DATA MINING – ASSIGNEMENT 4 REPORT

CSE 572

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GROUP - 12

Submitted To: Dr. Ayan Banerjee

Arizona State University

Submitted by:

Aritra Mitra - 1211172453 – amitra8@asu.edu
Arun Karthick Manickam Alagar Muthumanickam - 1213135077 - amanick4@asu.edu
Vinay Bhargav Arni Ragunathan - 1212712330 - varnirag@asu.edu
Giriraj NoLastName - 1213350721 - ggirira2@asu.edu
Deepthi Parvathy Puducode Radhakrishnan - 1213171633 - dpuducod@asu.edu

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1. Introduction:

As part of the Data Mining course requirement project, we are trying to recognize various American Sign language (ASL) gestures by reading the gestures through various sensors and recognizing them by using Data Mining algorithms. We are trying to extract features which are dominant to a particular action. The extracted features are used to classify using various classification techniques like SVM, Decision trees and Neural Networks. The extracted feature data is divided into train and test. Based on the model results, we calculate precision, recall, F1 score and Accuracy.

2. Phase 1:

Data Collection:

In the Data Collection phase, we worked on collecting the raw data by performing ASL gestures using wrist bands. In this phase, one member from each team wore the wrist bands and performed the given 20 ASL gestures. Each gesture was performed 20 times and the wrist band readings were read. The 20 gestures which we performed were – About, And, Can, Cop, Deaf, Decide, Father, Find, Go out, Hearing, Here, Hospital, If, Cat, Cost, Day, Gold, Good Night, Hurt and Large. The actions were done for about 3s and were recorded at 15Hz frequency.

The raw data of the wrist bands had data of various sensors such as – Accelerometer – X, Y, Z; EMG pod (0-7); Gyroscope - X, Y, Z; Orientation roll, Pitch, Yaw and Kinect data for both the hands.

3. Phase 2

In the Phase 2 of the project, we worked on reading the data and segregate it for different gestures. The next part of this phase is to extract interesting features of each gesture. We are studying the gesture and intuitively trying to find out its features, then using MATLAB we are trying to extract these features using different feature extraction methods. Post this we are using Principle Component Analysis to perform feature reduction. This gives us the top latent features for an action and the eigen vector analysis shows which features have high variance and define a gesture uniquely. In this phase we are concentrating only on 10 ASL gestures – About, And, Can, Cop, Deaf, Decide, Father, Find, Go out, Hearing.

4. Phase 3

In the Phase 3 of the project, we are working with the feature extracted data in phase 2 to get the user specific predictions. We are building ten different machines for 10 different gestures. Machines are built to classify one gesture from all others for a specific user. We are using classification techniques in MATLAB such as Decision trees, SVM and Neural Networks. We are calculating metrics such as Accuracy, precision, Recall and F1 score to predict how good the classification technique is for the given data. In this phase we are concentrating only on 10 ASL gestures – About, And, Can, Cop, Deaf, Decide, Father, Find, Go out, Hearing. We are doing a user dependent analysis.

5. Phase 4

In the Phase 3 of the project, we are working with the feature extracted data in phase 2 to get the user specific predictions. We are building ten different machines for 10 different gestures. Machines are built to classify one gesture from all others common to all the users. We are using classification techniques in MATLAB such as Decision trees, SVM and Neural Networks. We are calculating metrics such as Accuracy, precision, Recall and F1 score to predict how good the classification technique is for the given data. In this phase we are concentrating only on 10 ASL gestures – About, And, Can, Cop, Deaf, Decide, Father, Find, Go out, Hearing. We are doing a user independent analysis.

5.1 Task 1: Data Preparation

In this task we are reading the raw data from phase 1 and separating the reading for the different users. The data contains the actions done by 37 groups. We are collating all the actions for a user in a single file thereby generating 37 users. At this point of time we are considering 10 users for training and 27 users for testing to do a user independent analysis. Each team has done each action 20 times with 5 persons we are getting the data for each gesture for 20*5 = 100 times, this gives a good person to person variation and will suffice in extracting important features for the action.

Steps done in MATLAB for task 1 (*Task1.m*):

a) Reading the data for gestures: About, And, Can, Cop, Deaf, Decide, Father, Find, Go out, Hearing for folders individually using *xlsread().*
b) From this we are extracting the numeric data and the text data. The numeric data contains all the sensor values and the text data contain the sensor names.
c) We are then transposing the numeric data because we need the sensor data row wise. We are taking only 50 readings for each sensor to maintain the consistency. If the readings are less than 50 we do zero padding.
d) The row header contains the action name. The Row header for About looks like 'About'.
e) We are appending the data for 10 actions for 20 times for one user.
f) For a given Action we add a label column at the end for supervised learning. The Label of the current action is set as 1 and Label of all the other actions is set as 0.
g) This total data is stored in a csv file named as the user name 'DM02.csv' using *xlswrite*() and then stored in a folder named 'Output2'.

Some sample output data:

About	-0.96729	-0.96729	-0.96729	-0.96729	-0.96729	-0.96729	-0.96729..
About	0.211914	0.211914	0.211914	0.211914	0.211914	0.211914	0.211914..
About	-0.15283	-0.15283	-0.15283	-0.15283	-0.15283	-0.15283	-0.15283..
About	-0.97803	-0.97803	-0.97803	-0.97803	-0.97803	-0.97803	-0.97803..
About	-0.25684	-0.25684	-0.25684	-0.25684	-0.25684	-0.25684	-0.25684..
About	-0.08008	-0.08008	-0.08008	-0.08008	-0.08008	-0.08008	-0.08008..
About	-5	-5	-5	-5	-5	-5	-5..
About	-3	-3	-3	-3	-3	-3	-3..

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5.2 Task 2: Decision Tree

In Task 2 we are building a Machine for classifying the given 10 gestures using Decision Trees. In this phase we are using the Feature set which we obtained in Assignment two. We extract the eigen vectors from the PCA output for the input data and multiply this with the input matrix to get the new feature set. We are using this feature set of all actions performed by one user as our input for Task 2 classification.

Decision Trees: It's a tree-like graph, where the condition at node decides the path to be taken for classification. It's a supervised classification algorithm, which uses different purity metrics like Gini impurity, Information gain to form the conditions for the nodes. As the layers of the tree increases the classification error of training data tends to decrease, but we don't want a deep tree because it increases the chance of overfitting. The classification at each node is based on any one feature which best classifies the data at that point.

5.2.1 Decision Tree

ABOUT

a) For Sign 'About' for all users we obtained the CSV file from Task 1 and divided the data into Test and Training. First 10 users are considering as train set and the rest 27 users are test set. We have 20 latent features for About.
b) Training set contains 60% of the data with label 1 and 60% of data with label 0. Test set contains the remaining.
c) The Decision tree is created using 'fitctree' functionality of matlab using the Training Data set.
d) The accuracy metrics are calculated by getting the predictions of the test dataset by the decision tree for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel.
e) The metrics we are calculating:
   Accuracy % : Total correct predictions/Total no of Inputs * 100
   True Positives = Total no of correct predictions for label 1
   True Negatives = Total no of Correct predictions for label 0
   False Positives = Total no of predicted 1 which are incorrect
   False Negative = Total no of Predicted 0 which are incorrect

   Precision = True Positive / (True Positive + False Positive)
   Recall = True Positive / (True Positive + False Negative)
   F1 Score = 2* ((precision*recall)/ (precision + recall))

Overall values:

DT_Accuracy	DT_Precision	DT_Recall
0.753868	0.172252	0.120535

All the other signs we have followed the same process for generating the Decision tree and Accuracy metrics.

AND

a) The Decision Tree is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the decision tree for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

DT_Accuracy	DT_Precision	DT_Recall
0.829848	0.099788	0.106568

CAN

a) The Decision Tree is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the decision tree for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

DT_Accuracy	DT_Precision	DT_Recall
0.827072	0.122915	0.14611

COP

a) The Decision Tree is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the decision tree for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.
b) The overall metrics for test user data we obtained are:

DT_Accuracy	DT_Precision	DT_Recall
0.837661	0.053057	0.082201

DEAF

a) The Decision Tree is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the decision tree for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

DT_Accuracy	DT_Precision	DT_Recall
0.815198	0.080645	0.079307

DECIDE

a) The Decision Tree is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the decision tree for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

DT_Accuracy	DT_Precision	DT_Recall
0.82958	0.070235	0.090325

FATHER

a) The Decision Tree is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the decision tree for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

DT_Accuracy	DT_Precision	DT_Recall
0.804305	0.06833	0.062135

FIND

a) The Decision Tree is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the decision tree for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

DT_Accuracy	DT_Precision	DT_Recall
0.845569	0.101452	0.130693

GO OUT

a) The Decision Tree is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the decision tree for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

DT_Accuracy	DT_Precision	DT_Recall
0.821408	0.133392	0.100846

HEARING

a) The Decision Tree is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the decision tree for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

DT_Accuracy	DT_Precision	DT_Recall
0.784977	0.135609	0.084205

5.3 Task 3: Support Vector Machines

In Task 3 we are building a Machine for classifying the given 10 gestures using Support Vector Machines (SVM). In this phase we are using the Feature set which we obtained in Assignment two. The PCA output for the input data gives us the eigen vectors, when we multiply this with the input matrix we get the feature set. We are using this feature set of all actions performed by one user as our input for Task 3 classification.

Support Vector Machines: SVM is a classification technique which divides the data with a hyperplane into two broad categories. It's a supervised learning technique if we know what the possible class labels are. SVM identifies the hyper plane which divides the data into categories in such a way that it is closer to neither of the boundary.

5.3.1 Support Vector Machine model:

ABOUT

a) For Sign About for user 1 (DM02) we obtained the CSV file from Task 1 and divided the data into Test and Training. We have 20 latent features for About.
b) Training set contains 60% of the data with label 1 and 60% of data with label 0. Test set contains the remaining.
c) The SVM model is created using 'fitcsvm' functionality of matlab using the Training Data set.
d) The accuracy metrics are calculated by getting the predictions of the test dataset by the SVM model for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.
e) The metrics we are calculating :
Accuracy % : Total correct predictions/Total no of Inputs * 100
True Positives = Total no of correct predictions for label 1
True Negatives = Total no of Correct predictions for label 0
False Positives = Total no of predicted 1 which are incorrect
False Negative = Total no of Predicted 0 which are incorrect

Precision = True Positive /(True Positive + False Positive)
Recall = True Positive /(True Positive + False Negative)

F1 Score = 2* ((precision*recall)/(precision + recall))

The metrics we obtained are:

SVM_Accuracy	SVM_Precision	SVM_Recall
0.886699	0	NaN

All the other signs we have followed the same process for generating the SVM model and Accuracy metrics.

AND

a) The SVM Model is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the SVM model for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

SVM_Accuracy	SVM_Precision	SVM_Recall
0.894778	0	NaN

CAN

a) The SVM Model is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the SVM model for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

SVM_Accuracy	SVM_Precision	SVM_Recall
0.899626	0	Nan

COP

a) The SVM Model is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the SVM model for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

SVM_Accuracy	SVM_Precision	SVM_Recall
0.898536	0	Nan

DEAF

a) The SVM Model is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the SVM model for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

SVM_Accuracy	SVM_Precision	SVM_Recall
0.900082	0	Nan

DECIDE

a) The SVM Model is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the SVM model for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

SVM_Accuracy	SVM_Precision	SVM_Recall
0.899301	0	Nan

FATHER

a) The SVM Model is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the SVM model for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

SVM_Accuracy	SVM_Precision	SVM_Recall
0.905172	0	NaN

FIND

a) The SVM Model is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the SVM model for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

SVM_Accuracy	SVM_Precision	SVM_Recall
0.902676	0	Nan

GO OUT

a) The SVM Model is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the SVM model for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

SVM_Accuracy	SVM_Precision	SVM_Recall
0.907525	0	Nan

HEARING

a) The SVM Model is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the SVM model for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The overall metrics for test user data we obtained are:

NN_Accuracy	NN_Precision	NN_Recall
0.650675	0.344165	0.10302

5.4 Task 4: Neural Networks

In Task 4 we are building a Machine for classifying the given 10 gestures using Neural Networks. In this phase we are using the Feature set which we obtained in Assignment two. The PCA output for the input data gives us the eigen vectors, when we multiply this with the input matrix we get the feature set. We are using this feature set of all actions performed by one user as our input for Task 3 classification.

Neural Networks: Neural Networks are inspired by brain cells. Neural Networks have nodes or neurons. The nodes can be a part of Visible layers or Hidden layers. Based on the type and complexity we can add hidden layers in the Neural Network. The Nodes are interconnected by edges and we have an activation function which activates the nodes. The Neural Networks provides non-linear classification. Here we are using 10 Layers and 1000 epochs. We are using the patternnet function, commonly known as Pattern recognition network. These are feed forward networks which can be trained to classify inputs based on the target class.

5.4.1 Neural Network model:

ABOUT

a) For Sign 'About', user 1 (DM02) we obtained the CSV file from Task 1 and divided the data into Test and Training. We have 20 latent features for About.

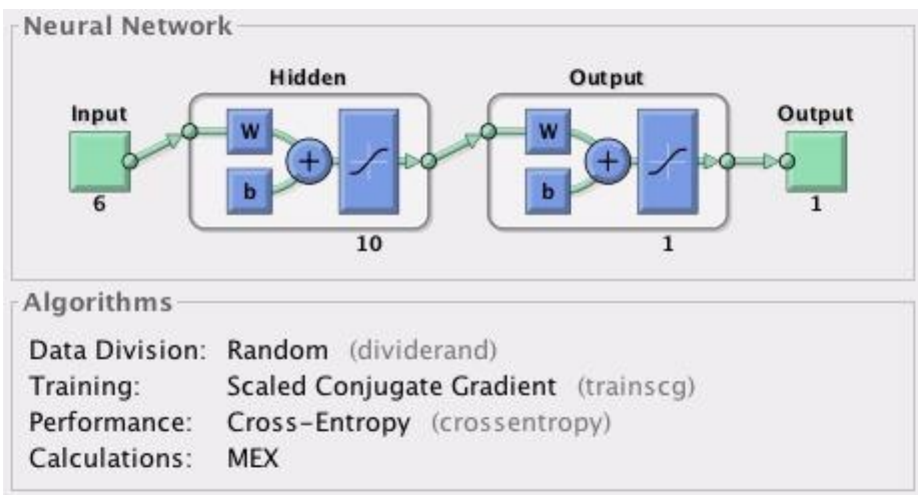
b) We split the dataset into three. One is the training set contains which contains 40% of the data, next is the validation set containing 10% of the data, and the remaining 50% forms the test data.

c) The Neural Network model is created using 'patternnet' functionality of matlab.

d) We use the features and class variables of the data separately and the number of layers to train the model.

e) We modify some of the parameters of the Neural Network to achieve better accuracy and build a more efficient model. Some of the parameters which were modified are
1. The TransferFcn block, which is used to model a linear system by a transfer function of the Laplace-domain variable. We chose the "tansig" model.
2. We set the minimum gradient value to 1.0000e-15. We keep a very low value so that the learning is not stopped, and sufficient learning is done before this value is reached.
3. We set the learning rate to 0.0001.
We started with a very basic neural network and improved the efficiency of the model by iteratively changing the values of the aforementioned parameters.

f) The Pattern Recognition Neural Network of this gesture looks like this:



g) The accuracy metrics are calculated by getting the predictions of the test dataset by the Neural Network for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

h) We use the confusion matrix to calculate the following metrics:

Accuracy% = Total correct predictions/Total no of Inputs * 100

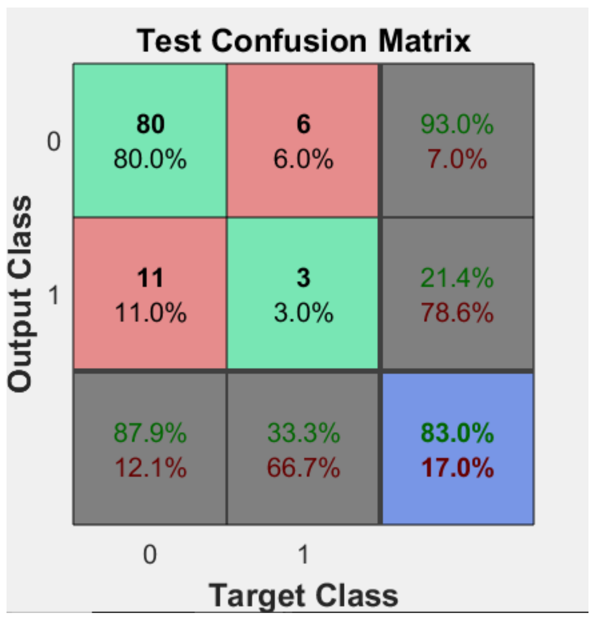
True Positives = Total no of correct predictions for label 1
True Negatives = Total no of Correct predictions for label 0
False Positives = Total no of predicted 1 which are incorrect
False Negative = Total no of Predicted 0 which are incorrect

Precision = True Positive / (True Positive + False Positive)
Recall = True Positive / (True Positive + False Negative)

F1 Score = 2* ((precision*recall)/ (precision + recall))

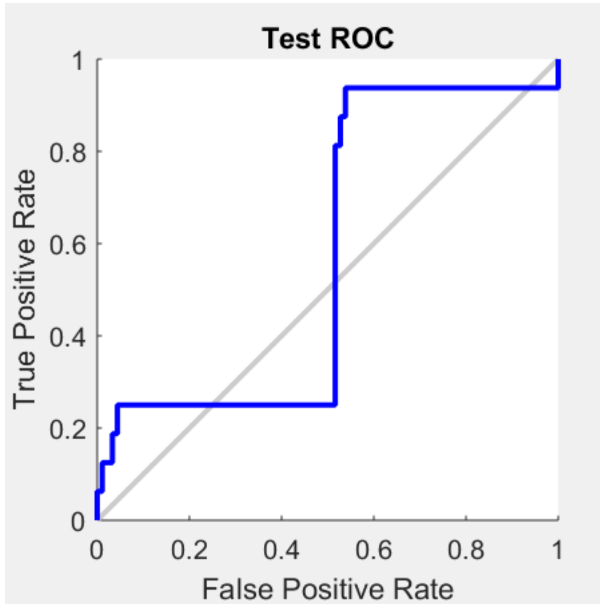
i) We also compute the confusion matrix for training, validation and test data separately.

j) The confusion matrix of ABOUT gesture for this user is:



k) We generate the ROC curve to illustrate the diagnostic ability of a binary classifier system as its discrimination threshold is varied. We create the ROC curve by plotting the True Positive Rate against the False Positive Rate. The ROC curve of the About gesture is given below.

l) The ROC curve of the ABOUT gesture is:



The metrics we obtained are:

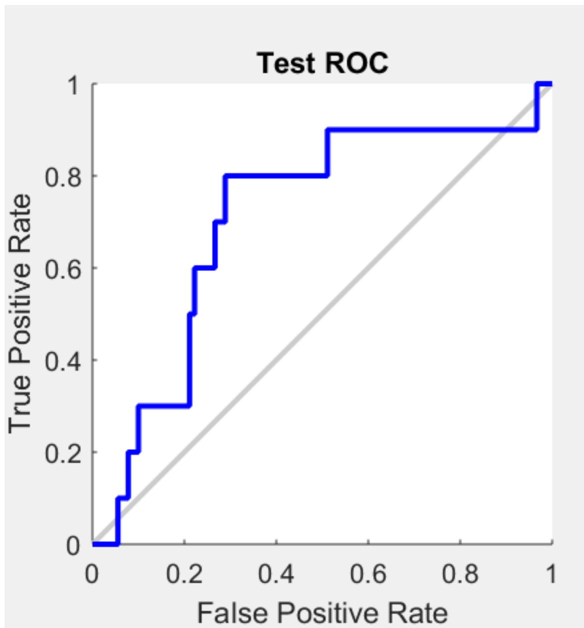
NN_Accuracy	NN_Precision	NN_Recall
0.550285	0.434708	0.180026

All the other signs we have followed the same process for generating the NN model and Accuracy metrics.

AND

a) The Neural Network is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the Neural Network for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The ROC curve of the AND gesture is:



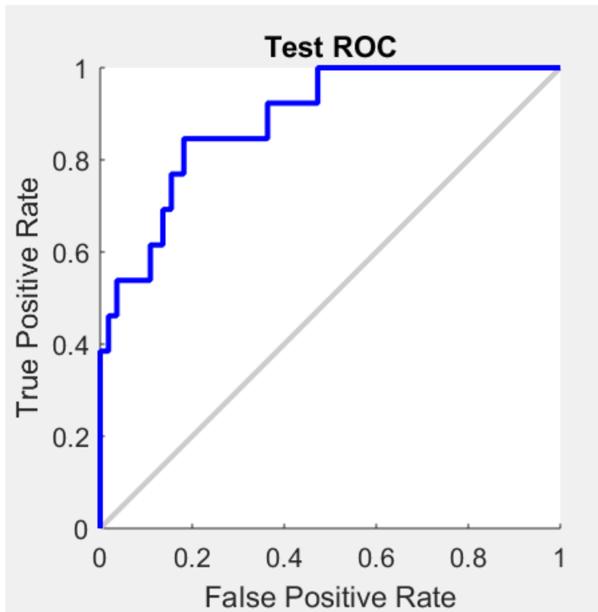
c) The overall metrics for test user data we obtained are:

NN_Accuracy	NN_Precision	NN_Recall
0.606844	0.336027	0.132962

CAN

a) The Neural Network is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the Neural Network for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The ROC curve of the CAN gesture is:



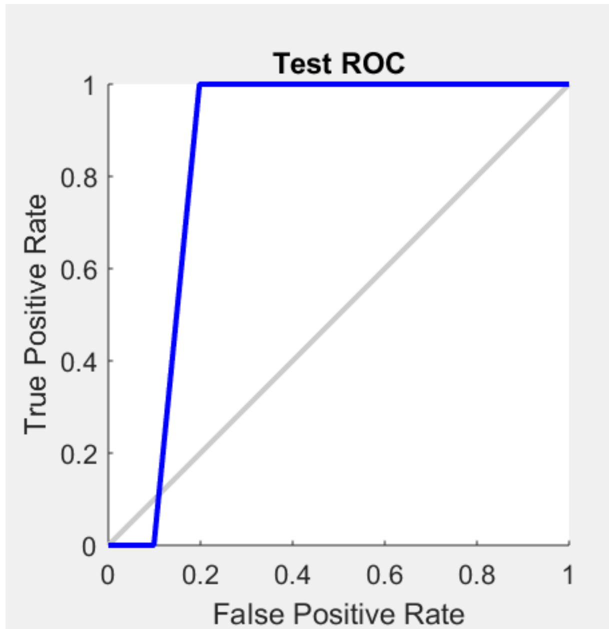
c) The overall metrics for test user data we obtained are:

NN_Accuracy	NN_Precision	NN_Recall
0.661525	0.36707	0.369778

COP

a) The Neural Network is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the Neural Network for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The ROC curve of the COP gesture is:



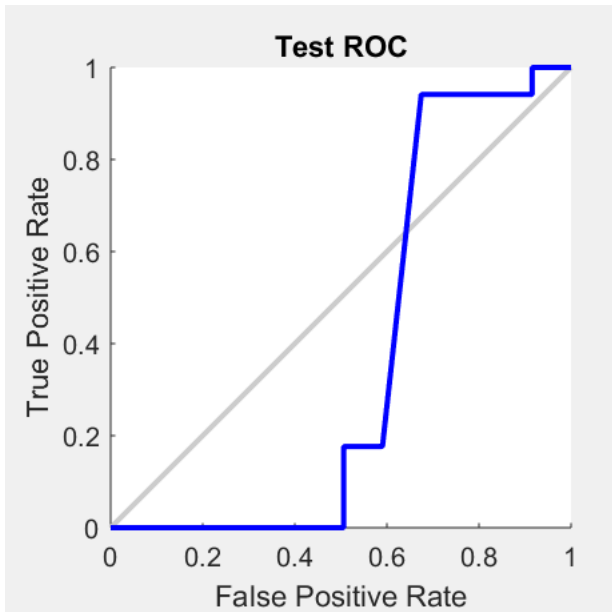
c) The overall metrics for test user data we obtained are:

NN_Accuracy	NN_Precision	NN_Recall
0.614692	0.32337	0.109872

DEAF

a) The Neural Network is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the Neural Network for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The ROC curve of the DEAF gesture is:



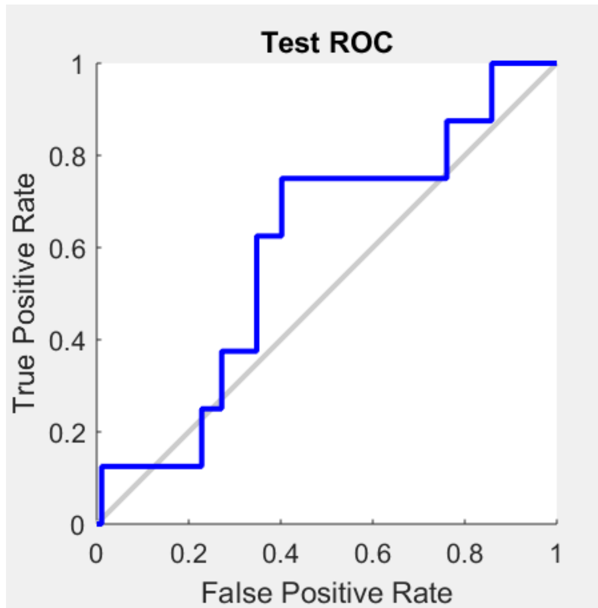
c) The overall metrics for test user data we obtained are:

NN_Accuracy	NN_Precision	NN_Recall
0.691174	0.257896	0.06263

DECIDE

a) The Neural Network is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the Neural Network for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The ROC curve of the DECIDE gesture is:



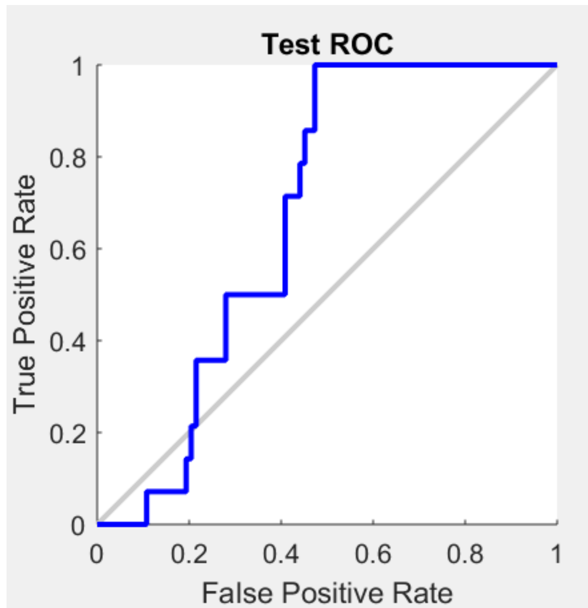
c) The overall metrics for test user data we obtained are:

NN_Accuracy	NN_Precision	NN_Recall
0.568355	0.42411	0.12958

FATHER

a) The Neural Network is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the Neural Network for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The ROC curve of the FATHER gesture is:



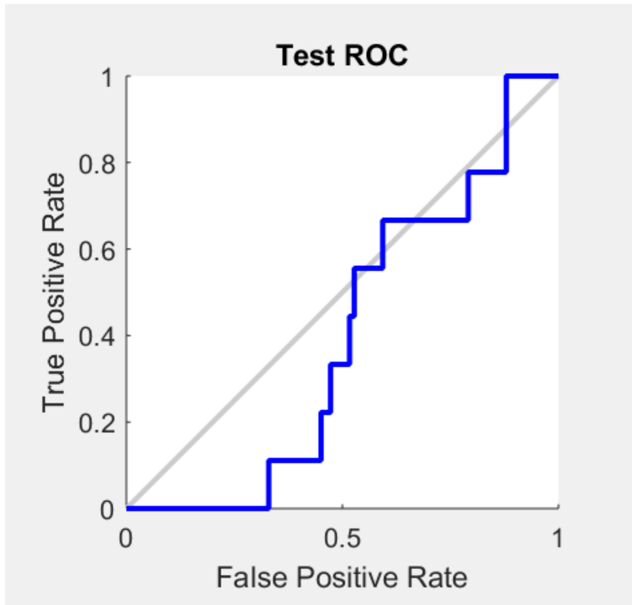
c) The overall metrics for test user data we obtained are:

NN_Accuracy	NN_Precision	NN_Recall
0.603578	0.381034	0.07724

FIND

a) The Neural Network is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the Neural Network for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The ROC curve of the FIND gesture is:



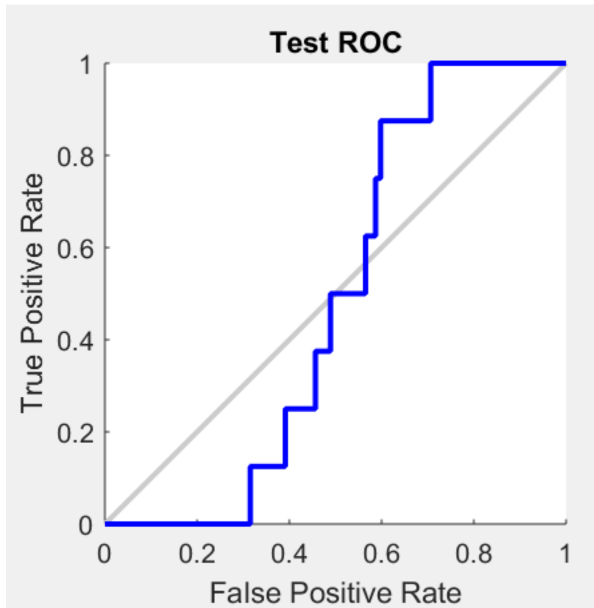
c) The overall metrics for test user data we obtained are:

NN_Accuracy	NN_Precision	NN_Recall
0.655406	0.325092	0.153916

GO OUT

a) The Neural Network is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the Neural Network for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The ROC curve of the AND gesture is:



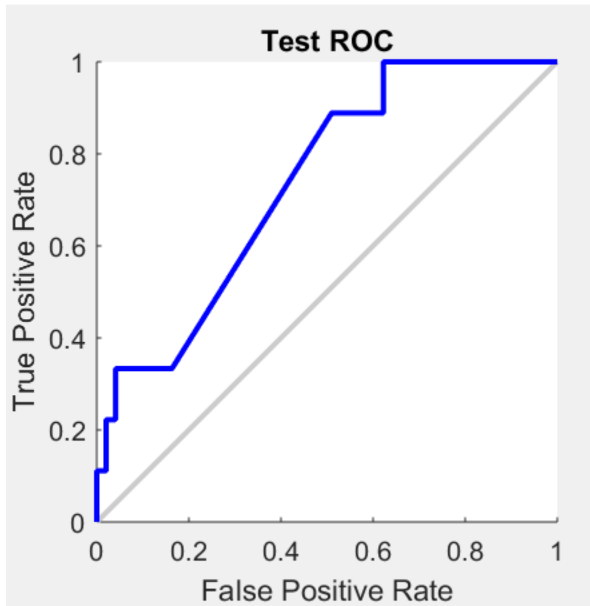
c) The overall metrics for test user data we obtained are:

NN_Accuracy	NN_Precision	NN_Recall
0.807858	0.139403	0.115097

HEARING

a) The Neural Network is constructed. The accuracy metrics are calculated by getting the predictions of the test dataset by the Neural Network for all the test users from DM11 to DM37. Accuracy, Precision and Recall values are calculated in a user independent way for the complete test data and are attached in the excel at user level.

b) The ROC curve of the AND gesture is:



c) The overall metrics for test user data we obtained are:

NN_Accuracy	NN_Precision	NN_Recall
0.650675	0.344165	0.10302

6. Statistical Measures:

a) Below excel contains the statistical measure of all the gestures from users DM11 to DM 37 which was considered for testing different users.

performance.xlsx

7. Conclusion

a) Classification of gestures using all the 3 algorithms on an average gave an Accuracy of about 80 – 90% for majority of the users.
b) Due to sparse data for positive class, it was difficult to classify the gesture with user independency and the precision and recall values were not up to the expectations. Though for some of the gestures we still got precision value of 1, at the same time for some users we also got '0/0' value for recall and F1-score (especially for SVM). Even though the accuracy was high, as the number of class 0 data was very high when compared to class 1 data, we can't be sure that the machine which we built is very efficient as it can be seen from the precision, recall and F1 scores.
c) The above results show that the feature extraction and PCA performed during phase 2 of the project was useful in classifying the data.

8. Bibliography

a) https://www.mathworks.com/
b) https://www.wikipedia.com/
c) https://www.stackoverflow.co