BraiNet

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ABSTRACT
The password-based authentication methods have proved to be insecure because of attacks such as Phishing attacks and keystroke based attacks. This is starting to make the developers incline towards biometric-based authentication such as Fingerprint scanning and Retina scanning to make their applications more secure. But even these methods are not 100% foolproof. Many researchers have investigated the characteristics of the brain waves i.e. the electroencephalogram (EEG) signals and have observed that each person has a unique set of brain signals and these can be effectively used for authentication. This project aims at developing a mobile application which authenticates the user on the basis of brain waves recorded using BCI2000 system. This application provides the functionality to store the brainwave data in database and query it. The brainwave recognition has been implemented using machine learning algorithms like Naive Bayes.

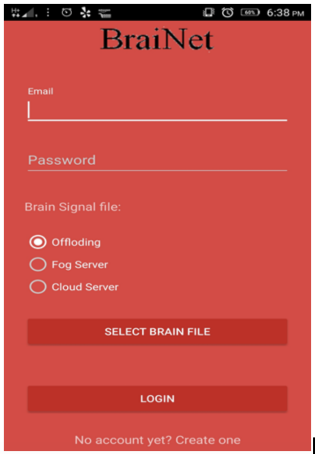
KEYWORDS
Brain sensor, Brain waves, Password-less authentication, Fog Server.

INTRODUCTION
Authentication has always been very important factor in technology. Password based authentication schemes are quite common and have been there for quite some time. However, after numerous accounts of hacking attempts that were successful in bypassing the password based authentication methods, a need was felt to come up with a scheme that could not be compromised that easily. Here biometric based authentication came in handy. Since our biometric records such as fingerprints, retinas, brain signals are unique for each one of us, trying to impersonate someone using that person‘s biometric features is extremely difficult, if not impossible. Over the last few years, fingerprint based authentication has become prevalent. Retina based authentication is also quite popular in extremely high confidential and critical environments such as military. However, there is one more biometric feature that has not been fully tapped in yet; Our brainwaves. each person‘s brain wave signal is unique to that person only and is way too complex to be tried to be imitated which makes this a great authentication scheme. Sensor devices to record brain waves and stream them to devices such phones are available easily, which makes the implementation of this scheme, feasible.

APPLICATION WORKFLOW
After the application is installed, the user has to register himself into the system if he is a first time user. On registration, an unique user ID will be generated and displayed to the user.

User interface
The user interface for the project is simplistic is has basically 3 activities, Login, Sign Up and welcome screen.

Login Screen



. Fig. Login Activity

The login screen is shown in below figure âĂIJLoginâĂİ It has text boxes for user email, user password and check boxes for selecting the method to be used for the signal processing.

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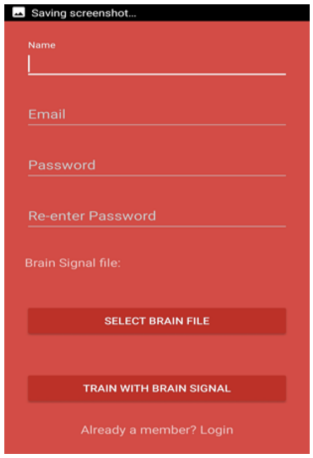
A user can select the brain signal file using button "Select Brain File" on clicking the button, the application calls Intent Broadcast to show a file manager, using which user can select the brain signal file. The screen has a button to Login, on click this button the application performs offloading depending upon the selected radio button. Depending upon selected option the app can perform either offloading or select the Cloud server or fog server for processing.

SignUp Screen



. Fig. Sign Up Activity

The sign-up screen is shown in below figure âĂIJSign UpâĂİ The screen is used to capture basic user details, It has text boxes for User name, Email, Password, and Retype password. A user can select the brain file by clicking button "Select Brain File" It fires an intent activity to view file manager, using this view a user can select the brain file for log in. On clicking the button "Train with brain Signal" The activity calls a POST request containing the user data along with the content of brain file.

Welcome Screen

. Fig. Welcome Screen

The welcome screen is shown when the user is successfully logged in and it shows the details about the user along with the details such as time required for the fog server and time required for cloud server in case offloading option is selected.

PROJECT SET UP

The Project set up primarily comprises of 4 components: 1. Brain Sensor Device: BCI2000 system is used for the brain sensor. This device streams data at a sampling rate of 160 Hz. 2. Client Application: This part is the android application that resides on the mobile phone. It collects data from the sensor device and sends the data to the web server for authentication and storage. 3. Web Server: The Mobile device-Server connection has been done via HTTP protocol. The Web server has been set up using Python-Flask framework. 4. Database server: MS SQL server is used for database. The database interacts with our application via web server.

IMPLEMENTATION DETAILS (MACHINE LEARNING)

Feature Extraction

The alpha signals of the brain waves are used since they represent the relaxed awareness of the human brain. These waves have a frequency range 160 Hz. After user logs into the application with his user ID and records its brain signal, the available brain signals for the same user are retrieved from the database. Both of these fetched and recorded brain signals are then divided into buckets of 512 data values and Fast Fourier Transform is applied to each bucket to get the set of 6 feature vectors. All the feature vectors of fetched signals (training data) are labeled as 1 and those of recorded signals (test data) are labeled as 0. Algorithm The main idea in this authentication scheme is that a decision boundary is tried to be found between the feature vectors of fetched and recorded signals of the user. Both the training and test feature vectors obtained from feature extraction process are used collectively as the training data and fed to the model. The model then generates a decision boundary the best it can. The same training data is used as the test data and the confusion matrix is calculated. Why ? The main aim here is to check to how much extent the fetched and recorded data is separable by the decision boundary. Separability of data indicates the extent of the accurate decision boundary.

```
If confusionMat[0][0] > confusionMat[0][1]
and confusionMat[1][1] > confusionMat[1][0]
{
  authenticated = False
}
Else {
  authenticated = True
}
```

1.The authentication decision relies on the confusion matrix.
2. The interpretation of the Algorithm 1 is as follows:

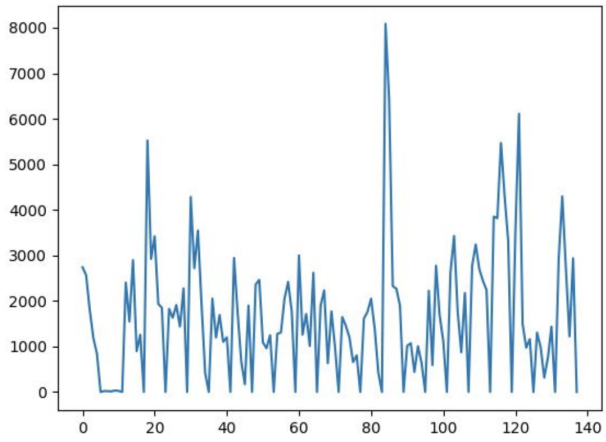
- If the decision boundary is correctly classifying both the samples, this means that the two samples are significantly different than each other. Hence, the user is not authenticated.

- Whereas if it is incorrectly classifying samples, it represents that the two signals are similar and thus the user is authenticated.

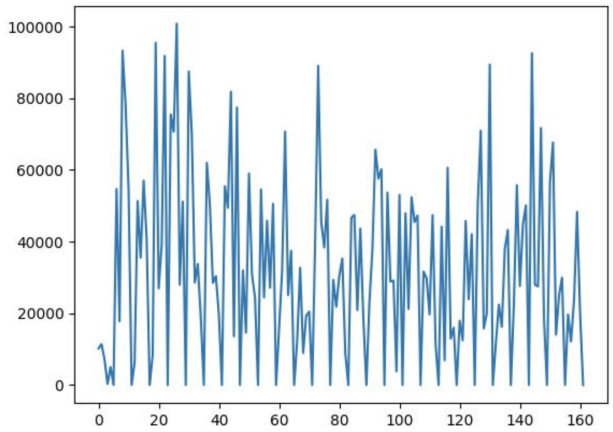
RESULTS

Machine Learning Approach

Naive Bayes implemented for authentication achieved 54% of accuracy. It was observed that signals with smaller duration result in poor classifier performance. Thus, the model was tested on longer duration signals which significantly enhanced the performance. It was also observed that even though 2 brainwave signals are of the same person, they can still significantly differ from each other.



. Fig: Brain wave graph of subject A



. Fig: Another Brain wave graph of subject A. Notice the difference from the previous graph.

Performance

When using only fog server, the communication time was less but the computation time was more when compared to using cloud server. This is because the fog server is in the same network as the mobile whereas the cloud server is in a different network. The fog server is a laptop which has less computing capacity than the cloud servers. When adaptive algorithm is selected, the fog server was always selected because the communication time was very less compared to the cloud server but the computation time had not much difference to choose cloud server. The power consumption of the mobile was more for cloud server as the radio was active for longer time when using cloud server and radio was active for lesser time when using fog server. So, using fog server consumes less energy than using cloud server.

Future Work

The results we got from our experiments did show that the machine learning approach is the way to go for trying to recognize the brain wave for authentication. However, the results were not totally unambiguous. There were scenarios where the classifier gets them wrong even though they are for the same subject. But on closely looking at the plotted graphs for those cases, we can see that even though the subject is same, the brainwaves are not that similar, meaning the results are highly dependent on the quality collection, which forms the future work for this project

Conclusion

From this project, we observed that brainwave signals, being highly unique to each person, are a very good feature for being used in authentication schemes. We believe that as the wearable sensors become ubiquitous, the use of brainwave based authentication will becomes more and more feasible and prevalent and provide a way for us to effectively secure our data.

CONTRIBUTION

		BraiNet Project
Name	*Phase*	*Percentage*
Sagar Patni	Phase I	100%
Sachin Chhabra	Phase II & IV	70% 30%
Sachin Sundar	Phase III	100%
Pratik Mishra	Phase II & IV	30% 70%

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