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Face Authentication using MTCNN and FaceNet

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Abstract: The realm of facial recognition technology is witnessing a surge in advancements, thanks to the strides made in deep learning methodologies and the availability of expansive training datasets. Nevertheless, its practical implementation for authentication purposes encounters hurdles in real-world settings marked by variations in facial poses, angles, lighting conditions, and potential obstructions. To tackle these obstacles, this paper introduces an innovative deep learning API that amalgamates the functionalities of MTCNN and FaceNet. By leveraging MTCNN for precise face detection and FaceNet for extracting facial features, the API employs a two-step verification process. FaceNet facilitates the mapping of facial images into a compact Euclidean space, where spatial distances directly correlate with facial similarity, subsequently storing this data securely within a MongoDB database. Utilizing the Deep Face model developed by Facebook's AI research team, the system achieves remarkable accuracy in user verification. This API not only enhances user authentication but also optimizes the user experience, thereby mitigating the risk of unauthorized access. While acknowledging areas for potential improvement, this paper offers a comprehensive summary of its findings and delves into the challenges lying ahead.

Keywords: **Facial recognition, deep learning, MTCNN, FaceNet, MongoDB, authentication, Deep Face model, user verification.**

I. INTRODUCTION

In today's digital landscape, the importance of robust authentication systems cannot be overstated. Conventional methods like passwords and email verifications are increasingly vulnerable to sophisticated cyber threats. Recognizing this growing challenge, our research project sets out to develop an advanced authentication system by harnessing the potential of facial recognition technology.

Our approach involves integrating Multi-Task Cascaded Convolutional Networks (MTCNN) for precise face detection and FaceNet for accurate facial feature extraction. This two-step verification process not only strengthens security but also enhances user experience. Facial recognition technology offers a unique and biometrically secure method of authentication. MTCNN, known for its effectiveness in detecting facial landmarks, forms the foundational stage of our system. Following this, FaceNet, a cutting-edge deep learning model developed by Google, maps facial features into a compact Euclidean space, generating a reliable and distinctive representation for each individual. By combining these technologies, we aim to address the weaknesses of traditional authentication methods and significantly enhance security measures.

Our project delves into the nuances of facial recognition, grappling with challenges such as variations in facial expressions, poses, and lighting conditions. Through a thorough examination of MTCNN and FaceNet, we aim to uncover their combined potential in creating an authentication system that balances accuracy, efficiency, and user-friendliness. The insights gained from our research contribute not only to the academic understanding of biometric security but also offer practical guidance for implementing facial recognition-based authentication systems in real-world scenarios.

As we delve into our research methodology and literature review, our paper strives to provide a comprehensive overview of our endeavors. We aim to highlight the progress made and the challenges faced in our quest for a more secure digital environment.

II. PROPOSED MODEL

The proposed model integrates MTCNN for precise face detection and FaceNet for high-dimensional facial embeddings, enabling robust and efficient facial recognition-based authentication. This fusion ensures accurate verification under challenging conditions, offering a seamless and secure authentication experience while facilitating easy integration into existing systems.

1) MTCNN (Multi-task Cascaded Convolutional Neural Network):

1st Stage: This stage employs a fully convolutional network without any fully connected layers. It utilizes convolutional layers with a kernel size of 12x12 to create boundary boxes around detected faces. The objective is to identify potential face regions in the input image.

2nd Stage (R-Net): The second stage aims to reduce the number of boundary boxes generated in the previous stage. It applies further processing to refine the candidate face regions and discard redundant boxes with large overlaps.

3rd Stage (Output Network): In the final stage, only one boundary box is retained per detected face region. This stage also predicts facial landmarks, such as the positions of eyes, nose, and mouth, within the detected faces.

2) FaceNet:

Architecture: FaceNet utilizes a 22-layer deep neural network architecture for facial feature extraction. It is trained using a triplet loss function, which compares triplets of images: an anchor image (belonging to the same person), a positive image (also belonging to the same person), and a negative image (belonging to a different person). The objective is to learn embeddings that minimize the distance between embeddings of the anchor and positive images while maximizing the distance between embeddings of the anchor and negative images.
Triplet Loss Function: The triplet loss function ensures that embeddings of the same person's face are closer together in the embedding space compared to embeddings of different individuals. This helps in learning discriminative features for face recognition.

3) MongoDB:

User Collection: MongoDB contains a collection dedicated to storing user information, such as usernames, passwords, and other relevant details.
Embedding Collection: Another collection within MongoDB is used specifically for storing facial embeddings generated by FaceNet. Each document in this collection may contain the embedding vector along with metadata associated with the corresponding user or image.

III. BLOCK DIAGRAM OF THE PROPOSED MODEL

Given below is the block diagram of the proposed model:

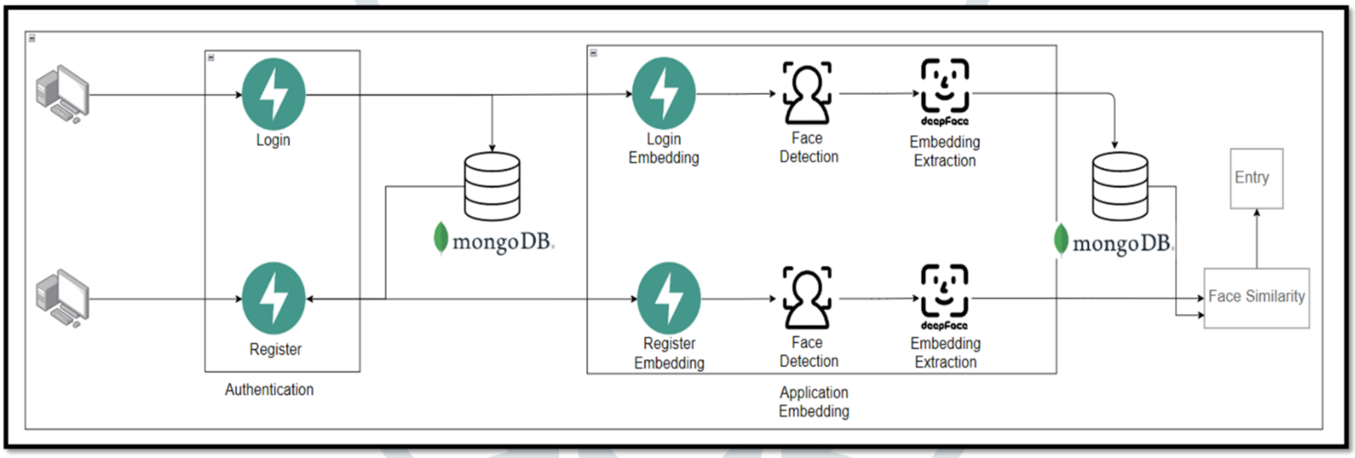

Figure 1: Block Diagram of the Proposed Model

1) User Login:

This component verifies the user's embedding during login. It identifies the user's face from the provided image, generates embeddings, matches them with the stored embeddings in the database, and confirms the user's identity by assessing cosine similarity.

2) User Registration:

This module saves the user's embedding during registration. During registration, it computes embeddings from the provided images, computes the average embedding (if multiple images are available), and persists this data in the database for subsequent authentication.

3) MongoDB Client:

This functionality handles the MongoDB connection and data access for user-related information. It initializes the MongoDB client with the specified URL, establishes connectivity with the MongoDB database, and ensures a single client instance throughout the application's lifecycle. This interface facilitates interaction with the MongoDB database housing user data.

IV. ALOGRITHM USED IN THE PROPOSED MODEL

The algorithm used in the proposed model is a combination of Multi-task Cascaded Convolutional Networks (MTCNN) and the FaceNet model.

1) MTCNN (Multi-task Cascaded Convolutional Networks):

This algorithm is employed for precise face detection. It consists of three stages: face detection, bounding box regression, and facial landmark localization. MTCNN is known for its robustness and accuracy in detecting faces under various conditions, including different poses, scales, and occlusions.

2) FaceNet:

After face detection, the FaceNet model is utilized for facial feature extraction. FaceNet employs deep convolutional neural networks (CNNs) to directly map facial images into a compact Euclidean space, where spatial distances directly reflect facial similarity. This embedding space enables accurate comparison and recognition of faces based on their unique features.

By combining MTCNN for face detection and FaceNet for feature extraction, the proposed algorithm ensures precise identification of individuals, even in challenging scenarios with variations in facial poses, angles, lighting conditions, and potential obstructions.

V. EXPERIMENTAL RESULTS

A) User Interface of the Developed GUI

1) Initial Access

- Access the application via the browser (localhost).
- The user initiates the registration process.

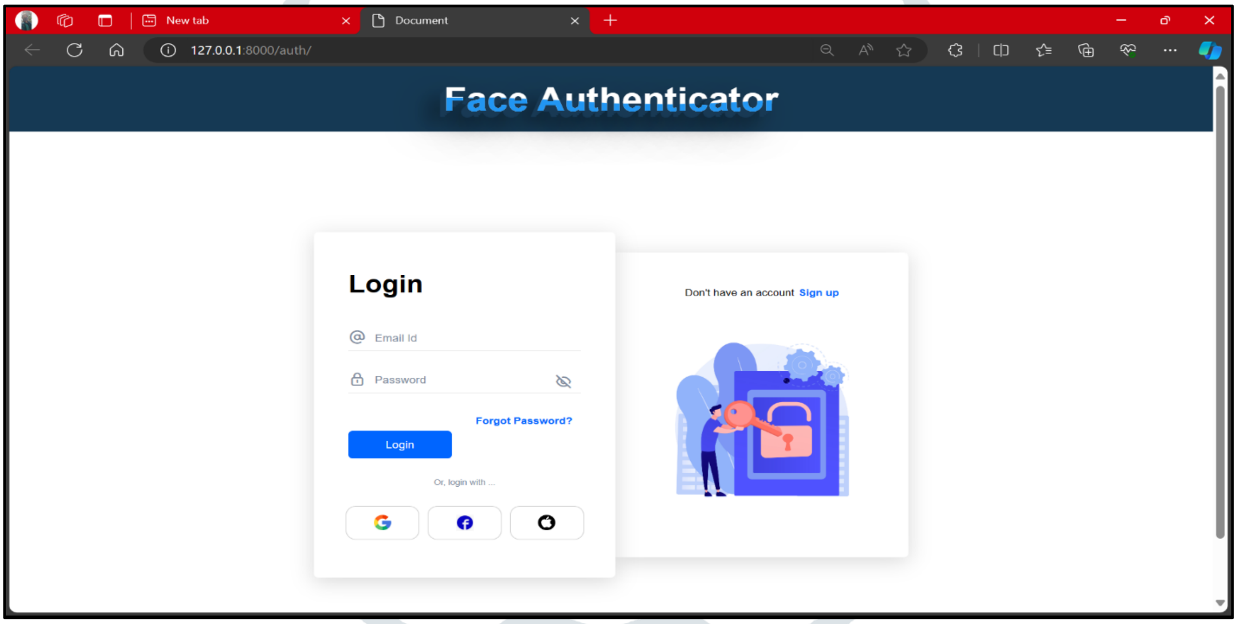

Figure 2: Login Page

- Application Overview – Web-App Initialization

2) Registration

- User proceeds with the registration, providing necessary details.
- Camera access is granted for capturing 8 images.
- The captured images are stored as part of the user's registration in MongoDB.

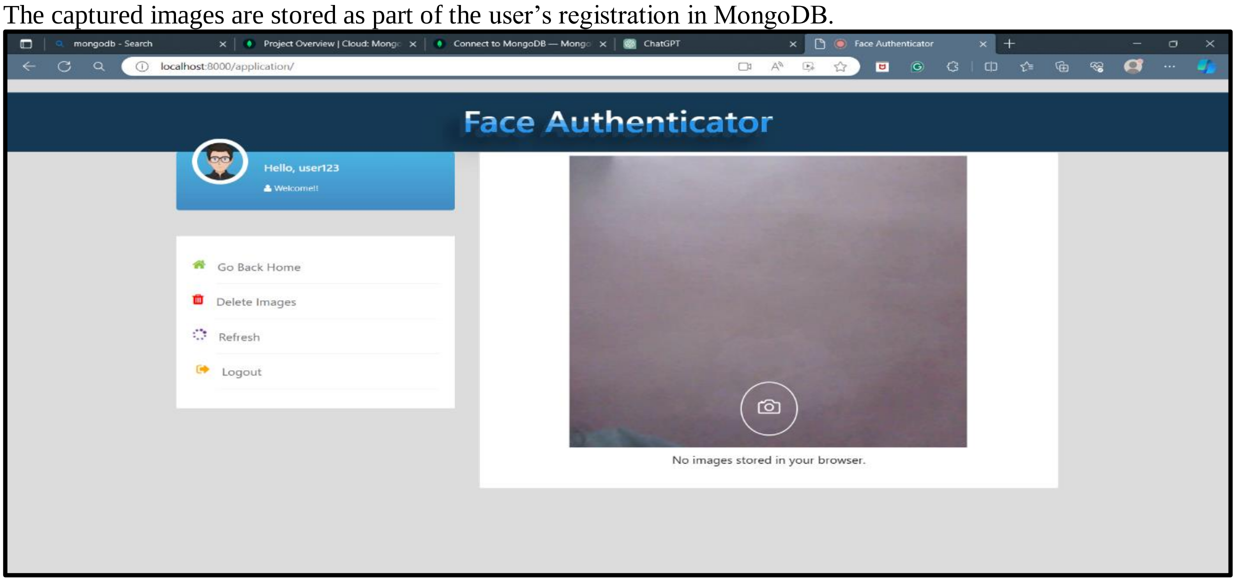

Figure 3: Camera Activation

- Camera Activation – Registration Embedding

- Collecting Images after Camera Activation

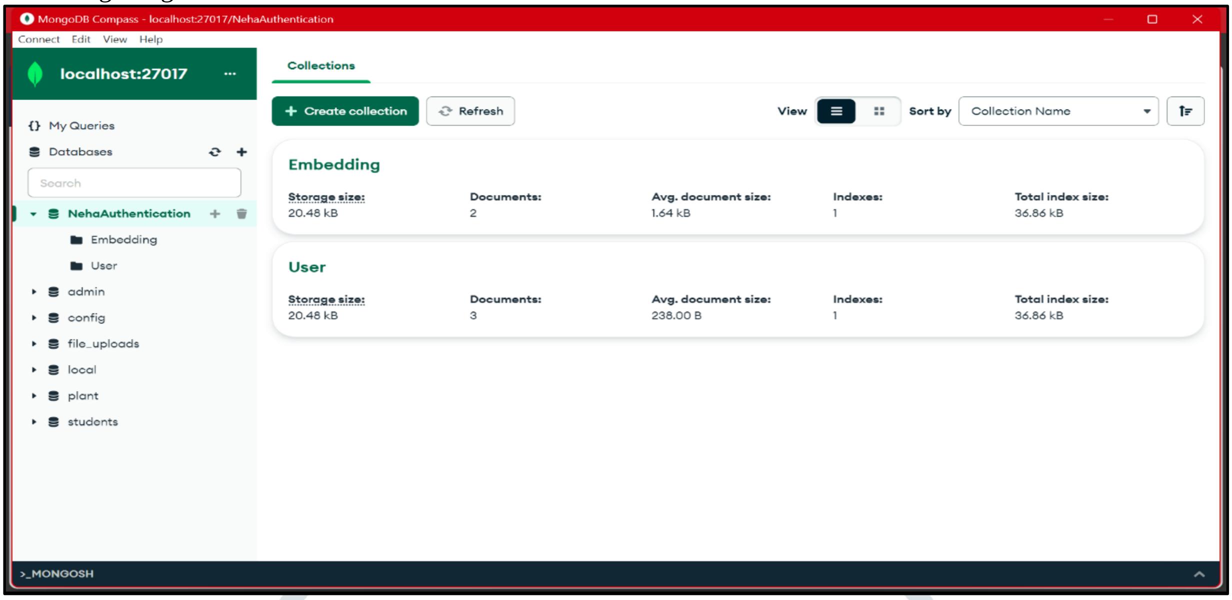

Figure 4: MongoDB Embedding

- View MongoDB Embedding Information
- Generating Embedding in the Backend

3) Login

- Once registered, the user logs into the system using their username and password.

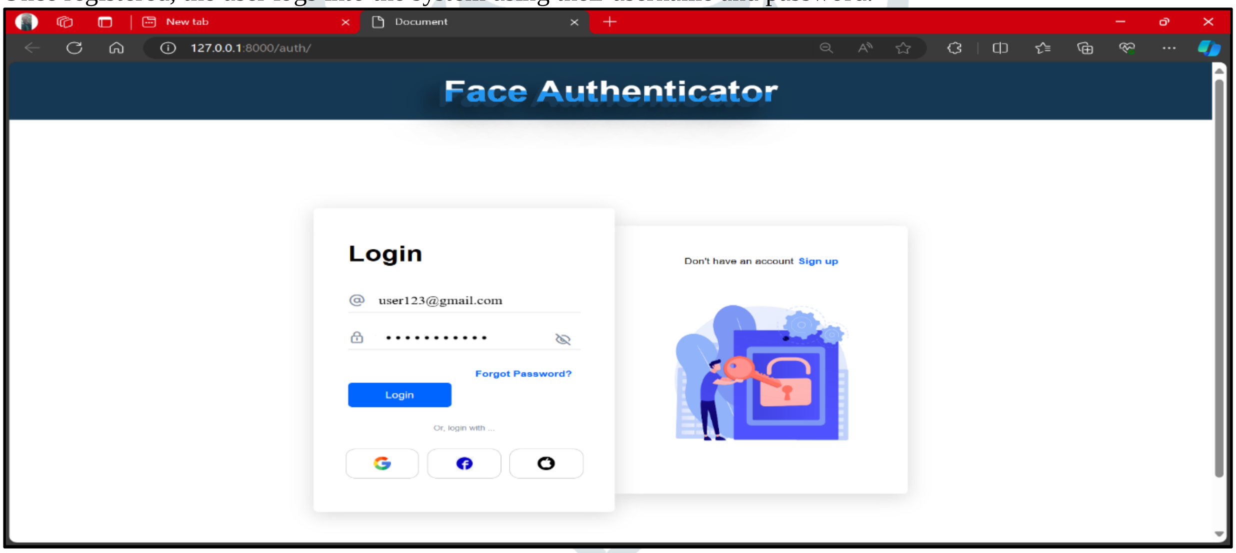

Figure 5: Login with Username and Password

- Application Overview – Web-App Initialization

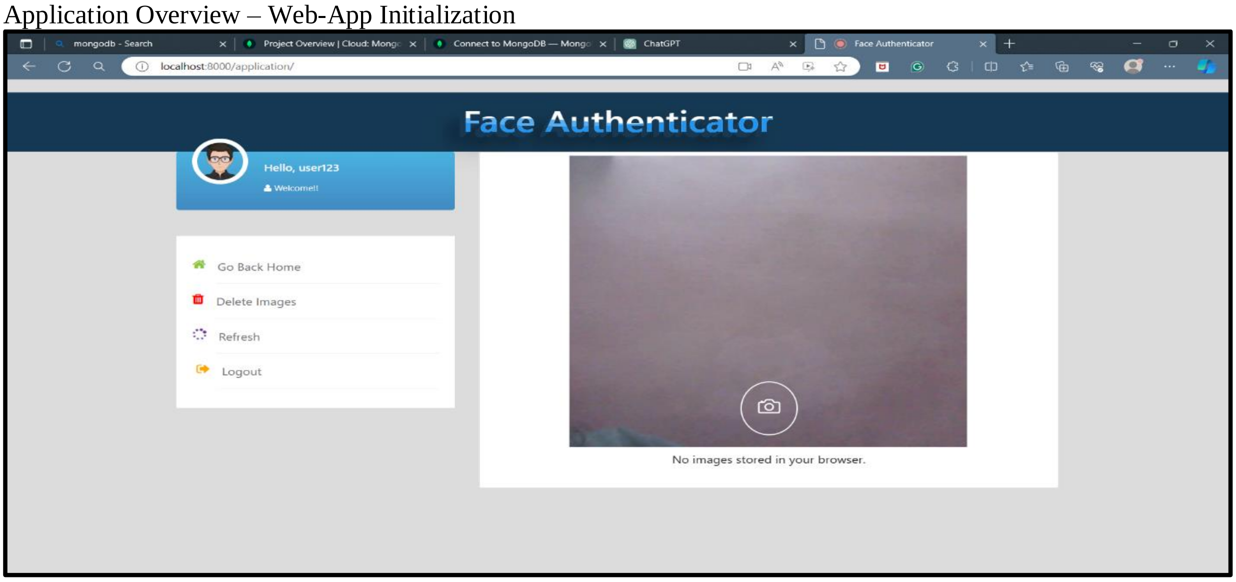

Figure 6: Login Camera

- Setting Up the Login Camera

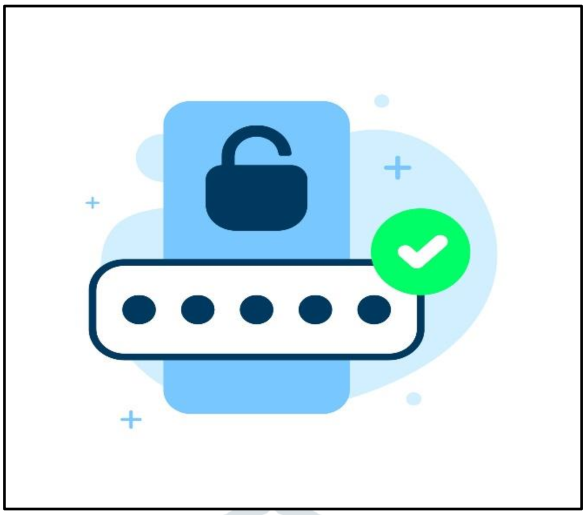

Figure 7: User Authentication Successful

- User Authentication Successful

B) Given Below is the result of the experiment

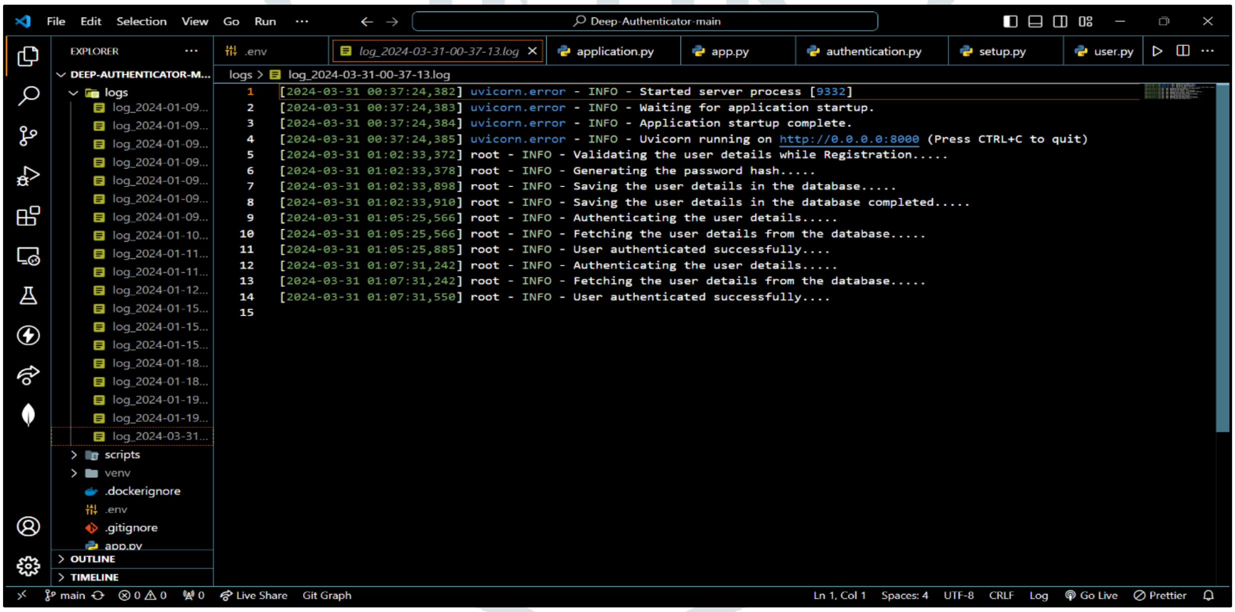

Figure 8: Results

VI. CONCLUSION AND FUTURE SCOPE

In the facial recognition process, two key steps involve image capture and similarity assessment. Initially, the system captures images, either during registration or login, by activating the camera. Subsequently, these images undergo processing by the backend to create unique embeddings, which are stored in a database such as MongoDB. During login, a new image is captured by the camera and compared against the stored embeddings. The backend then computes the cosine similarity, and if a match is identified, the user is authenticated. This method ensures secure access through facial recognition technology, employing a two-step approach. The future scope of the project includes integrating multi-factor authentication methods, implementing continuous learning mechanisms, enabling real-time updates, extending mobile integration, ensuring scalability, enhancing privacy, customization, and cross-platform compatibility features, thereby evolving into a comprehensive and adaptable solution to address evolving security needs and technological advancements.

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