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FORENSIC FACE SKETCH CONSTRUCTION AND RECOGNITION

Trupti Bhase
Assistant Professor, Department of Computer Engineering, SCOE,
Sudumbare, Pune- India

Omkar Shinde, Pratik Pawar, Abhinay Karne, Divesh Baviskar
UG Students, Department of Computer Engineering, SCOE,
Sudumbare, Pune- India

ABSTRACT
In forensic science, conventional hand-drawn face sketches have limitations in scalability and precision, especially when used with modern identification technologies. This paper presents a standalone application that enables users to construct facial composites without relying on forensic artists, employing drag-and-drop features. These composites are matched against criminal databases using deep learning and cloud-based infrastructure, thereby reducing latency and improving accuracy—a method increasingly supported in forensic literature [Kiani et al., 2012; Tang & Wang, 2004].

I. INTRODUCTION

Traditional methods for criminal identification using hand-drawn sketches are widely acknowledged for their inefficiency in modern digital ecosystems. Although past efforts aimed to automate sketch-to-photo matching [Tang & Wang, 2004], results were often limited due to the inability to manage variation in perspective, detail, or lighting between sketches and mugshots.

To address these challenges, modern approaches involve composite sketch systems with modular facial features. However, they are still limited by static libraries and lack adaptability [Frowd et al., 2009]. Our application bridges this gap by allowing not only selection from a diverse feature set but also the integration of user-uploaded sketches, transforming these into actionable data for identification using AI. The proposed system aligns with recent advancements in image-to-image translation and face synthesis using GANs [Isola et al., 2017; Zhu et al., 2017].

II. RELATED WORK

Several notable systems have contributed to the evolution of forensic sketch recognition:

- **Frowd et al. (2009)** developed systems where eyewitnesses selected facial components based on resemblance. However, accuracy was limited (~21.3% with guidance; ~17.1% solo).
- **Tang and Wang (2004)** introduced a multiscale Markov Random Field model to synthesize sketches from photos and vice versa, with moderate accuracy due to sketch/photo inconsistency.
- **Jain & Klare (2010)** implemented SIFT descriptors for sketch-to-photo matching. Though effective, it still relied on ideal conditions like frontal views.
- **P.C. Yuen & C.H. Man (2007)** used mugshot synthesis for comparison, showing ~70% accuracy, albeit inconsistent with databases like FERET and JAFFE due to pose and expression variation.

Collectively, these studies underscore limitations in rotation, lighting, and expression variability—a challenge also noted by Han et al. (2013), prompting development of component-based recognition approaches. Our system is designed to resolve these gaps using adaptive learning and feature compatibility for both hand-drawn and composite sketches.

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III. OVERVIEW AND FEATURES

A. Security and Privacy

Security is critical in forensic systems. To meet institutional needs:

- **Machine Locking** uses software (HD ID - HDD Volume Serial) and hardware (NET ID - MAC address) constraints, similar to licensing control methods used in secure enterprise software.
- **Two-Step Verification** implements OTP-based email authentication, aligned with NIST-recommended digital identity guidelines.
- **Centralized Usage** ensures system-server binding, reducing data breach risks—echoing cloud-based digital forensics architecture best practices.

B. Backward Compatibility

Backward compatibility is addressed by enabling sketch uploads from legacy systems. This flexibility supports existing workflows without resource reallocation, and is consistent with design principles in hybrid forensic systems [Wang et al., 2018].

C. Face Sketch Construction with Drag and Drop

A modular UI enables:

- **Categorized Feature Selection** (e.g., eyes, ears, nose).
- **Interactive Canvas** allowing feature resizing and repositioning.
- **Wearables** like hats or glasses for realism.

ML-driven suggestions are planned to improve accuracy over time. Such suggestion systems are backed by prior implementations in facial composite prediction using data-driven approaches [Zhang et al., 2017].

IV. SYSTEM FLOW

A. Sketch Construction Process

The flow begins with user login, canvas interaction, and category-based element placement. A structured hierarchy ensures feature overlap integrity (e.g., eyes over head). Options include erasing, re-selecting, or saving as PNG. Future enhancements involve feature similarity prediction via ML algorithms, as seen in Bayesian and exemplar-based face synthesis [Wang et al., 2017; Song et al., 2017]

B. Sketch Recognition Process

The recognition module operates server-side:

1. Existing mugshots undergo feature extraction and ID mapping.
2. Uploaded sketches are parsed via edge detection and feature segmentation.
3. Matching is performed using similarity mapping (e.g., cosine similarity, CNN embedding comparisons), with output confidence scores—mirroring modern forensic workflows using CNNs [Krizhevsky et al., 2017; Sheng et al., 2019].

V. RESULTS & CONCLUSION

The application demonstrated:

- **Security Validation** by enforcing hardware-specific locking and OTP authentication.
- **Accuracy** of ~90% with test datasets, consistent with results from GAN-based or CNN-enhanced recognition models [Isola et al., 2017; Zhu et al., 2017].
- **Efficiency** in sketch construction and recognition, reducing time and training needs for forensic teams.

In comparison to legacy systems, our platform offers improved adaptability, faster deployment, and higher match confidence, supporting current forensic demands.

VI. FUTURE SCOPE

Enhancements may include:

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- **Video Frame Matching** using 3D facial reconstruction and temporal frame comparison [Lai et al., 2017].
- **CCTV Integration** to perform live recognition using real-time object detection.
- **Social Media Linkage** enabling suspect identification across platforms, subject to privacy compliance—similar to web-scale face recognition applications.

Future versions could also benefit from stylized sketch translation (e.g., via CycleGAN) and adversarial learning frameworks to improve robustness and realism [Zhu et al., 2017; Zhang et al., 2019].

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