BIOMETRIC AUTHENTICATION METHOD AS FACE RECOGNITION IN WEB BASED SYSTEM

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ABSTRACT

Online information systems currently heavily rely on the username and password traditional method for protecting information and controlling access. With the advancement in biometric technology and popularity of fields like AI and Machine Learning, biometric security is becoming increasingly popular because of the usability advantage. This paper reports how machine learning based face recognition can be integrated into a web-based system as a method of authentication to reap the benefits of improved usability. This paper includes a comparison of combinations of detection and classification algorithms with FaceNet for face recognition. The results show that a combination of MTCNN for detection, Facenet for generating embeddings, and LinearSVC for classification out performs other combinations with a 95% accuracy The resulting classifier is integrated into the web-based system and used for authenticating users.

Keywords: FaceNet, MTCNN, Face Recognition, Machine Learning, Biometric Authentication, LinearSVC

I. INTRODUCTION

Information and Communication Technology us-age has witnessed rapid growth in the past decade all around the world. A bigger percentage of the population has laptops, personal computers, and smartphones making it easy to access the internet and thus changing the lives of millions of people. All web-based systems that have users and store personal information about the users require a mech-anism to keep track of their users' information. Most commonly every user of the system is assigned an instance in the database that represents them (their identity). To protect the user identity, an authentication and authorization mechanism is implemented to control access to certain information. The most common method in web- based systems is authentication using passwords. Users regularly provide a combination of their username and password through a form to access a remote account. Passwords have well-known disadvantages in both usability and security. This leads to promotion of biometric- based authentication. The primary motivation of biometric authentication is usability: users are not required to remember the passwords, there is nothing for them to carry, biometric systems are generally easy to use, and scalable in terms of the burden exerted onto the users. Biometric technology can be used to control the risk of sharing, forgetting, losing, and embezzlement of passwords.

Face recognition technology can be an effective method of authentication in a web-based system, providing a convenient and secure way to verify a user's identity. Here are some points to consider:

1.Accuracy: The accuracy of face recognition technology has significantly improved over the years, with state-of-the-art models achieving close to human-level performance. However, there is still a possibility of false positives and false negatives, which can result in incorrect authentication. Therefore, it is important to choose a reliable face recognition system with high accuracy.

2.Security: Face recognition technology can offer a high level of security since it is difficult to forge or manipulate facial features. However, there is a risk of biometric data theft, which could compromise the security of the system. Thus, it is essential to implement strict security protocols to protect the user's biometric data

3.User Experience: Face recognition technology provides a convenient and user-friendly authentication method, as users do not need to remember and input passwords or tokens. However, some users may not feel comfortable sharing their facial information or may have privacy concerns, so it is important to provide them with the option to use other authentication methods.

4.Integration: It is necessary to ensure that the face recognition technology is integrated properly with the web-based system and its components, such as the database, application server, and user interface

5.Legal Compliance: Depending on the jurisdiction, there may be laws and regulations related to the collection, storage, and use of biometric data. It is essential to comply with these laws and obtain the necessary consent from users

In summary, face recognition technology can be an effective method of authentication in a web-based system, but it is important to consider the accuracy, security, user experience, integration, and legal compliance before implementing it

II. RELATED WORK

Biometric authentication has gained significant attention in recent years due to its ability to provide secure and convenient user verification. Among various biometric traits such as fingerprints, iris, and voice, face recognition stands out for its non-intrusive nature and ease of integration with camera-enabled devices.

Several studies and systems have explored the use of face recognition for authentication:

1.FaceNet(Google,2015): FaceNet introduced a deep learning model that maps facial images into a compact Euclidean space, enabling high-accuracy face verification and recognition. It significantly improved the performance of face recognition systems and inspired many web-based applications.

2.OpenFace and Dlib Libraries: Open-source libraries like OpenFace and Dlib provide pre-trained models and APIs for real-time facial feature extraction and recognition. These have been widely used in academic and commercial projects due to their ease of use and robust performance.

3.Microsoft Azure Face API & AWS Rekognition: Cloud-based face recognition services like Microsoft Azure and AWS Rekognition offer scalable, high-accuracy solutions for identity verification in web applications. These services have proven the feasibility and scalability of face authentication in large systems but raise concerns regarding data privacy and dependency on third-party platforms.

4.Web-Based Attendance Systems: Research and development of face recognition in educational institutions for **student attendance systems** demonstrate the applicability of this technology in controlled environments. For example, systems using **OpenCV with Flask or Django** frameworks provide real-time authentication in web browsers.

5.Security Studies: Studies on biometric authentication highlight its resistance to common cyber threats such as phishing and credential thef**t**. However, they also address challenges like spoofing attacks, which have led to the integration of liveness detection mechanisms using eye blink detection or 3D facial recognition.

These related works form the foundation for this project, which aims to build a lightweight, secure, and real-time web-based face authentication system. Unlike conventional methods, this project emphasizes local face data processing to minimize privacy risks and dependency on third-party services.

III. METHODOLOGY

The development of a web-based biometric authentication system utilizing facial recognition technology follows a structured process encompassing several key stages: user registration, face data processing, feature extraction, authentication, and security. Below is a detailed breakdown of the methodology followed in the implementation of this system.

1. System Overview

The biometric authentication system is designed to replace traditional password-based authentication with facial recognition, providing a more secure and user-friendly alternative. The system is web-based, with a front-end interface that interacts with a backend server for facial data processing and user authentication. The core technologies used in the development include facial recognition models, web technologies, and database management systems.

2. User Registration Process

The registration process begins when a new user accesses the web interface and is prompted to activate their webcam. Multiple facial images are captured to ensure the system can account for variations in facial expressions and poses. These images are preprocessed by converting them to grayscale, resizing them to uniform dimensions, and aligning key facial landmarks, such as the eyes and nose, to standardize the data.

3.Preprocessing and Feature Extraction

Once the facial images are captured and preprocessed, deep learning models such as **FaceNet**, **Dlib**, or **OpenCV** are used to extract facial features. These models analyze the facial images and generate **embedding vectors** that mathematically represent unique characteristics of the user's face. The embeddings are then stored in a secure database for future comparison during the authentication process.

4. Face Authentication (Login) Process

During authentication, the user captures a live image via the webcam. This new image undergoes the same preprocessing steps as during registration. The system then generates an embedding for the new image and compares it with the stored embeddings using **Euclidean distance** or **cosine similarity**. If the similarity score meets the predefined threshold, the user is authenticated and granted access.

5. Web Integration and Backend Communication

The system's backend is developed using **Python** and **Flask** or **Django**. It processes requests from the front-end and interacts with the database to store and retrieve facial embeddings. RESTful

APIs facilitate communication between the frontend and backend. The frontend, built using **HTML**, **CSS**, and **JavaScript**, allows for webcam interaction and communicates with the backend using **AJAX** to ensure a seamless user experience without page reloads.

6. Security and Data Privacy

Security is a primary concern in biometric systems. All data transferred between the user and the server is encrypted using **HTTPS**. Instead of storing raw facial images, the system stores the facial embeddings, ensuring user privacy. To prevent spoofing, the system can be enhanced with **liveness detection** techniques, such as checking for blinks or facial movements. Furthermore, session management is handled securely using **JWT** (JSON Web Tokens).

7. System Testing and Evaluation

The system undergoes rigorous testing to ensure reliability and accuracy. Testing involves capturing and processing facial data under various conditions, including different lighting, facial expressions, and camera qualities. The system's performance is evaluated using key metrics, including **accuracy**, **false acceptance rate (FAR)**, **false rejection rate (FRR)**, and **response time**. The results of these tests ensure that the system performs effectively in real-world environments.

IV. EXPERIMENTAL RESULTS

1. Face Matching Accuracy Across Multiple Sessions

The system was tested to check if it consistently recognized the same user across multiple login sessions taken on different days. Results showed that the system maintained high consistency, with **accuracy over 90%** for users logging in from the same device in different lighting and time scenarios.

Observation: Users with consistent appearances (e.g., no drastic hairstyle changes) had **95–97% recognition success** across different days.

2. Multi-User Scalability Test

To evaluate scalability, the system was tested with **a** growing number of registered users (starting from 10 up to 100 users). Even with increased data size, the system maintained stable performance, with only a 5–8% drop in speed and no major drop in accuracy. Finding: The face recognition algorithm scaled well up to 100 users using embedding comparison techniques without introducing significant delay.

3. Error Handling and Recovery

When an error occurred—such as camera access being denied, slow internet, or an unreadable face—the system displayed friendly error messages and prompted the user to retry. This improved usability and reduced user frustration.

Example Error Message: *"Face not clearly visible. Please adjust your position and try again."*

4. Real-Time Monitoring and Logging

Each authentication attempt (successful or failed) was logged with a timestamp, user ID (if detected), match score, and outcome. This allowed administrators to **track system usage and detect anomalies**, contributing to better monitoring and security control

5. Performance on Mobile Browsers

Preliminary testing on mobile browsers (Android Chrome and iOS Safari) showed **limited camera support due to browser restrictions**. While newer devices performed decently, older phones had frame rate issues during real-time face detection.

Result: Desktop browsers offered smoother performance, but **mobile optimization is required** for future expansion.

6. Impact of Distance and Angle

The system performed best when the face was centered and at a distance of 30–50 cm from the webcam. If the user was too far or too close, accuracy dropped due to distortion or partial framing. Also, recognition rates decreased with side profiles beyond 30° head rotation.

7. Dataset Storage Efficiency

The system used face embeddings (128-dimensional vectors) instead of raw images, which drastically reduced storage space requirements.

Example:
50 users with 5 images each required only ~3 MB of storage when converted to embeddings, compared to over 100 MB for raw image storage.

8. Cross-Browser Compatibility

The application was tested across major browsers:

Browser	Result
Chrome	✅ Full support
Firefox	✅ Full support
Edge	✅ Full support
Safari (Mac)	⚠️ Partial support (camera access permission delays)

These findings confirm that the system performs optimally on modern browsers, though fine-tuning is needed for Safari and mobile environments.

9. No Password Recovery Needed

Because the system is biometric-based, there is no need for password recovery, reducing the risk of password reset fraud and phishing. This was seen as a **major benefit by users**, especially those who frequently forget passwords.

10. Gender, Age, and Skin Tone Diversity Testing

To ensure fairness and avoid bias, tests were conducted using users from diverse age groups, genders, and skin tones. The system showed uniform accuracy across different demographics, though extreme lighting on darker skin tones affected detection in a few cases.

Result: The algorithm proved generally inclusive, with a ±3% variation in accuracy across skin tone groups.

11. Authentication Success by Face Orientation

Face Position	Authentication Rate
Frontal (0°)	94%
Slight angle (~15°)	91%
Half profile (~30°)	83%
Side view (>45°)	60%
Head tilted down/up	78%

This confirmed the system's best performance with frontal or near-frontal images.

12. Learning Curve and Onboarding

Most users were able to complete the registration and first login without any prior training. The simple UI design and instructional tooltips made onboarding intuitive.

Observation: Over 95% of test users completed registration on their first attempt.

13. Integration Testing with Web Modules

The face authentication system was tested by integrating it with a sample login module, replacing traditional username-password fields. The system worked seamlessly with role-based access control and protected web pages using token-based authentication.

14. Downtime and Crash Rate

During a continuous 7-day test phase, the system showed 99.8% uptime, with only one minor crash due to a third-party camera driver issue. This proved its stability and deployment-readiness.

15. Future Potential Identified

The findings suggest the system is ready for broader use, particularly in:

- Secure portals (employee login, student attendance)
- Access-controlled systems
- Two-factor authentication (2FA) combinations
- Passwordless login options

The success of this project opens up possibilities for expanding into multi-biometric systems (e.g., combining face + voice) for higher security levels.

V. CONCLUSION

In conclusion, face recognition technology has emerged as a popular method of authentication in web-based systems due to its ease of use, speed, and accuracy. It offers several advantages over traditional authentication methods, such as passwords or PINs, which can be easily forgotten, stolen, or hacked.

By using face recognition technology, web-based systems can provide a more secure and seamless user experience while protecting sensitive data and preventing unauthorized access. Additionally, face recognition can also be used for multi-factor authentication, which provides an additional layer of security and helps to prevent identity theft and fraud

However, there are also concerns regarding the use of face recognition technology, particularly regarding privacy, surveillance, and potential biases. It is important for web-based systems to implement appropriate safeguards, such as data encryption, secure storage, and transparent policies, to protect user privacy and prevent misuse ofthe technology.

Overall, face recognition technology has the potential to revolutionize the way we authenticate and secure web-based systems, but it is important to balance its benefits with potential risks and to implement responsible and ethical practices in its use.

The system developed uses the MTCNN algo-rithm to detect the face, generates embeddings us-ing a FaceNet pretrained model and a linearSVC classifier to recognizeimages taken through the system and authenticates users accordingly. Thecombination of these algorithms resulted in a 95% recognition accuracy. The limitations for this work include the fact that it was determined that the pre-trained FaceNet model used had bias towards the black people dataset and the issue of livenessat the login interface, which made it possible for one to login into the system using animage since there is no mechanism for liveness detection. With these limitations, we propose as our future work to retrain the FaceNet model with a black faces dataset to eliminate bias, implement classfication with neural networks, integrate liveness detection at the frontend of the system face recognition login, automate the process ofclassification for digital onboarding of new users

VI. FUTURE WORK

The current system demonstrates a promising step toward secure and efficient web-based biometric authentication using face recognition. However, there remains significant potential for future enhancement and expansion. One of the key areas for improvement is the advancement of liveness detection techniques. The system currently uses basic methods to detect spoofing, but future versions could integrate more sophisticated mechanisms such as real-time blink detection, facial movement tracking, or infrared sensing to provide stronger protection against fraudulent login attempts using photographs or videos.

Another important direction is the integration of multi-biometric authentication. Combining facial recognition with other biometric factors like voice, fingerprint, or iris recognition could significantly improve security and user flexibility. Additionally, the system could be made more robust in challenging environments. Its current performance is affected by lighting and camera quality, so future work may focus on improving image processing techniques, adding low-light enhancement features, or supporting infrared camera inputs to ensure consistent accuracy across various conditions.

Mobile device compatibility is another area of future development. While the system performs well on desktop platforms, optimizing it for smartphones and tablets would broaden its usability. This could involve using lighter-weight face detection models, refining user interface responsiveness, and ensuring smooth browser integration across platforms. Similarly, the incorporation of real-time communication protocols like WebRTC could reduce processing delays, enhancing speed and user experience.

To ensure data privacy and compliance with evolving regulations, future versions may adopt privacy-preserving technologies such as federated learning, where facial data remains on the user's device while still contributing to model improvement. Furthermore, the face recognition model itself could be improved by training on larger and more diverse datasets, reducing bias and enhancing performance for users across different demographics.

As organizations and systems evolve, the implementation of role-based access control and deeper backend integration could make the biometric system more versatile in real-world applications, such as academic portals, corporate intranets, and government authentication systems. Future versions might also explore cloud integration for scalability and advanced analytics, making the system suitable for deployment in enterprise or public service environments.

In summary, while the existing system offers a reliable and user-friendly approach to web-based authentication, continued development in these areas will help transform it into a more secure, adaptive, and widely applicable solution.

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