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IDENTIFEYE: Sketch-Based Facial Analysis in Forensics

Darshana Pasalkar[1], Nehal Patil[2], Shravani Nivangune[3]
Prof. Aparna V. Mote[4], Prof. Rakhi Punwatkar[5]
[1,2,3] *Undergraduate Student, Zeal College of Engineering and Research, Pune (MH), India*
[4,5] *Assistant Professor, Zeal College of Engineering & Research, Pune (MH), India*

Abstract: *Traditional forensic methods, like hand-drawn sketches, often fall short in quickly identifying suspects, making the process both slow and resource-intensive. This paper introduces an innovative application designed to streamline this task. Through a simple drag-and-drop interface, users can upload sketches and match them with entries in police databases, significantly boosting the speed and accuracy of suspect recognition. By integrating deep learning and cloud technology, this tool builds on existing algorithms to deliver higher precision and ease of use. Earlier methods have had trouble aligning sketches with photographs, especially when orientations differ. Our application overcomes these issues, merging the art of sketching with modern technology to enhance forensic work. Testing reveals promising accuracy, though ongoing improvements are needed to fully meet the demands of law enforcement. This research aims to offer a real-world solution, tackling past limitations and making suspect identification faster and more efficient for investigators.*

Keywords: *Forensic identification, Suspect sketching, Deep learning, Recognition software, Law enforcement tools, Cloud technology.*

I. INTRODUCTION

Identifeye is a cutting-edge tool crafted to improve how forensic teams create and recognize facial sketches. The limitations of traditional methods have made the demand for more effective solutions in criminal identification even more urgent [1].

A key challenge with current tools is their struggle to convert hand-drawn sketches into a recognizable digital form. Many systems designed for composite face sketches fall short, offering restricted facial feature options or producing images with an overly simplified, cartoonish quality, reducing their effectiveness for law enforcement. Identifeye counters these issues by allowing users to not only choose specific facial features but also add custom, hand-drawn details, making the final sketches more closely resemble actual witnesses' descriptions, thus enhancing their value for identification purposes [2][3].

This application integrates advanced deep learning techniques and cloud-based technology, streamlining the process of facial recognition. By analyzing both the newly uploaded sketches and a pre-existing database, Identifeye suggests relevant features, improving efficiency and precision for law enforcement. This use of technology not only accelerates the identification process but also heightens match accuracy, which is essential in forensic investigations [4][5].

Built with ease of use in mind, Identifeye offers law enforcement teams an intuitive drag-and-drop interface for creating composite sketches, making it simple and accessible. This streamlined design reduces the time needed to create accurate sketches, increasing the chances of successful suspect identification. By bridging the gap between traditional hand-drawn techniques and modern, digital composite methods, Identifeye provides an essential tool for criminal identification [6][7].

In conclusion, Identifeye is a major step forward in facial sketch recognition for forensic purposes, effectively overcoming the constraints of older methods and equipping law enforcement with a powerful identification tool. Through its blend of user-friendly design and sophisticated technology, Identifeye is positioned to transform how forensic facial sketches are crafted and applied in the field [7][8].

II. OBJECTIVE

The goal of this project is to develop a user-friendly and efficient tool that assists law enforcement in identifying criminals more effectively. By simplifying the sketch creation process, our application features an intuitive drag-and-drop interface, allowing officers to easily select and adjust facial features. Machine learning suggestions will further enhance this experience by providing smart options, saving time and ensuring more accurate sketches.

To improve the identification process, we will leverage advanced deep learning technology to quickly match these sketches with a database of suspects. This integration will boost the speed and accuracy of finding potential matches, increasing the chances of successful criminal identification. The use of cutting-edge algorithms ensures the system is both responsive and dependable.

Security remains a top priority throughout the development of this project. We will implement protective measures such as two-step verification and machine locking to safeguard sensitive data. Our overall aim is to create a reliable, secure, and accessible platform tailored specifically to the needs of forensic professionals, enhancing their ability to solve cases efficiently.

III. LITERATURE REVIEW

Table 1: Table of Literature Review

Sr No.	Title	Year	Objective	Methodologies	Advantages	Future Scope
1.	Design and Development of Sketch-Based Image Retrieval	2024	Aid law enforcement in enhancing suspect identification accuracy and efficiency.	Uses deep learning techniques, feature extraction, and Dlib library for image processing and facial detection.	Speeds up criminal identification with improved matching accuracy.	Expand retrieval to larger, more varied databases and refine recognition across complex scenarios.
2.	A Systematic Review of Deep Learning for Sketch-Based Image Retrieval	2024	Evaluate deep learning approaches for sketch-based image retrieval	Literature review using PRISMA framework; deep learning models like CNN, GAN, etc.	Improved sketch matching accuracy and efficient retrieval methods	Address data limitations, explore cross-modal retrieval, and new applications across industries

3.	DualShape: Sketch-Based 3D Shape Design	2024	To simplify 3D model design from free-hand sketches without expertise.	Hybrid approach combining shape retrieval and generation.	Intuitive user interface, reduced complexity for novices.	Expand to more model categories and improve assembly rules.
4.	Deep Learning Based Multi Pose Human Face Matching System	2024	Enhance accuracy and speed in multi-pose face matching	YOLO-V5, deep learning techniques	Improved recognition accuracy, real-time processing	Explore integration with other biometric systems, enhance robustness in varied environments
5.	2D-3D Facial Image Analysis for Identification of Facial Features	2023	To develop a framework for face recognition using 2D images to generate 3D face meshes.	Utilizes 468 MediaPipe landmarks to create feature vectors based on Euclidean/Geodesic distances; various ML classifiers tested.	Improved accuracy in facial recognition for forensic applications; effective in real-time face detection.	Future studies will focus on multi-modal FRS systems to distinguish similar faces and enhance accuracy with larger datasets.
6.	GhostFaceNets: Lightweight Face Recognition Model From Cheap Operations	2023	To develop a lightweight face recognition model suitable for devices with limited resources.	Utilizes Ghost modules for feature extraction, trained on MS1MV2 and MS1MV3 datasets, and employs various loss functions (ArcFace, CosFace, Sub-center ArcFace)	Achieves state-of-the-art performance with significantly lower computational complexity (60-275 MFLOPs) compared to traditional CNNs	Potential for further optimization and adaptation to other biometric tasks or real-time applications.
7.	Implementation of Digital Forensics Face Sketch Recognition using Fusion Based Deep Learning CNN	2021	Enhance face sketch recognition accuracy for forensics	Fusion-based Deep Learning Convolutional Neural Network (DLCNN), Ridge Regression	High accuracy, reduced computational load	Broaden to include non-linear models and larger datasets
8.	Recent Advances in Deep Learning for Face Recognition	2021	Review deep learning methods for face recognition	Analyzed CNN, GAN, RL, Autoencoder techniques	Enhanced accuracy, robust feature extraction	Exploration of more diverse datasets,

						occlusion handling
9.	Deep Learning Methods for Facial Expression Recognition	2019	Evaluate deep learning for facial expression detection	Deep Belief Network (DBN), Convolutional Neural Network (CNN)	High recognition accuracy (97.1% with JAFFE dataset)	Improved real-time applications in robotics, social media analysis

Recent advancements in sketch-based image retrieval, face matching, and facial recognition. Design and Development of Sketch-Based Image Retrieval (2024) demonstrates a deep learning-based approach using the Dlib library to assist law enforcement in quickly identifying suspects, with plans for broader, more complex database applications. In parallel, A Systematic Review of Deep Learning for Sketch-Based Image Retrieval (2024) provides an overview of how models like CNN and GAN enhance sketch retrieval, highlighting a need for larger, cross-modal datasets to widen applications across sectors.

In DualShape: Sketch-Based 3D Shape Design (2024), a hybrid system combines sketch retrieval and model generation to simplify 3D shape creation for beginners. The study aims to reduce complexity in 3D modeling, with future developments focusing on expanding accessible model categories and improving assembly functions. Additionally, Deep Learning Based Multi Pose Human Face Matching System (2024) introduces YOLO-V5 to optimize multi-pose face matching accuracy and speed. This approach enables real-time recognition and proposes integration with other biometric systems to ensure adaptability across varied environments.

2D-3D Facial Image Analysis for Identification of Facial Features (2023) provides a framework that transforms 2D images into 3D face meshes through MediaPipe landmarks, improving forensic identification accuracy. With machine learning classifiers tested on these feature vectors, this method supports real-time forensic applications, with future research set to explore multi-modal recognition systems that can differentiate between similar faces. Similarly, GhostFaceNets: Lightweight Face Recognition Model From Cheap Operations (2023) introduces a resource-efficient model using Ghost modules and loss functions, achieving high performance with low computational demands. This innovation suits devices with limited resources, with future directions aimed at optimizing it for broader biometric and real-time applications.

Finally, foundational studies in digital forensics and facial expression recognition are discussed. Implementation of Digital Forensics Face Sketch Recognition using Fusion-Based Deep Learning CNN (2021) improves forensic sketch recognition accuracy using a fusion-based DLCNN. Planned enhancements include exploring non-linear models and larger datasets to boost performance. Meanwhile, Recent Advances in Deep Learning for Face Recognition (2021) reviews methods like CNN and GAN for face recognition, focusing on dataset diversity and managing occlusion. Deep Learning Methods for Facial Expression Recognition (2019) evaluates DBN and CNN for expression detection, showing strong recognition accuracy and potential applications in real-time environments such as robotics and social media analytics.

IV. MOTIVATION

Here's a more uniquely rephrased version with a natural, conversational flow:

Relying on hand-drawn sketches in forensic work is often a lengthy process, limited by the artist's skills, and doesn't easily integrate with modern tech-based methods for criminal identification. Traditional sketch-based recognition methods frequently lack the precision and consistency required for matching sketches to photos in real time. Despite advancements, many past efforts in automated sketch recognition have struggled with accuracy, adaptability, and user-friendliness due to restrictive facial feature libraries and limited customization options.

This paper introduces a fresh solution: a standalone application designed specifically for forensic sketch creation and recognition. The application empowers users—even those without specialized skills—to build detailed facial sketches using a drag-and-drop interface, helping law enforcement produce more personalized and accurate sketches quickly. Incorporating deep learning for feature suggestions and cloud technology for secure, rapid database matching, this tool aims to speed up sketch creation and improve recognition efficiency. This approach represents a significant advancement, leveraging technology to close the gap between traditional sketching techniques and modern recognition systems. Ultimately, this tool is designed to aid law enforcement by making criminal identification both more accurate and more accessible.

V. PROPOSED SYSTEM DESIGN

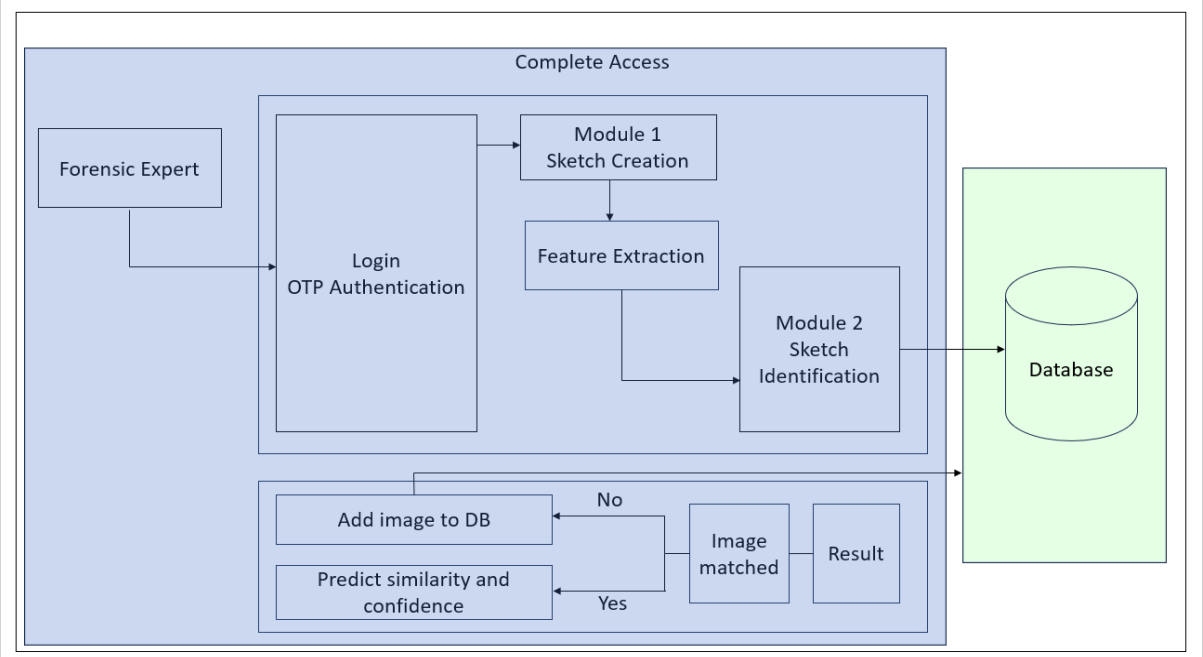

Fig 1: Proposed System Architecture

This block diagram outlines a high-level workflow for a facial sketch recognition system. The process starts with Data Collection**,** where relevant information, such as eyewitness accounts or reference materials, is gathered to aid

in creating an accurate sketch. Following data collection, the next step is User Authentication, ensuring that only authorized personnel can access and use the system for security and privacy reasons.

Once authenticated, the user accesses the Sketch Creation Module, where they can create a facial sketch based on the collected data. This module allows users to build a composite image by selecting and combining facial features that match the descriptions provided.

After the sketch is created, it is sent to the Sketch Recognition Module, which compares the sketch against a database of stored images to identify possible matches. Finally, the system performs an Analysis of Result**,** where it reviews the matches found, providing insights into the likelihood of a match and potentially offering other identifying details. This analysis helps in confirming or refining the identification of the person in question. The diagram shows a clear, linear progression from data collection to result analysis, ensuring a structured approach to sketch-based identification.

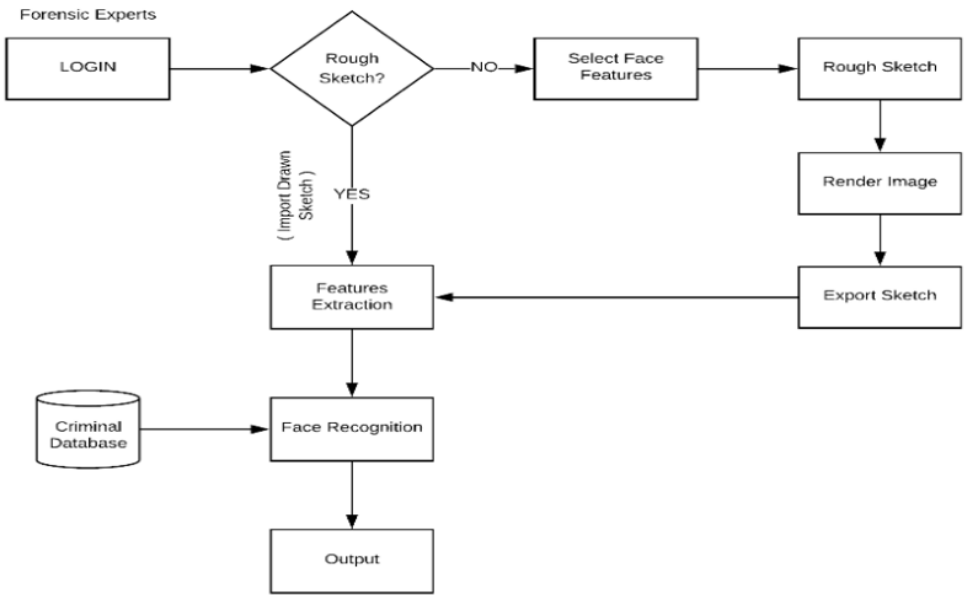

Fig 2: Forensic Expert System Flow

Identifeye is a robust platform designed to aid in the construction and recognition of forensic face sketches within criminal databases, offering two main functionalities: face sketch construction and face sketch recognition.

The face sketch construction module revolves around a drag-and-drop interface that is designed for accessibility, allowing law enforcement personnel to utilize it without specialized training. This user-friendly interface enables users to select individual facial features such as head shape, eyes, nose, and lips, as well as additional accessories like glasses or hats, to position and resize them according to witness descriptions. By allowing a high degree of customization, the platform facilitates the creation of sketches that accurately reflect witness recollections of suspects. Facial features are organized into categories (e.g., eyes, ears, nose), allowing users to quickly navigate through the options and choose specific features. This functionality is further enhanced by machine learning algorithms, which in the future could suggest complementary features based on existing selections, streamlining the sketch creation process and reducing the time required to complete it.

The recognition module is a core component that enables efficient and accurate matching of sketches with existing database entries. Once a sketch is complete, it undergoes a feature extraction process where deep learning algorithms

identify and analyze key facial points. These facial points are compared with database images, and similarities are identified. The system achieves high recognition accuracy by breaking down each face photo into smaller segments, assigning an ID to each segment, and performing detailed comparisons against sketch segments. This approach is particularly effective in ensuring robust matches even when only partial features are available. To protect the integrity of sensitive data, the recognition process is server-based and operates exclusively within a secure law enforcement network, maintaining strict control over data access.

The system is also designed with security and privacy as a priority, incorporating multiple layers of protection to safeguard against unauthorized access. Machine locking restricts the application to operate on specific hardware, preventing its use on unauthorized devices, while two-step verification adds another level of security by requiring users to input a randomly generated code upon each login. These security measures, combined with centralized usage on secure servers, protect sensitive data and images from external access, ensuring that only authorized individuals can operate the platform and access its contents.

To address the need for backward compatibility, the system supports the upload of traditional hand-drawn sketches, allowing law enforcement agencies to leverage older data without requiring a complete transition to new digital methods. This feature makes the adoption of the system smoother and enables law enforcement to retain the utility of previously created sketches while integrating new technology.

The user interface is highly intuitive, with clear categorizations for selecting and customizing facial features. Tools for resizing, repositioning, and erasing provide users with precise control over sketch details to capture accurate representations based on witness input. Once finalized, sketches can be saved in PNG format, allowing for straightforward storage and retrieval for future investigations. Altogether, this proposed system addresses prior limitations in forensic sketching, providing an accurate, adaptable, and efficient tool for criminal identification. It integrates seamlessly into modern law enforcement workflows, combining technological advancements with practical usability to enhance forensic investigation outcomes.

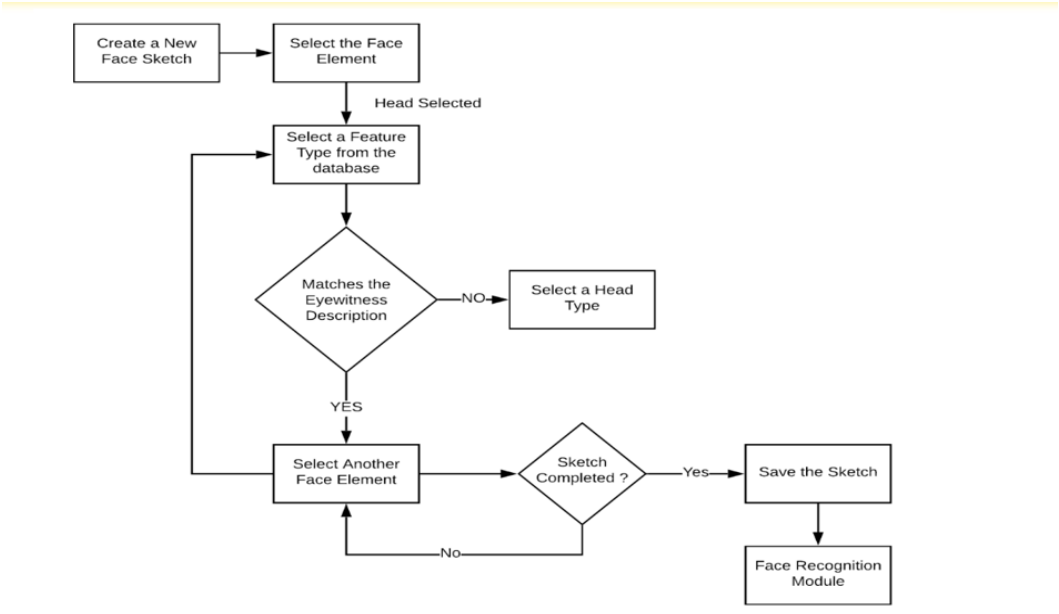

Fig 3: Flowchart of Sketch Creation

facial sketch based on eyewitness descriptions. It starts with the action "Create a New Face Sketch, initiating the sketching process. Following this, the next step, "Select the Face Element," prompts the user to choose which part of the face to work on first, beginning with the head.

Once the "Head Selected" step is reached, the user is directed to "Select a Head Type," where they choose a specific head shape or style from a database. Next, the user moves to "Select a Feature Type from the Database," allowing them to choose individual facial features, such as eyes, nose, or mouth, that match the general facial structure they are building.

The next decision point, "Matches the Eyewitness Description?" checks if the chosen feature aligns with what the eyewitness described. If the feature does not match (indicated by "No"), the flow loops back to "Select a Feature Type from the Database," allowing the user to pick another option. If the feature does match (indicated by "Yes"), the process advances to "Select Another Face Element, where the user can pick a new part of the face to design, restarting the cycle of selection and matching.

After each new element is added, the user reaches the decision point "Sketch Completed?" which checks if the entire sketch is finished. If the sketch is not complete (marked "No"), the user is directed back to select another face element and continues building. Once the sketch is fully completed (marked "Yes"), the user is instructed to "Save the Sketch."

Finally, the saved sketch is sent to the "Face Recognition Module" for further analysis or recognition. This systematic approach ensures that each feature is selected and verified against the eyewitness description, producing a detailed and accurate facial sketch.

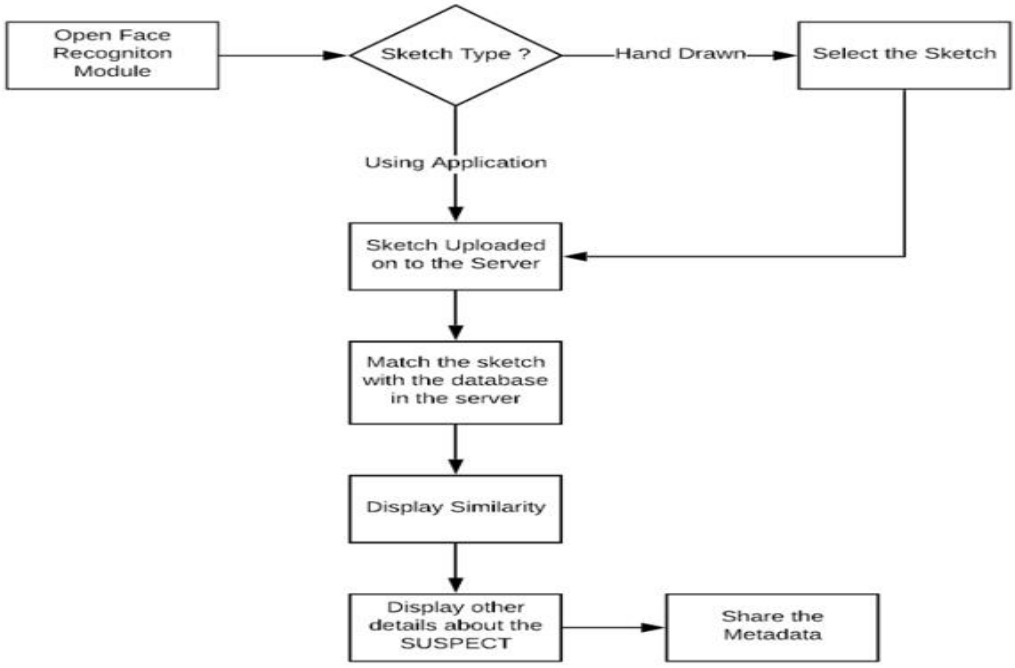

Fig 4: Flowchart of Recognition Sketch

This flowchart details the process of recognizing a facial sketch using a face recognition system. It begins with the "Open Face Recognition Module," where the user initiates the recognition process. The next step, "Sketch Type?" determines if the sketch is hand-drawn or created using an application. If it is hand-drawn, the user proceeds to "Select the Sketch," choosing the appropriate file or image of the sketch.

If the sketch is created using an application, it is directly "Uploaded onto the Server." Once the sketch is uploaded, the system proceeds to "Match the sketch with the database in the server," where the sketch is compared with existing records in a database to find potential matches. After the matching process, the system moves to "Display Similarity," where it shows the degree of similarity between the uploaded sketch and any matching records.

Following the similarity display, additional information about the identified person or suspect is shown in "Display other details about the SUSPECT." Finally, the option to "Share the Metadata" allows the user to share relevant metadata (such as timestamps, location, or related case details) associated with the recognition results, facilitating further processing or sharing with other stakeholders. This flowchart outlines a streamlined process for identifying and sharing information about a person based on a facial sketch.

VI. FUTURE SCOPE

The IDENTIFEYE project has significant potential for future enhancements and expansion to better serve law enforcement agencies. One possible improvement is integrating 3D facial reconstruction techniques, enabling the system to create more lifelike and detailed sketches that can be matched with both static images and live video feeds. This would be especially useful in identifying suspects from CCTV footage or other surveillance systems, broadening the application's utility in real-time crime prevention.

Additionally, the platform can be enhanced to leverage social media data for suspect identification. By connecting with publicly available data sources, the system could potentially match facial sketches with profiles on social networks, helping to trace individuals more efficiently.

VII. EXPECTED RESULT AND CONCLUSIONS

The anticipated result of this system is a reliable and efficient tool that enhances the process of forensic sketch construction and recognition for law enforcement. The platform aims to achieve an accuracy rate of over 90% in matching sketches to database images, along with a user-friendly experience that minimizes training requirements. The security features, including machine locking and two-step verification, are expected to maintain high standards of data privacy and ensure only authorized users can access the application. By centralizing the usage on a secure network, the system aims to protect sensitive data and reduce the risk of unauthorized access.

During testing, the platform demonstrated promising results with a high confidence level in both accuracy and speed of recognition, making it well-suited for use in real-world criminal identification. The innovative drag-and-drop interface combined with cloud infrastructure allows for quick access to database matches, significantly reducing the time required for sketch creation and suspect identification. Furthermore, backward compatibility with hand-drawn sketches extends the system's usability to include historical data, thereby increasing its effectiveness and utility.

In conclusion, this system represents a significant advancement in forensic technology by providing law enforcement agencies with a powerful tool for suspect identification. With features such as deep learning-based suggestion tools, secure access, and ease of use, the platform bridges traditional sketch methods with modern recognition technology, offering a practical and scalable solution. Future enhancements, such as integration with live CCTV feeds and social media data, can further improve the system's scope and accuracy, making it an indispensable resource in forensic investigations.

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