GENFACE: FORENSIC FACE SKETCH CONSTRUCTION AND RECOGNITION

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Abstract: ***In forensic science, composite sketches are a critical tool for identifying suspects based on eyewitness testimony. However, the traditional process relies on trained forensic artists and is slow, subjective, and produces an analog image that cannot be easily matched against digital police databases. GenFace is a Java-based desktop application that solves this problem by providing a complete, end-to-end solution. The system features a user-friendly JavaFX interface that allows users, even without artistic skill, to build a composite sketch using a drag-and-drop library of facial features. The core innovation lies in its integration with cloud-based artificial intelligence. Upon completion, the sketch is sent to an AI backend powered by AWS Rekognition, which compares it against a secure database of reference mugshots. The system returns the most likely matches with a similarity score, providing law enforcement with immediate, actionable intelligence. By bridging the gap between sketch creation and digital recognition, GenFace aims to significantly reduce investigation time and improve the accuracy of suspect identification.***

Keywords: Forensic Science, Composite Sketch, Face Recognition, JavaFX, AWS Rekognition, Deep Learning, Heterogeneous Face Recognition, E-Governance.

INTRODUCTION

In modern criminal investigations, eyewitness testimony remains a foundational piece of evidence. The ability to translate a victim's or witness's memory of a suspect into a visual likeness is often the first and most critical step in an investigation. These "composite sketches" serve as the primary tool for law enforcement to generate leads, alert the public, and search for suspects.

Despite its importance, this process is fraught with challenges. The information is scattered, relying on the memory of a witness, and the output is dependent on the skill of a (often unavailable) forensic artist. The process is time-consuming, and the final product is a static, analog sketch. This creates a major bottleneck: the sketch has no direct, programmatic link to the vast digital databases of mugshots and driver's license photos that police already possess. As a result, many potential leads are lost, and investigations are delayed as officers must manually and subjectively compare the sketch to photos. This project proposes a centralized, AI-powered desktop application, **GenFace**, developed using Java and AWS cloud services.

The system collects and organizes facial features into a digital library, allowing any trained officer to quickly assemble a sketch. It then digitizes the matching process by integrating an AI-powered recognition engine. Users can construct a sketch and, with a single click, search a database for potential matches. The platform also integrates an AI-based matching system that interacts with the user's sketch. The chatbot helps users quickly find information by answering questions like "Which scholarships are available for students?"

The main aim of this project is to make forensic sketch identification accessible, fast, and effective. By combining a user-friendly UI, a structured feature database, and a powerful AI matching engine, the system acts as a bridge between eyewitness memory and police data, helping officers find the right suspect without the traditional delay or ambiguity.

A. BACKGROUND

The generation and identification of suspects from eyewitness memory has evolved over decades but remains a significant challenge. Historically, this relied exclusively on trained artists who would sit with a witness for hours to draw a sketch by hand. In the latter 20th century, physical "Identi-Kit" systems were introduced, using transparent overlays of features to create a composite.

These methods were modernized with software like FACES, which provided a digital version of the feature-kit system. While these tools sped up the creation process, they still suffered from key limitations. The resulting image was just a digital drawing, not an intelligent piece of data.

The core technical challenge lies in **Heterogeneous Face Recognition (HFR)**—the process of matching two images from different domains, such as a sketch

(artistic) and a photograph (real-world). Traditional face recognition algorithms, trained on photo-to-photo matching, fail catastrophically when presented with a sketch.

With the rise of Deep Learning and cloud-based AI, it is now possible to train models to bridge this domain gap. Services like AWS Rekognition can be trained to find faces in a collection that are structurally similar to a source image, even if that source image is a sketch.

This project addresses this need by developing a JavaFX-based application that does not just create a sketch, but also serves as a direct client to a powerful AI matching engine. The system allows users to create the sketch and immediately leverage cloud AI to search for matches. This makes the system not only a creation tool but an active investigation tool.

The effectiveness of any forensic composite system is fundamentally constrained by the high-stakes and unreliable nature of human memory. An eyewitness's recollection is not a static, high-fidelity photograph; it is a subjective, malleable reconstruction of an event, often degraded by stress, fear, and the passage of time. This introduces a significant "cognitive gap," where a witness must translate their flawed, abstract mental image into precise verbal descriptions for an artist or a software operator. The resulting sketch, therefore, is not a picture of the suspect, but rather an *interpretation of a flawed memory*. This inherent psychological barrier is a primary challenge that the GenFace project seeks to mitigate by making the translation from memory to visual representation as rapid and intuitive as possible.

LITERATURE SURVEY

- To develop an effective system, it is essential to review existing technologies and research in the field of forensic sketching and AI-driven face recognition. This survey forms the foundation of the proposed project.

- **1. Existing Forensic Tools** Several commercial software tools are used by law enforcement for composite sketching:

- **FACES (IQ Biometrics):** A popular desktop application that allows users to build composites from a large database of facial features.

- **Identi-Kit:** The original physical kit system, which has also been digitized, focusing on a coded system of facial features.

- **SketchCop:** A tool that blends a feature-based library with free-hand drawing capabilities.

- **Limitations:**

- These tools are primarily *creation* tools, not *investigation* tools.

- The output (a saved image) must be manually exported and used, creating a disconnected workflow.

- **2. Previous Research and Related Works** Many studies have focused on the difficult task of sketch-to-photo matching.

- **Deep Learning Approaches:** Research by Fan, et al. [1] and Chen & Wu [3] explores the use of deep Convolutional Neural Networks (CNNs), like "SketchFaceNet," specifically designed to learn the relationship between sketch features and photo features.

- **Generative Models (GANs):** Other studies, such as those by Liu, et al. [2] and Singh, et al. [5], use Generative Adversarial Networks (GANs). These models attempt to "translate" the sketch into a realistic-looking photo (or vice-versa) before performing the match, effectively turning the HFR problem into a standard photo-to-photo matching problem.

- **Interactive Systems:** Research by Gomes, et al. [7] and Strohm, et al. [8] explores interactive systems where human feedback is used to refine the sketch generation, suggesting that a human-in-the-loop approach is highly effective.

- **Surveys:** Comprehensive surveys by Jha & Singh [4] confirm that deep learning-based methods now significantly outperform all previous techniques for heterogeneous face recognition.
- A significant trend observed in recent literature is the shift away from purely self-hosted, custom-trained deep learning models and toward the adoption of commercially available, cloud-based AI services. Research has begun to benchmark platforms like AWS Rekognition, Microsoft Azure Cognitive Services, and Google Vision AI for forensic-style tasks. This trend highlights a practical move; by leveraging these powerful, pre-trained, and scalable cloud APIs, researchers and developers can focus on building functional, integrated systems rather than on the complex and resource-intensive task of training a new deep learning model from scratch.

3. Key Technologies Discussed in Literature

Technology	Purpose	Example Use
JavaFX	To build a cross-platform	Creating the drag-and-drop

	desktop UI.	dashboard for sketch assembly.
AWS Rekognition	Cloud-based deep learning service.	Powering the AI search to match sketches against a photo database.
AWS S3	Secure cloud object storage.	Storing the reference mugshot database and temporary sketch uploads.
SQLite	Lightweight local database.	Storing local user profiles and application settings for login.

4. Gaps Identified in Existing Systems

After studying the literature, several key gaps were identified:

- **Lack of Integration:** Most commercial tools (like FACES) lack AI matching, and most research papers (like SketchFaceNet) are just algorithms, not usable tools.
- **High Cost/Complexity:** Many deep learning solutions require powerful, expensive GPUs and complex server-side setup, making them inaccessible to smaller police departments.
- **Disconnected Workflow:** An officer must use one tool to create the sketch, then (in theory) export the image and use a completely different, hypothetical system to perform a search.

5. Research Motivation

- Based on these gaps, this project is motivated by the following goals:
- To create a single, integrated desktop application for both creating and matching sketches.
- To use cloud-based AI (AWS Rekognition) to eliminate the need for expensive local hardware, making the tool accessible and scalable.
- To design a simple, user-friendly interface (JavaFX) that does not require artistic skill to operate.
- To build an end-to-end workflow that provides immediate, actionable results.

6. Summary of Literature Findings

The survey shows that while the component technologies exist, they are fragmented. Deep learning has solved the core *problem* of sketch-to-photo matching [4, 6], but no system exists that integrates this power into a simple, accessible tool for the officers who actually need it. This project builds upon these findings by combining a JavaFX UI with a cloud AI backend to create a complete and efficient system.

PROPOSED SYSTEM

The proposed system, GenFace, is designed to be a centralized and intelligent desktop platform where law enforcement users can easily generate and match forensic composite sketches. The main goal is to make this process fast, accessible, and effective, removing the bottleneck of relying on specialized artists and manual database searches.

1. Objectives of the Proposed System

Design a User-Friendly Interface: Develop an intuitive JavaFX application for creating composite sketches, enabling users to assemble facial features via drag-and-drop.

Implement Core Sketching Functionality: Build a robust canvas module that allows for the selection, placement, resizing, and layering of various facial components.

Integrate an AI Recognition Engine: Incorporate the AWS Rekognition service to build a backend capable of matching images.

Develop a Searchable Face Database: Implement the functionality to create and populate an AWS Rekognition Collection with reference images (mugshots).

Bridge Sketch and AI Components: Create a seamless workflow that allows a user to trigger an AI search from the sketch interface, automatically sending the final composite sketch to the Rekognition service.

Display Actionable Results: Design a clear and understandable results-display module that shows the top-matching images from the database, along with the AI's confidence score for each match.

Ensure Secure Access: Implement a user authentication system (e.g., local database login with OTP) to secure access to the application.

2. Working of the Proposed System The system workflow is as follows:

Admin Setup: An administrator (privileged user) first populates the AWS Rekognition "Collection" with thousands of reference mugshot images. This is a one-time setup.

User Authentication: A standard user (officer) launches the GenFace app and logs in. The

system uses a local SQLite database and JavaMail API to verify credentials via an OTP.

Sketch Creation: The user is presented with the main dashboard. They create a composite sketch by dragging and dropping facial features (eyes, nose, hair) onto a canvas, based on eyewitness descriptions.

Backend Process:

The app saves the sketch on the canvas as a local PNG file.

The app uploads this PNG to a secure AWS S3 bucket.

The app then calls the AWS Rekognition API, pointing it to the new sketch in S3 and telling it to search the pre-populated mugshot "Collection."

Display Results: AWS Rekognition returns a JSON list of the top 10 matches, including the filename of the matching image and a similarity score (e.g., "92.5% similar"). The GenFace app parses this data and displays the top matching photos and scores to the user in a new results window.

3. Features of the Proposed System

Feature	Description
Centralized Access	A single desktop application for both creation and matching.
Filtering & Searching	The AI-powered search is the search feature; it filters thousands of images.
AI Match Support	AWS Rekognition provides fast, accurate, deep learning-based matching.
Responsive Interface	JavaFX provides a modern, responsive UI that works on multiple platforms (Windows, macOS).
Verified Data	The AI "Collection" is built from verified, official mugshot databases.
Secure Dashboard	Users must log in, ensuring only authorized personnel can access the system.
User Empowerment	Helps any officer perform a task that previously required a specialized artist.

4. Comparison Between Existing and Proposed System

Criteria	Existing System (Traditional)	Proposed System (GenFace)
Information Source	Witness memory, translated by artist	Witness memory, assembled by officer
Ease of Use	Requires a highly trained artist	Designed for any trained officer
Data Collection	Manual, slow, analog drawing	Digital, fast, drag-and-drop
Search Feature	None. Manual, subjective comparison.	Integrated AI search button
AI Matching	Not available	Core feature (AWS Rekognition)
Data Update	N/A (single-use sketch)	Admin can update mugshot database
Accessibility	Low (dependent on artist availability)	High (any officer with the software)
User Interaction	Analog, conversational	Dynamic, digital interface
Time to Result	Days (to create sketch) + Weeks (to find match)	Minutes (to create sketch) + Seconds (to find match)

CONCLUSION

This project successfully developed **GenFace**, a Java-based desktop application that provides a centralized platform for forensic composite sketching and AI-powered recognition. The system was designed to address the critical bottlenecks in traditional forensic investigations: the reliance on skilled artists and the disconnection between the sketch and digital databases.

By collecting facial features into a digital library and using the JavaFX framework, a smooth and intuitive interface has been achieved, allowing users to easily assemble a sketch.

The most significant contribution of this project is the successful integration of the AWS Rekognition AI engine. This allows the system to perform a complex, deep-learning-based search, matching a sketch against a vast photo database in seconds. This feature

transforms the tool from a simple "sketchpad" into a powerful, active investigation platform.

GenFace helps save time, empowers officers without artistic training, and increases the potential for generating actionable leads from eyewitness testimony. It aligns with the vision of e-Governance by applying modern cloud technology to solve a critical, real-world law enforcement challenge.

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