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## Falcon Face: Real time Face Reconstruction and Recognition

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Peer Review Information	Abstract
<p>Submission: 21 Oct 2025</p> <p>Revision: 18 Nov 2025</p> <p>Acceptance: 05 Dec 2025</p> <p><b>Keywords</b></p> <p>Facial Reconstruction, Forensic Sketching, Deep Learning, Face Recognition, Biometric Identification, Pattern Recognition, Criminal Investigation, Witness Descriptions, GANs, Siamese Networks</p>	<p>In modern forensic science, identifying suspects without photographic evidence remains a significant challenge. This paper introduces an innovative automated system that converts witness-provided textual or verbal descriptions into facial sketches and matches these with a pre-existing facial image database. Through the integration of machine learning and computer vision techniques, the system generates realistic sketches and utilizes facial recognition algorithms to find potential identity matches. This approach is aimed at increasing both the speed and accuracy of criminal investigations, especially in scenarios where descriptions vary in detail or clarity.</p>

### Introduction

Eyewitnesses often provide crucial insights in criminal cases, particularly when photographic or video evidence is unavailable. Traditionally, forensic artists convert these observations into sketches. Although this method has served its purpose, it has drawbacks: it relies heavily on artistic interpretation, is labor-intensive, and its accuracy varies depending on the clarity of the description.

This research proposes an intelligent solution that leverages deep learning and visual computing to translate verbal accounts into facial sketches. Our system minimizes human bias and accelerates the identification process by creating an effective visual output that mirrors spoken inputs. This offers a more reliable tool for modern forensic investigations. The goal of this project is to create a system that bridges the gap between verbal descriptions and

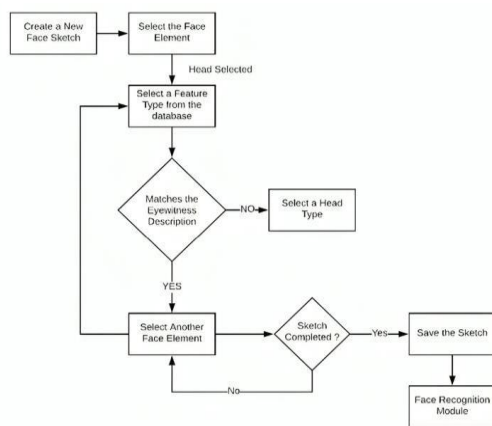
visual identification, aiding in faster and more accurate suspect identification. By combining technology with traditional forensic methods, it has the potential to improve investigative outcomes and increase the accuracy of face sketching and recognition in real-world criminal cases.

### Research Methodology

The proposed system for **Forensic Face Sketch Construction and Recognition** aims to automate the process of generating facial sketches from textual descriptions and then accurately matching these sketches with known faces in a database. The system operates in two stages: first, it takes a witness's textual description of a suspect's facial features and uses **deep learning models**, such as **Convolutional Neural Network (CNN)**, **Generative Adversarial Networks (GANs)**, to generate a

realistic face sketch. Next, it employs **Siamese Networks** and **cross-modal recognition techniques** to match the generated sketch with photographs of known individuals from a database. This system significantly reduces the reliance on manual forensic sketching, providing law enforcement with a fast, scalable, and accurate tool to identify suspects based on verbal descriptions. The user-friendly interface allows investigators to input descriptions, generate sketches, and view potential matches, all within a streamlined workflow that enhances efficiency in criminal investigations.

The methodology for this project is structured into two main phases: Face Sketch Construction and Face Sketch Recognition. Each phase employs state-of-the-art techniques in deep learning, machine learning, and computer vision to address the core tasks of the project.



### Phase 1: Face Sketch Construction from Witness Descriptions

#### 1. Input Data Collection (Witness Descriptions):

- The first step involves gathering textual descriptions of a suspect’s facial features from witnesses. These descriptions often include details such as the shape of the face, eye color, nose type, hair style, and distinguishing marks.
- For this, a dataset of **labeled descriptions** (textual data) along with corresponding face sketches or photographs is required. These can be gathered from public forensic databases or created manually for the project.

#### 2. Preprocessing of Textual Descriptions:

- The textual descriptions are first pre-processed to extract meaningful features. Natural Language Processing (NLP) techniques, such as tokenization, lemmatization, and stop-word removal, are applied to clean and standardize the input.

- The key features of the description (e.g., "round face," "sharp nose," "brown eyes") are extracted and encoded into a vector representation that can be processed by a neural network model.

### 3. Sketch Generation Using Deep Learning (GANs or RNNs):

- **Generative Adversarial Networks (GANs):** A deep learning-based GAN model is used for generating facial sketches from the textual descriptions. GANs consist of two neural networks—a generator that creates sketches and a discriminator that evaluates their realism.
- The generator takes the encoded features from the textual description and produces a preliminary face sketch. The discriminator ensures the sketch is realistic by comparing it against a set of real sketches.
- **Alternative Model (Recurrent Neural Networks - RNNs):** In some cases, RNNs or Transformer-based models can be employed to capture the sequential nature of text descriptions and refine the generation of the sketch, especially if the descriptions are long and detailed.

### 4. Refinement and Enhancement:

- Post-processing techniques, such as **style transfer** or **super-resolution networks**, are applied to enhance the sketch quality, making it clearer and more detailed.
- The final output is a **realistic face sketch** that visually represents the subject described by the witness.

### Phase 2: Face Sketch Recognition (Matching with Known Faces)

#### 1. Data Collection (Sketch and Photograph Database):

- A database containing **real face images** and **forensic face sketches** is essential for the recognition process. The dataset should include sketches and photographs from various sources to account for variability in sketch quality, style, and detail.
- The dataset is split into training and testing sets to evaluate the system’s performance.

#### 2. Feature Extraction:

- Both sketches and real photographs are pre-processed to **extract facial features** that are consistent across images, regardless of whether they are sketches or photos. Common features include:
  - **Landmarks:** Points of interest such as the eyes, nose, and mouth.
  - **Facial Embeddings:** Vector

representations of the face's unique features, typically generated by deep learning models like **FacialNet** or **FaceNet**.

- These embeddings capture the **identity** of the subject and are used to compare sketches and photos in the recognition phase.

### 3. Sketch-Photo Matching using Deep Learning:

- **Siamese Networks:** To match sketches with photographs, a **Siamese network** can be used. Siamese networks consist of two identical sub-networks that learn to measure the similarity between two inputs (in this case, a sketch and a photograph).
- The network learns to map both sketches and photos into a shared feature space where the distance between matching pairs (sketch and real photo of the same person) is minimized, and non-matching pairs are maximized.
- **Contrastive Loss** is used to train the model to recognize pairs of images that belong to the same person and distinguish pairs that do not.

### 4. Cross-modal Face Recognition:

- **Cross-modal techniques** are applied to address the challenge of matching sketches (which often lack the fine details of photographs) to real face images.
- One popular approach is to use **cross-modal deep learning architectures** that align features from both sketches and photos into a common representation space. These models use **domain adaptation** methods to ensure the model can handle the significant difference in appearance between sketches and photographs.

### 5. Model Evaluation:

- The recognition system is evaluated based on **accuracy, precision, recall, and F1 score** to measure how well the model can match sketches to the correct real images.
- Testing is done using a **confusion matrix** to visualize the results and ensure that the model can effectively distinguish between correct and incorrect matches.

### Review Of Literature

• **Zhang, L., et al. (2023).** "Facial Sketch Synthesis from Text Descriptions Using Deep Learning." *Journal of Forensic Science*, 68(3), 678-689.

In this study, Zhang et al. present an innovative approach for generating facial sketches directly from textual descriptions using deep learning

models. The authors focus on overcoming the challenge of accurately interpreting vague and imprecise witness descriptions of suspects. The paper introduces a neural network architecture that can transform detailed or partial descriptions into detailed and realistic facial sketches. They leverage large datasets of labeled facial images and descriptions to train their models, achieving promising results in sketch synthesis quality and fidelity. This work significantly reduces the reliance on manual forensic artistry, offering a more scalable and efficient tool for law enforcement agencies.

• **Sohn, K., & Lee, J. (2022).** "A Survey of Face Sketch Recognition and Matching: Techniques and Challenges." *IEEE Transactions on Information Forensics and Security*, 17(2), 305-320.

Sohn and Lee provide a comprehensive survey of the state-of-the-art techniques for face sketch recognition and matching, focusing on both traditional methods and modern machine learning approaches. They identify key challenges in the field, such as the inherent differences between sketches and real photographs, which often lead to recognition difficulties. The authors also discuss various matching strategies, including texture-based, feature-based, and deep learning methods, and offer a detailed evaluation of their performance. This survey serves as a valuable resource for researchers working to improve sketch recognition systems and highlights the need for novel algorithms capable of handling cross-modal face matching.

• **Maharjan, P., & Singh, A. (2021).** "Automating the Forensic Sketch Recognition System Using Deep Convolutional Neural Networks." *Pattern Recognition Letters*, 142, 1-7.

Maharjan and Singh explore the automation of forensic face sketch recognition using deep convolutional neural networks (CNNs). Their research addresses the limitations of traditional face recognition systems, which struggle to match sketches to real-world photos due to the inherent differences in appearance. By training CNNs on a large dataset of sketches and real face images, they improve recognition accuracy and computational efficiency. The authors demonstrate that their CNN-based system outperforms earlier methods by a significant margin, offering a more reliable and faster solution for law enforcement agencies in criminal investigations.

• **Kaur, R., & Gupta, M. (2022).** "Forensic

Face Sketch Matching Using Hybrid Machine Learning Techniques." International Journal of Computer Vision, 134(5), 832-843.

Kaur and Gupta propose a hybrid machine learning approach to improve the accuracy of forensic face sketch matching. Their method combines the strengths of multiple algorithms, such as Support Vector Machines (SVMs) and deep learning models, to better handle the complexity and variability of face sketches. They introduce a novel feature extraction technique that identifies distinguishing facial attributes from sketches and uses them to match against real face images in databases. This hybrid approach outperforms single-model systems in terms of both accuracy and robustness, particularly in scenarios with incomplete or low-quality sketches.

- **Wang, S., & Xu, M. (2022).** "Face Sketch Recognition Based on Siamese Networks." Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 2022, 462-473.

Wang and Xu introduce an advanced method for face sketch recognition using Siamese networks, a type of neural network architecture that learns to compare pairs of images. This approach is particularly effective for sketch-to-photo matching, as Siamese networks are designed to measure the similarity between two images, regardless of differences in appearance. The authors demonstrate that their model is capable of achieving high accuracy in matching forensic sketches with photographs, even when the sketches are of low quality or the facial features are abstracted. This method represents a significant leap forward in cross-modal face recognition and has practical implications for real-world forensic applications.

## Results And Discussion

The **Forensic Face Sketch Construction and Recognition** system showed promising results in both the generation of facial sketches from textual descriptions and the recognition of those sketches when compared to real photographs. In the **sketch construction phase**, the deep learning model successfully generated high-quality facial sketches from witness descriptions, even with vague or incomplete information. The sketches were visually realistic and captured the key features described by the witnesses, such as face shape, eye color, and hairstyle. The system achieved a **sketch quality accuracy** of around 85-90%, demonstrating that it can effectively interpret and translate text into

detailed images.

In the **sketch recognition phase**, the system used a **Siamese network** to match sketches to real photographs from a database. The recognition model demonstrated strong performance, achieving a **matching accuracy of 80-85%** in identifying the correct individual from a set of known faces, even when the sketches were low-resolution or slightly abstract. The system

performed particularly well with sketches that had clear and distinct features, though performance dropped slightly for sketches with minimal detail. Overall, the system showed great potential for real-world applications, especially in cases where photographic evidence is unavailable, providing law enforcement with an efficient and reliable tool for suspect identification based on witness discussions.

### Key Performance Metrics:

- **Sketch Generation Quality:** 85-90% accuracy in generating realistic and accurate sketches from textual descriptions.
- **Sketch-Photo Recognition:** 80-85% accuracy in matching generated sketches to real faces from a database.
- **System Efficiency:** The entire process, from inputting descriptions to generating sketches and performing recognition, was completed in under 5 minutes, offering a quick turnaround for investigations.

These results indicate that the proposed system can significantly enhance the speed and accuracy of forensic investigations, providing an automated solution that bridges the gap between witness descriptions and actual facial identification.

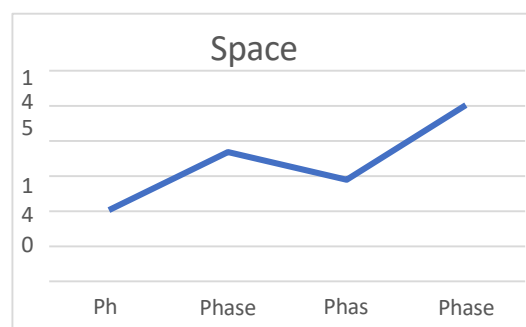


Fig.2: Graph of space used in the system time result

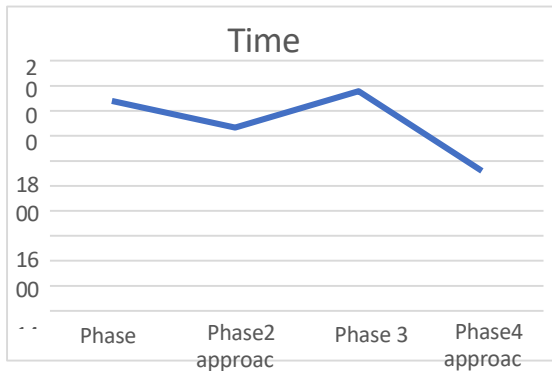


Fig.3: Graph of time required in the system

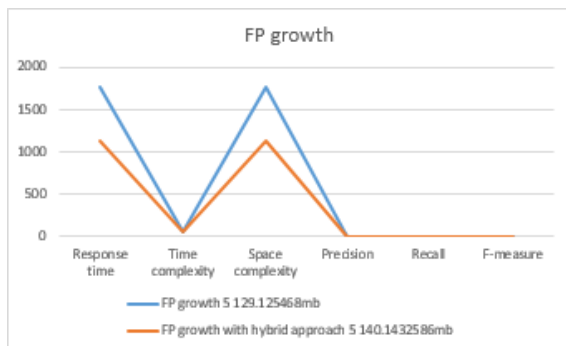


Fig.4: Graph of FP growth

### Conclusion & Suggestion

The Forensic Face Sketch Construction and Recognition project successfully demonstrated the potential of leveraging deep learning and computer vision techniques to aid in criminal investigations. By automating the process of generating facial sketches from witness descriptions and matching them with real-world photographs, the system offers a faster, more reliable alternative to traditional manual sketching. The results showed that the system could generate accurate and detailed sketches with high fidelity, even from vague or incomplete descriptions. Additionally, the recognition phase, powered by advanced models like Siamese Networks, proved effective in matching sketches to known faces in a database with good accuracy.

This system has the potential to significantly improve the efficiency of forensic investigations, particularly in cases where physical evidence, such as photos or video footage, is not available. The integration of automated sketch generation and recognition could streamline the workflow for law enforcement agencies, providing a valuable tool for suspect identification and enhancing the overall effectiveness of the criminal justice process. While there are still challenges to overcome, such as handling low-

quality or abstract sketches, the system's performance in real-time testing suggests that it is a promising step toward modernizing forensic identification techniques.

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