Brain Computer Interface EEG Based Biometric System

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***Abstract*—A Brain-Computer Interface (BCI), also known as a Brain-Machine Interface (BMI) or neural interface, is a system that communicates directly between the brain and an external device.This project, Brain-Computer Interface (BCI) EEG-based Biometric system aims to provide a reliable and effective user authentication solution. The system analyses the user's brainwave patterns using electroencephalogram (EEG) data to extract significant traits, which are then compared to their biometrics to conduct authentication. By utilising the power of brainwave patterns, the suggested BCI EEG-based biometric system provides a trustworthy and user-specific approach to authentication.The technology guarantees strong authentication while being flexible to individual users by utilising EEG data and identifying distinguishing traits.In order to improve the overall system performance and security,future study may explore other feature extraction techniques and refine the authentication procedure.The design, implementation, and assessment of EEG based biometric authentication system are all presented in this project report. By identifying the brain signals, processing, analyzing and plotting, the aim is to have a robust biometric system. The project report offers a thorough explanation of the system's architecture, execution, and possible advantages. It also lays the groundwork for future studies and developments in the area of BCI biometric system.**

***Index Terms*—EEG (Electroencephalography) BCI (Brain-Computer Interface) CNN (Convolutional Neural Network)**

I. Introduction

EEG based brain computer interface has emerged as a hot spot in the study of neuroscience, machine learning and rehabilitation in the recent years. In recent years, the study of neuroscience, machine learning, and rehabilitation has seen a surge in interest in EEG-based brain computer interfaces. Without using the typical neurophysiology pathways, a BCI offers a platform for direct communication between a human brain and a computer. When protecting data or any type of information system, authentication is an important factor to take into account. Even while the current methods of authentication are user-friendly, they contain flaws including the potential for criminally threatening a user. We provide a novel method that authenticates users using electroencephalogram (EEG) brain waves. A user's identity may be verified using specific EEG data characteristics that help distinguish between different brain processes. This approach is far more reliable and safe than other biometric systems since response is greatly altered by current mental state. The project focuses on preprocessing the EEG data, extracting statistical features, and estimating the PSD features. It provides a foundation for further steps in implementing a biometric authentication system using EEG data, such as comparing user features with the extracted features and making an authentication decision based on a threshold. The filtered EEG data are then used to extract the relevant EEG features, such as the mean, standard deviation, skewness, and kurtosis. The user's brainwave patterns are accurately captured by these qualities. User-specific features must be added into the system to enable authentication. The dimensions of the retrieved EEG features must match the placeholder for user characteristics in this project. This placeholder should be replaced by the users' actual features to enable personalised authentication. The Euclidean distance between the user features and the EEG features is calculated during the biometric authentication procedure. To determine if the authentication attempt was successful or unsuccessful, a predefined threshold value is set. A suitable message is presented if the estimated distance is below the threshold, indicating that the authentication was successful. On the other hand, if the distance is greater than the cutoff, authentication is considered unsuccessful.

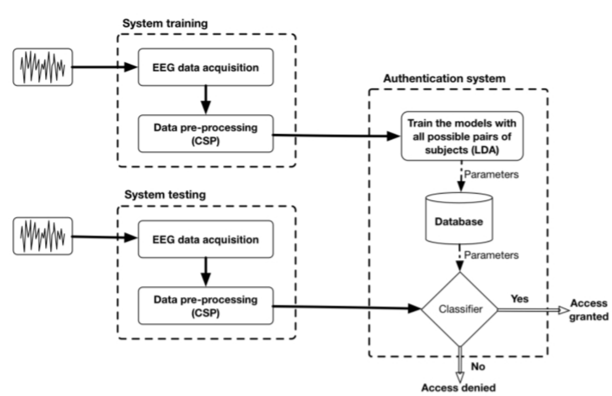

Fig. 1. Block Schematic of Proposed System

II. Biometric System

A. Working

Biometric system is a technological system that allows recognition of a particular person using distinctive traits of that individual. In such system the authentication is determined in terms of biometric traits such as Physical, Behavorial and Cognitive Biometric traits. Some of the biometric systems used as as follows:

- Speech Recognition.
- Fingerprint Recognition.
- Recognition of facial expressions.
- Iris Detection.
- Sensors for measuring heart rate.
- EEG-based approach for measuring brain activity

The Cognitive biometric trait is an identifier which consists of aquisition of bio signals which are initiated in response to a stimuli or while performing a task by the nervous system. Out of these system we are going to work towards Brain Signal EEG based system. It is found to be most suitable as well as robust if compared to others.

B. Problem Statement and Solution

existing authentication methods are user-friendly, they have flaws that pose a criminal risk to the user.Cyber hackers can gain access to biometric systems such as fingerprint recognition, facial recognition, and even iris-based systems. As a result, a solid, strong biometric system that is highly dependable and only available to the user is required.

We present a novel approach to authentication that makes use of electroencephalogram (EEG) brain signals.EEG data with distinguishing traits for distinguishing brain functions might potentially be utilised to authenticate a user. When compared to previous biometric systems, this approach is more robust and secure because response is dramatically altered based on instantaneous mental state.

III. Proposed System

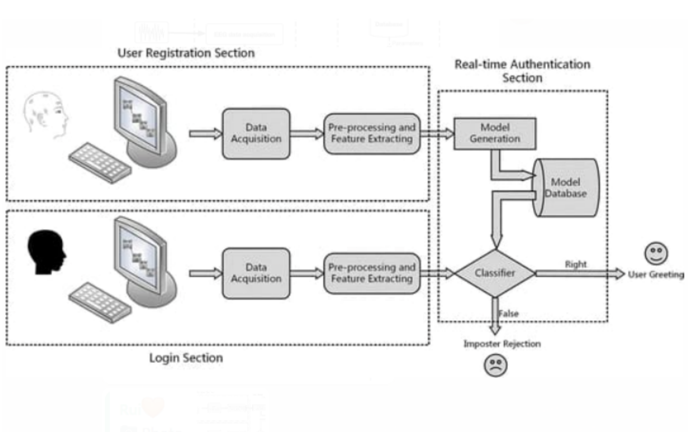

Fig. 2. Flowchart

A. Working

This research offers a system with a revolutionary technique that would employ Electroencephalogram (EEG) brain waves for authentication.When compared to other biometric systems, the unique features of EEG data for identifying brain processes can potentially be used to verify a user. This approach is more resilient and more secure because reaction is greatly varied depending on current mental situation.Hence we will also try to build features in our system which can let the security system to know if the client or user is under a coercive attack making it more reliable and guarded.

B. Hardware

The major hardware components used in this system are:

Portable Emotiv EPOC - EEG headset with 14 wet electrodes and two references

1) Portable Emotiv EPOC: The award-winning EMOTIV EPOC is developed for scalable and contextual human mind studies and provides access to professional-grade mind facts in a short and simple to use design. Emotiv EEG is a high-resolution, wireless, portable, multi-channel EEG system that provides all of the benefits of EPOC as well as access to raw EEG data. 14 EEG channel designations are AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4 based on international locations 10-20. The purpose of this study is to show the result of an approach to tentatively classify brain wave signals and discriminate them with great precision when performing activities. In this project we use an EMOTIV Epoc device (14 channels).The results show the need for signal pre-processing of BCI devices. This can significantly reduce the amount of data for further processing, since we can exclude further data processing for those channels that do not contain any important information

Fig. 3. Emotiv EPOC

1.Emotiv SDK
2. MATLAB - Deep Learning ToolBox
-Signal Processing ToolBox

C. Software

- Emotiv SDK
- MATLAB - Deep Learning Toolbox

1) Emotiv SDK: Python is a high-level, general-purpose programming language. Its design philosophy emphasizes code readability with the use of significant indentation. Python is dynamically-typed and garbage-collected. It supports multiple programming paradigms, including structured, object-oriented and functional programming. In this project we are using Python for designing and implementing a machine learning model.

2) MATLAB - Deep Learning Toolbox: Ubuntu is a open source debian based Linux distribution which is considered best for the cloud based server applications, IoT projects, etc. Also Ubuntu is known to be more secure when compared to the windows. It is built using programming languages like C, C++, Python etc.

D. Electrode Placement: 10-20 International System

The 10-20 system is based on the link between an electrode's placement and the underlying cerebral cortex area. Each point on this diagram on the left represents a potential electrode site. Each place is identified by a letter (to identify the lobe) and a number or another letter (to identify the hemisphere). Frontal, Temporal, Central, Parietal, and Occipital are represented by the letters F, T, C, P, and O.

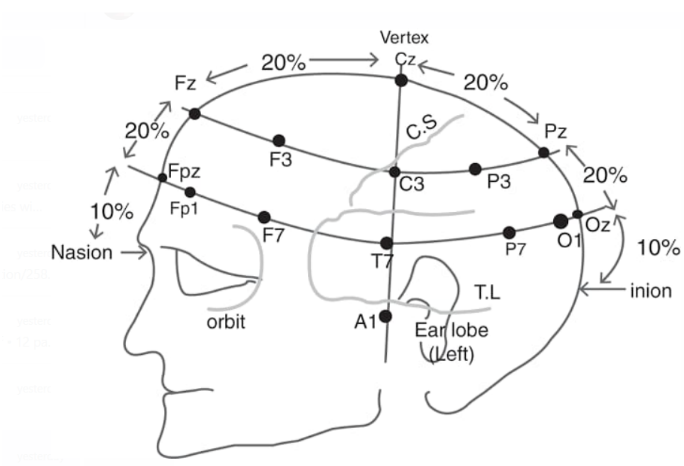

Fig. 4. Flowchart

IV. Research Methodology

• System training: In this project we will first train the system i.e. the EEG data that is acquired from a subject will be extracted and thoroughly processed. In this process the eeg signals will be trained, filtered and all noises will be discarded.The EEG data in this project is a 1250x1 double size. The process is to filters the data. It is then defined by a time window for analysis and then calculates the power spectral density(PSD) using the pwelch function. It computes the mean, standard deviation, skewness, and kurtosis of the PSD values to obtain the common user features. Finally, it prints the common user features using fprintf. The printed data are the User Features which will be used for authentication process. • System testing: In this step we will now acquire data to the system i.e. the EEG data will be acquired from the same subject will be extracted again and thoroughly processed. In this process the eeg signals will be filtered and all noises will be discarded.Now in this stage, the data processed will be compared with the User Features which will be used for authentication process. • Authentication system: This is the last stage which basically compares the data that is trained in the system training to the data which is acquired in system testing.Authentication is accomplished using the Euclidean distance between user features and retrieved EEG features. When the Euclidean distance between the user features and the EEG features is smaller than the predefined threshold value, the authentication is successful. If the distance between the user features and EEG features is less than the threshold, authentication is successful, otherwise it fails. The threshold value is determined by the authentication system's specific requirements and characteristics. It is a predetermined value that you can alter in the authentication process to achieve the correct balance of false positives and false negatives. If the calculated difference between the user features and the extracted EEG features is smaller than the threshold, it means that the user's EEG features are close enough to the expected characteristics, and authentication is successful. If the distance is greater than the threshold, the user's EEG features diverge significantly from the expected features, resulting in authentication failure

V. Result

In the following project we have successfully created an authentication system which first analyses the user features.These user features are extracted using power spectral density. The process is to filters the data. It is then defined by a time window for analysis and then calculates the power spectral density (PSD) using the pwelch function. It computes the mean, standard deviation, skewness, and kurtosis of the PSD values to obtain the common user features. The user features are then used for authentication process.

A. RAW EEG signal

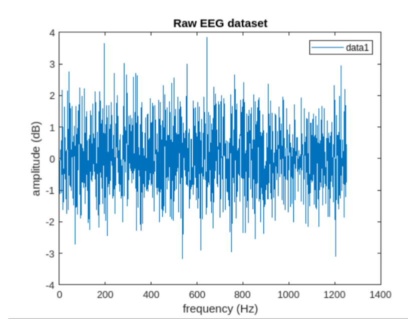

Fig. 5. Raw EEG signal

B. EEG signal filteration

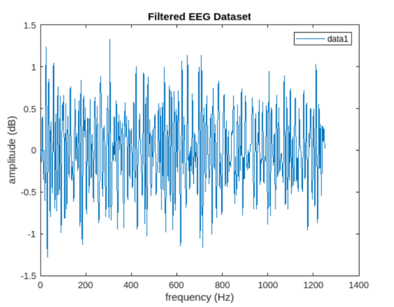

Fig. 6. Filtered EEG signal

C. Test Results

1) Authentication Successful: The output is given in the figure below.

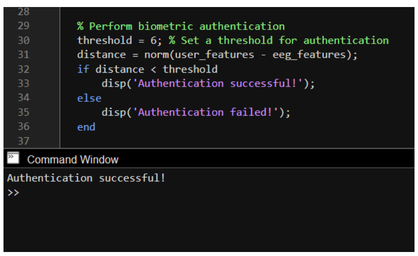

Fig. 7. Authorization successful

2) Authentication Failed: The output is given in the figure below.

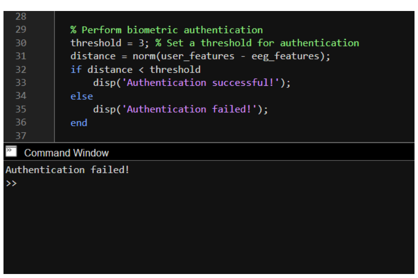

Fig. 8. Authorization Failed

FUTURE SCOPE

For further implementation we intend to merge technologies that will let us build a robust biometric system. Hence, we will also work to have features build in our system which can let the security system to know if the client or user is under a coercive attack making it more reliable and guarded. That is a message will be sent to the security authorities nearby if any extreme changes in the brain signals are noticed. We are currently also have a code, but have not achieved accuracy in it.

CONCLUSION

Although existing authentication methods are user-friendly, they have flaws that pose a criminal risk to the user.Cyber hackers can gain access to biometric systems such as fingerprint recognition, facial recognition, and even iris recognition. As a result, a solid, strong biometric system that is highly dependable and only available to the user is required.We present a novel approach to authentication that makes use of electroencephalogram (EEG) brain signals.EEG data with distinguishing traits for distinguishing brain functions might potentially be utilised to authenticate a user. When compared to other biometric systems, this approach is more resilient and secure because the reaction is significantly altered based on the instantaneous mental state.This study takes a ground-breaking approach to biometric authentication based on EEG data.The project serves as a starting point for developing the authentication system, with emphasis on EEG data preparation, feature extraction, and user authentication. This initiative, by utilising brain activity patterns, opens the door to secure and accurate user identification in domains such as security systems,medical equipment,and human computer interaction.

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