Mental State Classification by Using Brainwave Sensors

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Abstract: In recent researches, BCI (Brain-Computer Interface) is being pulled as a research topic. Development of BCI can be applied in various places from home to medical sectors. Basically, BCI is the interconnection of human brain and computer. BCI is the communication pathway between the external peripheral devices. We classify our research in two parts. Firstly, we tried to control the IoT device named MaBeee with the help of Neurosky Mindwave EEG sensor. The combination of these two different sensors is the first approach among the researchers. In another research, two different brainwave sensors Neurosky Mindwave Mobile and Emotiv EPOC+ sensors have been used. The purpose of this research is to analyze the brainwave data for the best accuracy result and also to compare the accuracy result between both sensors.

Keywords: Machine Learning, MaBeee, Neurosky MindWave EGG sensor, Emotiv Epoc+ sensor

1 INTRODUCTION

BCI (Brain-Computer Interface) is the communication pathway between the external peripheral devices. In this research, we are trying to control the IoT device named MaBeee with the help of Neurosky Mindwave EEG sensor. The combination of MaBeee with this sensor is our first attempt among the other researchers. The system consists of Neurosky MindWave EEG sensor that is paired with an Android application, which was developed to allow the user to control IoT device MaBeee.

BCI game [1] was designed on the basis of concentration and meditation level. In this game, “Attention”, “Meditation” and “Mix” modes are proposed. Mix mode is the combination of attention and meditation. In mix mode, attention level increases the speed and meditation level decreases the speed of the train. In this game, player can know their concentration and meditation level of the brain.

Another research was done to check the data accuracy between two sensors. Also use the machine learning concept under machine learning three type of classifiers has been used SVM, RandomForest, LSTM, the reason behind using these three type of classification was to check the where we can get the better data accuracy percent. In this research we collect the brainwave data from the 3 subject and compare the data accuracy level between 3 subject in the time interval of 1 minute, 2 minute and 3 minute.

2 BRAINWAVE SENSORS

In this research, 2 types of brainwave sensors have been used one is Neurosky MindWave sensor and another is Emotiv Epoc+ sensor.

2.1 Neurosky mindwave sensor

Neurosky MindWave Sensor is a simple brainwave sensor with single channel. The headset’s sensor measures the brain’s electrical activity and transfers the data readout with vie Bluetooth to a computer, smartphone, tablet or laptop. The Neurosky MindWave Sensor is suited for iOS as well as android devices. The high quality and reliability of brainwave signal is based on Neurosky TGAM chipset.

2.1 Emotiv Epoc+ sensor

Emotiv Epoc+ sensor is the advance brain wave sensor with 16 electrode and 14-channel. Emotiv Epoc+ Sensor is research-oriented wireless headset that record 14-channel EEG. This 14-channel sensor is designed for research and brain-computer interface (BCI).

3 Simple BCI Game

Before starting this project, we had gone through many references but we didn’t found that in any research related to MaBeee (a battery type IoT device). It was little bit challenging for us to start our research.

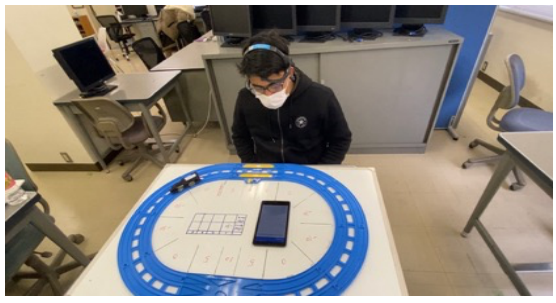

Fig. 1. Simple BCI game

During the period of research, got a chance to do study about the neurosky and also came to know about MaBeee. In our BCI game three modes has been created “Attention”,

"Meditation" and "MIX". Mix mode is the combination of attention and meditation.

Here in this game, players select the mode in which mode they want to play like "attention mode", "meditation mode" or "mix mode" in the selected time limit. There is starting point from where the game is started and also some points were written in the board. The game can be played by more than 2 players, the game was played thrice by one player and all the point's are added that gained by the players, the player with the highest point will win the game.

4 Mental State Classification

The main purpose of this research is to know the data accuracy level between three subject in three different pattern with three different machine learning classifiers SVM (Support Vector Machine), RandomForest and Deep Learning (LSTM).

To continue this research data were collected from the both sensor. To collect the data from the sensors, applications were developed for both sensors respectively. The data were collected from 3 subjects in 3 patterns for 1min, 2min and 3min respectively. For prediction data was collected for 1 min in 3 patterns from 3 subjects respectively.

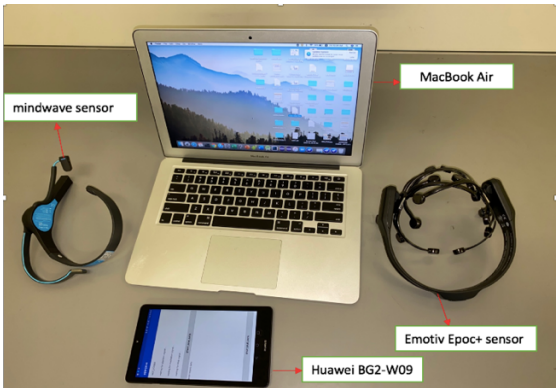

Fig. 2. Devices

Figure 2 shows the gadget that have been used through the entire research.

4.1 Neurosky MindWave Sensor Data Collection

We used Apple MacBook Air, simple Neurosky brainwave sensor and Huawei BG2-W09 tablet to collect the data [Fig. 2]. To collect data from the Neurosky MindWave sensor an android application was developed. EGG sensor is paired with android device, data start displaying on the android device screen. By tapping the "start saving data" button on the screen data will be saved in the android device memory and after tapping the "stop saving data" button data will stop saving.

4.2 Emotiv Epoc+ Sensor Data Collection

To collect data from Emotiv Epoc+ Sensor, application was developed in Xcode. In this application MacBook is connected with Sensor with the via Bluetooth. Through this application, data was collected for 5 parameters (theta, alpha, lowbeta, highbeta and gamma) from 14 channels. Data is automatically saved in csv file. In this application first sensor is connected with the application with the help of MacBook Bluetooth when the connection gets successfully. There is save button in application which save recorded data's.

5 DATA ANALYSIS

For the data analysis we used a tool named WEKA(a java based application introduced by Waikato University in New Zealand) [5]. Under WEKA three classifiers were used SVM, RandomForest, LSTM to analyze the data for the accuracy.

5.1 Neurosky Mindwave Sensor Data Analysis

Data that was collected from the Neurosky MindWave sensor [2] was analyzed through SVM [3], RandomForest [4] and Deep Learning [6] (LSTM) Classifiers.

5.1.1 SVM Analysis

Under SVM test option supplied test set is used and kernel type (k0) Linear: u'*v was used.

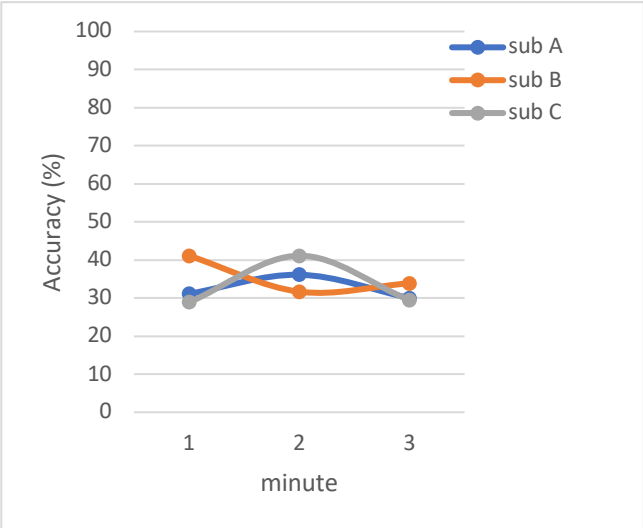

Fig. 3. Accuracy of SVM analyzed data

In figure 3, there was not seen a big difference in accuracy level in 3 subject. Here, subject B data accuracy level is high in 1min and 3min data, where subject C has high accuracy level in 2 min data.

5.1.2 RandomForest Analysis

While analyzing data through RandomForest test option supplied test set was used.

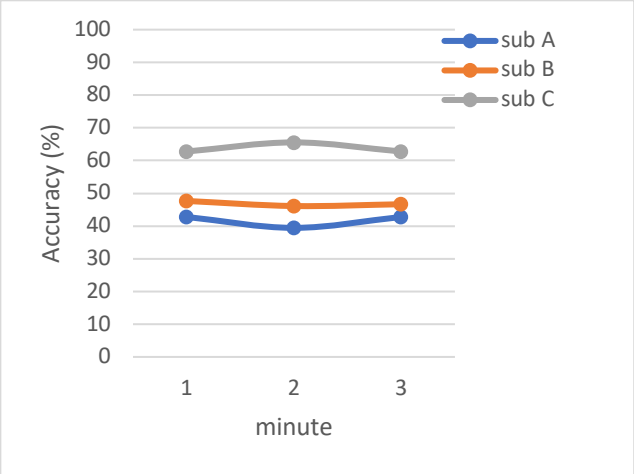

Fig. 4. Accuracy of RandomForest Analyzed data

Figure 4 shows the data accuracy graph that was analyzed through RandomForest classifier. Here subject C accuracy level is higher than the subject A and subject B.

5.1.3 LSTM Analysis

While analyzing the data through LSTM two layer have been used, first was LSTM layer and second was Output layer.

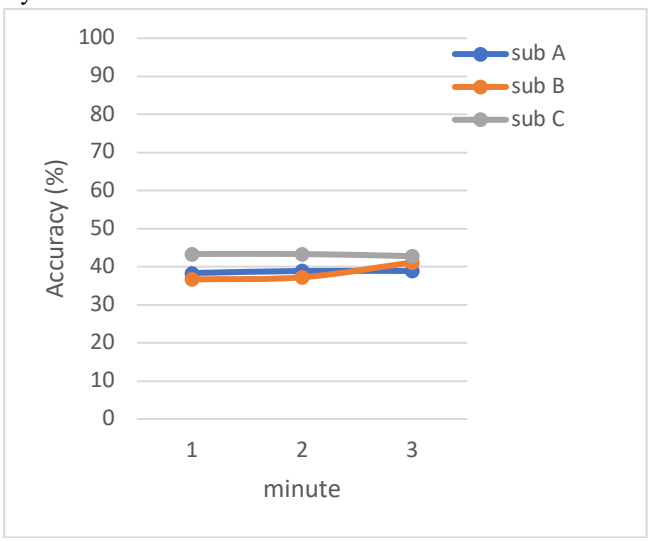

Fig. 5. Accuracy of LSTM analyzed data

Figure 5 shows the data accuracy graph that was analyzed through LSTM classifier. Subject C accuracy level is high but there is not much different in the comparison of subject A and subject B.

5.2 Emotiv Epoc+ Sensor Data Analysis

Data that was collected from the Emotiv Epoc+ sensor [6] was analyzed through SVM, RandomForest and LSTM classifiers.

5.2.1 SVM Analysis

Analyzing the data through SVM test option Supplied test set was used and kernel (k0) Linear: u'*v was used.

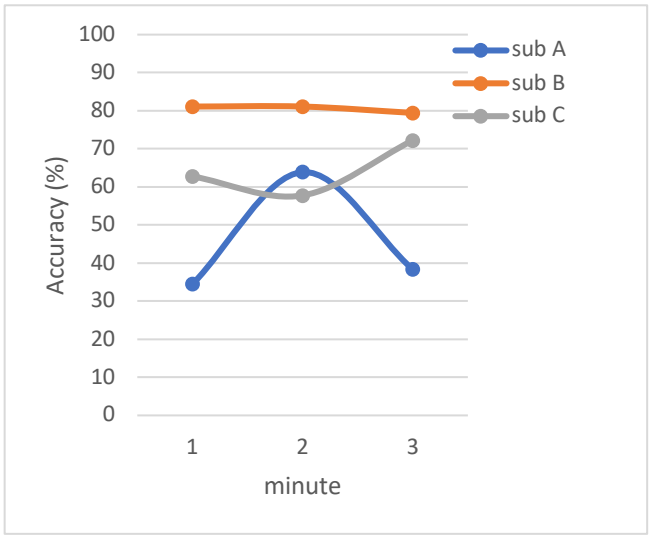

Fig. 6. Accuracy of SVM analyzed data

Figure 6 shows the graph of accuracy level between three subjects, here subject B data accuracy level is higher than the subject A and subject C.

5.2.2 RandomForest Analysis

Tests option supplied test set was used while analyzing the data through RandomForest classification.

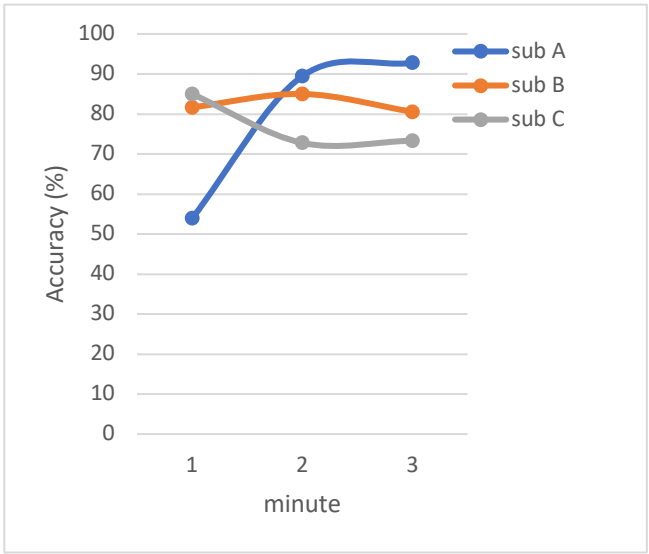

Fig. 7. Accuracy of RandomForest analyzed data

While comparing to subject B and C, subject A data accuracy rate was gradually increasing through 1 to 3 minute. Whereas subject C was highest in 1 minute and decreases at 3 minute.

5.2.3 LSTM Analysis

Analyzing data through LSTM, two layer have been used first was LSTM layer and second was output layer.

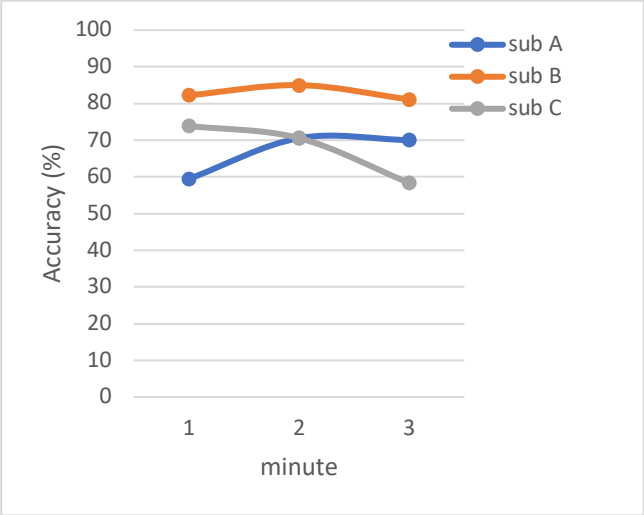

Fig. 8. Accuracy of LSTM analyzed data

Figure 8 shows the graph for LSTM accuracy. According to graph, subject C is decreasing from 73.88% to 58.33% in 1 minute to 3 minutes. Data Accuracy rate is high in subject B.

6 CONCLUSION

While starting the project we had gone through the different research that is related to this project. And also got chance to do study about the Neurosky MindWave sensor, Emotiv Epoc+ sensor, MaBeee device, brain computer Interface (BCI). Last but not least also did study about the Weka. Under Weka we got chance to learn about SVM, RandomForest and LSTM classifiers.

Design a BCI game were attention and meditation level was focused. Simple brainwave sensor with 1 signal channel was used. This research was done just for entertainment and to know the concentration and meditation level. In future work it would be interesting to conduct further analysis from a neuroscience perspective. One signal channel neuro sensor was used but in future we would like to use the sensor having more than one signal channel for the better performance. Our research is not just to create the BCI game, this research is just one step through which we can get chance to move on other steps.

Brain wave data is varies from person to person. And also came to know that concentration power is high in the silent environment. The data collected in the silent environment and in the noisy environment, the accuracy percent of data that was taken in silent environment was higher than the data that was taken in the noisy environment. Through this experiment we collect the data from in 3 pattern like for construction level (with simple mathematical problem), relaxing level (without doing anything), and while listening music.

Analyzing both Neurosky Mindwave sensor data and Emotiv Epoc+ sensor data, the accuracy level was not reliable for both sensor data in SVM classifier. Data accuracy level for both Neurosky Mindwave sensor data and Emotiv Epoc+ sensor data was higher in RandomForest classifier in the comparison of SVM classifier. Data accuracy on LSTM classifier was reliable for both sensors data, when the channel increases the data accuracy level also get higher. While comparing the data accuracy between Neurosky Mindwave sensor and Emotiv Epoc+ sensor data. Emotiv Epoc+ sensor data accuracy is high in each classifier.

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