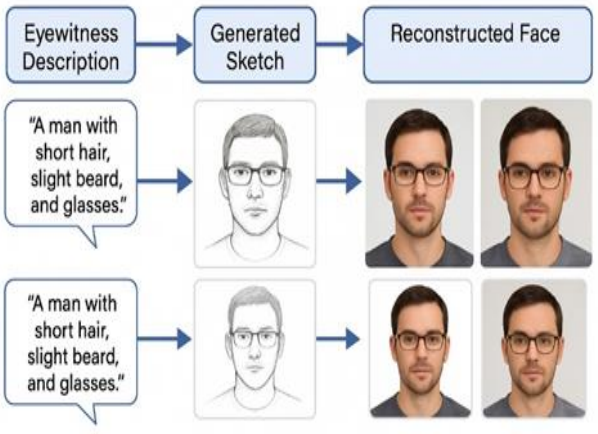

Figure 4 Process Flow of Proposed Model

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Overall, the combined method is predicted to increase the speed, accuracy, and efficacy of forensic face identification compared to current manual techniques [6].

3.2. Discussion

The proposed AI system demonstrates the possibility of consolidating NLP, GAN-based sketching, and 3D reconstruction in support of existing forensic approaches. By minimizing dependence on human memory and subjective sketching, it presents more accurate and consistent representations of suspects. The 3D models enhance spatial depth, which increases the accuracy of matching, and real-time notifications may also accelerate law enforcement response immensely. The system further illustrates the merit of multimodal fusion, increasing forensic investigation scalability and interactivity. Although performance is based on eyewitness detail and database breadth, modularity supports continuous improvement, casting a positive light on AI-facilitated criminal identification Shown in Figure 5.

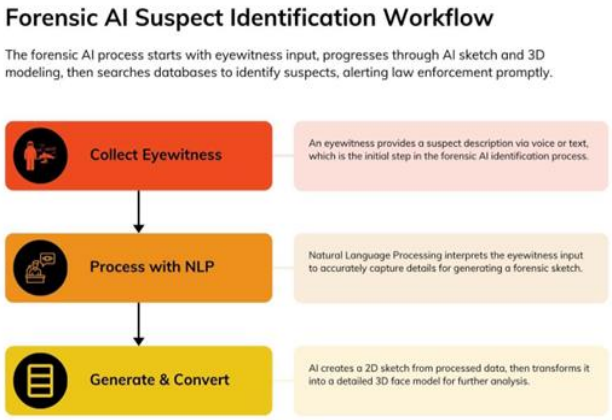

Figure 5 Process Workflow

Conclusion

The new system replaces the traditional process of suspect identification with a quicker, more objective, and scalable method through AI. Automating the translation of eyewitness descriptions to images and comparing them to known databases helps law enforcement agencies make their investigations more efficient and accurate. The project could be scaled up for real-time deployment in cities, airports, and public gatherings.

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