EEG CLASSIFICATION OF HAND MOVEMENT USING MACHINE LEARNING

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project titled "EEG CLASSIFICATION OF HAND MOVEMENT USING MACHINE LEARNING",submitted by MD. TANVIR AHMED, ID No: 151-15-5020, SOURAV DAS, ID No: 151-15-4927, JARIN TASNIM NISHA, ID No: 151-15-5414, SRABANI GAIN, ID No: 151-15-4848to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 11/12/2018.

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DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Professor Dr. Syed Akhter Hossain,Honorable Head, Department of CSE**Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

Brain computer interface can provide a communication pathway and control channel between brain and external devices. In this paper, we used global EEG dataset from UCI Machine Learning Repository *(https://archive.ics.uci.edu/ml/datasets/ Planning +Relaxx)* to classify the dataset associated with the left and right hand movement. Initially normalization is used to preprocess the dataset. This paper gives the result of deploying two classification algorithm random forest and Support Vector Machine (SVM) classifier to classify the dataset. Random forest and SVM got accuracy of 98.46% and 73.84% respectively. After preprocessing, the processed dataset was input into random forest and SVM classifier. Comparing with this two accuracy, the accuracy result of random forest classification algorithm is quite good and promised to be used in BCI context.

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CHAPTER 1

Introduction

1.1 Introduction

In recent years it has become possible to understand brain signals by Brain Computer Interface (BCI). BCI creates a direct connection between the human brain and a computer. By interfacing the brain signals directly, it is possible to design brain computer interfaces to control devices without mechanical interfaces. Especially direct controlling the prosthetic organs for disabled people. Although brain activities can be measured through non-invasive devices such as functional magnetic response imaging (fMRI), magneto-encephalogram (MEG), position emission tomography (PET) and so on. Due to low cost and portability the most common Brain Computer Interfaces are based on Electroencephalogram (EEG). In EEG based BCI systems, usually non-invasive sensors are placed on the scalp of the subject for detecting the changes in electrical potentials that are originated by the neurons.

1.2 Motivation

In the field of Biomedical Engineering the use of Motor Imagery EEG signals from Brain Computer Interfaces are extensively explored for various applications mostly for prosthetic organs and robot controlling. In research sector for neuroscience, cognitive science, cognitive psychology and psychological research, these motor imagery EEG signals are extensively used. But the challenge is how accurate the signals that are required. It's quite difficult to classify expected motor imagery EEG signals as per need without unnecessary signals obtained from Brain Computer Interfaces. More precisely a particular sector – left or right hand movement classification. When the EEG signal acquisition procedure is going on its quite general to get some non-physiological artifacts like power line artifacts, electrode popping, lose or broken electrodes and biological artifacts like eye blinking, lip movement, nose movement, facial movement which are capture alongside the left or right hand movement. The classification is needed to determine how accurate a device is that made for physically disable people or robot controlling.

1.3 Rationale of the Study

The impact made by project is long term. For example the earlier works related to same topic has been done so far of classification and comparison. None of them was used in real life device accuracy detection. That's the main gap between the study and the studies have been accomplished before. That specific problem will be focused throughout the project. And most importantly the result of the study will be used in the real life implementation such devices for disabled people and robotic control.

1.4 Research Question

We have developed some research questions which has been stated the issues our project focuses on and outlined the tasks that have to be completed. The research questions are as follows:

(a) Does the data only associated with left and right hand movement?

(b) Which classify techniques will be used accomplishing the satisfied and optimal classification accuracy and why?

1.5 Expected Output

There is a lot of research works exists that are able to classify EEG data but have a bunch of limitations. Some have only way to classify but no to extract prospective features extraction. Some works tend to remove non-physiological and biological artifacts but not to classify signals. This research work will accomplish the both that mean classifying left or right hand movement classification along with advance feature extraction. It focuses on the highest accuracy of the classification of motor imagery EEG signals with best and prospective features.

1.6 Report Layout

Chapter 1: Introduction

The very basic of our project will be focused in this section. As per project what is EEG signal classification actually and how we got this idea is the main point here. Besides some questions related to our project will be come in front. And the most importantly about the expected output of the project will be discussed in a nutshell.

Chapter 2: Background

From where we have got the idea about project will be discussed here as well, but in briefly. For that the literature review of some related works will be come in front. For example what they have done, what haven't and what couldn't able to implement. And from that what is the scope of our project in the same area yet will be mainly focused in the background section. Moreover what kind of challenges will have to face to get it done will also be discussed.

Chapter 3: Research Methodology

As per the title of this section the main goal of this part is form a research methodology. Most specifically how the project will be get done through which procedure. That’s the main area of discussion here. Very first of all the about the research subject and instrument will be discussed shortly. Since the main component of the project is Data, So the main focus will be on it. For example how to collect data, which algorithm will be used to analyzing the data, which will be used in particular case like preprocessing, classification and so on. A short description about the every single algorithm which will be used will be given here. And finally the whole stuffs will be shown very easily with just a block diagram along with a proper segmentation of the main methodology.

Chapter 4: Experimental result and discussion

Here comes the most important part of the project where all mathematical evaluation will be discussed briefly. The experimental result and descriptive analysis will be given in this section which will focus on the mathematical accomplishment of the project. And end of the section a through simple short way the whole section will be summarized.

Chapter 5: Summary, Conclusion, Recommendation and Implication for future research

In this section the whole project will be summarized very shortly. And the recommendation and further implication will be given. More specifically what is the ultimate result of the project and how this result can be used in the same field for more advanced research in the field of Biomedical Engineering.

CHAPTER 2

Background

2.1 Introduction

The floor point of the project is to classify EEG signals of Left and Right hand movement in the most authentic way and get the highest accuracy. The same type of works has been done before but in different way. What we have been choose to accomplish is to basically identify and monitor brain activity and brain states.

2.2 Related Work

As this is not the very first time this sort of research work has been done. So many renowned scholars have been done almost same sort of work.

Saugata Bhattacharya et al has been proposed a methodology to define the features to be extracted and developed a study of comparative performance analysis of different classifiers[1]. They have used two approaches in their research work – one is simple t-test and other is Principal Component Analysis (PCA).

Mohammad H. Alomari et al has proposed an automated computer platform to classify EEG data related with left and right hand movement [2]. They have been used NN and SVM to classify the signals and find out the optimal result. Their technique of using advance feature extraction method has simplified the area of classification in neuroscience.

Lavanya et al has been accomplished their work on classification of hand movements with Linear Discriminant Analysis (LDA) and has found the accuracy 90% from LDA classifier[3].

Rinkal G. Shah et al has been focused on the classification of left and right hand movement based on a specific set of features [4]. They have found a satisfied result using K-means and Support Vector Machine (SVM) algorithms.

Muhammed Zeeshan Baig et al has proposed an efficient approach to classify motor imagery EEG data of left and right hand movement with supervised and unsupervised methods[5]. Their main task was to reduce features to obtain optimal classification accuracy and they have found 84.17% classification accuracy using PCA.

Neethu Robinson et al has defined a signal processing techniques to classify non-invasive EEG data associated with hand movements and finally get a classification accuracy of 80.24% to classify them in left and right hand movement [6].

Nguyen Thi Minh Huong etal has mainly focused on the classification with a specific set of features [7]. They have use Artificial Neural Network (ANN) to classify the EEG signals which are on left and right hand movements.

Prasant Kumar Pattnaik et al has used their proposed technique on a small dataset of finger and hand movements [8]. They have applied filtering techniques to extracted their expected features and Wavelet Transform to classify the signals.

2.3 Research Summary

Our main focus is to obtain the optimal result of classification of EEG signals of left and right hand movements acquired from Brain Computer Interface. We have used Normalization technique to pre-process data and to classify Random Forest and Support Vector Machine algorithm has been used. And finally we recommend the random forest algorithm with highest accuracy by comparing between random forest and SVM classifier.

2.4 Scope of the Problem

The principle scope of our research works is to define the optimal algorithm in terms of classification of EEG signals associated with left and right hand movements. The main objective of this project is accomplished with the comparative performance analysis between Random Forrest and Support Vector Machine classifiers.

2.5 Challenges

In any sort of analysis the most faced problem is *Data*. The scenario is not different here. We have been facing the data collection problem. Our main plan was to use real time data for analysis with a 14-channel emotive headset. But we couldn't have managed the device because of lengthy process and higher price. We have been looking for the positive response from National Institute of Neuroscience for data collection. But we didn't get so. That's why we have used a free data from UCI machine learning repository. The data was noisy and wasn't well attributed. Bu finally we have allocated attributed and accomplished our project.

CHAPTER 3

Research Methodology

3.1 Introduction

The main task of the implementation of the research work is to develop a methodology. Throughout the step by step of the methodology any research work can be accomplished. We have been working with EEG data. In two ways EEG data can be analyzed: one is – image data and the other is numerical value. Since we were working with numerical value of the EEG data, the working procedure is different from the regular image data processing.

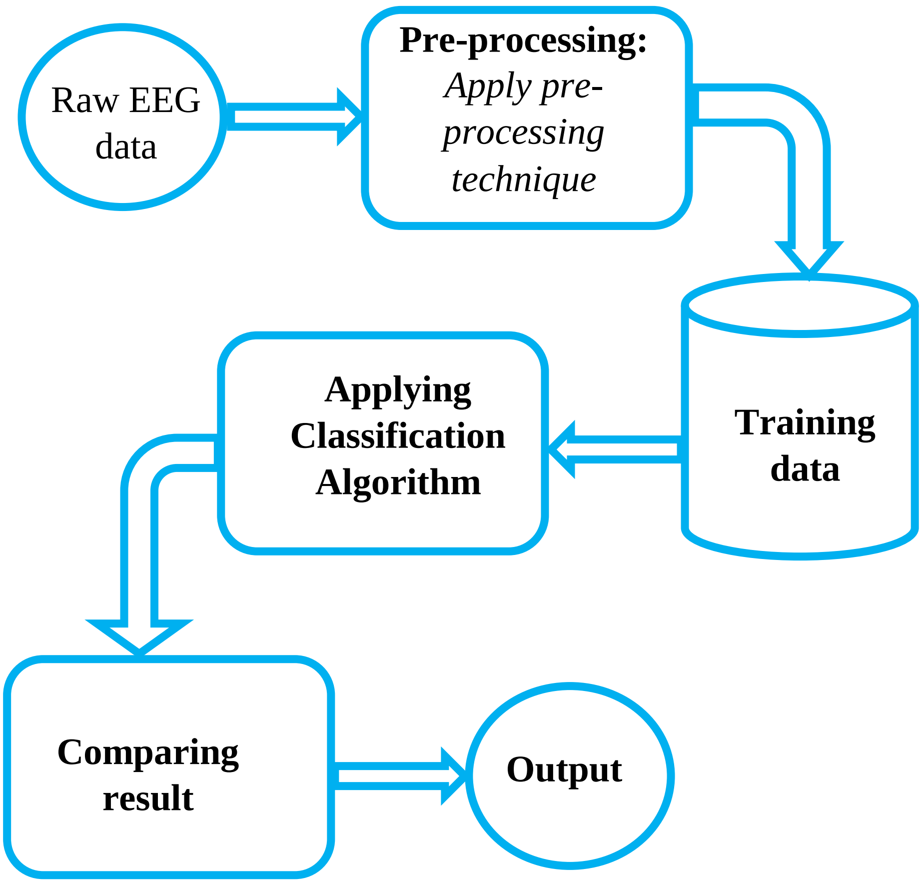

Figure 3.1.1: Block diagram of the proposed methodology

3.2 Research Subject and Instrumentation

The main objective of this research work is to classify left or right hand movement of motor imagery EEG signals obtained from Brain Computer Interface using Machine Learning techniques. So that the brain states of the subject (human here) can be classified by identifying and monitoring the brain activity.

3.3 Data Collection Procedure

The data we have been working with is from UCI machine learning repository. The data was collected from volunteer person aka subject in term of data collection methodology. A 14-channel EEG headset has been placed on the scalp of a healthy subject. Then five minutes long EEG records was taken while the subject is resting and eyes are shut. Then a beep sound of 60-70 dB was heard and the subject was asked to plan to move left hand for five seconds. After 5 minutes of stable situation subject was asked to plan the right hand for five seconds. These records were stored on a computer connected to the BCI headset placed right before the subject.

3.4 Statistical Analysis:

a) Data preprocessing: Data normalization is most widely used preprocessing technique in data preprocessing stage. Data normalization is such an important transformation technique that by using this, considering datasets it can improve accuracy and accomplish better performance. Here min-max normalization is used.

Min-max normalization: The min-max normalization technique (*Kotsiantis et.al.)* normalizes [9]the dataset using linear transformation and transforms the input data into a new fixed range. This technique ensures that the input values which are very extreme are constrained in a specific range. Specifically max normalization is used here. Min-max normalization transforms a value from X0 to Xn. This fits in the specified range and it is given by equation.

$$Xn = \frac{X0 - Xmin}{Xmax - Xmin}$$

Where Xn is a new value for variable X, X0 is a current value for variable X, X min is the minimum data point in the dataset and Xmax is the maximum data point in the dataset.

b) Classification using random forest and support vector machine (SVM): Hand movement classification using EEG data requires choosing an accurate classifier for proper classification and improving accuracy. SVM classifier is widely used in hand movement and random forest is also used.

Random forest: Random forest is an ensemble learning method for classification. It aims to construct a multitude of decisions trees in training time and outputting the class that is the mode of the classes or mean or mean prediction of the individual trees.

Support Vector Machine classifier: A support vector machine is a classifier which is discriminative classifier formally defined as separating hyper plane. It can be used for classification, regression or other different tasks.

3.5 Implementation Requirements: We have developed a methodology for the implementation of proposed research plan.

We have segmented the whole methodology into three steps. The whole research work has accomplished these step by step with selected algorithms for data preprocessing, classification and find out the best result.

Step 1:Pre-processing
Technique: Normalization

Step 2: Apply some classification algorithm
Algorithm: Random Forest and SVM assembly classifier

Step 3: Find out the best result by comparing between them

CHAPTER 4

Experimental Result and Discussion

4.1 Introduction

In this section, we represent the results of different methodologies and the results of different algorithm which are applied in EEG data.

4.2 Experimental Result

In data preprocessing stage, normalization is used, specifically max normalization is used. Norm = 12 as max value is used.

Random forest and SVM classifier are used here. Random forest got 98.46% classification accuracy whereas SVM classifier got 73.84% classification accuracy.

4.3 Descriptive Analysis

After preprocessing data by max normalization, dataset is ready to apply classification algorithm. First random forest algorithm was used where estimator = 100, max_depth = 500 and random state = 0. Random forest algorithm got 98.46% accuracy.

Confusion matrix represents a summary of predictions result on a classification problem. The confusion matrix summarized the number of correct and incorrect predictions with count values and broke down each class.

True Positive (TP)

Interpretation: Observation is positive, and is predicted to be positive.

False Negative (FN): Type 2 Error

Interpretation: Observation is positive, but is predicted negative.

True Negative (TN)

Interpretation: Observation is negative, and is predicted to be negative.

False Positive (FP): Type 1 Error

Interpretation: Observation is negative, but is predicted positive.

TABLE 1: CONFUSION MATRIX FOR RANDOM FOREST

	Actual Values	
	True Positive (TP)	False positive (FP)
Predicted Values	47	1
	False Negative (FN)	True Negative (TN)
	0	17

TN= 17, FP= 1, FN= 0, TP= 47

True Positive (TP) = 47 (In percentage of 100)

False Negative (FN) = 0

True Negative (TN) = 17

False Positive (FP) = 1

Precision: Out of all the classes, the model predicted correctly.

Recall: Out of all the positive classes, how much the model predicted correctly. Recall percentage should be high as possible

f-score: f-score is used to compare between two models. f-scores helps to measures recall and precision at the same time. It uses Harmonic Mean in place of Arithmetic Mean by punishing the extreme values more.

	Precision	recall	f1-score	support
Class 0	1.00	0.94	0.97	18
Class 1	0.98	1.00	0.99	47
Avg / total	0.98	0.98	0.98	65

Here, Precision = 98%

Recall/Sensitivity/True Positive Rate = 98%

F1-score = 98%

Specificity: $\frac{TN}{TN+FP}$ = 0.944 = 94%

False Positive Rate: $\frac{FP}{FP+TN}$ = 0.055 = 6%

Receiver Operating Characteristic Curve (ROC Curve): It illustrates the diagnostic ability of a binary classifier system. The ROC Curve is created by True Positive Rate against False Positive Rate at various threshold settings.

Area under the Curve (AUC) = AUC represents the classification performance.

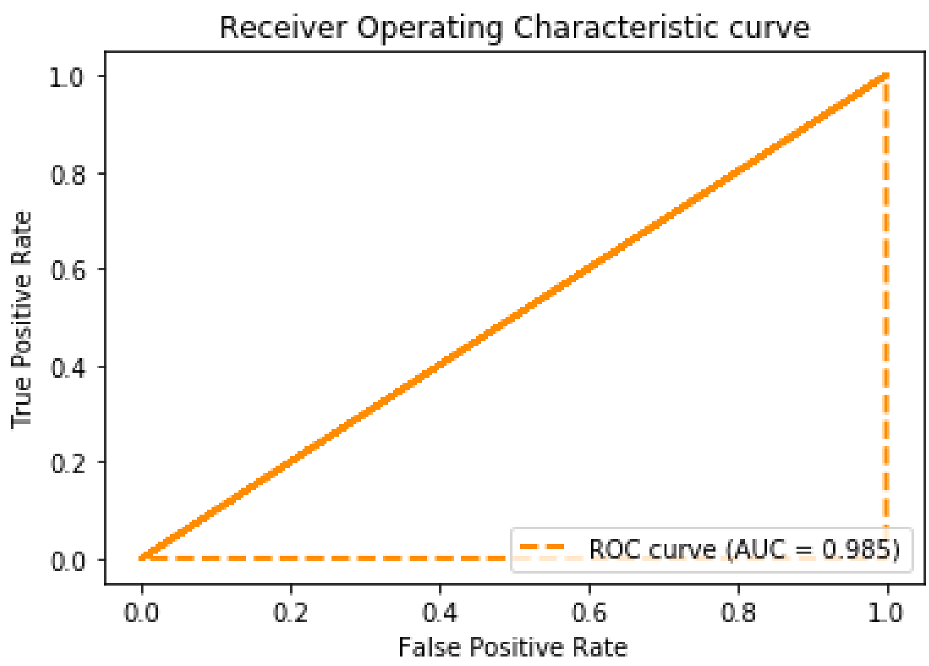

Figure 4.3.1: Roc curve of random forest

Here AUC = 0.985 = 98%. So we can say classification performance rate is 98%.

After that, we applied SVM classifier whereas SVM classifier got 73.84% classification accuracy.

TABLE 2: CONFUSION MATRIX FOR SVM CLASSIFIER

	Actual Values	
Predicted Values	True Positive (TP)	False positive (FP)
	48	17
	False Negative (FN)	True Negative (TN)
	0	0

TN= 0, FP= 17, FN= 0, TP= 48

True Positive (TP) = 48

False Negative (FN) = 0

True Negative (TN) = 0

False Positive (FP) = 17

	precision	recall	f1-score	support
Class 0	0.00	0.00	0.00	17
Class 1	0.74	1.00	0.85	48
Avg / total	0.55	0.74	0.63	65

Here, Precision = 55%

Recall/Sensitivity/True Positive Rate = 74%

F1-score = 63%

Specificity: $\frac{TN}{TN+FP}$ = 0

False Positive Rate: $\frac{FP}{FP+TN}$ = 1

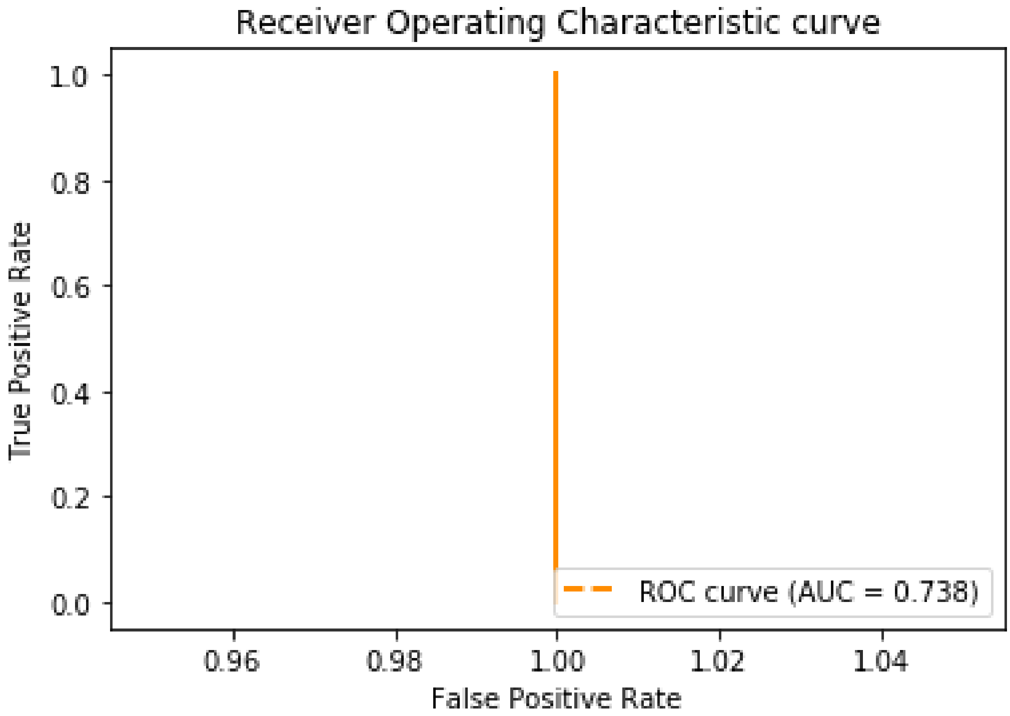

Figure 4.3.2: Roc curve of SVM classifier

Here, AUC = 0.738 = 74%.

4.4 Summary: After applying two classifications algorithm in preprocessed data random forest and SVM classifier got 98.46% and 73.84% accuracy respectively. So analyzing the accuracy result, random forest got highest classification accuracy.

CHAPTER 5

Summary, Conclusion, Recommendation and Implication for future research

5.1 Summary of the study

In data preprocessing stage we applied normalization technique to get data in well refined format. More specifically we used max normalization technique. After getting processed data, data is ready for applying classification algorithm. We applied two classification algorithms such as random forest and SVM classifier. Random forest and SVM classifier got 98.46% and 73.84% accuracy respectively. We will recommend random forest classification algorithm to get highest accuracy.

5.2 Conclusion

As comparing two algorithms random forest classification got highest accuracy, random forest will be recommended.

5.3 Recommendations

Random forest classification algorithm as it got highest accuracy of 98.46% comparing with SVM classifier accuracy of 73.84%

5.4 Implication for further study

We worked with acquired data from human brain. There is much scope to do research in this area. Real time EEG raw data analysis system can be made.

APPENDICES

Source Code:

```
import numpy as np

import matplotlib.pyplot as plt

from sklearn.metrics import classification_report

from itertools import cycle

from sklearn.metrics import confusion_matrix

from sklearn.ensemble import RandomForestClassifier

from sklearn.svm import SVC

from sklearn.preprocessing import normalize

import pandas as pd

from sklearn.model_selection import train_test_split

from sklearn.metrics import  accuracy_score

import pickle

data=pd.read_csv('bci.csv')

data=pd.DataFrame(data)

y=data['status']

y=y.values

data.drop(['status'],axis=1,inplace=True)

X=data.values

X=normalize(X,norm='l2',axis=1)

X_train, X_test, y_train, y_test = train_test_split(X,y, test_size=0.33)

#clf=RandomForestClassifier(n_estimators=100,max_depth=500,random_state=0)
```

```
clf=SVC(C=0.1,gamma=0.1,kernel='poly',degree=2,max_iter=150)

filename='bci5.sav'

clf.fit(X_train,y_train)

pickle.dump(clf, open(filename, 'wb'))

print('predicting')

loaded_clf = pickle.load(open(filename, 'rb'))

predictions=loaded_clf.predict(X_test)

predictions=clf.predict(X_test)

accuracy=accuracy_score(predictions,y_test)

print(accuracy*100)

confusion_mat=confusion_matrix(y_test,predictions)

tn, fp, fn, tp = confusion_mat.ravel()

print(confusion_mat)

print('\ntn=',tn,',fp=',fp,',fn=',fn,',tp=',tp)

target_names = ['class 0', 'class 1']

classification_rep=classification_report(y_test,predictions)

print(classification_report(y_test, predictions, target_names=target_names))

lw = 2

plt.figure()

plt.plot(predictions,y_test, color='darkorange',

         lw=lw, linestyle='--', label='ROC curve (AUC = %0.3f)'% accuracy )


plt.xlabel('False Positive Rate')
```

```
plt.ylabel('True Positive Rate')

plt.title('Receiver Operating Characteristic curve')

plt.legend(loc="lower right")

plt.show()

plt.savefig('roc_auc.png')

plt.close()
```

REFERENCES:

[1] Saugat Bhattacharyya, Anwesha Khasnobish, Amit Konar “Performance Analysis of Left/Right Hand Movement Classification from EEG Signal by Intelligent Algorithms” 2011 IEEE Symposium on Computational Intelligence, Cognitive Algorithms, Mind, and Brain (CCMB) April, 2011.

[2] Mohammad H. Alomari, Aya Samaha, and Khaled AlKamha “Automated Classification of L/R Hand Movement EEG Signals using Advanced Feature Extraction and Machine Learning” (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 4, No. 6, 2013

[3] Lavanya T H, Jyothi K S “EEG Based Classification of Hand Movements using BCI” International Journal of Computer Science and Network, Volume 5, Issue 4, August 2016

[4] Rinkal G. Shah, Prof. Rutu Nayak “Hand Movement Classification Using Motor Imagery EEG” International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 6, June 2016

[5] Muhammad Zeeshan Baig, Ehtasham Javed, Yasar Ayaz, Waseem Afzal “Classification of Left/Right Hand Movement from EEG Signal by Intelligent Algorithms” 2014 IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE) , April 7 - 8, 2014, Penang, Malaysia.

[6] Neethu Robinson, Cuntai Guan, A P Vinod, Kai Keng Ang and Keng Peng Tee “Multi-class EEG classification of voluntary hand movement directions” Journal of Neural Engineering, 2013, vol. 10(5), p.056018 (11pp)

[7] Nguyen Thi Minh Huong, Huynh Quang Linh, and Le Quoc Khai “Classification of Left/Right Hand Movement EEG Signals Using Event Related Potentials and Advanced Features”6th International Conference on the Development of Biomedical Engineering in Vietnam (BME6), 2010, pp 209-215

[8] Prasant Kumar Pattnaik, Jay Sarraf “Brain Computer Interface issues on hand movement” Journal of King Saud University – Computer and Information Sciences, January 2018, Vol.30(1), pp.18-24

[9] “(PDF) Data Preprocessing for Supervised Learning,” *ResearchGate*. [Online]. Available: https://www.researchgate.net/publication/228084519_Data_Preprocessing_for_Supervised_Learning. [Accessed: 24-Nov-2018].

[10] Indu Dokare, Naveeta Kant “Classification of EEG Signal for Imagined Left and Right Hand Movement for Brain Computer Interface Applications” Special Issue for International Technological Conference-2014

[11] A.B.M. Aowlad Hossain, Md. Wasiur Rahman, Manjurul Ahsan Riheen “Left and Right Hand Movements EEG Signals Classification Using Wavelet Transform and Probabilistic Neural Network” International Journal of Electrical and Computer Engineering (IJECE) Vol. 5, No. 1, February 2015, pp. 92~101

[12] D. Garrett, D. A. Peterson, C. W. Anderson, M. H. Thaut, “Comparison of linear and nonlinear methods for EEG signal classification”, IEEE Transactions on Neural Systems and Rehabilitation Engineering, 2003.

[13] M. Nandish, M. Stafford, P. H. Kumar, F. Ahmed, “Feature Extraction and Classification of EEG Signal Using Neural Network Based Techniques”, International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 4, October 2012.

[14] K. Sercan Bayram, M. Ayyüce Kızrak, Bülent Bolat “Classification of EEG Signals by using Support Vector Machines” 13th International Multidisciplinary Scientific GeoConference & EXPO SGEM 2013.

[15] Rajdeep Chatterjee1, Tathagata Bandyopadhyay "EEG based Motor Imagery Classification using SVM and MLP" 2nd International Conference on Computaional Intelligence and Networks (CINE).

[16] Ibtisam A. Aliazaery, Abduladhem Abdulkareem Ali, Hayder Mahdi Abdulridha "Classification of Electroencephalograph (EEG) Signals Using Quantum Neural Network" Signal Processing: An International Journal (SPIJ)

[17] Homri Ines, Yacoub Slim and Ellouze Noureddine " EEG Classification using Support Vector Machine" 10th International Multi-Conference on Systems, Signals & Devices (SSD) Hammamet, Tunisia, March 18-21, 2013

[18] Sreeja. S. R, Joytirmoy Rabha, K. Y. Nagarjuna, Debasis Samanta, Pabitra Mitra, Monalisa Sarma "Motor Imagery EEG Signal Processing and Classification using Machine Learning Approach" 2017 International Conference on New Trends in Computing Sciences.

[19] Kumar, Shiu, Sharma, Alok, Mamun, Kabir, Tsunoda, Tatsuhiko "A Deep Learning Approach for Motor Imagery EEG Signal Classification" Proceedings Asia-Pacific World Congress on Computer Science and Engineering 2016.

[20] V. Khare, J. Santhosh and S. Anand , "Classification of EEG signals based on neural network to discriminate five mental states", Proceedings of SPIT-IEEE Colloquium and International Conference, Mumbai, India, Vol 1, pp 24-26, 2007.

[21] Anderson R.A., Musallam S., Pesaran B., "Selecting the signals for a brain-machine interface", Curr Opin Neurobiol Vol.l4 (6), pp.720- 726, December 2004.

[22] Farid Ghani,Hameedah Sultan,Dilnashin Anwar,Omar Farooq,Yusuf Uzzama Khan "EEG Based Wrist Movement Classification"2014 International Conference on Medical Imaging, m-Health and Emerging Communication Systems, Nov. 2014, pp.193-196