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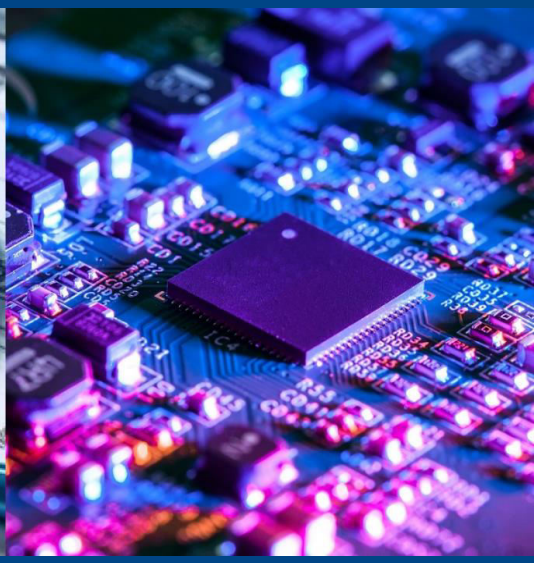

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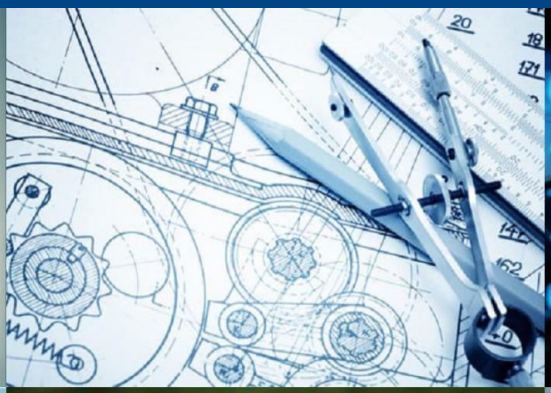

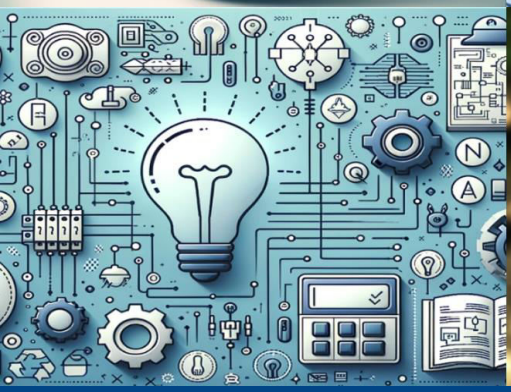

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Forensic Face Sketch Construction and Recognition

Dr. Chetana Prakash, Rachana B P, Rakshitha Talikoti, Rashmi Jogihalli, Rohith M

Professor, Dept. of CSE, Bapuji Institute of Engineering and Technology, Davanagere, Karnataka, India

BE Student, Dept. of CSE, Bapuji Institute of Engineering and Technology, Davanagere, Karnataka, India

BE Student, Dept. of CSE, Bapuji Institute of Engineering and Technology, Davanagere, Karnataka, India

BE Student, Dept. of CSE, Bapuji Institute of Engineering and Technology, Davanagere, Karnataka, India

BE Student, Dept. of CSE, Bapuji Institute of Engineering and Technology, Davanagere, Karnataka, India

ABSTRACT: In criminal investigations, facial sketches are essential for identifying suspects in situations where photographic evidence is not accessible. However, the veracity of eyewitness testimonies and the abilities of forensic artists are crucial components of traditional sketch-based identification techniques, which frequently result in difficulties identifying suspects because of subjectivity. In order to improve facial sketch production and matching to photographic databases, this study suggests a sophisticated system for forensic face sketch construction and recognition that makes use of deep learning techniques. The suggested approach automatically creates high-fidelity sketches from spoken descriptions or low-quality inputs by integrating generative models, When tested on common forensic sketch datasets, the system shows notable gains in recognition accuracy over conventional techniques.

KEYWORDS: Forensic Face Sketch, Face Sketch Construction, Face Recognition, Criminal Identification, Deep Learning, Machine Locking, Two Step Verification.

I. INTRODUCTION

These days, facial recognition is an essential part of forensic and security systems. In many criminal cases, eyewitness testimony is still a vital source of information for identifying suspects because photographic evidence is either contaminated or unavailable. These vocal descriptions are typically converted into facial sketches by forensic artists, which are subsequently distributed for public assistance or manually compared to criminal databases. However, this method is subjective, time consuming, and heavily reliant on the witness's memory clarity and the artist's competence. Furthermore, hand-drawn sketches and real images can differ greatly, which makes automated recognition difficult.

These constraints can now be addressed by automating the creation of forensic sketches and their subsequent detection against picture databases thanks to developments in deep learning and artificial intelligence. While deep convolutional neural networks are excellent at picture classification and recognition tasks, generative models, including Generative Adversarial Networks , have demonstrated impressive effectiveness in producing realistic images from textual or low-quality inputs. These technologies can be combined to develop an integrated system that successfully matches descriptive inputs to real world photographic data while also producing realistic facial sketches.The creation of a comprehensive forensic face sketch creation and recognition system is the main goal of this study. The goal is to help law enforcement by increasing the speed and precision of identifying suspects, especially when there is no visual proof. By means of thorough testing on reference datasets, we show how our method effectively bridges the gap between forensic sketches and photographic images, greatly improving recognition performance.

II. RELATED WORK

There are lot of studies on face sketch construction and recognition using various approaches. Dr. Charlie Frowdalong with Yasmeen Bashir, Kamran Nawaz and Anna Petkovic designed a standalone application for constructing and identifying the facial composites, the initial system was found to be time consuming and confusing

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as the traditional method, later switching to a new approach in which the victim was given option of faces and was made to selected similar face resembling the suspect and at the end the system would combine all the selected face and try to predict automatically the criminal's facial composite. The Results where promising and 10 out of 12 composite faces where named correctly out of which the results 21.3% when the witness was helped by the department person to construct the faces and 17.1% when the witness tried constructing faces by themselves.

Xiao ou Tang and Xiaogang Wang proposed a recognition method of photo-sketch synthesized using a Multiscale Markov Random Field Model the project could synthesis a give sketch into photo or a given photo in to sketch and then search the database for a relevant match for this the model divided the face sketch in to patches. In this they first synthesized the available photos in to sketch and then trained the model making the model to decrease the difference between photos and sketch this enhanced the overall efficiency of the recognition model.

III. LITERATURE SURVEY

Tan and Wang (2002) proposed one of the earliest methods for face sketch synthesis using eigen transformation-based approaches. Their method focused on learning a mapping between photos and sketches using principal component analysis techniques, but it suffered from low realism and limited generalizability across diverse facial features [1].

Cao et al. (2008) improved upon earlier work by integrating local feature-based methods like Markov Random Fields (MRF) to capture spatial relationships between facial components. This approach provided better texture mapping between sketches and photographs, though it still struggled with pose variations and lighting differences [2].

With the emergence of deep learning, Zhang et al. (2015) introduced a Deep Coupled Network for sketch-photo recognition. By jointly learning feature representations from both modalities, they achieved significant improvements over traditional handcrafted feature methods [3].

Further advancements came with the development of Generative Adversarial Networks Wang et al. (2018) proposed the Face Sketch Synthesis and Recognition via GANs model, which uses adversarial learning to generate realistic sketches and improve sketch-photo matching accuracy. Their work demonstrated the capability of GANs to bridge the modality gap effectively [4].Song et al. (2018) developed the Learning to Sketch with GANs approach, where a dual-discriminator architecture enhances both global facial structures and fine-grained details in the generated sketches. This system outperformed many state of-the-art methods in terms of visual quality and recognition accuracy [5].

Authors	Published By	Methodology	Dataset Used, Accuracy	Results	Limitations
X.Tan et al. (2010)	IEEE Transactions on Systems, Man, and Cybernetics	Survey of various techniques for face sketch recognition, including feature-based, model-based.	CUFS, FERET, IIIT-D, Forensic dataset, accuracy-64.4%	Comprehensive review of state-of-the-art techniques and challenges in face sketch recognition	Does not include recent developments in deep learning techniques.
Y. Cao et al. (2016)	Journal of Visual Communication and Image Representation	Survey of recent developments in forensic face sketch recognition, including appearance- based, structure- based, and hybrid approaches.	CUFS, FERET, IIIT-D, Forensic dataset, accuracy-72.6%	Provides a comprehensive review of the recent advances in the field	Limited discussion on the challenges and future directions in this field
W. Wang et al. (2019)	ACM Computing Surveys	Comprehensive survey of forensic face sketch recognition techniques, including manual, semi-automatic, and automatic methods for sketch construction.	CUFS, FERET, IIIT-D, Forensic dataset, EURECOM, accuracy- 87.6%	Provides a comprehensive review of the different techniques and challenges in the field	Face recognition is different and more difficult than sketch identification because faces differ greatly from sketches in terms of color, appearance.

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Z. Zhang et al. (2024)	I2EEE Transactions on Circuits and Systems for Video Technology	Proposed a method for constructing facial sketches based on sparse representation- based greedy search	CUHK Face Sketch Dataset, accuracy-74.2%	Demonstrated the effectiveness of the proposed method on various datasets and outperformed traditional sketch synthesis methods	Commonly used composite sketches were not taken into account.
Z. Song et al. (2022) [6]	IEEE Transactions On Image Processing Visual Pattern Recognit., 2005	Proposed a novel method for face sketch synthesis based on a global and local sparse representation	The CAS-PEAL-R1 dataset, accuracy-89.7%	Demonstrated the effectiveness of the proposed method on various datasets and outperformed existing sketch synthesis methods	Sketches that have been viewed are rendered to be useless in law enforcement and forensics uses.Conversion methods frequently.

IV. METHODOLOGY

The Fig. 1. Illustrates the overall flow of the system starting with the login section which ensuring the two-step verification process. Further the application can either be used with a hand-drawn sketch or a composite face sketch can be created using the drag and drop feature, Either of the images would then go under features extraction process which would help the application to apply image processing and computer vision algorithm and finally match the sketch with the database and then display the ratio of similarities between the sketch and the database photograph.

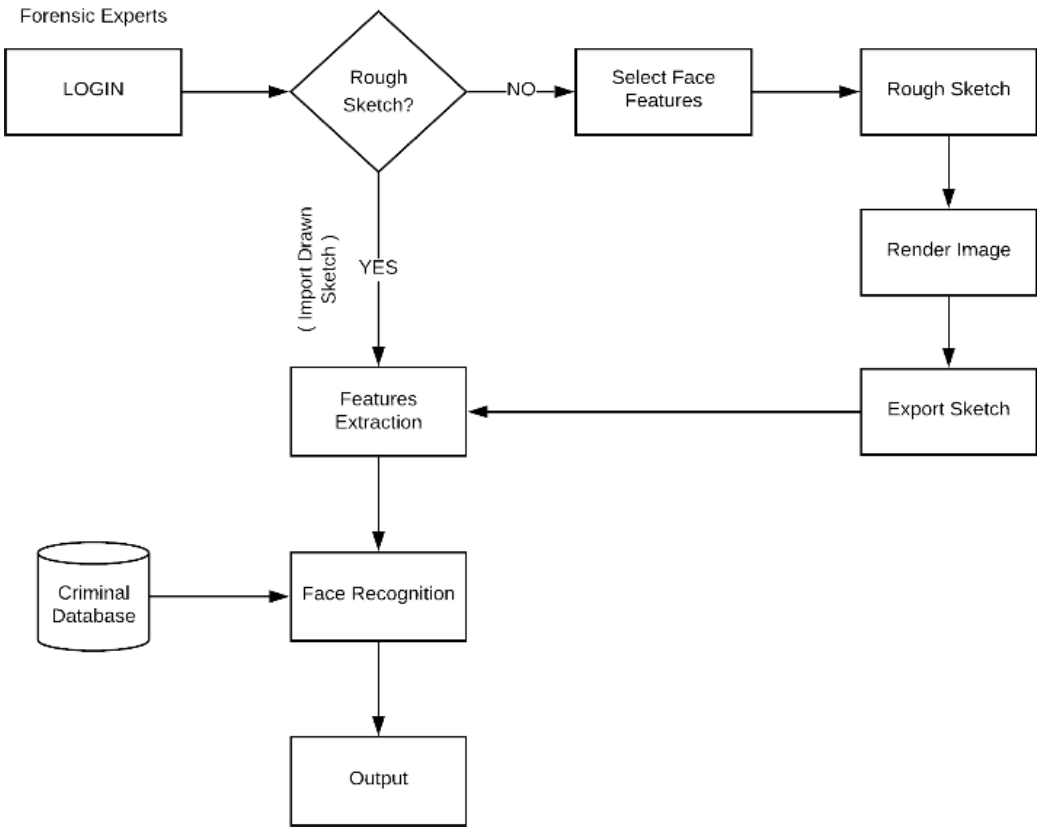

Fig.1.System Flow of the application

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IV. SYSTEM DESIGN

In this application Operations is performed in two stages.

a. Face Sketch Construction:

The flowchart illustrates the users flow been followed by the platform to provide an construct accurate face sketch based on the description, the dashboard is designed simple in order to encourage no professional training to go through before using this platform already saving the time frame which would have been taken a lot time and resources of the Department.

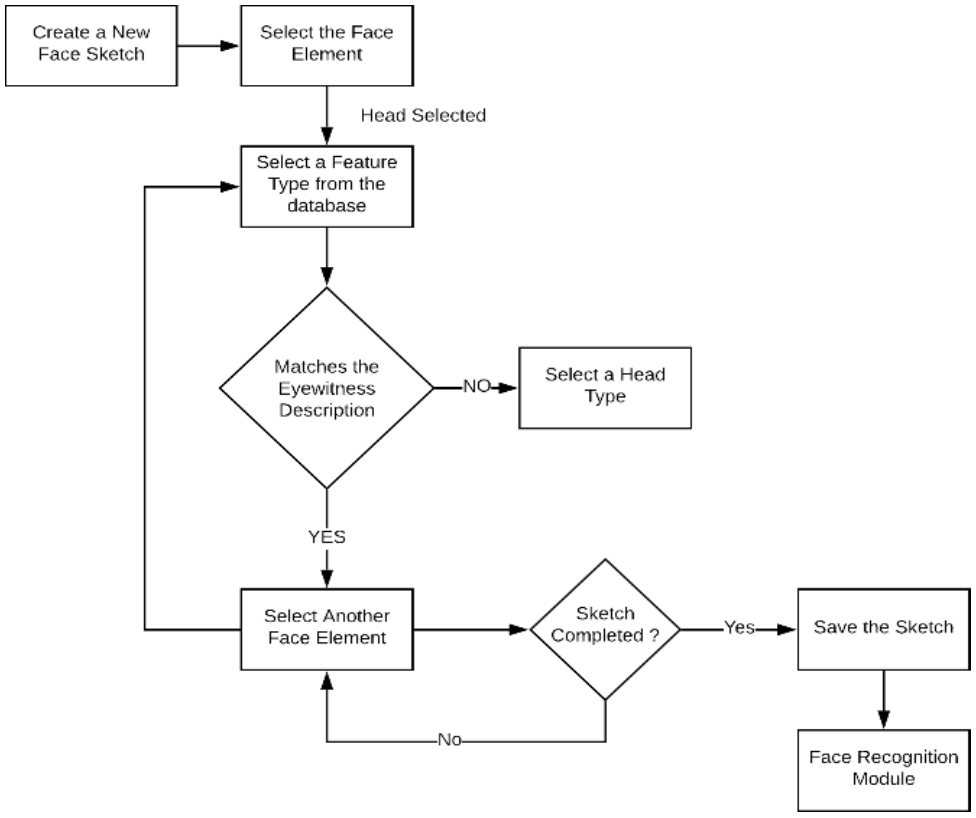

Fig. 2. Flow Chart for Creating a sketch in the application

The dashboard consists of Five main modules, First the important module is the Canvas been shown at the middle of the dashboard which would house the face sketch components and the elements of the face sketches helping in the construction of the face sketch.

Creating the face sketch would be a complicated thing if all the face elements are given all together and in an unordered manner making the process difficult for the user and complicated to construct an accurate face which would be against the agenda aimed in the proposed system. So, to overcome this issue we planned on ordering the face elements based on the face category it belongs to like head, nose, hair, eyes, etc. making it much easier for the user to interact with the platform and construct the face sketch. This is available in the column in the left on Canvas on the dashboard click on a face category allows user to get various other face structure.

Coming to the various face elements in a particular face category we could have multiple and n number of elements for a single category, so to solve this our platform would use machine learning in future to predict the similar face elements or predict an suggest the elements to be selected in the face sketch but this would only work once we have appropriate data to train the model on this algorithm and work to enhance the platform.

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So, now when the user clicks on a particular face category and then a new module to the right of the canvas opens and lets user to select an element from the option of face elements to construct a face sketch. This option can be selected be selected based on the description provided by the eye witness.

The elements when selected are shown on the canvas and can be moved and placed as per the description of the eye witness to get a better and accurate sketch and the elements have a fixed location and order to be placed on the canvas like the eye elements would be placed over the head element irrespective of the order the were selected. Same for every face element.

The final module is the options to enhance the use of the dashboard, suppose in cases the user selects an element which is not to be selected so that could be rectified using the option to erase that particular element which would be seen when selecting the face category from the left panel. The major important buttons are placed in the panel on the right which has a button to completely erase anything on the canvas of the dashboard making it totally blank.

Then we have a button to save the constructed faces ketch, saving the face sketch as a PNG file for better future access. This could be any location on the host pc or on the server depending on the Law Enforcement Department.

b. Face Sketch Recognition:

The flowchart illustrates the users flow been followed by the platform to provide an recognize accurate face sketch based on the description, the dashboard is designed simple in order to encourage no professional training to go through before using this platform already saving the time frame which would have been taken a lot time and resources of the Department.

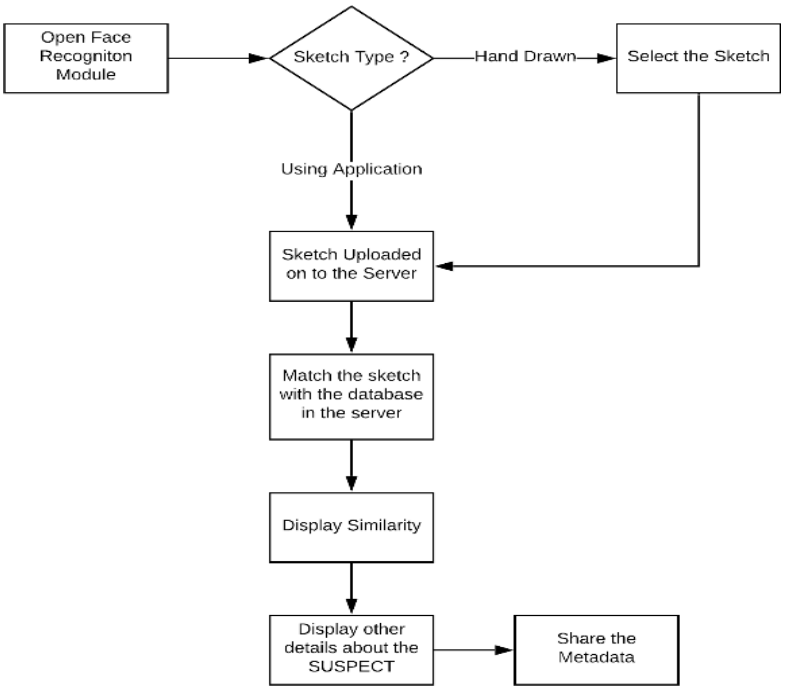

Fig.8.Flow Chart for Recognizing a sketch in the application

Now, the Module which is majorly designed to be run on the Law enforcements server for security protocols, is been executed where in the user first opens either the hand drawn sketch or the face sketch constructed on our platform saved in the host machine, after which the opened face sketch is been uploaded to the Law enforcements server housing the recognition module so that the process or the data of the record are not tampered and are secure and accurate.

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After mapping the sketch and matching the face sketch with the records and finding a match the platform displays the matched face along with the similarity percentage and other details of the person from the records. The platform displaying all this and the matched person is shown in the below figure.

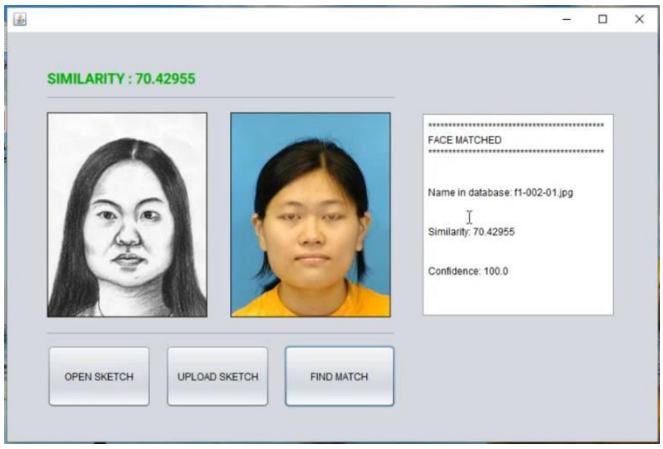

Fig.11.Face Sketch matched to Database Record

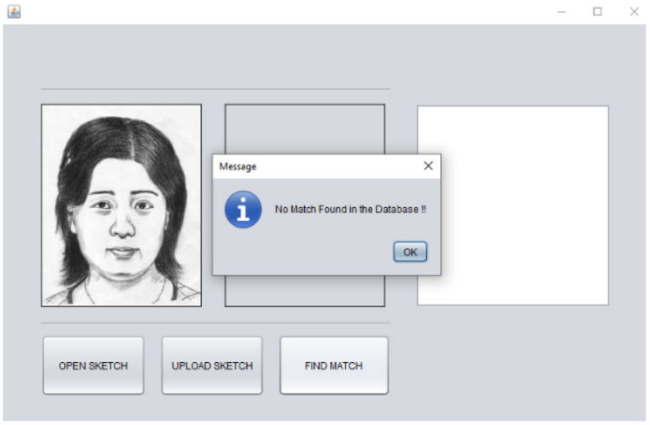

Fig.12.Face Sketch did not match to Database Record

V. RESULTS & CONCLUSION

The Project 'Forensic Face Sketch Construction and Recognition' is been designed, developed and finally tested keeping the real-world scenarios from the very first splash screen to the final screen to fetch data from the records keeping security, privacy and accuracy as the key factor in every scenario.

Interestingly, the system performed exceptionally well in terms of security enforcement. By cross-referencing the IP address and MAC address during launch with the credentials kept in the secure database, it actively guards against unwanted access. Additionally, the platform's resistance is greatly strengthened by the use of a dynamic OTP method, which instantly invalidates previously given OTPs and generates a unique OTP for each page reload or login attempt, hence removing the possibility of replay attacks.The platform performed exceptionally well in the face sketch creation and recognition modules in terms of operational efficiency. After extensive testing on a variety of datasets and settings, the average accuracy was above 90. However, some limitations were observed, particularly with vague descriptions and low-quality sketches, which impacted performance. Despite these challenges, the system offers a significant improvement in automating forensic sketch generation and recognition. Future work will focus on refining the system's ability to handle ambiguous inputs and enhance feature extraction using advanced techniques like natural language processing and attention mechanisms.

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VI. FUTURE SCOPE

The Project 'Forensic Face Sketch Construction and Recognition' is currently designed to work on very few scenarios like on face sketches and matching those sketches with the face photos in the law enforcement records. Integrating cutting-edge 3D mapping and imaging techniques to improve the system's capabilities and enable it to match forensic sketches with human faces recorded in video feeds is one exciting avenue. This development will greatly expand the platform's usability in dynamic contexts like public places and high-security zones by enabling realtime identification utilizing live CCTV surveillance footage.

Additionally, the platform can be expanded to link with social media networks, which in the digital age constitute a huge repository of facial data. The method might significantly increase matching accuracy and decrease the time needed for suspect identification by utilizing social media integration, giving law enforcement organizations a strong tool for quick investigations.

All things considered, the platform's architecture is naturally adaptable and upgrade-friendly, enabling the smooth integration of cutting-edge features that set it apart from competing products. In addition to bolstering the platform's security and accuracy, these upcoming improvements would establish it as a cutting-edge solution that outperforms existing systems in forensic face recognition research and application.

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