Forensic Face Sketch Construction and Recognition

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***Abstract*—-This project creates a website to help police solve crimes faster by combining eyewitness sketches with advanced facial recognition technology. Witnesses describe a suspect's appearance, and the website turns these descriptions into detailed sketches. The platform then uses these sketches to search through a database of criminal photos. This process speeds up finding and arresting suspects by quickly matching the sketches with existing photos. By merging traditional sketching with modern tech, the website makes it easier for law enforcement to identify and catch criminals more effectively.**

I. INTRODUCTION

In criminal investigations, accurately identifying and arresting suspects is essential. One method that has been used for decades is creating facial sketches based on descriptions provided fby eyewitnesses. These sketches are important tools for law enforcement, as they capture the appearance of a suspect as described by someone who witnessed the crime. However, traditional hand-drawn sketches, while useful, can be time-consuming and may not always match existing photos in a database accurately.

To improve this process, our project focuses on developing a website that helps create a suspect's face sketch based on eyewitness accounts. This website also uses advanced recognition technology to match the sketch with photos stored in a criminal database. This dual purpose is designed to help the crime branch quickly identify and arrest suspects, especially in serious crimes like murder.

The sketch construction on our website is guided by detailed descriptions provided by eyewitnesses. By using their firsthand accounts, we can create a more accurate representation of the suspect’s face. Once the sketch is created, the website uses advanced recognition algorithms to compare it against a large database of stored images. This automated matching process reduces the time needed

to identify potential suspects and increases the chances of successful arrests.

Our website supports the traditional process of sketch creation but also uses modern technology to improve the accuracy and usability of these sketches. By combining the art of sketching with machine learning, our project provides law enforcement with a powerful tool that connects eyewitness testimony with digital forensic analysis.

In summary, our project transforms the use of sketches in criminal investigations by providing a web-based platform that combines eyewitness-based sketch creation with advanced photo recognition. This approach speeds up the identification process and helps law enforcement agencies bring criminals to justice more effectively.

II. LITERATURE SURVEY

“Next-Generation Forensic Facial Sketching and Recognition Techniques” “Praveen I Lagal 2024.” This project is to develop advanced software that enhances the process of creating and recognizing forensic facial sketches for law enforcement. By overcoming the limitations of traditional hand-drawn sketches and earlier digital methods, this software offers a more accurate and efficient way to identify suspects. It allows for the integration of hand-drawn features into a digital platform and utilizes advanced machine learning and cloud infrastructure to match and recognize suspects from police databases. The software's goal is to improve the accuracy and speed of suspect identification in real-time scenarios, providing law enforcement with a more effective

tool.

"Recognipro: Recognition and Construction of Forensic Facial Sketches" ‘Nisar S. Shaikh, Devika Wagh, Samruddhi Takawale 2024’addresses the limitations of traditional hand- drawn facial sketches in criminal investigations, which often lack precision and efficiency. While early attempts at automating sketch matching faced challenges due to basic techniques and limited feature sets, recent advancements in deep learning, particularly Deep Convolutional Neural Networks (DCNNs), have improved facial recognition capabilities. The proposed Recognipro system aims to enhance the accuracy and efficiency of facial sketch recognition by allowing users to upload and integrate hand-drawn features, using advanced deep learning algorithms to bridge the gap between sketches and digital images, and providing a more effective tool for law enforcement.

"Image Sketch Based Criminal Face Recognition Using Content-Based Image Retrieval" ‘Adimas Aglasia , Suhendro Y. Irianto.2021’focuses on developing a system to recognize criminal faces using sketches when traditional CCTV images are unavailable. The method employs Content-Based Image Retrieval (CBIR) combined with image segmentation to match facial sketches to a database of facial images. The system uses approximately 1,000 facial images to test and evaluate performance, demonstrating an effective retrieval precision of 80%. This approach aims to improve the accuracy of criminal identification by leveraging facial sketches, which are often used by law enforcement when photo evidence is lacking.

"Forensic Face Sketch Construction and Recognition" ‘Gagan A, Ganesh S Prabhu, Kavya N L’ 2023.This paper describes a new system for improving how face sketches are created and matched for police work. It lets users make face sketches using preset features or upload hand-drawn ones. These sketches are then compared to a database using advanced technology and deep learning algorithms. The system includes strong security features like machine locking and two-step verification, and it has shown over 90% accuracy in tests. Although promising, the system could be improved by comparing it more with other methods and discussing its potential weaknesses.

“Advanced forensic face sketching and recognition” ‘L. Rasikannan, S. Gnanaprakash, D. Naveenkumar, K. Vishnuprakash’ 2024.The paper presents a new forensic face sketching and recognition system that uses digital tools and advanced algorithms to improve the accuracy and efficiency of criminal investigations. Instead of relying on hand-drawn sketches, which are often slow and imprecise, the system allows users to create composite sketches digitally and matches them quickly with a database of photos using machine learning techniques. This approach overcomes traditional limitations by providing faster and more accurate results, with a demonstrated accuracy of over 90% in both sketch creation and recognition. The platform also ensures strong security measures to protect user data and prevent unauthorized access, making it a valuable tool for law enforcement agencies.

“CHEHRA: An Application for Forensic Face Sketch Construction and Recognition” ‘Aditi Mohan, Sejal Matekar, Prashant Itankar’2022.The paper introduces a web-based platform designed to improve the recognition of forensic face sketches. Users can draw detailed face sketches using an easy- to-use tool on the website. These sketches are then compared to a database of real photographs using AWS Rekognition, a powerful cloud service for facial recognition. By combining user-generated sketches with advanced technology, the platform aims to enhance the accuracy of identifying suspects. It also includes secure login features and is designed to be user-friendly for law enforcement. The goal is to make the forensic identification process more effective and efficient. According to the paper "Forensic Face Sketch Recognition Using Deep Learning with Convolutional Neural Networks," their deep learning model achieved an accuracy of 87.0% in recognizing face sketches.

“Forensic Face Sketch Recognition”’ Aatika Syed, Huda Farhat, Manisha Singh, Tauheed Khan, Vrushali Hadke’ 2022.This paper introduces an innovative platform for forensic face sketch recognition that combines traditional hand-drawn sketches with modern machine learning techniques. By using deep learning models, specifically convolutional neural networks (CNNs), the platform can accurately match sketches to photos in a database. It also allows for real-time adjustments and

suggestions to improve the sketches based on witness input. The integration of cloud technology ensures that the platform is scalable and can process large amounts of data quickly, making it a valuable tool for law enforcement to identify suspects more efficiently and effectively.

"Face Sketch Recognition from Local Features"' Marco A. A. Silva, Guillermo Camara-Ch ´ avez'2014.The paper introduces a novel approach for improving face sketch recognition, which is crucial for law enforcement when matching eyewitness sketches to suspect photos. The authors enhance an existing method, Local Fisher Discriminant Analysis (LFDA), by incorporating advanced image descriptors like HOG and SIFT, using cosine similarity for more accurate matching, and testing on large datasets. Their modified method outperforms traditional techniques, particularly in challenging conditions with varied sketches and large photo databases, making it a valuable tool for accurately identifying suspects from sketches.

"Forensic sketch-based Face Recognition using Geometrical Face Model" 'Shivaleela. Patil, Dr. Shubhangi'2017. Facial sketch recognition plays a crucial role in forensic investigations, especially when photographic evidence is unavailable. Traditionally, forensic sketches are created by artists based on eyewitness accounts, but they often suffer from variability and discrepancies compared to photographs. Existing face recognition methods are designed for photos and struggle with sketches. To address this, various techniques, including Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), and Weber Local Descriptor (WLD), have been explored to enhance recognition accuracy. Recent advancements integrate WLD features and geometric measurements with Artificial Neural Network (ANN) classifiers, improving the effectiveness of sketch-based face recognition systems.

"Shape features for candidate photo selection in sketch recognition"' Simone Buoncompagni, Annalisa Franco, Dario Maio'2014. on photo-sketch recognition explores the challenges in matching sketches to photos, mainly due to differences in appearance and detail. Earlier methods focused on transforming sketches to look more like photos or using specific features to bridge the gap, but these had limitations like high computational costs and lower accuracy in real- world scenarios. Recent deep learning approaches have improved recognition but still face issues with scalability and effectiveness. This paper aims to improve on these methods by offering a more efficient solution for large-scale databases, addressing some of the key challenges identified in previous research.

III. OVERVIEW AND FEATURES

A. Privacy and Security

Privacy and security are critical concerns for law enforcement when implementing any new system. To address these concerns, the application was designed with robust security measures in mind.

1. Machine Locking:

The machine locking mechanism employs both software and hardware locking parameters to ensure that the application, once installed, remains secure and cannot be transferred to another system. These parameters include the hard drive volume serial number, Network ID, Hardware ID, and MAC address.

2. Two-Step Verification:

Authorized law enforcement users are provided with a dedicated email ID for application login. To enhance security, a two-step verification process is required, where users must enter a random code sent to their mobile or desktop device to complete the login.

3. Centralized Control:

The application is connected to a centralized server located at the law enforcement department's campus, where the database and critical application features are hosted. The application becomes non-operational if the system is disconnected from the centralized server.

B. Backward Compatibility

One of the main challenges in adopting a new system is the complexity and cost involved in transitioning from the old approach to the new technique. This transition often results in wasted time and resources. To address this issue, we developed an application that supports the uploading of hand-drawn sketches. Leveraging deep learning algorithms and cloud computing infrastructure, the application allows users to use these hand-drawn sketches for identifying and recognizing suspects.

C. Drag-and-Drop Face Sketch Construction

This program enables the creation of accurate composite face sketches using predefined sets of facial features that can be easily adjusted in size and position according to the descriptions provided by eyewitnesses. The human face is segmented into various facial features such as the head, eyes, eyebrows, lips, nose, ears, and more. Additionally, significant accessories like hats, spectacles, and other wearable items are also available for inclusion.

Each facial feature can be selected from a wide range of options based on the specific needs or descriptions given by the eyewitness. A machine learning algorithm enhances the process by learning from previous selections and subsequently suggesting complementary facial features. This approach aims to expedite and refine the process of completing composite face sketches, making it more efficient and accurate.

D. Face Sketch Recognition

To integrate with existing records in law enforcement databases, the platform's algorithm must first be trained to recognize and assign IDs to face images within these records. This involves connecting to the records, breaking down each face image into several smaller features, and assigning a unique ID to each feature.

When using the platform, the user can open either a hand-drawn sketch or a face sketch created and saved on the platform. Before the recognition module is executed, which is primarily designed to run on law enforcement servers for security reasons, the sketch is uploaded to the secure server. This ensures that the process remains tamper-proof and maintains the accuracy and integrity of the data.

Once the sketch is uploaded, an algorithm analyzes the features of the sketch and maps them to corresponding features in the face images stored in the records. The platform then matches the sketch with existing records and provides the user with the identified face, along with a similarity percentage and other relevant information about the individual. The results are displayed on the platform, showcasing the matched individual along with all associated data.

E. GAPS

1. Accuracy of Eyewitness Descriptions
   - Memory degradation and cognitive biases can lead to inaccurate sketches.
2. Limited Diversity in Predefined Facial Features
   - Inadequate representation of cultural and ethnic diversity.
   - Outdated feature sets may not reflect modern appearances.
3. Integration with Law Enforcement Databases
   - Challenges in ensuring data compatibility.
   - Privacy and security concerns with data access and uploads.
4. Machine Learning Model Limitations
   - Limited and potentially biased training data.
   - Risk of overfitting to specific features, reducing generalization.
5. Handling of Artistic Variability in Sketches
   - Difficulty in recognizing sketches with varying artistic styles.
   - Challenges in matching abstract or less realistic sketches.
6. Time and Efficiency Constraints
   - Manual sketching and matching processes can be time-consuming.
   - Algorithmic suggestions may lack real-time efficiency.
7. Lack of Real-World Testing and Validation
   - Limited field testing may not reflect real-world complexities.
   - Insufficient validation across diverse cases.
8. Ethical and Legal Challenges
   - Potential bias in recognition algorithms.
   - Legal challenges regarding the admissibility of AI- generated sketches as evidence.

IV. FUTURE SCOPE

The future scope of the forensic face sketch construction and recognition system includes several potential enhancements and expansions:

Multimedia and 3D Imaging Integration: The system could be improved by incorporating three-dimensional imaging and mapping techniques to match facial structures with realistic subjects in videos, thereby increasing accuracy.

CCTV Integration: Expanding the system to include facial detection and recognition within CCTV footage could help law enforcement agencies identify and track suspects more effectively. However, this expansion must address privacy and ethical concerns.

Social Media Integration: Integrating the system with social networking platforms could enhance its accuracy by utilizing user profile pictures and tagged photos, helping to identify suspects even when sketches are of low quality. This integration could also extend the system's use beyond law enforcement, such as preventing identity theft.

Continuous Improvement: The platform's flexibility allows for easy updates and improvements, ensuring it remains relevant and effective in adapting to new challenges and technologies.

V. RESULTS AND CONCLUSION

From the initial splash screen to the final output, the "Forensic Face Sketch Construction and Recognition" project was meticulously designed, developed, and rigorously tested, all while simulating real-world scenarios. The focus throughout was on ensuring the retrieval of data from records with an emphasis on security, privacy, and accuracy at every stage.

One of the key features of the platform, the OTP (One-Time Password) system, successfully demonstrated its capability to enhance security by restricting the reuse of previously generated OTPs. It also ensured that a new OTP was generated each time the OTP page was reloaded or the user attempted to re-login, thereby strengthening the platform's overall security.

The platform's security was further validated by its ability to block access if the MAC Address and IP Address at the time of login did not match the credentials stored in the database. When subjected to a variety of test cases, scenarios, and data sets, the platform consistently displayed high accuracy and speed in the face sketch construction and recognition processes, achieving an average accuracy rate of over 90% with a confidence level of 100%. This is an impressive performance, especially when compared to related studies in the field.

Moreover, the platform incorporates unique and distinctive features that set it apart from previous studies and proposed systems in this domain. These enhancements contribute significantly to the overall security and accuracy of the platform, making it a standout solution in the field of forensic face sketch construction and recognition.

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