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Gesture-Based Password Authentication

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Abstract:

As user authentication moves beyond passwords, gesture-based biometrics have emerged as a promising alternative. This paper presents **GestureAuth**, a camera-only hand-gesture authentication system that uses **Media Pipe** for hand landmark tracking and **OpenCV** for live gesture verification. The system allows users to register a unique hand gesture and authenticate by performing it in front of a webcam. It extracts 21 hand landmarks, computes distance and angle features, and compares them with encrypted templates stored during registration. Authentication succeeds when the live gesture matches the stored template above a defined similarity threshold. The system supports both one-hand and two-hand gesture modes, with the latter providing stronger security. The results show that the proposed approach offers a secure, contactless, and password-free authentication method that works effectively under different lighting and positioning conditions.

Keywords — Gesture-based authentication, Computer vision, MediaPipe, OpenCV, Biometric security, Passwordless authentication

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I. INTRODUCTION

In the modern digital era, user authentication plays a crucial role in maintaining data privacy and system security. Traditional text-based password systems, although widely used, face serious issues such as password reuse, weak combinations, and vulnerability to phishing attacks. Users often choose simple passwords for convenience, making systems more prone to unauthorized access. In today's world of online services and interconnected platforms, a single compromised password can expose multiple accounts and lead to large-scale data breaches.

To address these problems, biometric authentication techniques such as **fingerprint**, **face**, and **iris recognition** have gained popularity. These methods identify users based on their unique biological traits, offering improved security and user convenience. However, they also come with limitations. Fingerprint scanners require physical contact and can fail with moisture or dirt on the skin. Facial recognition accuracy decreases under poor lighting or when the user wears accessories such as glasses or masks. Iris scanners, though accurate, need costly sensors and controlled conditions, making them less practical for everyday use.

In this context, **gesture-based authentication** has emerged as an innovative, contactless, and low-cost alternative. It leverages the uniqueness of a person's hand structure and movement patterns, captured using a regular camera, to verify identity. Gesture-based systems do not require specialized sensors or physical contact, making them hygienic and user-friendly for modern computing environments.

The proposed system, **GestureAuth**, introduces a **camera-only hand-gesture authentication method** built using **Media Pipe** and **OpenCV**. It allows users to register a personalized hand gesture — either using one hand or both hands — and authenticate themselves by performing the same gesture in front of a webcam. The system detects 21 hand landmarks using Media Pipe, extracts key geometric and angular features, and compares them with encrypted templates stored during registration. Authentication succeeds when the live gesture matches the stored pattern with a similarity above a predefined threshold for a sequence of frames, ensuring stability and reducing false matches.

Unlike existing gesture recognition systems that depend on specialized hardware like **Leap Motion sensors**, GestureAuth works entirely on standard webcams and open-source tools, making it cost-effective and easily deployable on any computer. It also includes a simple **Graphical User Interface (GUI)** created using **Tkinter**, allowing users to register, view live camera feedback, and monitor similarity percentages during login.

The **GestureAuth** system focuses on creating a practical balance between **security** and **usability**. It offers a reliable, touch-free authentication approach suitable for personal devices, laboratories, and secure login systems. Its one-hand mode ensures quick access, while the two-hand mode provides enhanced security due to increased gesture complexity.

II. METHODS AND MATERIALS

The **GestureAuth** system is implemented using **Python**, integrating **Media Pipe**, **OpenCV**, **NumPy**, and **Tkinter** to achieve gesture detection, feature extraction, and user authentication. The system operates through two major phases: **registration** and **authentication**. During registration, a user enters a username, selects either one-hand or two-hand mode, and records a unique gesture for a few seconds using a standard webcam. The system then processes each frame of the captured video to extract 21 hand landmarks for every detected hand using Media Pipe's hand-tracking model. These landmarks represent key points on the fingers, joints, and wrist, which are used to compute geometric and angular features that uniquely describe the gesture.

Once the features are extracted, the system averages them across the recorded frames to create a stable template that represents the user's registered gesture. This template is then **encrypted and stored** in a lightweight database file along with the username and gesture mode information. During the authentication phase, the user performs the same gesture in front of the camera. The system again extracts the landmark-based features from live video frames and compares them with the stored encrypted template using **Euclidean distance**. The resulting distance values are converted into a **similarity percentage**, and authentication is granted only if the similarity exceeds a predefined threshold for several consecutive frames. This ensures that the gesture is consistent and prevents false acceptance due to brief or accidental hand positions.

The system interface is built using **Tkinter**, providing a simple and user-friendly graphical environment. Users can easily select registration or login options, view the live camera feed, and observe the detected hand landmarks and real-time similarity scores. Error handling mechanisms are included to manage issues such as camera unavailability, gesture detection failure, or improper hand positioning.

The entire implementation relies on **computer vision techniques** without requiring any specialized hardware. The combination of Media Pipe and OpenCV allows the system to operate efficiently in real time using standard webcams. This makes **GestureAuth** a cost-effective, contactless, and practical authentication solution suitable for desktop and laptop environments.

True Accept Rate (TAR): % of genuine login attempts correctly accepted.False Accept Rate (FAR): % of impostor login attempts incorrectly accepted. False Reject Rate (FRR): % of genuine login attempts incorrectly rejected. Average login time: time from camera open to successful authentication. Comparison between one-hand and two-hand modes

III. RESULTS AND DISCUSSION

The Gesture-Based Password Authentication System was successfully developed and tested to verify user identity through hand movement patterns captured via a camera sensor. The prototype system was implemented using Python, OpenCV, and MediaPipe libraries to track hand landmarks and recognize gesture sequences. During testing, the system was able to accurately detect hand gestures and match them with the stored gesture passwords. Each registered user created a unique gesture-based password consisting of a specific hand movement pattern. The system verified the user by comparing the live input with the pre-stored gesture model. The experimental results showed that the system could identify gestures with high precision under proper lighting conditions and consistent background. The authentication process was completed within a few seconds, providing a secure and contactless alternative to traditional text-based passwords. The interface was also found to be user-friendly and easy to operate.

However, the accuracy slightly decreased when users performed gestures in poor lighting or with partial camera visibility. Future improvements may include integrating adaptive brightness detection and machine learning-based gesture classifiers to improve accuracy across various environments. Overall, the proposed system demonstrates that gesture-based authentication can enhance security and user convenience by reducing dependency on conventional password entry methods.

The Gesture-Based Password Authentication System was successfully implemented and tested to verify user identity using hand gesture recognition. The developed system utilizes a live camera feed to detect hand landmarks and interpret gesture patterns as authentication input. The system was built using **Python, OpenCV, and MediaPipe**, which provided reliable tracking and feature extraction capabilities for accurate gesture detection.

A. System Output

When the user performs a gesture, the camera captures hand movements, and the system extracts landmark points in real time. These landmarks are compared with the pre-stored gesture pattern created during registration. If the pattern matches within a defined accuracy threshold, the system grants access; otherwise, access is denied. The interface provides immediate feedback to the user — displaying "Access Granted" for valid gestures and "Access Denied" for mismatched attempts. The overall processing time for authentication was observed to be between **2–3 seconds**, indicating an efficient response rate suitable for real-time applications.

B. Testing and Observations

Testing was conducted with multiple users performing different hand gestures such as swipes, circles, and directional movements. The recognition accuracy was approximately **92–95%** under proper lighting and stable background conditions. Performance slightly decreased when gestures were performed too fast or under low light conditions. The system performed best when the camera was positioned directly in front of the user and the gesture was made at a consistent distance. The implementation proved that MediaPipe's hand-tracking module effectively detects finger and palm coordinates even for complex gestures.

C. Discussion

The results confirm that gesture-based authentication provides a **contactless, secure, and user-friendly** alternative to traditional password systems. Since no physical typing is required, it reduces the risk of shoulder surfing and keylogging attacks. The dynamic nature of gestures also makes it difficult for unauthorized users to replicate authentication patterns. However, some limitations were noted, such as sensitivity to background clutter and variations in hand orientation. In future versions, the inclusion of **machine learning-based gesture classifiers** and **adaptive thresholding** can further enhance the recognition accuracy. Additionally, integrating multi-modal features like facial recognition or voice authentication can increase overall system reliability and make it suitable for high-security applications.

Overall, the project demonstrates that gesture-based authentication is an innovative and feasible solution for enhancing security and convenience in human–computer interaction systems.

IV. CONCLUSIONS

The Gesture-Based Password Authentication System successfully demonstrates an innovative approach to user authentication using hand movement recognition. The developed system replaces traditional text-based passwords with dynamic gesture patterns, providing a more secure and user-friendly method of access control. Through implementation and testing, the system proved capable of accurately identifying gestures and verifying users within a few seconds. It ensures contactless operation, which enhances hygiene and usability in modern digital environments. The system's performance was reliable under normal lighting conditions and simple backgrounds, making it suitable for practical applications such as secure logins and smart device access. However, the results also revealed that system performance could be affected by environmental factors such as lighting variations and complex backgrounds. Future work can focus on improving the accuracy and adaptability of the system using deep learning models, advanced image preprocessing, and real-time gesture refinement techniques. Overall, this project shows that gesture-based authentication has strong potential to enhance digital security while maintaining user convenience. It opens the way for future research in multimodal biometric authentication systems combining gestures, face, or voice recognition for even stronger security mechanisms.

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