Assignment 3 Report

CSE 572: Data Mining
Spring 2018

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1. Introduction

This project is a part of CSE 572 - Data Mining course for Spring 2018 semester. It is an experiment to develop an intelligent system that can understand human gestures via American Sign Language. In this assignment we use the top 5 selected set of features obtained by multiplying the PCA output with the feature set. We divide this projected data into two parts for each user as training and test as 60% and 40% respectively. We then use Decision Trees, Support Vector Machines and Neural Networks to predict the particular action per user. We train each machine with the training data and then use the test data to report accuracy. Accuracy is reported for each of the 20 users in terms of Precision, Recall and F1 score.

2. Team Members

Following are the group members of this project:

- Jagadeesh Basavaraju(jbasavar@asu.edu)
- Sahan Vishwas (shvishwa@asu.edu)
- Shailee Desai (smdesai2@asu.edu)
- Suraj Kattige (suraj.kattige@asu.edu)
- Vishal Vaidhyanathan (vvaidhya@asu.edu)

3. User Dependent Analysis

The main aim of this phase is to evaluate the performance of different models (using Precision, Recall and F1 Score) when classifying actions of different users. For the above classification task, data from various sensors was collected from 37 users. This data was then preprocessed and divided into 10 different gestures. Feature matrix was generated from this data by applying different signal processing techniques including DWT, FFT, RMS, STD and AVG. Later, the dimensions of this feature matrix was reduced to 5 by applying PCA on the standardized feature matrix and the new features which are the linear combination of the original features are then used in the classification model.

The projected matrix obtained after the PCA is then divided into the training and the testing set. Three different classification models: Decision Trees, Support Vector Machines and Neural Networks are used to train the model. These models are then tested on the test data and performance is obtained using different accuracy metrics. Precision, Recall and F1 Score are calculated for each users independently to get the performance.

3.1 Techniques Used

Classification

In machine learning and statistics, classification is the problem of identifying to which of a set of categories (sub-populations) a new observation belongs, on the basis of a training set of data containing observations (or instances) whose category membership is known. In the terminology of machine learning, classification is considered an instance of supervised learning, i.e. learning where a training set of correctly identified observations is available. An algorithm that implements classification, especially in a concrete implementation, is known as a classifier.

Decision Trees

This is one of the predictive models used in data mining. The goal is to create a model that predicts the value of a target variable based on several input variables. Each interior node corresponds to one of the input variables; there are edges to children for each of the possible values of that input variable. Each leaf represents a value of the target variable given the values of the input variables represented by the path from the root to the leaf. [1]

Support Vector Machines

In Machine learning, support vector machines are supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis. Given a set of training examples, each marked as belonging to one or the other of two categories, an SVM training algorithm builds a model that assigns new examples to one category or the other, making it a non-probabilistic binary linear classifier. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. [2]

Neural Networks

A Neural Network is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. A Neural Network is configured for a specific application, such as pattern recognition or data classification, through a learning process. [3]

3.2 Performance Metrics Used

We'll use the following four parameters to define the following

- True Positive (TP) - Positive class correctly classified by the classifier
- True Negative (TN) - Negative class correctly classified by the classifier
- False Positive (FP) - Negative class wrongly classified by the classifier
- False Negative (FN) - Positive class correctly classified by the classifier

Accuracy

Accuracy = (TP+TN)/(TP+TN+FP+FN)

Precision

Precision = (TP)/(TP+FP)

Recall

Recall = (TP)/(TP+FN)

F1 Score

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

4. Implementation

Decision Tree

Parameters used:

Type of Decision Tree - Binary
Number of Classes – 10
Input Matrix Dimensions: number of actions * 5 (Top 5 PCA components)

Input:

Features are extracted from the raw data of the sensors for the 10 different gestures of each user (group). PCA is applied on the feature matrices of different gestures and different users. Feature matrix is then multiplied with the output of the PCA to obtain projection of the dataset onto the eigen vectors obtained from PCA. Only top 5 eigen vectors are considered as they explain the majority of variance in the data. This feature matrix obtained after PCA for different gestures are combined resulting in 1 matrix per user. An additional column containing the labels (gesture) is appended horizontally. Since its a multinomial classification using binary classifier, 1 vs all classification method has been used. So, the classification technique has to be applied 10 times as there are 10 classes, each time labelling actions corresponding to a gesture as 1 and remaining as 0. The feature matrix is divided in the ratio of 60:40 for training and testing respectively. The decision tree is trained on the training set and tested on the testing set. Accuracy metrics are calculated on the results after testing and reported for each user and each gesture.

Support Vector Machine

Parameters used:

Type of SVM: Binary SVM
Kernel Function: RBF Kernel
Input Matrix Dimensions: number of actions * 5 (Top 5 PCA components)

Input:

Features are extracted from the raw data of the sensors for the 10 different gestures of each user (group). PCA is applied on the feature matrices of different gestures and different users. Feature matrix is then multiplied with the output of the PCA to obtain projection of the dataset onto the eigen vectors obtained from PCA. Only top 5 eigen vectors are considered as they explain the majority of variance in the data. This feature matrix obtained after PCA for different gestures are combined resulting in 1 matrix per user. An additional column containing the labels (gesture) is appended horizontally.

Since its a multinomial classification using binary classifier, 1 vs all classification method has been used. So, the classification technique has to be applied 10 times as there are 10 classes, each time labelling actions corresponding to a gesture as 1 and remaining as 0. The feature matrix is divided in the ratio of 60:40 for training and testing respectively. The SVM model is trained on the training set and tested on the testing set. Accuracy metrics are calculated on the results after testing and reported for each user and each gesture.

Neural Network

Parameters used:

Input Layer = 1
Output Layer = 1
Number of Hidden layers: 1
Number of neurons in 1st Hidden Layer: 15
Type of neural network: Feed Forward Network
Input Matrix Dimensions: number of actions * 5 (Top 5 PCA components)

Input:

Features are extracted from the raw data of the sensors for the 10 different gestures of each user (group). PCA is applied on the feature matrices of different gestures and different users. Feature matrix is then multiplied with the output of the PCA to obtain projection of the dataset onto the eigen vectors obtained from PCA. Only top 5 eigen vectors are considered as they explain the majority of variance in the data. This feature matrix obtained after PCA for different gestures are combined resulting in 1 matrix per user. An additional column containing the labels (gesture) is appended horizontally. Since its a multinomial classification using binary classifier, 1 vs all classification method has been used. So, the classification technique has to be applied 10 times as there are 10 classes, each time labelling actions corresponding to a gesture as 1 and remaining as 0. The feature matrix is divided in the ratio of 60:40 for training and testing respectively. The feed forward network is trained on the training set and tested on the testing set. Accuracy metrics are calculated on the results after testing and reported for each user and each gesture.

5. Results

Analysis is done on the data of 20 groups (users). The results of the analysis on the data of each user gesture model combination are tabulated below.

User: DM01

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.98592	0.875	1	0.93333
About	SVM	1	1	1	1
About	NN	1	1	1	1
And	DT	0.85915	0	0	0
And	SVM	0.88732	0	0	0
And	NN	0.87324	0	0	0
Can	DT	0.95775	0.8	0.66667	0.72727
Can	SVM	1	1	1	1
Can	NN	0.97183	0.83333	0.83333	0.83333
Cop	DT	0.95775	0.66667	1	0.8
Cop	SVM	1	1	1	1
Cop	NN	0.94366	0.6	1	0.75
Deaf	DT	0.91549	0.66667	0.28571	0.4
Deaf	SVM	0.97183	1	0.71429	0.83333
Deaf	NN	0.97183	1	0.71429	0.83333

Decide	DT	0.98592	1	0.875	0.93333
Decide	SVM	1	1	1	1
Decide	NN	1	1	1	1
Father	DT	0.94366	0.66667	0.4	0.5
Father	SVM	0.97183	0.8	0.8	0.8
Father	NN	0.94366	0.57143	0.8	0.66667
Find	DT	0.94366	0.83333	0.625	0.71429
Find	SVM	0.98592	1	0.875	0.93333
Find	NN	0.97183	1	0.75	0.85714
GoOut	DT	0.90141	1	0.125	0.22222
GoOut	SVM	0.95775	1	0.625	0.76923
GoOut	NN	0.92958	1	0.375	0.54545
Hearing	DT	0.98592	1	0.875	0.93333
Hearing	SVM	0.98592	1	0.875	0.93333
Hearing	NN	0.92958	0.63636	0.875	0.73684

User: DM05

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.92405	1	0.14286	0.25
About	SVM	0.91139	0	0	0
About	NN	0.88608	0.375	0.42857	0.4
And	DT	0.93671	0.8	0.5	0.61538
And	SVM	0.96203	1	0.625	0.76923
And	NN	0.89873	0	0	0
Can	DT	0.94937	0.75	0.75	0.75
Can	SVM	0.92405	1	0.25	0.4
Can	NN	0.93671	0.66667	0.75	0.70588
Cop	DT	0.92405	0.6	0.75	0.66667
Cop	SVM	0.97468	1	0.75	0.85714
Cop	NN	0.89873	0	0	0
Deaf	DT	0.92405	0.66667	0.5	0.57143
Deaf	SVM	0.94937	1	0.5	0.66667
Deaf	NN	0.89873	0	0	0
Decide	DT	0.91139	0.54545	0.75	0.63158
Decide	SVM	0.94937	1	0.5	0.66667

Decide	NN	0.97468	0.875	0.875	0.875
Father	DT	0.96203	1	0.625	0.76923
Father	SVM	1	1	1	1
Father	NN	0.98734	0.88889	1	0.94118
Find	DT	0.97468	1	0.75	0.85714
Find	SVM	0.97468	1	0.75	0.85714
Find	NN	0.94937	0.7	0.875	0.77778
GoOut	DT	0.97468	0.875	0.875	0.875
GoOut	SVM	1	1	1	1
GoOut	NN	0.97468	0.8	1	0.88889
Hearing	DT	0.93671	0.61538	1	0.7619
Hearing	SVM	1	1	1	1
Hearing	NN	0.98734	0.88889	1	0.94118

User: DM07

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.98734	0.88889	1	0.94118
About	SVM	0.93671	1	0.375	0.54545
About	NN	0.91139	1	0.125	0.22222
And	DT	0.93671	0.66667	0.75	0.70588
And	SVM	0.97468	1	0.75	0.85714
And	NN	1	1	1	1
Can	DT	0.97468	0.875	0.875	0.875
Can	SVM	0.93671	0.8	0.5	0.61538
Can	NN	0.96203	0.77778	0.875	0.82353
Cop	DT	0.97468	0.875	0.875	0.875
Cop	SVM	0.94937	1	0.5	0.66667
Cop	NN	0.89873	0	0	0
Deaf	DT	0.96203	0.77778	0.875	0.82353
Deaf	SVM	1	1	1	1
Deaf	NN	1	1	1	1
Decide	DT	0.94937	0.83333	0.625	0.71429
Decide	SVM	0.97468	0.875	0.875	0.875

Decide	NN	0.94937	0.7	0.875	0.77778
Father	DT	0.96203	0.75	0.85714	0.8
Father	SVM	0.98734	1	0.85714	0.92308
Father	NN	0.92405	1	0.14286	0.25
Find	DT	0.94937	0.66667	1	0.8
Find	SVM	1	1	1	1
Find	NN	1	1	1	1
GoOut	DT	0.97468	0.875	0.875	0.875
GoOut	SVM	0.96203	1	0.625	0.76923
GoOut	NN	0.98734	1	0.875	0.93333
Hearing	DT	0.91139	0.57143	0.5	0.53333
Hearing	SVM	0.97468	0.8	1	0.88889
Hearing	NN	0.94937	0.66667	1	0.8

User: DM09

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.96203	0.85714	0.75	0.8
About	SVM	0.98734	1	0.875	0.93333
About	NN	0.96203	0.85714	0.75	0.8
And	DT	1	1	1	1
And	SVM	1	1	1	1
And	NN	0.98734	0.88889	1	0.94118
Can	DT	1	1	1	1
Can	SVM	1	1	1	1
Can	NN	1	1	1	1
Cop	DT	0.88608	0.44444	0.5	0.47059
Cop	SVM	0.94937	0.83333	0.625	0.71429
Cop	NN	0.92405	0.75	0.375	0.5
Deaf	DT	0.96203	1	0.625	0.76923
Deaf	SVM	0.98734	1	0.875	0.93333
Deaf	NN	1	1	1	1
Decide	DT	0.81013	0.1	0.14286	0.11765
Decide	SVM	0.92405	0.66667	0.28571	0.4

Decide	NN	0.93671	0.75	0.42857	0.54545
Father	DT	0.91139	0.5	0.71429	0.58824
Father	SVM	0.94937	1	0.42857	0.6
Father	NN	0.91139	0	0	0
Find	DT	0.92405	0.66667	0.5	0.57143
Find	SVM	0.93671	1	0.375	0.54545
Find	NN	0.91139	0.54545	0.75	0.63158
GoOut	DT	0.96203	0.85714	0.75	0.8
GoOut	SVM	0.97468	1	0.75	0.85714
GoOut	NN	0.98734	1	0.875	0.93333
Hearing	DT	0.93671	0.71429	0.625	0.66667
Hearing	SVM	0.98734	1	0.875	0.93333
Hearing	NN	0.98734	0.88889	1	0.94118

User: DM11

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.975	0.875	0.875	0.875
About	SVM	0.9875	1	0.875	0.93333
About	NN	0.975	0.875	0.875	0.875
And	DT	0.9875	1	0.875	0.93333
And	SVM	0.9625	0.85714	0.75	0.8
And	NN	0.9375	0.61538	1	0.7619
Can	DT	0.95	0.83333	0.625	0.71429
Can	SVM	0.95	1	0.5	0.66667
Can	NN	0.9875	1	0.875	0.93333
Cop	DT	0.925	0.75	0.375	0.5
Cop	SVM	0.975	0.875	0.875	0.875
Cop	NN	0.95	0.7	0.875	0.77778
Deaf	DT	0.975	0.875	0.875	0.875
Deaf	SVM	0.9875	1	0.875	0.93333
Deaf	NN	1	1	1	1
Decide	DT	0.9	0.5	0.25	0.33333
Decide	SVM	0.9875	1	0.875	0.93333

Decide	NN	0.975	0.875	0.875	0.875
Father	DT	0.9375	0.66667	0.75	0.70588
Father	SVM	1	1	1	1
Father	NN	0.975	0.8	1	0.88889
Find	DT	0.975	0.8	1	0.88889
Find	SVM	0.975	1	0.75	0.85714
Find	NN	0.975	0.875	0.875	0.875
GoOut	DT	0.9125	0.6	0.375	0.46154
GoOut	SVM	0.975	1	0.75	0.85714
GoOut	NN	1	1	1	1
Hearing	DT	0.9375	0.8	0.5	0.61538
Hearing	SVM	1	1	1	1
Hearing	NN	1	1	1	1

User: DM13

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.925	1	0.25	0.4
About	SVM	0.9375	1	0.375	0.54545
About	NN	0.9125	0.66667	0.25	0.36364
And	DT	0.9	0.5	0.125	0.2
And	SVM	0.975	1	0.75	0.85714
And	NN	0.975	0.875	0.875	0.875
Can	DT	0.975	1	0.75	0.85714
Can	SVM	1	1	1	1
Can	NN	0.9875	1	0.875	0.93333
Cop	DT	0.9625	0.72727	1	0.84211
Cop	SVM	0.95	0.83333	0.625	0.71429
Cop	NN	0.9625	0.85714	0.75	0.8
Deaf	DT	0.9875	1	0.875	0.93333
Deaf	SVM	1	1	1	1
Deaf	NN	0.9875	0.88889	1	0.94118
Decide	DT	0.9875	0.88889	1	0.94118
Decide	SVM	1	1	1	1

Decide	NN	1	1	1	1
Father	DT	0.9	0.5	0.5	0.5
Father	SVM	1	1	1	1
Father	NN	0.9875	0.88889	1	0.94118
Find	DT	0.9625	0.72727	1	0.84211
Find	SVM	0.9875	0.88889	1	0.94118
Find	NN	0.9875	1	0.875	0.93333
GoOut	DT	0.9375	0.71429	0.625	0.66667
GoOut	SVM	0.925	0.75	0.375	0.5
GoOut	NN	0.9625	0.72727	1	0.84211
Hearing	DT	0.9375	0.61538	1	0.7619
Hearing	SVM	0.925	0.625	0.625	0.625
Hearing	NN	0.9375	1	0.375	0.54545

User: DM15

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.91358	0.625	0.55556	0.58824
About	SVM	0.92593	1	0.33333	0.5
About	NN	0.90123	1	0.11111	0.2
And	DT	0.96296	0.85714	0.75	0.8
And	SVM	1	1	1	1
And	NN	1	1	1	1
Can	DT	1	1	1	1
Can	SVM	1	1	1	1
Can	NN	1	1	1	1
Cop	DT	1	1	1	1
Cop	SVM	1	1	1	1
Cop	NN	0.92593	1	0.25	0.4
Deaf	DT	0.98765	0.88889	1	0.94118
Deaf	SVM	1	1	1	1
Deaf	NN	0.88889	0	0	0
Decide	DT	0.98765	0.88889	1	0.94118
Decide	SVM	0.96296	1	0.625	0.76923

Decide	NN	0.97531	0.875	0.875	0.875
Father	DT	1	1	1	1
Father	SVM	1	1	1	1
Father	NN	1	1	1	1
Find	DT	1	1	1	1
Find	SVM	1	1	1	1
Find	NN	1	1	1	1
GoOut	DT	1	1	1	1
GoOut	SVM	1	1	1	1
GoOut	NN	1	1	1	1
Hearing	DT	0.92593	0.57143	1	0.72727
Hearing	SVM	0.98765	0.88889	1	0.94118
Hearing	NN	0.92593	0.58333	0.875	0.7

User: DM16

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.95402	0.8	0.8	0.8
About	SVM	1	1	1	1
About	NN	0.89655	0.55556	0.5	0.52632
And	DT	0.96552	0.75	1	0.85714
And	SVM	1	1	1	1
And	NN	1	1	1	1
Can	DT	0.97701	0.83333	1	0.90909
Can	SVM	1	1	1	1
Can	NN	0.98851	1	0.9	0.94737
Cop	DT	0.95402	0.75	0.75	0.75
Cop	SVM	0.97701	1	0.75	0.85714
Cop	NN	0.95402	0.83333	0.625	0.71429
Deaf	DT	0.95402	0.7	0.875	0.77778
Deaf	SVM	0.98851	0.88889	1	0.94118
Deaf	NN	0.96552	0.72727	1	0.84211
Decide	DT	0.98851	1	0.88889	0.94118
Decide	SVM	1	1	1	1

Decide	NN	0.98851	0.9	1	0.94737
Father	DT	0.97701	1	0.75	0.85714
Father	SVM	0.98851	1	0.875	0.93333
Father	NN	0.98851	1	0.875	0.93333
Find	DT	0.96552	1	0.66667	0.8
Find	SVM	0.98851	1	0.88889	0.94118
Find	NN	0.97701	0.88889	0.88889	0.88889
GoOut	DT	1	1	1	1
GoOut	SVM	1	1	1	1
GoOut	NN	1	1	1	1
Hearing	DT	0.97701	0.8	1	0.88889
Hearing	SVM	1	1	1	1
Hearing	NN	1	1	1	1

User: DM19

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.97436	0.875	0.875	0.875
About	SVM	1	1	1	1
About	NN	1	1	1	1
And	DT	0.91026	0.6	0.66667	0.63158
And	SVM	0.92308	0.8	0.44444	0.57143
And	NN	0.88462	0.5	0.66667	0.57143
Can	DT	0.88462	0.42857	0.375	0.4
Can	SVM	0.91026	0.66667	0.25	0.36364
Can	NN	0.9359	0.71429	0.625	0.66667
Cop	DT	0.85897	0.33333	0.375	0.35294
Cop	SVM	0.92308	0.75	0.375	0.5
Cop	NN	0.84615	0.3	0.375	0.33333
Deaf	DT	0.91026	0.57143	0.5	0.53333
Deaf	SVM	0.97436	0.875	0.875	0.875
Deaf	NN	0.96154	0.77778	0.875	0.82353
Decide	DT	0.96154	0.72727	1	0.84211
Decide	SVM	0.98718	1	0.875	0.93333

Decide	NN	0.96154	0.72727	1	0.84211
Father	DT	0.9359	0.8	0.5	0.61538
Father	SVM	0.96154	1	0.625	0.76923
Father	NN	0.94872	0.75	0.75	0.75
Find	DT	0.88462	0.36364	0.66667	0.47059
Find	SVM	0.97436	1	0.66667	0.8
Find	NN	0.94872	0.75	0.5	0.6
GoOut	DT	0.98718	1	0.85714	0.92308
GoOut	SVM	1	1	1	1
GoOut	NN	1	1	1	1
Hearing	DT	0.9359	0.71429	0.625	0.66667
Hearing	SVM	0.94872	1	0.5	0.66667
Hearing	NN	0.97436	1	0.75	0.85714

User: DM20

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.96296	0.77778	0.875	0.82353
About	SVM	0.95062	0.75	0.75	0.75
About	NN	0.93827	0.66667	0.75	0.70588
And	DT	0.98765	1	0.875	0.93333
And	SVM	0.92593	1	0.25	0.4
And	NN	0.96296	1	0.625	0.76923
Can	DT	1	1	1	1
Can	SVM	1	1	1	1
Can	NN	0.96296	0.72727	1	0.84211
Cop	DT	0.90123	0.5	0.375	0.42857
Cop	SVM	0.98765	0.88889	1	0.94118
Cop	NN	0.96296	0.77778	0.875	0.82353
Deaf	DT	0.92593	0.66667	0.5	0.57143
Deaf	SVM	0.97531	1	0.75	0.85714
Deaf	NN	0.88889	0	0	0
Decide	DT	0.93827	0.64286	1	0.78261
Decide	SVM	0.98765	0.9	1	0.94737

Decide	NN	0.95062	0.72727	0.88889	0.8
Father	DT	0.92593	0.75	0.375	0.5
Father	SVM	0.98765	1	0.875	0.93333
Father	NN	1	1	1	1
Find	DT	0.95062	1	0.5	0.66667
Find	SVM	0.93827	1	0.375	0.54545
Find	NN	0.96296	1	0.625	0.76923
GoOut	DT	0.87654	0.25	0.125	0.16667
GoOut	SVM	0.88889	0	0	0
GoOut	NN	0.90123	0	0	0
Hearing	DT	0.93827	0.66667	0.75	0.70588
Hearing	SVM	0.98765	1	0.875	0.93333
Hearing	NN	0.97531	1	0.75	0.85714

User: DM22

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.75	0.076923	0.11111	0.090909
About	SVM	0.9625	1	0.66667	0.8
About	NN	0.8625	0.375	0.33333	0.35294
And	DT	0.8875	0.42857	0.375	0.4
And	SVM	0.925	1	0.25	0.4
And	NN	0.975	1	0.75	0.85714
Can	DT	0.925	0.66667	0.5	0.57143
Can	SVM	0.975	0.875	0.875	0.875
Can	NN	0.95	0.75	0.75	0.75
Cop	DT	0.9875	0.88889	1	0.94118
Cop	SVM	0.9875	1	0.875	0.93333
Cop	NN	0.9875	1	0.875	0.93333
Deaf	DT	0.975	1	0.75	0.85714
Deaf	SVM	0.9875	1	0.875	0.93333
Deaf	NN	0.9625	0.72727	1	0.84211
Decide	DT	0.9375	1	0.28571	0.44444
Decide	SVM	0.9375	0.66667	0.57143	0.61538

Decide	NN	0.9375	1	0.28571	0.44444
Father	DT	1	1	1	1
Father	SVM	1	1	1	1
Father	NN	1	1	1	1
Find	DT	1	1	1	1
Find	SVM	1	1	1	1
Find	NN	1	1	1	1
GoOut	DT	0.9	0.5	0.5	0.5
GoOut	SVM	0.95	0.83333	0.625	0.71429
GoOut	NN	0.95	1	0.5	0.66667
Hearing	DT	0.975	1	0.75	0.85714
Hearing	SVM	0.9625	1	0.625	0.76923
Hearing	NN	0.9875	1	0.875	0.93333

User: DM24

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.98765	1	0.875	0.93333
About	SVM	1	1	1	1
About	NN	0.98765	1	0.875	0.93333
And	DT	0.93827	1	0.44444	0.61538
And	SVM	0.96296	1	0.66667	0.8
And	NN	0.95062	0.69231	1	0.81818
Can	DT	0.97531	1	0.75	0.85714
Can	SVM	0.96296	1	0.625	0.76923
Can	NN	0.98765	1	0.875	0.93333
Cop	DT	0.96296	0.85714	0.75	0.8
Cop	SVM	0.97531	1	0.75	0.85714
Cop	NN	1	1	1	1
Deaf	DT	0.92593	0.6	0.75	0.66667
Deaf	SVM	0.98765	0.88889	1	0.94118
Deaf	NN	0.98765	0.88889	1	0.94118
Decide	DT	1	1	1	1
Decide	SVM	1	1	1	1

Decide	NN	1	1	1	1
Father	DT	0.90123	0.5	0.875	0.63636
Father	SVM	1	1	1	1
Father	NN	0.98765	0.88889	1	0.94118
Find	DT	0.96296	0.77778	0.875	0.82353
Find	SVM	1	1	1	1
Find	NN	1	1	1	1
GoOut	DT	0.97531	1	0.75	0.85714
GoOut	SVM	1	1	1	1
GoOut	NN	0.98765	0.88889	1	0.94118
Hearing	DT	0.96296	0.77778	0.875	0.82353
Hearing	SVM	1	1	1	1
Hearing	NN	1	1	1	1

User: DM26

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.98305	1	0.83333	0.90909
About	SVM	1	1	1	1
About	NN	1	1	1	1
And	DT	0.98305	0.85714	1	0.92308
And	SVM	1	1	1	1
And	NN	1	1	1	1
Can	DT	0.89831	0.5	0.16667	0.25
Can	SVM	0.98305	1	0.83333	0.90909
Can	NN	0.94915	1	0.5	0.66667
Cop	DT	1	1	1	1
Cop	SVM	1	1	1	1
Cop	NN	1	1	1	1
Deaf	DT	1	1	1	1
Deaf	SVM	0.91525	1	0.16667	0.28571
Deaf	NN	0.94915	0.66667	1	0.8
Decide	DT	0.98305	0.85714	1	0.92308
Decide	SVM	0.9661	1	0.66667	0.8

Decide	NN	0.94915	1	0.5	0.66667
Father	DT	0.86441	0.25	0.16667	0.2
Father	SVM	0.91525	0.66667	0.33333	0.44444
Father	NN	0.86441	0.25	0.16667	0.2
Find	DT	0.98305	0.83333	1	0.90909
Find	SVM	0.94915	1	0.4	0.57143
Find	NN	1	1	1	1
GoOut	DT	0.98305	1	0.83333	0.90909
GoOut	SVM	1	1	1	1
GoOut	NN	0.98305	0.85714	1	0.92308
Hearing	DT	0.83051	0.33333	0.66667	0.44444
Hearing	SVM	0.89831	0.5	0.33333	0.4
Hearing	NN	0.9322	0.75	0.5	0.6

User: DM27

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.93827	0.63636	0.875	0.73684
About	SVM	0.96296	1	0.625	0.76923
About	NN	0.97531	0.8	1	0.88889
And	DT	0.98765	1	0.88889	0.94118
And	SVM	0.97531	1	0.77778	0.875
And	NN	0.93827	0.75	0.66667	0.70588
Can	DT	0.92593	0.75	0.375	0.5
Can	SVM	0.95062	0.83333	0.625	0.71429
Can	NN	0.98765	0.88889	1	0.94118
Cop	DT	0.98765	1	0.875	0.93333
Cop	SVM	0.96296	0.85714	0.75	0.8
Cop	NN	0.88889	0.47059	1	0.64
Deaf	DT	0.97531	0.8	1	0.88889
Deaf	SVM	0.98765	0.88889	1	0.94118
Deaf	NN	1	1	1	1
Decide	DT	1	1	1	1
Decide	SVM	1	1	1	1

Decide	NN	1	1	1	1
Father	DT	0.93827	0.66667	0.75	0.70588
Father	SVM	1	1	1	1
Father	NN	0.97531	1	0.75	0.85714
Find	DT	1	1	1	1
Find	SVM	1	1	1	1
Find	NN	1	1	1	1
GoOut	DT	0.90123	0.5	0.375	0.42857
GoOut	SVM	0.98765	1	0.875	0.93333
GoOut	NN	0.93827	1	0.375	0.54545
Hearing	DT	0.90123	0.5	0.25	0.33333
Hearing	SVM	0.98765	1	0.875	0.93333
Hearing	NN	0.96296	0.77778	0.875	0.82353

User: DM28

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.9625	0.72727	1	0.84211
About	SVM	0.9625	0.72727	1	0.84211
About	NN	0.975	0.8	1	0.88889
And	DT	0.95	0.83333	0.625	0.71429
And	SVM	0.95	1	0.5	0.66667
And	NN	1	1	1	1
Can	DT	1	1	1	1
Can	SVM	1	1	1	1
Can	NN	1	1	1	1
Cop	DT	0.9	0.5	0.375	0.42857
Cop	SVM	0.9625	1	0.625	0.76923
Cop	NN	0.925	0.625	0.625	0.625
Deaf	DT	0.9625	0.72727	1	0.84211
Deaf	SVM	1	1	1	1
Deaf	NN	0.9875	0.88889	1	0.94118
Decide	DT	1	1	1	1
Decide	SVM	1	1	1	1

Decide	NN	1	1	1	1
Father	DT	0.9625	0.72727	1	0.84211
Father	SVM	1	1	1	1
Father	NN	1	1	1	1
Find	DT	0.975	0.875	0.875	0.875
Find	SVM	0.9625	1	0.625	0.76923
Find	NN	1	1	1	1
GoOut	DT	1	1	1	1
GoOut	SVM	1	1	1	1
GoOut	NN	0.9875	1	0.875	0.93333
Hearing	DT	0.9125	0.6	0.375	0.46154
Hearing	SVM	0.975	1	0.75	0.85714
Hearing	NN	0.975	0.8	1	0.88889

User: DM29

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.85897	0.33333	0.375	0.35294
About	SVM	0.98718	1	0.875	0.93333
About	NN	0.98718	0.88889	1	0.94118
And	DT	0.97436	1	0.75	0.85714
And	SVM	0.97436	1	0.75	0.85714
And	NN	0.98718	1	0.875	0.93333
Can	DT	1	1	1	1
Can	SVM	1	1	1	1
Can	NN	1	1	1	1
Cop	DT	0.91026	0.53333	1	0.69565
Cop	SVM	0.96154	1	0.625	0.76923
Cop	NN	0.96154	0.77778	0.875	0.82353
Deaf	DT	1	1	1	1
Deaf	SVM	0.97436	1	0.66667	0.8
Deaf	NN	0.97436	0.83333	0.83333	0.83333
Decide	DT	0.98718	1	0.875	0.93333
Decide	SVM	1	1	1	1

Decide	NN	0.98718	1	0.875	0.93333
Father	DT	0.98718	1	0.875	0.93333
Father	SVM	0.97436	1	0.75	0.85714
Father	NN	0.96154	0.77778	0.875	0.82353
Find	DT	0.97436	1	0.75	0.85714
Find	SVM	1	1	1	1
Find	NN	1	1	1	1
GoOut	DT	0.97436	1	0.75	0.85714
GoOut	SVM	0.96154	1	0.625	0.76923
GoOut	NN	0.98718	1	0.875	0.93333
Hearing	DT	0.9359	0.8	0.5	0.61538
Hearing	SVM	0.98718	1	0.875	0.93333
Hearing	NN	0.91026	0.57143	0.5	0.53333

User: DM31

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.93243	0.8	0.5	0.61538
About	SVM	0.93243	1	0.375	0.54545
About	NN	0.87838	0.33333	0.125	0.18182
And	DT	0.98649	1	0.85714	0.92308
And	SVM	1	1	1	1
And	NN	1	1	1	1
Can	DT	0.94595	0.83333	0.625	0.71429
Can	SVM	0.95946	1	0.625	0.76923
Can	NN	0.98649	1	0.875	0.93333
Cop	DT	0.97297	0.77778	1	0.875
Cop	SVM	0.98649	0.875	1	0.93333
Cop	NN	0.98649	0.875	1	0.93333
Deaf	DT	0.94595	0.75	0.75	0.75
Deaf	SVM	0.98649	1	0.875	0.93333
Deaf	NN	0.97297	0.8	1	0.88889
Decide	DT	0.91892	0.75	0.375	0.5
Decide	SVM	0.93243	0.8	0.5	0.61538

Decide	NN	0.93243	0.8	0.5	0.61538
Father	DT	0.98649	1	0.875	0.93333
Father	SVM	0.95946	1	0.625	0.76923
Father	NN	0.95946	1	0.625	0.76923
Find	DT	0.93243	0.71429	0.625	0.66667
Find	SVM	0.93243	0.8	0.5	0.61538
Find	NN	0.97297	0.875	0.875	0.875
GoOut	DT	0.94595	0	0	0
GoOut	SVM	0.98649	1	0.75	0.85714
GoOut	NN	0.98649	0.8	1	0.88889
Hearing	DT	0.97297	0.8	1	0.88889
Hearing	SVM	1	1	1	1
Hearing	NN	0.98649	0.88889	1	0.94118

User: DM32

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	1	1	1	1
About	SVM	0.97368	1	0.77778	0.875
About	NN	0.97368	0.88889	0.88889	0.88889
And	DT	0.90789	1	0.22222	0.36364
And	SVM	0.93421	1	0.44444	0.61538
And	NN	0.90789	1	0.22222	0.36364
Can	DT	0.93421	0.8	0.5	0.61538
Can	SVM	0.98684	1	0.875	0.93333
Can	NN	0.98684	0.88889	1	0.94118
Cop	DT	0.98684	1	0.875	0.93333
Cop	SVM	1	1	1	1
Cop	NN	0.97368	0.8	1	0.88889
Deaf	DT	0.94737	0.75	0.75	0.75
Deaf	SVM	0.98684	0.88889	1	0.94118
Deaf	NN	0.94737	0.66667	1	0.8
Decide	DT	0.96053	0.57143	1	0.72727
Decide	SVM	0.98684	0.8	1	0.88889

Decide	NN	0.94737	0	0	0
Father	DT	0.93421	0.75	0.42857	0.54545
Father	SVM	0.90789	0.5	0.14286	0.22222
Father	NN	0.94737	1	0.42857	0.6
Find	DT	0.97368	0.875	0.875	0.875
Find	SVM	0.96053	0.77778	0.875	0.82353
Find	NN	0.93421	0.71429	0.625	0.66667
GoOut	DT	0.97368	1	0.71429	0.83333
GoOut	SVM	0.97368	1	0.71429	0.83333
GoOut	NN	0.96053	1	0.57143	0.72727
Hearing	DT	0.97368	0.875	0.875	0.875
Hearing	SVM	0.97368	0.8	1	0.88889
Hearing	NN	0.97368	0.8	1	0.88889

User: DM34

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.9875	1	0.875	0.93333
About	SVM	0.9875	1	0.875	0.93333
About	NN	0.9	0	0	0
And	DT	0.9875	0.88889	1	0.94118
And	SVM	1	1	1	1
And	NN	0.975	0.8	1	0.88889
Can	DT	0.975	1	0.75	0.85714
Can	SVM	0.9625	1	0.625	0.76923
Can	NN	0.975	1	0.75	0.85714
Cop	DT	0.85	0	0	0
Cop	SVM	0.9125	1	0.125	0.22222
Cop	NN	0.875	0	0	0
Deaf	DT	0.9875	0.88889	1	0.94118
Deaf	SVM	1	1	1	1
Deaf	NN	0.9875	0.88889	1	0.94118
Decide	DT	0.925	0.66667	0.5	0.57143
Decide	SVM	0.9625	0.85714	0.75	0.8

Decide	NN	0.925	0.66667	0.5	0.57143
Father	DT	0.95	0.75	0.75	0.75
Father	SVM	0.9875	1	0.875	0.93333
Father	NN	0.975	0.875	0.875	0.875
Find	DT	0.975	1	0.75	0.85714
Find	SVM	0.9875	1	0.875	0.93333
Find	NN	0.9875	1	0.875	0.93333
GoOut	DT	0.9125	0.54545	0.75	0.63158
GoOut	SVM	0.975	0.875	0.875	0.875
GoOut	NN	0.975	0.8	1	0.88889
Hearing	DT	0.9625	1	0.625	0.76923
Hearing	SVM	0.975	0.875	0.875	0.875
Hearing	NN	0.95	0.83333	0.625	0.71429

User: DM36

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.9125	0.57143	0.5	0.53333
About	SVM	0.9875	1	0.875	0.93333
About	NN	1	1	1	1
And	DT	0.9625	1	0.625	0.76923
And	SVM	0.975	1	0.75	0.85714
And	NN	0.975	1	0.75	0.85714
Can	DT	1	1	1	1
Can	SVM	1	1	1	1
Can	NN	1	1	1	1
Cop	DT	0.9875	0.88889	1	0.94118
Cop	SVM	1	1	1	1
Cop	NN	1	1	1	1
Deaf	DT	0.95	1	0.5	0.66667
Deaf	SVM	1	1	1	1
Deaf	NN	1	1	1	1
Decide	DT	0.9875	0.88889	1	0.94118
Decide	SVM	1	1	1	1

Decide	NN	0.9875	1	0.875	0.93333
Father	DT	0.925	0.75	0.375	0.5
Father	SVM	0.9875	1	0.875	0.93333
Father	NN	0.9625	0.77778	0.875	0.82353
Find	DT	0.8875	0.45455	0.625	0.52632
Find	SVM	0.9375	1	0.375	0.54545
Find	NN	0.9375	0.8	0.5	0.61538
GoOut	DT	0.925	0.57143	1	0.72727
GoOut	SVM	0.95	0.75	0.75	0.75
GoOut	NN	0.95	0.7	0.875	0.77778
Hearing	DT	0.9625	1	0.625	0.76923
Hearing	SVM	1	1	1	1
Hearing	NN	0.9625	0.77778	0.875	0.82353

5. Conclusion

Based on the results of the user dependent analysis, it can be observed that the accuracy metrics are coherent across all the users, gestures and classification techniques. There are a few outliers present in the data which is resulting in unsatisfactory values in the accuracy metrics for negligible number of combinations. Overall the accuracy metrics for the user dependent analysis are satisfactory. This suggests that feature extraction and feature selection done in the previous assignment are accurate enough.

6. References

1. https://en.wikipedia.org/wiki/Decision_tree_learning
2. https://en.wikipedia.org/wiki/Support_vector_machine
3. https://www.doc.ic.ac.uk/~nd/surprise_96/journal/vol4/cs11/report.html#What%20is%20a%20Neural%20Network