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A Novel Classifier Algorithm for EEG Signal Based Person Authentication from Cz Channel with 2D-Wavelet Compression for the Online Voting System Using Touch Panel

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ABSTRACT

Issues such as trustworthiness, refuge and affordability of voting events might be seen as factors than stimulate enthusiasm upon democracy system among potential voters and increase participator. This paper argue that online voting may play important role on pretty security and curtail of encumber human and financial resources allocation to election process by the EEG signal for voter authentication based on CZ-channel electrodes, for avoiding over load of EEG signal data sets in the data base, a 2D-multichannel EEG wavelet compression technique is used and in the person authentication process Space Time Frequency Linear Discriminant Analysis (STFLDA) classifier algorithm is used which extracts the CZ channel from the user those who trained by the dataset. In the voting process, the voters EEG signal dataset is being stored by the EEG Emotiv Epoch neuro headset which has 14 channel electrode sensor. The proposed STFLDA classifier algorithm provides high efficiency and accuracy rate of 97.3% compared to the existing classification algorithms such as LDA, SVM, The election is made to be online and the person can vote any where throughout the country by replacing ballot via 3.2-inch TFT Color LCD 240374PQ Module Graphical User Interface with 4 wire analog touch panel for the display of election members through UART device and the vote which is storing in the host pc will be encrypted and it will be decrypted in the remote machine for the secrecy of vote.. By this system the election result can be displayed simultaneously which is in the main server. However, in the emerging democratic system, like some of Asian countries reveal other issue such as political, cultural, educational, economic responsiveness, with the intention might be weighted before any online voting system is displayed.

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INTRODUCTION

The general election itself consists of several activities such as the process of registering people to vote, preparing secret ballot, conducting elections and tabulating results. In India, voting system is being done by electronic voting by means of ballot; the personal identification has been made by means of Aadhar card. In aadhar card the identification is done by iris recognition, fingerprint, and finger vein recognition system as shown in the Figure 1. It has been replaced by the Brain Computer Interface (BCI) using EEG signal for personal identification.

Biometrics	**Behavioral**	**Voice**
		Keystroke
		Signature
	Physiological	**Face**
		Fingerprint
		Vein
		Iris
		DNA

Fig. 1: A variety of biometrics.

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The existing system can be hacked by the duplicate finger print or iris pattern. But the human brain interface signal cannot able to hack for the identification purpose. The voting system in India can be replaced by online system with the serial port UART touch screen graphical user interface (Dictson D., 2000) system instead of ballot.

Online voting has been well thought-out as the reliable way to replace the older election method (Julius Jillbert, 2003). This system can be divided into 3 categories namely: "voting from home via email; voting from home via a web link to the ballot; and voting from regional polling center which is equipped with an internet connection"

Literature Survey:

a) Voting System A Survey:

The first sort of electronic voting structure is to some extent similar with current absconder voting process. The diverse would be on the way the voter sends the ballot.

This method allows the elector to send the secret ballot via secure message to election bureau. This method has several advantages compare to using the web such as it would be a lesser amount of voter's threats for voter with little or no internet knowledge and keep away from transmission restricted access during high internet traffic times (Elliot, 1999).

The second type would be consummate using the Dictson and Ray (2000, p.3) stated that this process allows the elector to log in through protected way, verify their identities, and vote on electronic ballots. This method seems to be more suitable, since the electors can vote through internet right of entry from public and private places where the internet likely to be accessed. This method also has some return in which the transaction can be take place in factual time, close that the web site will hold the electors with online help and information that is needed to fill out their secret ballot.

In terms of conventional bureaucrat, customary polling sites can be improved by utilizing the website technology. The web access system can link the regional voting center and the electors. The ballot workers then identify the electors have sent the correct secret ballot. Once the workers believe that the secret ballots have been packed out correctly they will delivery over the internet directly to the polling station. Dictson and Ray (2000, p.4) believe that this method afford protection and ease for the elector and make the system more proficient as it needs less employees than conservative method safe money and time. One of the flaw in the method is, it does not permit the voter to vote at more than one polling place, as the complete election would be linked to main server database (Dictson *et al*, 2000).

b) EEG Based Authentication a Survey:

For the identification of the person, the person database is stored in the system by EEG signal Brain Computer Interfaces (BCI). One such method to extract the human brain information is the EEG based biometry. The concept of the biometry has recently been more and emerging. For example, face, fingerprint and iris have been considered and the part of those has been in practical use. By using human brain activities as a new modality, it provides several advantages (Marcel *et al*., 2007). It is secret, very hard to impersonate, and almost not viable to whip, and furthermore easy to change on rationale the 'password' according to the users mental tasks or intentions.

In spite of the expected use, there has been little work on the EEG based biometry. Paranjape *et al*., 2001studied on the EEG signals recorded from the subjects with the eyes open and close. On examining of EEG signals trials from 40 subjects, and the classification accuracy of about 80 percent was achieved.

Poulos *et al*. 1999 investigated one channel EEG on occipital site to extract the four major EEG rhythms (alpha, beta, delta and theta) in closed eyes, where the arrangement performance of 95 percent was obtained involving 4 subjects and more than 250 EEG patterns

Palaniappan *et al* 2007 reported the VEP based biometry and Marcel *et al*. 2007, studied the person authentication based on motor imageries and word generation tasks.

Thorpe *et al*. 2006, reported the concept of 'pass-thought' using P300 evoked potentials based on oddball exemplar with flashing letters on a computer monitor. These works revealed the feasibility of the EEG based biometry. However, it would be difficult to change the EEG signals (password) on purpose, except for the method using P300 responses.

The EEG dataset which is being extracted from the EPOC EMOTIV headset is shown in Figure 2.The signal is being extracted from the Epoc Emotiv headset makes the authentication and made to transfer the IIS7 server which gets the voter database from the remote server. After the person database is accessed the voting process made to be under process and the ballot system is replaced by the LCD touch panel system which displays the election party member details in the runtime environment as shown in the Fig 3.

In this paper, we have discussed 2- D Multi channel EEG lossy compression Proposed STFLDA Classifier Algorithm, Touch panel interface replacing ballot system and Voting system process, and Experimental results in the forthcoming sections.

Fig. 2: EEG signal dataset extraction.

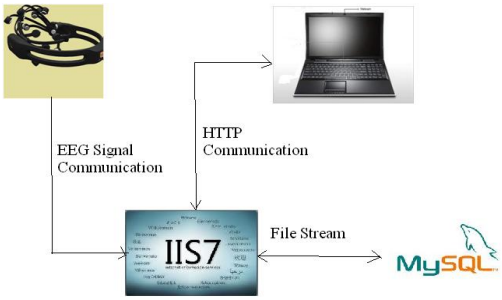


Fig. 3: Overall system flow.

2-D Multichannel EEG Lossy Compression Technique:

The 2D multi channel EEG compression based on two stages to exploit the spatial and temporal correlation in due course of action, in the first stage the tensor is made with the lossy compressed wavelet coder and made to be distorted basd on the residual to reconstruct the data for avoiding the large storage of values in the database.

a) Multi Channel Image Formation:

The 2D channels are arranged in a spiral fashion in adjacent rows, the cells are decreased when it moves across the rows and columns to make matrix X as smooth

$$X = \{x_i(t) | i=1,2\ldots\ldots,M;\ t=1,2,\ldots..,L\} = \begin{bmatrix} x_1(1) & x_1(2) \ldots\ldots\ldots & x_1(L) \\ x_2(1) & x_2(1) & x_2(1) \\ & & \\ x_{M(1)} & x_{M(L)} & x_{M(L)} \end{bmatrix}_{M \times L} \quad (1)$$

The matrix M and L denotes the rows and columns of the datasets which are made to be compressed by the residual distortion method

b) Wavelet Based Lossless Coder Stages:

Figure 6 shows a diagram of the proposed two-stage near lossless coder for multichannel EEG. A scalable wavelet encoder compress the matrix which is formed by *I* on successive bit plane encoding the compressed data I_{en} , which is decoded to give I_i of original tensor I

$\varepsilon = I - I_l$, the residue of the compressed data I_{en} is reconstructed by lossless matrices of I_i with residue ε'

$$I_n = I_1 + \varepsilon' \quad (2)$$

Where, $\varepsilon \rightarrow$ *quantized residue*

$\varepsilon' \rightarrow$ *dequantized residue*

$I_l \rightarrow$ *Original data*

$I_{en} \rightarrow$ *Compressed data*

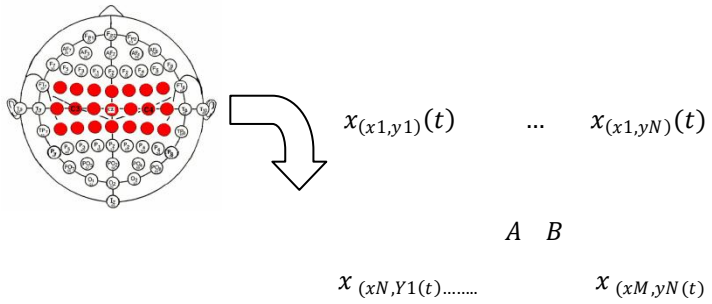


Fig. 4: Multichannel EEG formation matrices for 64 channels electrodes.

In is rearranged to produce the original EEG signal which was captured can be determined from the equation

$$I = I_1 + \varepsilon \quad (3)$$

$$I_{n1} = I_1 + \varepsilon \quad (4)$$

Therefore, it follows that

$$\|I - I_n\|\infty = \|\varepsilon - \varepsilon'\|\infty \quad (5)$$

and hence

$\|\|\varepsilon - \varepsilon'\|\infty \leq \delta$ is equivalent to $\|I - I_n\|\infty \leq \delta$

The quantized indices ε_q is generated from the residual function

$$E_q = \left\lfloor \frac{\varepsilon+\delta}{2\delta+1} \right\rfloor, \varepsilon > 0 \quad (6)$$

$$\left\lfloor \frac{\varepsilon-\delta}{2\delta+1} \right\rfloor, \varepsilon > 0$$

The quantized residual ε_q is encoded by I_{en} with index which was quantized to produce the ourput layer

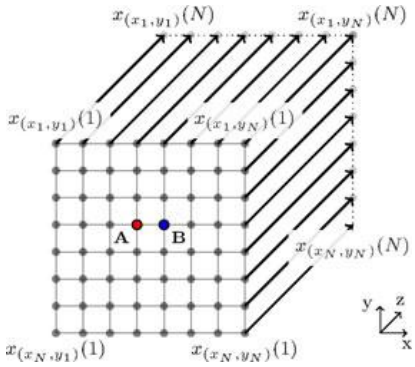


Fig. 5: Volume formation along the multichannel EEG matrix.

The residual bit stream ε_{q-en} is decoded at the end to provide the output of $\|\|\varepsilon - \varepsilon'\|\infty \leq \delta$

$$\varepsilon' = (2\delta + 1)_{\varepsilon_q} \quad (7)$$

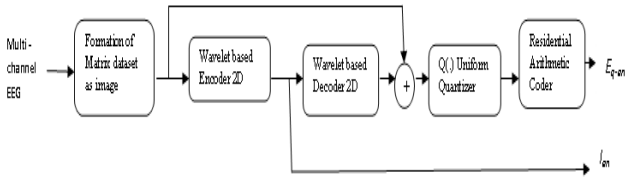
The lossy compression I_l is added with dequantized residual ε' to give I_{n1} which leads to $\|I - I_{n1}\|\infty \leq \delta$

The datasets can be obtained from the differences which have been occurred in the compression of image and by the wavelet partitioning principle which leads to high data volumetric rate of the image.

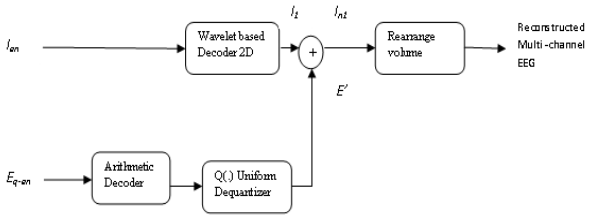
The residual arithmetic coding is used for reducing the complexity during computation process in the processing of image which is faster than the direct coding process

Table 1: EEG Data sets for testing algorithm.

Dataset Name	No.of Channels	Fs(Hz)	Resolution (bits)	Total Duration	No.of Subjects
EEG-MMI	64	80	12	24 min	12
BCI3-MI	118	100	16	50 s	5
BCI4-MI	64	1000	16	50 s	5



a) Encoder



b) Decoder

Fig. 6: Block diagram of the coder amd decoder based on EEG Wavelet compression.

Proposed Novel STFLDA Classifier Algorithm:

STFLDA classifer is a discriminant algorithm for the feature extraction and classification of person uniqueness identification and authentication purpose. We can use linear functions as well as Space, time and frequency component functions to distinguish the component analysis which is better than the existing LDA algorithms by average recognition accuracy of 96.8%.

They are probably the most popular algorithms for BCI applications. Two main Review of Classification Algorithms for EEG-based Brain-Computer Interface kinds of adaptive classifer have been proposed for BCI design, namely, Linear Discriminant Analysis (LDA), PCA and space-time-frequency analysis process which increases the frequency spectrum and efficiency of classification of datasets. The proposed signal processing and classification system first implements a discriminative Time -frequency analysis on a multi-channel EEG data set as shown in Fig 8. This step learns the most discriminant time segments for a given sensor space by implementing a merge/divide strategy in time axis and it is followed by a frequency domain clustering to select the most active frequency bands in each adapted segment. We have used the Euclidean distance

$$D(p,q) = \|p_i - q_i\|^2 \quad (8)$$

for time segmentation. Further, we implemented the Fisher class separability criterion

$$F = \frac{(\mu_1 - \mu_2)^2}{\sigma_1^2 + \sigma_2^2} \quad (9)$$

for ordering the features, where μ and σ are the mean and standard deviation of the features

Then the most discriminant t-f patterns are sorted from sensors and processed by Space time frequency. Finally a linear discriminant analysis (LDA) was used to classify the reduced feature set.

Linear Discriminant with Time frequency analysis The aim of LDA (also known as Fisher's LDA) is to use hyperplanes to separate the data representing the diverse module. For a two-class crisis, the class of a feature vector depends on which side of the hyperplane the vector is (see Fig 7).

STFLDA assumes normal distribution of the data, with identical covariance matrix for all classes. The separating hyperplane is obtained by seeking the projection that maximize the distance between the two classes means and minimize the interclass variance. To solve an N-class problem (N > 2) several hyperplanes are used. The strategy generally used for multiclass BCI is the \One Versus the Rest" (OVR) strategy which consists in separating each class from all the others. This technique has a very low computational requirement which makes it suitable for online BCI system. Moreover this classifer is simple to use and generally provides good results. Consequently, LDA has been worn with achievement in a great quantity of BCI systems such as motor imagery BCI, P300 speller, multiclass or asynchronous BCI. The main drawback of LDA is its linearity that can provide poor results on complex nonlinear EEG data.

Touch Panel Interface Replacing Ballot:

On the successful completion of the members name display, it will make to transfer to the DS Touch Screen which is is a 4-wire analog touch screen originally designed for the Nintendo DS with the 3.2-inch TFT Color LCD 240374PQ unit is a TFT LCD display unit, 40 pins interface, not just a LCD split but include the Touch, SD card and Flash design. It is a 65K color, 320x240 resolution, and 3.2 inch TFT LCD screen. The LCD has a large screening angle; the contrast is also very pertinent. The touch IC is XPT2046, and touch interface is included in the 40 pins breakout. Readings are taken by putting 5V across two of the pins and doing an analog to digital conversion on the other two pins. Full X and Y position can be achieved with only 4 GPIOs.

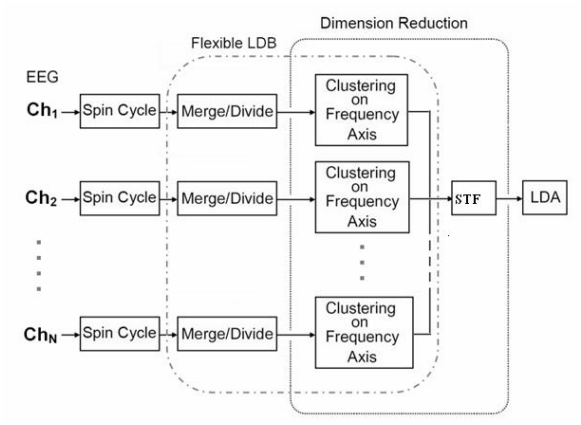


Fig. 7: Proposed STFLDA Data Flow Diagran.

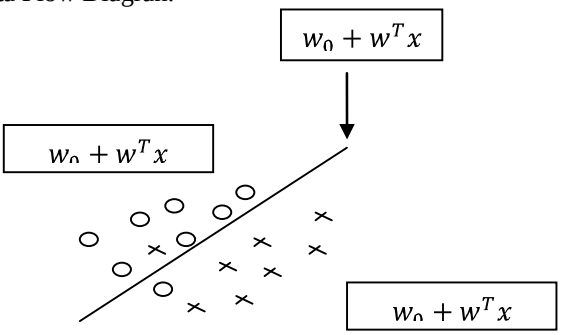


Fig. 8: Hyperplane problem for identification of person EEG.signal.

These touch-panels fit over a graphics display and come in many sizes. The support software #TP4WIRE.TDS is suitable for 4-wire resistive touch-panels having resistive elements in both the X and Y directions. A voltage is applied across the X direction and, by potentiometer action, the location of the finger is read from the Y terminals as an analog voltage. The drive is then reversed and the X position is read.

2 PNP and 2 NPN transistors are needed, together with one inverter gate and a few resistors and capacitors. A suitable circuit is shown in the fig 9. The software was developed using an ATP057 5.7 inch touch screen from Carroll Touch.

For the ease of voting, the person can able to vote any where throughout the country by the interfacing of user touch panel system in the polling booth. The touch interface will display the election members on selecting the state, district, town, and ward and person authentication using EEG neuroheadsets.

Online Voting Process:

The authentication process is shown in the Fig 10. After the successful of the authentication process the system is made to the administrator login in the polling section makes the voter to vote through the following process:

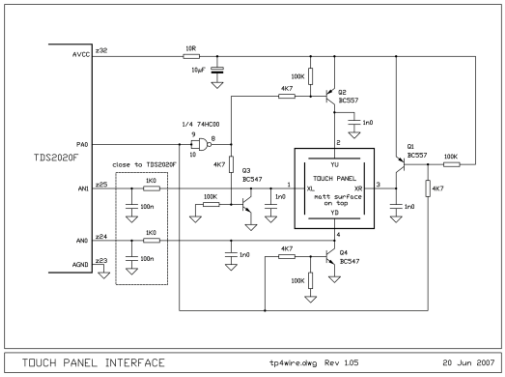


Fig. 9: Touch panel interfacing circuit.

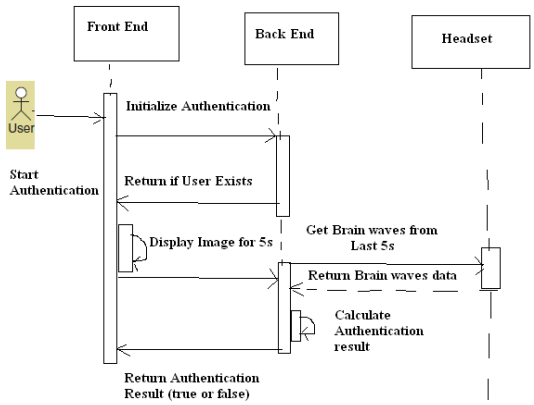


Fig. 10: Sequence diagram showing interaction between back end and front end with EEG headset.

Communication between the front end and back end in complete view approach end querying the back end with GET parameters and the back-end server responding with XML files

- Authentication by STFLDA classifier algorithm
- The successful entry of authentication makes to transfer to the voting screen.
- The voting screen displays the State, District, Town, Village or ward which will makes to display the election party members in the List box,
- Upon selection of the party members, it will be made to transfer to the LCD touch panel device which is made to be operated in the run time environment by pressing the transfer button in the window.
- The voter is ready to vote now, he/she can vote by having a sensitive touch in the corresponding LCD touch panel
- After the selection it will send the vote to the server through UART file transfer protocol.
- It is made to be stored in the corresponding table database desktop which is running in the booth.
- On every one hour the database which is stored in the desktop server is made to transfer via the online remote server
- Using this method of voting the result of election can be released every one hour,
- By using this method man power is very much less compared to the current polling method.

Experimental Results:

To assess the efficiency of the proposed STFLDA algorithm we compared its performance to CZ electrode locations. We selected an analysis window of 50 samples and a hierarchy distance downward of 4. The cell size for the merge/divide approach is chosen to be equal to the deepest segment, which is 260ms. For the STFLDA analysis procedure, typically select k=48 because most of the discrimination power is concentrated in these coefficients. We encompass 10 times and 10 fold fractious validation to estimate the categorization truth. Table 2 shows the classification accuracy for 9 subjects. The proposed STFLDA analysis provided an average classification accuracy of 84.9% for s7 and 97.3 % for s8 on further training the accuracy has been improved. Whenever the conventional C3/C4/CZ electrode locations of a 10/20 system are used the classification performance drops to 80.6%. With the exclusion of area under discussion S1, on all focus the categorization error decreased when additional channels are used. Especially for subject S3, S4 and S8 the s-t-f approach has provided around 10% of improvement, also subject S7 has reached the maximum classification performance. We individually checked the discrimination power of each electrode location for these subjects. We have observed that the best discriminative locations are not always C3/C4 electrodes. In Fig 11 and Fig 12.we visualize the topographical distribution of discrimination analysis for subjects S7 and S8 with cz channels of eye close and eye open, Fig 13 and Fig 14 defines the EEG signal analysis accuracy and performance of the signal classifier.

When just C3/C4/CZ electrodes were used a classification accuracy of 89% and 70% was obtained for these subjects. When 21 electrodes were used then the classification accuracy for each of these subject moved up to 96.8% and 80.1%. The topographical maps explain this improvement.. Besides this, there exists a hemispherical asymmetry for subject S8. The ability to capture this asymmetry can be another advantage of achieving better classification rates. For Person identification and registration for voting, we have taken 5 sample EEG signal datasets, subjects to train the signals by means of eye close and eye open using Neuro headset which is Emotiv Epoc product. The person identification can be done by extracting the features in the reference electrode potential of CZ channel.

From the experimental result the EEG signal is extracted for person identification in the polling process with the accuracy rate of 90%. On subject to training for every three to six months the accuracy will be made high for the person identification. The EEG signal dataset will take the high capacity of data to store in the database;

meanwhile we made a compression algorithm for the analysis of dataset by 2-D Multichannel wavelet EEG lossless compression technique

After the selection of ward number, the election members will be displayed in the drop down list. On the successful completion of the members name display, it will make to transfer to the DS Touch Screen which is is a 4-wire analog touch screen originally designed for the Nintendo DS. Add this touch screen to LCD GRAPHIC DISPLAY - 128X64 model JHD128X64. Readings are taken by putting 5V across two of the pins and doing an analog to digital conversion on the new-fangled two pins. Full X and Y arrangement can be achieved with only 4 GPIOs

3.2-inch TFT Color LCD 240374PQ Module is a TFT LCD panel Module, 40pins interface, not just a LCD break but include the Touch, SD card and Flash design. It's a 65K color, 320*240 (resolution), 3.2 inch TFT LCD screen. The LCD has a wide viewing angle; the contrast is also very suitable.

After the successful entry of authentication which is shown in Fig 15, the page will transfer to the main voting webpage which shows the particulars regarding state, district town, ward election members name as shown in the Fig 16. The election members name is made to display in touch panel LCD as shown in the Fig 17.

On selection of the touch panel election members name it is made to transfer through the UART device to the host computer. On the storage of the data in the host computer it is being encrypted by the public key algorithm.

Table 2: Comparison of classifier algorithms.

	Linear	Non Linear	Gene-rative	Discri minant	Dynamic	Static	Regu-larized	Stable	Un-stable	High dimension robust
FLDA	X			X		X		X		
RFLDA	X			X		X	X	X		
linear-SVM	X			X		X	X	X		X
RBF-SVM		X		X		X	X	X		X
MLP		X		X		X			X	
BLR NN		X		X		X			X	
ALN NN		X		X		X			X	
TDNN		X		X	X				X	
FIRNN		X		X	X				X	
GDNN		X		X	X				X	
Gaussian NN		X		X		X			X	
LVQ NN		X		X		X			X	
Perceptron	X			X		X		X		
RBF-NN		X		X		X			X	
PeGNC		X		X		X	X		X	
fuzzy ARTMAP NN		X		X			X		X	
HMM		X	X		X				X	
IOHMM		X		X	X				X	
Bayes quadratic		X	X			X			X	
Bayes graphical network		X	X			X			X	
k-NN		X		X		X			X	
Mahalanobis distance		X		X		X			X	

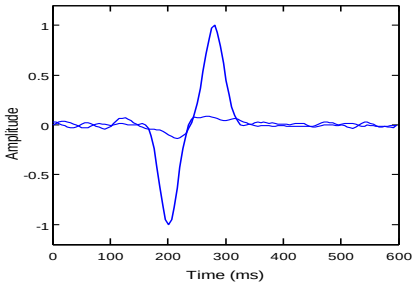


Fig. 11: Simulation results of EEG signal amalysis eye close.

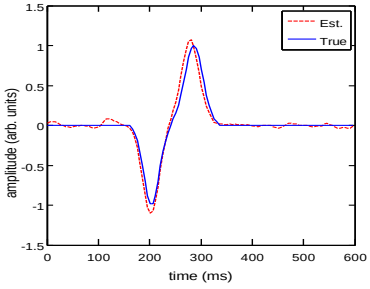


Fig. 12: Simulation results of EEG signal amalysis eye open.

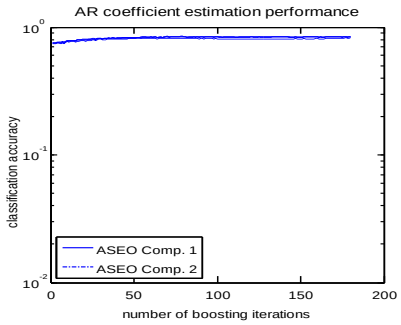


Fig. 13: Simulation results of EEG STFLDA signal amalysis accuracy rate.

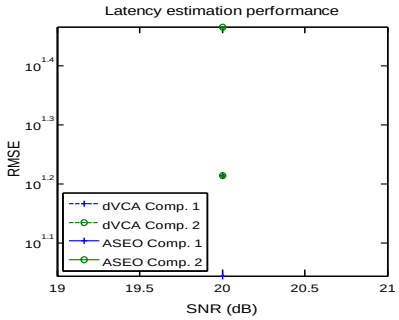


Fig. 14: Simulation results of EEG STFLDA signal amalysis performance.

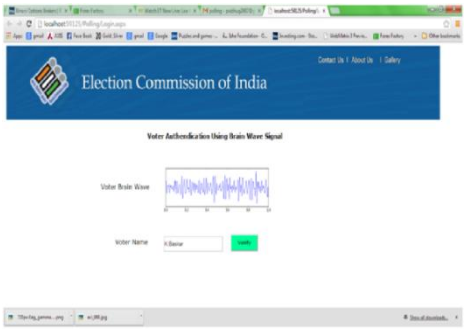


Fig. 15: Online Polling system EEG signal Authentication Login Page.

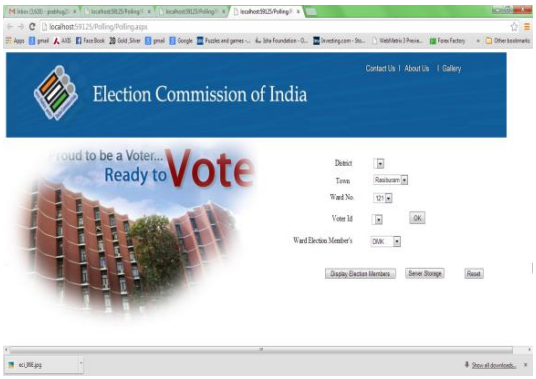


Fig. 16: Online Polling system Main Page.

Fig. 17: Touch panel device with LCD display.

Conclusion:

From the above experimental results, the EEG signal based voter authentication provides the high accuracy by the EEG signal STFLDA classifier algorithm and for reducing the large value of EEG datasets, the data have been compressed which makes it to store in the less storage space. The online election makes the voter more convenient for voting anywhere throughout the state by touch panel election polling system and the encrypted data will provide the high secure features to avoid from the changing of votes in the host computer, Meanwhile, the election result is being displayed simultaneously during the voting process. In the future work, 90% accuracy of the data can be eliminated by analyzing the potential CZ channel electrode by some modification algorithm. For the further improvement in the work, the face detection is added for improving the accuracy during the person authentication process.

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