Assignment 4 Report

CSE 572: Data Mining
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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 all users together 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 for all users. We train each machine with the training data and then use the test data to report accuracy. Accuracy is reported in terms of Precision, Recall and F1 score.

2. Team Members

Following are the group members of this project:

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3. User Independent 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 all 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 20 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 test data to get the performance metrics.

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

<u>Parameters used:</u>
Type of Decision Tree - Binary
Number of Classes – 10
Input Matrix Dimensions: number of actions * 20 (Top 20 PCA components)

<u>Input:</u>
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 for all users together. 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 20 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 gesture.

Support Vector Machine

<u>Parameters used</u>:
Type of SVM: Binary SVM
Kernel Function: RBF Kernel
Input Matrix Dimensions: number of actions * 20 (Top 20 PCA components)

<u>Input</u>:
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 all users together. 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 20 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 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 * 20 (Top 20 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 20 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 gesture.

5. Results

Analysis is done on the data of groups (users). 60% users' data were used for training and tested on the remaining users' data together. The results of the analysis on the test data for each gesture model combination are tabulated below.

Gesture	Machine	Accuracy	Precision	Recall	F1
About	DT	0.90268	0.53371	0.56548	0.54913
About	SVM	0.95696	0.91597	0.64881	0.75958
About	NN	0.91703	0.59162	0.67262	0.62953
And	DT	0.94386	0.74675	0.69277	0.71875
And	SVM	0.96569	0.97436	0.68675	0.80565
And	NN	0.98129	0.91975	0.89759	0.90854
Can	DT	0.9189	0.60127	0.58642	0.59375
Can	SVM	0.93949	0.82178	0.51235	0.63118
Can	NN	0.932	0.68794	0.59877	0.64026
Cop	DT	0.92514	0.65354	0.52201	0.58042
Cop	SVM	0.96631	0.93388	0.71069	0.80714
Cop	NN	0.97006	0.83234	0.87421	0.85276
Deaf	DT	0.96694	0.85333	0.80503	0.82848
Deaf	SVM	0.99688	1	0.96855	0.98403
Deaf	NN	0.9844	0.8764	0.98113	0.92582

Decide	DT	0.90954	0.54491	0.56875	0.55657
Decide	SVM	0.97879	1	0.7875	0.88112
Decide	NN	0.9476	0.69588	0.84375	0.76271
Father	DT	0.96007	0.77778	0.81818	0.79747
Father	SVM	0.98565	0.98519	0.86364	0.92042
Father	NN	0.97941	0.86228	0.93506	0.8972
Find	DT	0.94635	0.73684	0.70886	0.72258
Find	SVM	0.97318	0.98319	0.74051	0.84477
Find	NN	0.9738	0.89726	0.82911	0.86184
GoOut	DT	0.94011	0.71329	0.64968	0.68
GoOut	SVM	0.9738	0.96	0.76433	0.85106
GoOut	NN	0.97567	0.88312	0.86624	0.8746
Hearing	DT	0.92015	0.625	0.5	0.55556
Hearing	SVM	0.96694	0.98198	0.68125	0.80443
Hearing	NN	0.95197	0.832	0.65	0.72982

5. Conclusion

Based on the results of the user independent 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 independent analysis are satisfactory. This suggests that feature extraction and feature selection done in the previous assignment are accurate enough. It can also be concluded from the user independent and user dependent analysis that user dependent analysis yielded better results. This is because of the fact that in the user dependent analysis, the data in the training and testing set will be from the same user all the time and hence the pattern will be learnt easily by the model. This is not true in case of user independent analysis as the testing set will have data of different users compared to the training set.

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