Classify Gestures by Reading Human Hand Muscle Activity

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***Abstract*— To classify the different hand gestures made by human muscles particularly scissors, paper, rock and OK three different classification algorithms are used. These are K Nearest Neighbor Classifier, Decision Trees, Gaussian Naive Bayes algorithms .In addition Confusion Matrix and F Score methods are used for evaluation.**

Keywords-component; Pattern; Recognition; Feature; Machine Learning; Classify

I. INTRODUCTION

In this project, our aim is to classify the human gestures particularly scissors, paper, rock and OK. To provide this classification, machine learning algorithms has been used.

II. DESIGN CYCLE

A. Feature Selection

It is the process of discarding the features that will not affect or slightly affect our results by looking at the relations of the features in our data with each other and with our output.

Method: Sequential Forward Selection (SFS) is used. In this method, it starts by looking at the relationship between all the features and the target variable and selecting the feature that affects the target variable the most. It puts all the features into the model process one by one. The feature that performs best will be the feature you choose first.

B. Model Selection

There are various of machine learning algorithms. Among these algorithm, three algorithms we use are as follows: K Nearest Neighbor Classifier, Decision Trees, Gaussian Naive Bayes. K nearest neighbor classifier is one of the algorithms used for classification and regression in supervised learning. It is considered the simplest machine learning algorithm. Unlike other supervised machine learning algorithms, it does not have a training phase. Training and testing pretty much the same thing. It is a lazy type of learning. Basically, looking for points closest to new point. K represents the amount of nearest neighbors of the unknown point. We choose k quantities of the algorithm (usually an odd number) to predict the results. In KNN classification the output indicates that it belongs to the class. An object is classified by the majority of its neighbors; the object is assigned the class most common among its nearest neighbors (k is a small positive integer). If k equals to one, the object is simply assigned to the nearest neighbor's class.

Tree-based learning algorithms are considered as one of the most widely used and supervised learning methods. Tree-based methods have high accuracy, stability, and ease of interpretation. Unlike linear models, they can also map nonlinear relationships quite well. Classification or regression can be adapted to solve any given problem. Methods such as decision trees, random forest, gradient reinforcement are widely used in problems.

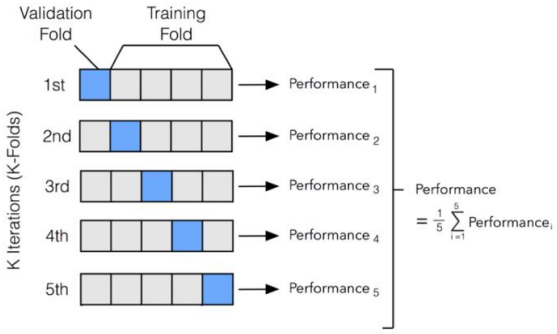
Decision tree have three structures: decision nodes, branches and leaves. Root Nodes: It is a node which has no former branch and can create one or more branch. Root nodes show the dependent variable and show which variable will be used for the classification. Interior Node: It is a node which has one incoming branch and can have two or more outgoing branches. Leaf or Terminal nodes: These are the nodes which has an incoming branch but no outgoing brand. [1]

The Naive Bayes classifier is a probabilistic approach to the pattern recognition problem that can be used with a proposition that seems rather restrictive at first glance. This proposition is that each descriptive attribute or parameter to be used in pattern recognition should be statistically independent. Although this proposition limits the use of the Naive Bayes classifier, it gives comparable results with methods such as more complex artificial neural networks, even when used by stretching the statistical independence condition. A Naive Bayes classifier can also be thought of as a Bayesian network where each attribute is conditionally independent from each other and the concept to be learned is conditionally dependent on all these attributes. When the estimators take a continuous value and are not discrete, we assume that these values are sampled from a Gaussian distribution. [2]

In addition to the methods K Fold Cross Validation Method is used. K-Fold Cross Validation is one of the methods of splitting the dataset for evaluating classification models and training the model. In K-Folds Cross Validation, we divide our

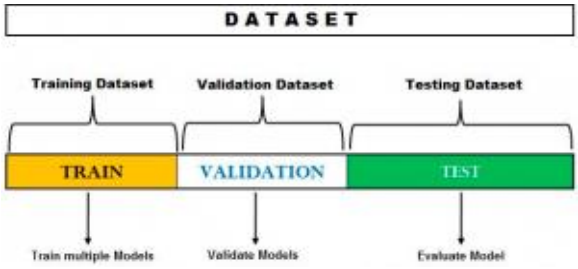
data into k different subsets. We use k-1 subsets to train our data and leave the final subset as test data. The average error value obtained as a result of k experiments indicates the validity of our model [3].

Figure 1: 5-Fold Cross Validation



The hold-out method for training the machine learning models is a technique that involves splitting the data into different sets: one set for training, and other sets for validating and testing. The hold out method is used to check how well a machine learning model will perform on the new data [4].

Figure 2: Hold-out Method



C. *Evaluation Metrics*

In the project, two different evaluation methods are used as follows: Confusion Matrix and F Score. A confusion matrix is a table often used to describe the performance of a classification model on a set of test data for which the actual values are known.

Figure 3: Confusion Matrix

From this matrix we can extract the following information:

- True Positives (TP): These are instances where the true value is 1 and the predicted value is 1.
- True Negatives (TN): These are instances where the true value is 0 and our predicted value is 0.
- False Positives (FP): These are instances where the true value is 0 but our predicted value is 1.
- False Negatives (FN): These are instances where the true value is 1 but our predicted value is 0.

F Score: This is the harmonic mean of the ratio of true positive values (recall) and precision. It is a measure of how well the classifier is performing and is often used to compare classifiers.

$$\frac{2 * \text{Precision} * \text{Recall}}{\text{Precision} + \text{Recall}}$$

III. RESULT

The results were compared using three different classifiers. 5 K fold cross validation method was used for all feature selections, and 70% training and 30% test data holdout method were used for algorithm training and prediction.

A. *K Nearest Neighbors*

The selected parameters are 7 for the number of neighbors and 12 for the number of features. As a result of the feature selection, the top 12 features for KNN are given below:

Figure 4: KNN Selected Features

```
Selected features: (1, 6, 9, 14, 17, 22, 33, 38, 46, 49, 57, 62)
```

The results obtained are as follows:

Figure 5: Best KNN Results

```
Test set accuracy: 83.70 %

f1_score_weighted:  0.837856556507991
f1_score_macro:  0.8379529510685384
f1_score_micro:  0.8370433789954338
f1_score:  [0.89041096 0.845      0.82367758 0.79272326]

              precision    recall  f1-score   support

           0       0.98      0.82      0.89       873
           1       0.75      0.97      0.85       871
           2       0.93      0.74      0.82       883
           3       0.77      0.82      0.79       877

    accuracy                           0.84      3504
   macro avg       0.85      0.84      0.84      3504
weighted avg       0.85      0.84      0.84      3504


Confusion matrix:
 [[715   2  28 128]
 [  0 845  11  15]
 [  4 150 654  75]
 [ 14 132  12 719]]
```

B. *Decision Trees*

The selected parameters are 15 for maximum depth and 20 for the number of features.

Selected feature is given below:

Figure 6: Decision Tree Selected Features

```
Selected features: (0, 1, 4, 6, 17, 19, 25, 27, 38, 39, 46, 51, 52, 53, 54, 55, 57, 58, 6
2, 63)
```

The results obtained are as follows:

Figure 7: Decision Tree Best Results

```
Test set accuracy: 78.25 %


f1_score_weighted:  0.7836339952458528
f1_score_macro:  0.7837942054296427
f1_score_micro:  0.7825342465753425
f1_score:  [0.84351367 0.82101617 0.7672664  0.70338059]
```

	precision	recall	f1-score	support
0	0.86	0.83	0.84	873
1	0.83	0.82	0.82	871
2	0.79	0.75	0.77	883
3	0.67	0.74	0.70	877
accuracy			0.78	3504
macro avg	0.79	0.78	0.78	3504
weighted avg	0.79	0.78	0.78	3504

```
Confusion matrix:
 [[725   4  46  98]
 [  0 711  61  99]
 [ 47  60 661 115]
 [ 74  86  72 645]]
```

C. *Gaussian Naive Bayes*

The selected feature number is 10.

Selected feature is given below:

Figure 8: Gaussian Naïve Bayes Selected Features

```
Selected features: (6, 9, 14, 25, 30, 33, 46, 54, 57, 62)
```

The results obtained are as follows:

Figure 9: Gaussian Naïve Bayes Best Results

```
Test set accuracy: 86.04 %


f1_score_weighted:  0.8601816839901507
f1_score_macro:  0.8602442579990329
f1_score_micro:  0.860445205479452
f1_score:  [0.91501746 0.87413702 0.87410926 0.77771329]
```

	precision	recall	f1-score	support
0	0.93	0.90	0.92	873
1	0.81	0.94	0.87	871
2	0.92	0.83	0.87	883
3	0.79	0.76	0.78	877
accuracy			0.86	3504
macro avg	0.86	0.86	0.86	3504
weighted avg	0.86	0.86	0.86	3504

```
Confusion matrix:
 [[786   0   8  79]
 [  0 823  25  23]
 [ 23  50 736  74]
 [ 36 139  32 670]]
```

IV. CONCLUSION

In this project, the aim is to classify the muscle structures formed by various hand shapes created by the human hand using sensor data. For this problem, 3 different classifier algorithm methods were used, and it is observed that the Gaussian Naive Bayes method gave the best results, considering the F1 score and the confusion matrix.

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