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EVALUATING THE ML MODELS FOR MINDBIGDATA (IMAGENET) OF THE BRAIN SIGNALS

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Abstract: Even though humans performance is excellent still humans can't reach machines mechanism in visualizing the objects and images. Most of the new rediscovery of Neural Networks which has led to a notable performance and advancements in automated visual classification and their generalization capabilities are not up to human expectations, since machines learn biased feature space, which majorly turn on the working of the training datasets despite of its general principles. This project mainly inspects about the define classification of image-based processing of electroencephalogram [EEG] signals caused by the observer's brain. In our project the main chore was to focus on the particular task of processing the EEG signals resulted in brain when an image is spotted, so the kind of object appeared in the image will be well defined. Proposed methodology focuses at interpreting an input multichannel temporal EEG sequence into a low proportions feature vector summing up the relevant content for an input sequence by directly connecting the time sequences from innumerable channels into a unique feature vector, neglecting temporal.

Keywords : Brain Computer Interface(BCI), Electroencephalogram (EEG),Logistic Regression, Knn, SVM, MindBigData, Emotiv Insight ,IMAGENET.

I. Introduction

A BCI (Brain Computer Interface) is an innovation that sends and receives signals among the brain and peripheral device. Brain-computer interfaces are priorly known as brain-machine interfaces. BCIs gather and analyses brain signals and the transfer them to attached machine that output orders related with the brain signals is required. BCI can be passive or active. A passive device just explains brain signals to give perception about the intellectual state of a person. A BCI can also be called a brain-machine interface, a neural-control interface, a mind-machine interface or a direct neural interface.

An Electroencephalogram [EEG] is a trial that calculates electrical activity in the brain using small metal discs called electrodes linked to the scalp. Brain cells convey via electric impulses and are energetic all the time, even while the sleep. EEG signals are used in applications such as auditing of awareness and mental engagement etc., The EEG Electrode Placement of 10-20 system of the international federation is an internationally recognized method that uses anatomical landmarks to standardize the placement of electroencephalography (EEG) electrodes. The system is based on the connection among electrode placement and the fundamental areas of the cerebral cortex whilst guaranteeing all the brain regions are required.

The figure 1 shows the EEG Electrode placement of international 10/20 system

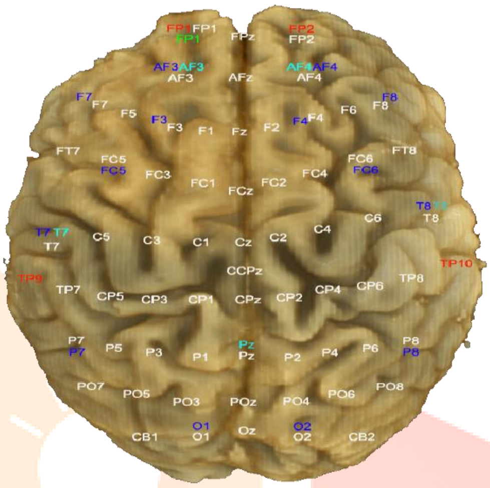


Figure 1 – International 10/20 system for electrode placement

The position of the electrodes on the scalp is based on the International 10-20 system.

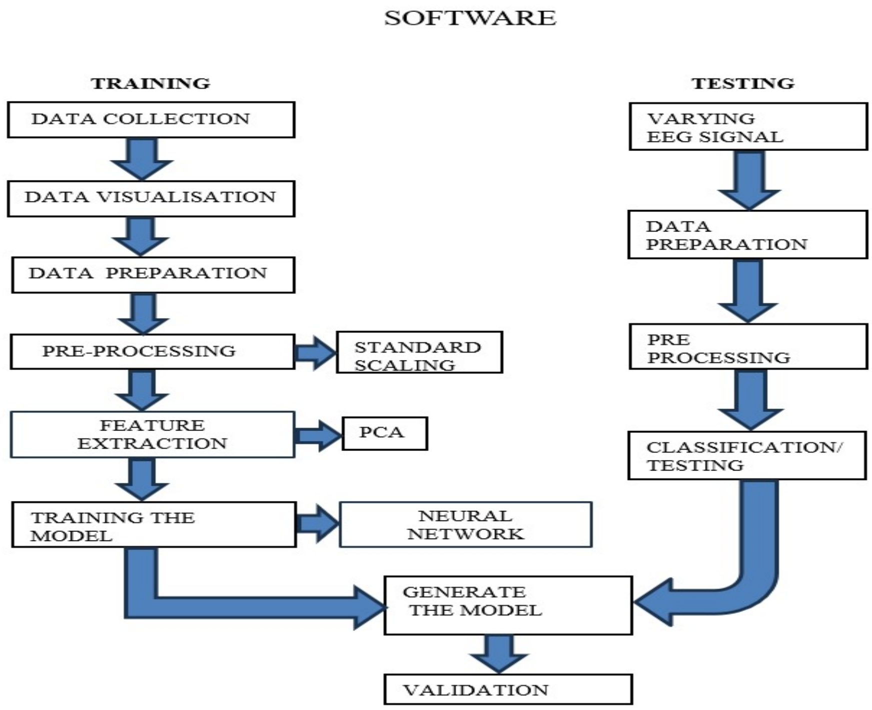
- *F – frontal lobe*
- *C – central lobe*
- P - parietal lobe
- O – occipital lobe
- T- temporal lobe

II. LITERATURE SURVEY

[1] this is the website were we collect the dataset which we are analyzing and they also explained the procedure they while collecting the data. [2] tells the biomedical signals of EEG and the different types of EEG and the different locations of electrode placements which vary the EEG signals to a different level which in turn goes to the other interesting topic that the EEG signal is not transmitted through neurons rather it is the white matter present in the brain. [3] Mind Big Data provides the updated datasets which contains the various set of activities performed by humans which uses most of the advanced technology to classify the set of activities of humans based on its by using various ML or DL algorithms**.** [4] This paper tells us about the various methods of EEG trials using an array or sequence of methods to get the best out of it. Here we use matrix multiplication to categories a largest of EEG datasets to get the required accuracy.[5] The

various colours a human brain can differentiate and the different categories varies from one electrode placement to other and the Muse 2 headband which is a portable non-invasive device that allows capturing of EEG signals. [6] This paper tells about how to compare the signal acquired by the developed EEG device using Emotive Insight device as a benchmark, which is already an established wireless and dry electrode-based EEG on the market.

III. RESEARCH METHODOLOGY



The datasets is separated into train and test data separately then it is evaluated at different instants the training phases comprises of many steps:

A. **Data Collection**: Data collection is the process of gathering and measuring information on variables of interest in a systematic and organized way.

The data which we are collected is publically available Mind Big Data[IMAGENET] where the data's are stored in such a manner that it is extracted in csv format viewing the available url http://mindbigdata.com/opendb/imagenet.html.

Here while collecting the data they are used Emotiv Insight headcap with a frequency of 128Hz. The data is saved in a simple text arrangement, with one CSV file for each EEG documentation related with a unique image. There are a total of 14012 CSV files which contain data of 5 channels each, this data consists of 26,850,320 data points. These 14012 files are consolidated into a single CSV file creating a data setting inclusive all the required features from data.

- Since they used 5 different channels (AF3, AF4, T7, T8, Pz) in 10/20 system for the recognition of the images using EEG headset.

While capturing brain signals with a stimulus of seeing a random image eacg images are shown for 3 seconds here to avoid the long recording time only 5 images are shown for each session with a 3 seconds of visualisation and 3 seconds of blank screen between them

In [1] the structure of the files is as follows:

The naming convention if we take for example the file:

"MindBigData_Imagenet_Insight_n09835506_15262_1_20.csv".

Mind Big Data Imagenet Insight: relates to the EEG headset used Insight atm only.

n09835506: relates to category of the image from the “Synsent of ILSVRC2013”.

15262: relates to the exact image from the above category, all the images are from the ILSVRC2013_train dataset, downloaded from the Kaggle Website.

_1: relates to the number of EEG sessions recorded for this image, usually there will be only 1 but it is possible to have several brain recordings for the same image, second will be 2 and so on.

20: relates to a global session number where the EEG signal for this image was recorded, to avoid long recording times only 5 images are shown in each session with 3 seconds of visualization and 3 seconds of black screen between them.

Inside each of the csv files there are 5 lines of plain text one for each EEG channel recorded, ending with a new line escape character. Each line starts with the Channel name from the Emotive Insight Headset as a text "AF3, "AF4", "T7","T8" or "Pz". And then separated by (,) for this headset data rate is at 128Hz.

B. **Data Visualization**: Is the representation of data in a graphical or pictorial format to help people understand the significance of the information. The obtained data’s are visualized with taking different Synsent id values and plotted against the data points to know the variations of brain by seeing different images and the variations are calculated by various techniques.

Since they used 5 different channels (AF3, AF4, T7, T8, Pz) for the recognition of the images using EEG headset.

If you plot all the raw values for the AF3 channel (first line of the file) you have this signal -128HZ

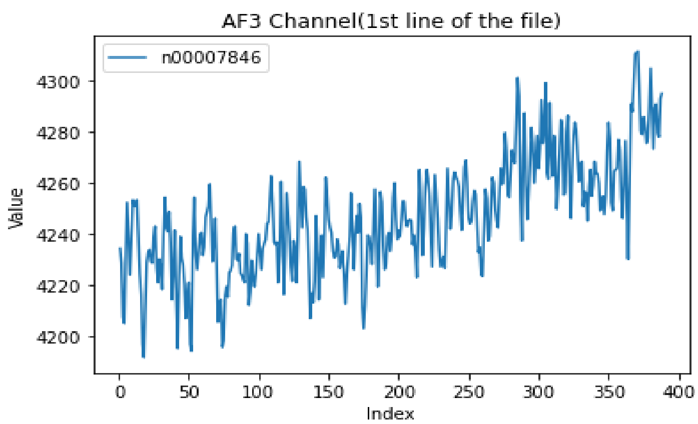


Figure 2 Shows that variation of AF3 channel with single synsent id

Here we separated datasets of 5 channels and stored in different file. Then the graph were plotted to visualize separately.

Here we are considering the 10 different categorize of image and plot the graph for all the 5 channels (2,24, 57, 75, 110, 130, 155, 175, 202, 222) separately.

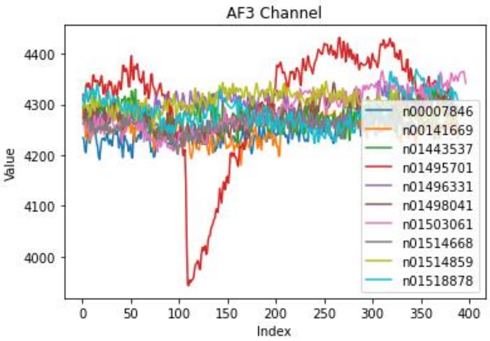


Figure 3(a): Graph of AF3 channel with 10 different synsent id's

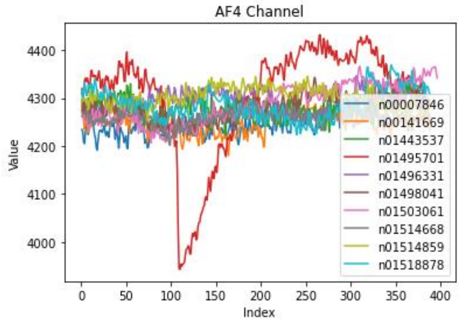


Figure 3(b): Graph of AF4 channel with 10 different synsent id's

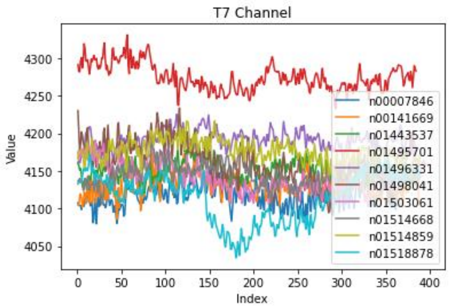


Figure 3(c) Graph of T7 channel with 10 different synsent ids

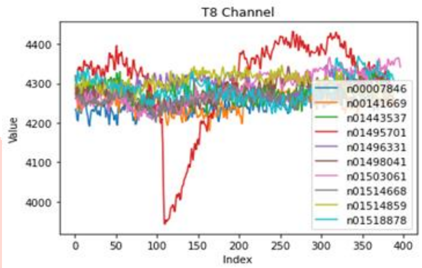


Figure 3(d) Graph of T8 channel with 10 different synsent ids

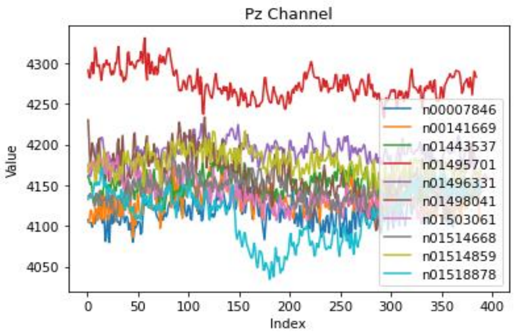


Figure 3(e): Graph of Pz channel with 10 different synsent id's

C. **Data Preparation**: It is a crucial step in the data analysis pipeline. It involves transforming raw data into a format that is suitable for analysis.

The data which are collected from [1] are altered in such a way that all the channels of all the images are collected in different 5 files in such a way that all the data points are represented by their respective synsent id's in the last column of the csv file. The uneven data sets is made even by using normalization where different channels EEG files are made even and stored in csv format.

D. Pre-processing: It involves cleaning, transforming, and organizing the data into a format that is suitable for modeling or other analytical processes.

The pre-processing method which we are used in our project is standard scalar which is used in Machine Learning to standardize the features of the data. Here the features are rescaled so that the properties of standard normal distribution is satisfied with a mean of 0 and standard deviation of 1.

The formula for standard scalar is given by

$$Z= (x- \mu)/ \sigma$$

Where ,

Z is the standardized value

x is the original value

μ is the mean of the feature and

σ is the standard deviation of the feature

D. Feature extraction: The process of selecting or transforming relevant features from raw data to create a reduced-dimensional representation retains the essential information for analysis or model building. The data's are extracted using Machine Learning algorithm techniques and the data's are made even and normalized to get the require eigen values.

Principle Component analysis (PCA) is the method which we have used in the feature extraction technique The PCA involves mean normalization of the features, creating the co-variance matrix, determine the eigen values and obtain the minimized features of primary components. Here our data points has been reduced to 384 from 444 dimensions.

E. Training the model: The process of using a machine learning algorithm to learn patterns and relationships within a dataset. Here we try different Machine Learning algorithms by splitting the data and the training and testing with a different percentages and randomness. Since it has a 564 categories we are using the classification algorithms to train the model. Here the different Machine learning algorithm used are Logistic Regression, KNN , SVM.

- **Logistic Regression**: is a supervised machine learning algorithm mainly used for predicting the categorical dependent variable a given set of independent variables. It can be either Yes or No, 0 or 1, true or False, etc. but instead of giving the exact value as 0 and 1, it gives the probabilistic values which lie between 0 and 1.

  In Logistic regression, instead of fitting a regression line, we fit an "S" shaped logistic function. Logistic Regression classify the observations using different types of data.

  The general equation

  $$P(Y=1)=1/(1+e-(b0+b1X1+b2X2+\ldots+bnXn))$$

  Where

  P(Y=1) is the probability that the dependent variable Y is equal to 1.

  e is the base of the natural logarithm.

  b0 is the intercept (constant term).

  b1,b2,…,bn are the coefficients associated with the predictor variables 1,2,…,X1,X2,…,Xn.

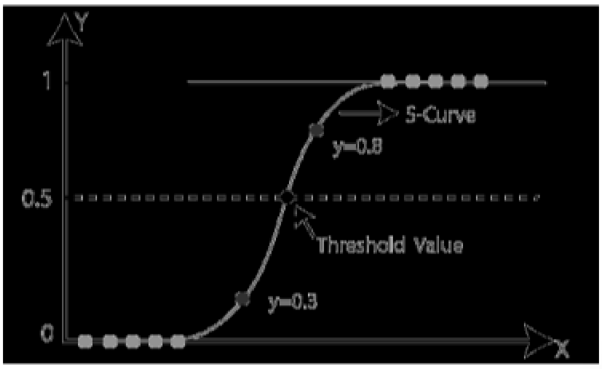


Figure 4 : Sigmoid function

- **K-Nearest Neighbor(KNN):** The k-nearest neighbor algorithm, also known as KNN or k-NN, is a non parametric, supervised learning classifier, which uses proximity to make classifications or predictions about the grouping of an individual data point. Similarity between the new case/data and available cases and put the new case into the category that is most similar to the available categories.

  Euclidean Distance is the distance between the two points which are in the plane/hyperplane.

  $$\text{distance}(x, X_i) = \sqrt{\sum_{j=1}^{d}(x_j - X_{i_j})^2]}$$

  Where

  The algorithm selects the K data points from X that have the shortest distances to x.

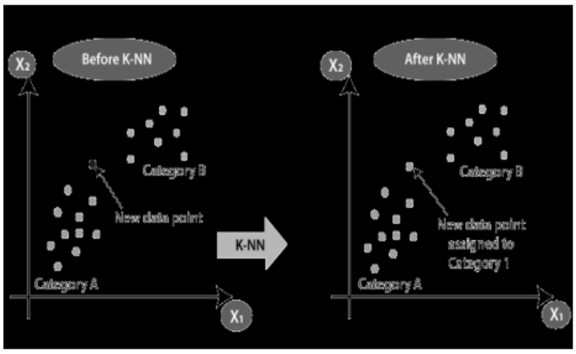


Figure 5 :KNN

- **Support Vector Machine :** SVM is known as support vector machines. The goal of the SVM algorithm is to create the best line or decision boundary that can segregate n-dimensional space into classes so that we can easily put the new data point in the correct category in the future. This best decision boundary is called a hyperplane.

  The equation is given by

  f(x)=sign(w·x+b)

  Where

  f(x) is the decision function.

  w is the weigh vector.

  b is the bias term.

  sign(·) is the sign function, which output +1 for positive values, -1 for negative values, and 0 for zero

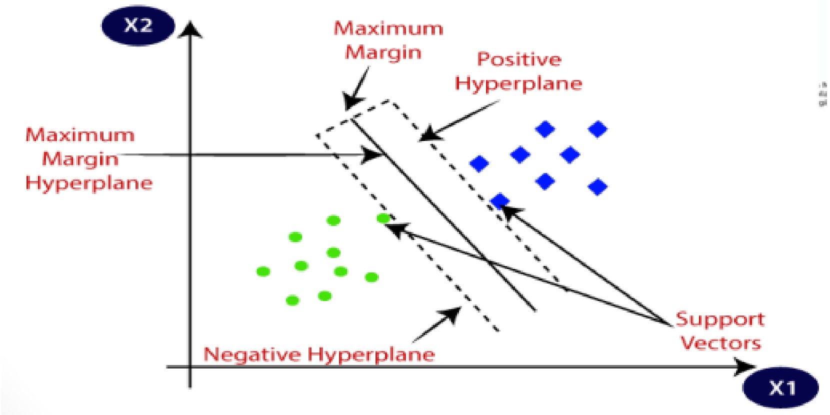


Figure 6: SVM

F. Varying EEG signal: Here the EEG signals are taken where the categories are unknown for testing the already trained data to obtain the required results and precise accuracy.

Data Preparation and Feature Extraction are similar to the trained database.

G. Classification Testing: Classifying the required data for convenience and comparing it with trained data to obtain the categories with its match and to find the accuracy

H. Generate the model: Then the model is generated by comparing the trained and tested data sets by using types of Machine Learning algorithm techniques in order to obtain the accuracy which will be further explained in final

IV. RESULTS AND DISCUSSION

The accuracy of each channels is above specified the accuracy is obtained by using various ML algorithm techniques prior to that normalization of data is done to find the average values of individual channels respectively then the standard scaler are taken to reduce the complex data into a distinguishable manner to get accuracy in the simpler manner.

As the above mentioned the accuracy is obtained as follows for various ML algorithm techniques above mentioned techniques we can see that accuracy is more and precise in Logistic Regression since in Logistic regression, instead of fitting a regression line, we fit an "S" shaped logistic function, which predicts two maximum values (0 or 1). Hence the object or image classification for 5 EEG channels can be seen.

Then we get KNN is suitable since k-NN is a type of classification where the function is only approximated locally and all computation is deferred until function evaluation. Since this algorithm relies on distance for classification, if the features represent different physical units or come in vastly different scales then normalizing the training data can improve its accuracy dramatically.

Here the least accuracy is obtained for Support Vector Machine hence SVM is least preferable.

MACHINE LEARNING TECHNIQUES	90%(TRAINING) 10%(TESTING)	80%(TRAINING) 20%(TESTING)	70%(TRAINING) 30%(TESTING)	60%(TRAINING) 40%(TESTING)	50%(TRAINING) 50%(TESTING)
LOGISTIC REGRESSION	10.5909	10.7978	10.952	11.8969	12.4892
KNN	5.8665	5.5875	6.0211	6.62894	6.9821
SVM	2.9822	2.4203	2.8556	3.1258	3.7238

From the above result we can say that the algorithm which are been used in the above are giving very less accuracy and even we had also tried the Random Forest, Decision Tress algorithm which are also not appropriate for the dataset which we are taken. So from above we can conclude that further you guys can try other deep learning algorithms which improve our accuracy.

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