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PERFORMANCE ANALYSIS OF VARIOUS DATA MINING ALGORITHMS

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ABSTRACT

The Data Mining is the essential point of data combination for business intelligence. Now a day, there has been emerging trends in database to discover useful patterns and/or correlations among attributes, called data mining. This paper presents the data mining techniques like Classification, Clustering and Associations Analysis which include algorithms of Decision Tree (like C4.5), Rule set Classifier,kNN and Naïve Bayes ,Clustering algorithms(like k-Means and EM)Machine Learning (Like SVM),Association Analysis(like Apriori). These algorithms are applied on data warehouse for extracting useful information. All algorithms contain their description, impact and review of algorithms. We also show the comparison between the classifiers by accuracy which shows ruleset classifier have higher accuracy when implement in MATLAB.These algorithms useful in increasing sales and performance of industries like banking, insurance, medical etc and also detect fraud and intrusion for assistance of society.

Keywords: Decision Tree, Rule set Classifier, kNN, Naïve Bayes , k-Means, EM, SVM, Apriori.

I. INTRODUCTION

As the data sizes accumulated from various fields are exponentially increasing, data mining techniques that extractinformation from large amount of data have become popular in commercial and scientific domains, including marketing,customer relationship management, quality management.We studied various articles regarding performance evaluation of Data Mining algorithms on various tools, some of themare described here, Abdullah [3] compared various classifiers with different data mining tools & found WEKA as besttool, Mahendra Tiwari &Yashpal Singh [1] evaluated performance of 4 clustering algorithms on different datasets inWEKA with 2 test modes. Some people worked on use of classification algorithms in WEKA for datasets from specificareas such as Tanuja S, Dr. U. Dinesh Acharya, and Shailesh K R [9] compared

different data mining classificationtechniques to predict length of stay for an inpatient in hospital.

Generally arff datasets have 2 types of attributes nominal & numeric. There is need to find suitable classifiers for datasetswith different type of class (either nominal or numeric), so we focused on evaluating performance of different classifiersin WEKA on datasets with numeric & nominal class attribute. During the evaluation, the input datasets and the numberof classifier used are varied to measure the performance of Data Mining algorithm. Datasets are varied with mainly typeof class attribute either nominal or numeric. We present the results for performance of different classifiers based oncharacteristics such as accuracy, time taken to build model identify their characteristics in acclaimed Data Mining tool-WEKA.

Classification maps data into predefined classes often referred as supervised learning because classes are determinedbefore examining data. A classification algorithm is to use a training data set to build a model such that the model can beused to assign unclassified records in to one of the defined classes. A test set is used to determine the accuracy of themodel. Usually, the given dataset is divided in to training and test sets, with training set used to build the model and test set used to validate it.There are various classifiers are an efficient and scalable variation of Decision tree classification. The Decision tree modelis built by recursively splitting the training dataset based on an optimal criterion until all records belonging to each of thepartitions bear the same class label. Among many trees are particularly suited For data mining, since they are built relatively fast compared to other methods, obtaining similar or often better accuracy.

Bayesian classifiers are statistical based on Bayes' theorem, they predict the probability that a record belongs to aparticular class. A simple Bayesian classifier, called Naïve Bayesian classifier is comparable in performance to decisiontree and exhibits high accuracy and speed when applied to large databases.Rule-based classification algorithms generate if-then rules to perform classification. PART, OneR&ZeroR of Rule, IBK,and KStar of Lazy learners, SMO of Function are also used in evaluation process.

II. MATERIALS AND METHODS

We have used the popular, open-source data mining tool Weka (version 3.6.6) for this analysis. Three different data sets have been used and the performance of a comprehensive set of classification algorithms (classifiers) has been analyzed. The analysis has been performed on a Windows 7 Enterprise system with Intel Dual Core CPU, 3GHz Processor and 4.00 GB RAM. The data sets have been chosen such that they differ in size, mainly in terms of the number of attributes.

A. Data set

The first data set is a BPO Employeedata used in our earlier study [7]. The data set contains 9 attributes apart from the class attribute with 500 instances.

B. Classifiers Used

A total of 14 classification algorithms have been used in this comparative study. The classifiers in Weka have been categorized into different groups such as Bayes, Functions, Lazy, Rules, Tree based classifiers, etc. A good mix of algorithms have been chosen from these groups that include Bayes Net & Naive Bayes (from Bayes), Multilayer Perceptron, Simple Logistics & SMO (from functions), IBk&KStar (from Lazy), NNge, PART &ZeroR (from Rules) and ADTree, J48, Random Forest & Simple Cart (from Trees). The following sections explain a brief about each of these algorithms.

1. **SMO**

Sequential Minimal Optimization (SMO) is used for training a support vector classifier using polynomial or RBF kernels. It replaces all the missing the values and transforms nominal attributes into binary ones [14]. A single hidden layer neural network uses exactly the same form of model as an SVM.

2. IBk

IBk is a k-nearest-neighbor classifier that uses the same distance metric. k-NN is a type of instance based learning or lazy learning where the function is only approximated locally and all computation is deferred until classification. In this algorithm an object is classified by a majority vote of its neighbors [15].

3. Bayes Net

Bayes Nets or Bayesian networks are graphical representation for probabilistic relationships among a set of random variables. A Bayesian network is an annotated Directed Acyclic Graph (DAG) that encodes a joint probability distribution [10].

4. Naive Bayesian

Naive Bayesian classifier is developed on bayes conditional probability rule used for performing classification tasks, assuming attributes as statistically independent; the word Naive means attributes of the data set are considered as independent and strong of each other [11].

5. Simple Logistics

It is a classifier used for building linear logistic regression models. LogitBoost with simple regression functions are base learners used for fitting the logistic models. The optimal number of LogitBoost iterations to perform is cross-validated, which leads to automatic attribute selection [12].

6. KStar (K*)

Aha, Kibler& Albert describe three instance-based learners of increasing sophistication. IB1 is an implementation of a nearest neighbor algorithm with a specific distance function. IB3 is a further extension to improve tolerance to noisy data. Instances that have a sufficiently bad classification history are forgotten and only instances that have a good classification history are used for classification. Aha [16] described IB4 and IB5, which handle irrelevant and novel attributes.

7. Multilayer Perceptron

Multilayer Perceptron is a nonlinear classifier based on the Perceptron. A Multilayer Perceptron (MLP) is a back propagation neural network with one or more layers between input and output layer. The following diagram illustrates a perception network with three layers [13].

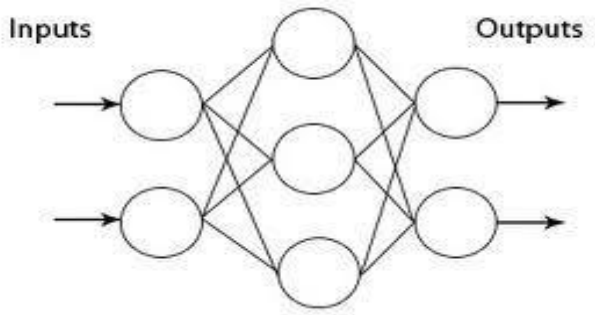

Figure 1.Illustration of a perception network with three layers

8. PART

PART uses the separate-and-conquer strategy, where it builds a rule in that manner and removes the instances it covers, and continues creating rules recursively for the remaining instances. Where C4.5 and RIPPER does global optimization to produce accurate rule sets, this

added simplicity is the main advantage of PART [18].

9. ZeroR

ZeroR is the simplest classification method which depends on the target and ignores all predictors. ZeroR classifier simply predicts the majority category (class). Although there is no predictability power in ZeroR, it is useful for determining a baseline performance as a benchmark for other classification methods [19].

10. NNge

Instance-based learners are "lazy" in the sense that they perform little work when learning from the data set, but expend more effort classifying new examples. The simplest method, nearest neighbor, performs no work at all when learning. NNge does not attempt to out-perform all other machine learning classifiers. Rather, it examines generalized exemplars as a method of improving the classification performance of instance-based learners [17].

11. ADTree

Alternating Decision Tree is one of the classification methods used in Machine learning which consists of decision nodes and prediction nodes. An instance is classified by an ADTree for which all decision nodes are true and summing any prediction nodes that are traversed. This makes it different from basic classification tree models that follow only one path through the tree [20].

12. J48

The J48 algorithm is a WEKA's implementation of the C4.5 decision tree learner. The algorithm uses a greedy technique to induce decision trees for classification and uses reduced-error pruning [21].

13. Simple Cart

CART is a recursive and the gradual refinement algorithm of building a decision tree, to predict the classification situation of new samples of known input variable value. Breimanet. al., 1984 provided this algorithm and is based on Classification and Regression Trees (CART) [23]. In our study, we have applied all the above classifiers on the 3 different cancer data sets and the results have been analyzed.

14. Random Forest

Random forest is an ensemble classifier which consists of many decision trees and gives the class as outputs i.e., the mode of the class's output by individual trees. Random Forests give many classification trees without pruning [22].

III. PERFORMANCE MEASURES

In this approach, the classification accuracy rates for the datasets were measured. For example, in the classification problem with two-classes, positive and negative, a single prediction has four possibility. The True Positive rate (TP) and True Negative rate (TN) are correct classifications. A False Positive (FP) occurs when the outcome is incorrectly predicted as positive when it is actually negative. A False Negative (FN) occurs when the outcome is incorrectly predicted as negative when it is actually positive.

Table 1. Confusion Table

Prediction		**Disease**	
		+	**-**
Test	**+**	**True Positive (TP)**	**False Negative (FP)**
	-	**False Negative (FN)**	**True Negative (TN)**

1. Accuracy - It refers to the total number of records that are correctly classified by the classifier.

$$Accuracy = \frac{TP+TN}{TP+FP+FN+TN} \text{----------(2)}$$

2. Classification error - This refers to the misclassified datasets from the correctly classified records.
3. True Positive Rate (TP): It corresponds to the number of positive examples that have been correctly predicted by the classification model.
4. False Positive Rate (FP): It corresponds to the number of negative examples that have been wrongly predicted by the classification model.
5. Kappa Statistics - A measure of the degree of nonrandom agreement between observers or measurements of the same categorical variable.
6. Precision - is the fraction of retrieved instances that are relevant.

$$Precision = \frac{TP}{TP+FP} \text{----------(3)}$$

7. Recall - is the fraction of relevant instances that are retrieved.

$$Recall = \frac{TP}{TP+FN} \text{----------(4)}$$

8. Root-Mean-Squared-error - It is a statistical measure of the magnitude of a varying quantity. It can be calculated for a series of discrete values, or for a continuously varying function. Since the class label prediction is of multi-class, the result on the test set will be displayed as a two-dimensional confusion matrix with a row and a column for each class. Each matrix element shows the number of test cases for which the actual class is the row and the predicted class is the column.Finally, the error rate is one minus this.

ROC curves depict the performance of a classifier without regard to class distribution or error costs. They plot the number of positives included in the sample on the vertical axis, expressed as a percentage of the total number of positives, against the number of negatives included in the sample, expressed as a percentage of the total number of negatives, on the horizontal axis. Information retrieval researches define parameters called recall and precision.

$$\text{recall} = \frac{\text{number of documents retrived that are relevant}}{\text{Total number of documents that are relevant}}$$

$$\text{Precision} = \frac{\text{number of documents retrived that are relevant}}{\text{number of documents retrived that are retrived}}$$

F-measure is another information retrieval measure that is calculated from TP, FP, FN or recall or precision values

$$\text{f} - \text{measure} = \frac{2 * \text{recall} * \text{Precision}}{\text{recall} + \text{Precision}}$$

$$\text{f} - \text{measure} = \frac{2 * \text{TP}}{2 * \text{TP} + \text{FP} + \text{FN}}$$

IV. RESULTS AND DISCUSSION

Our proposed algorithm runs efficiently on large databases and has the capability of handling thousands of input variables. It generates the generalization error as the effective method for estimating missing data and maintains accuracy when large proportion of the data are missing. Our proposed that has been generated can be saved in order to make comparative study about the features of the attributes. To measure the effectiveness of the approach experiments have been conducted.

Meanwhile, Decision trees are constructed in a top-down recursive divide-and-conquer manner and the compatibility of Decision trees degrades because the output is limited to one attribute. Trees created from the numeric datasets seems to be more complex and also when the database is large the complexity of the tree increases. In comparison with the 16 algorithms the time complexity of Decision trees increases exponentially with the tree height. Hence shallow trees tend to have large number of leaves and high error rates.

As the tree size increases, training error decreases. However, as the tree size increases,

testing error decreases at first since we expect the test data to be similar to the training data, but at a certain point, the training algorithm starts training to the noise in the data, becoming less accurate on the testing data. At this point we are no longer fitting the data and instead fitting the noise in the data. This is called over fitting to the data, in which the tree is fitted to spurious data. As the tree grows in size, it will fit the training data perfectly and not be of practical use for other data such as the testing set.

Table 2. Performance Analysis of Various Classifiers

Classifier	Accuracy(%)	True Positive Rate	False Positive Rate	Precision(%)	Recall(%)	Classification Error (%)	Kappa Statistics	RMS Error
Decision Tree	50.68	0.507	0.230	0.478	0.507	49.32	0.211	0.404
Random Forest	63.34	0.633	0.254	0.570	0.633	36.66	0.354	0.313
J48	64.45	0.500	0.544	0.521	0.500	35.55	0.344	0.310
PRISM	63.45	0.750	0.350	0.825	0.750	36.55	0.635	0.718
IBK	54.50	0.871	0.594	0.571	0.871	45.50	0.484	0.539
Naïve Bayes	53.75	0.571	0.594	0.528	0.571	46.25	0.484	0.539
SMO	54.00	0.643	0.465	0.629	0.643	46.00	0.589	0.632
Bayes Net	52.50	0.681	0.502	0.625	0.681	47.50	0.585	0.536
Simple Logisitics	49.80	0.547	0.450	0.520	0.547	50.20	0.580	0.598
KStar	50.25	0.564	0.459	0.561	0.564	49.75	0.480	0.654
NNge	51.20	0.655	0.500	0.540	0.655	48.80	0.490	0.655
PART	49.99	0.652	0.550	0.650	0.652	50.01	0.500	0.654
ZeroR	52.25	0.584	0.546	0.643	0.584	47.75	0.480	0.680
AD Tree	61.18	0.500	0.640	0.684	0.500	38.82	0.465	0.500
Simple Cart	60.16	0.600	0.490	0.682	0.600	39.84	0.470	0.654
Multi Layer Perception	61.58	0.546	0.500	0.855	0.546	38.42	0.495	0.356
Proposed	68.80	0.650	0.545	0.420	0.650	31.20	0.301	0.212

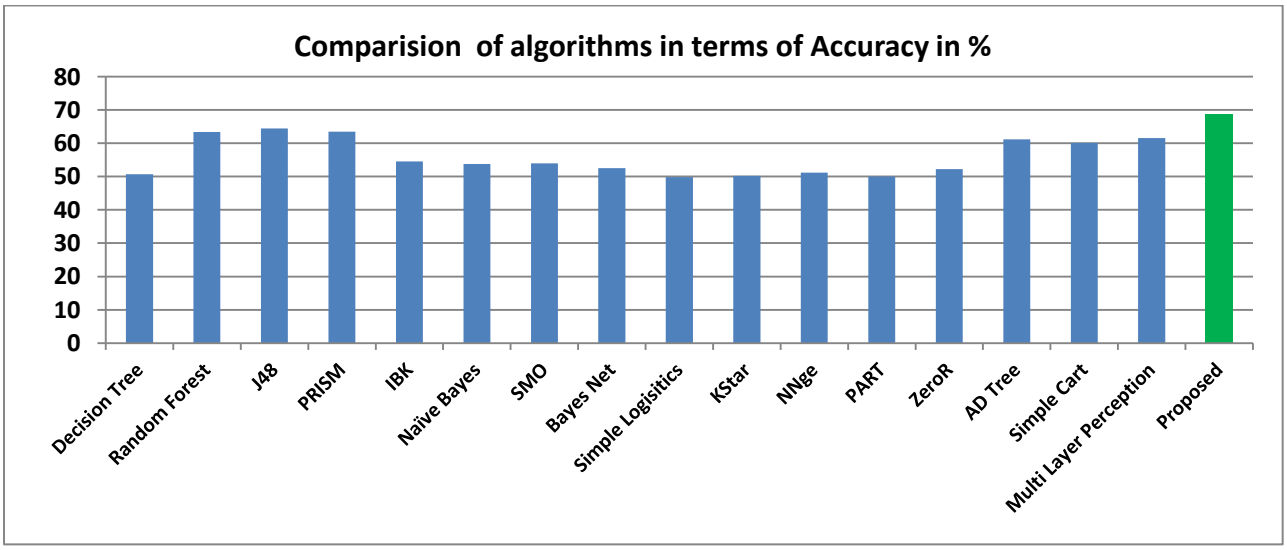

Figure 2.Comparison of accuracy in between the seventeen algorithms

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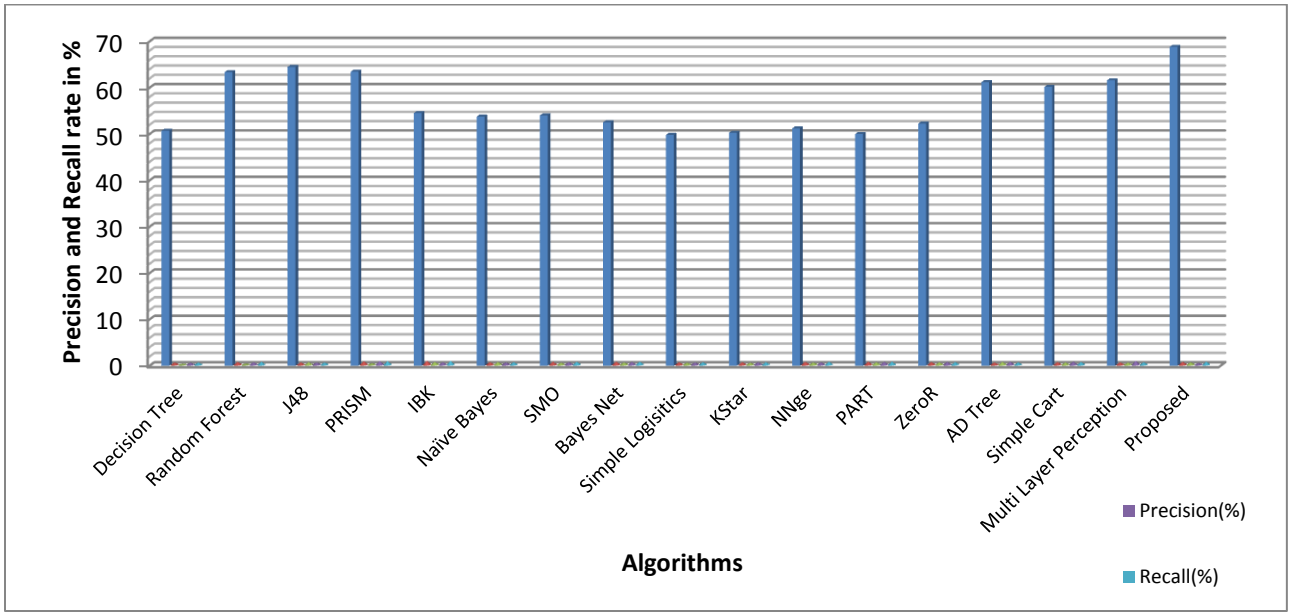

Figure 3 . Comparison of Precision and Recall values in between the seventeen algorithms

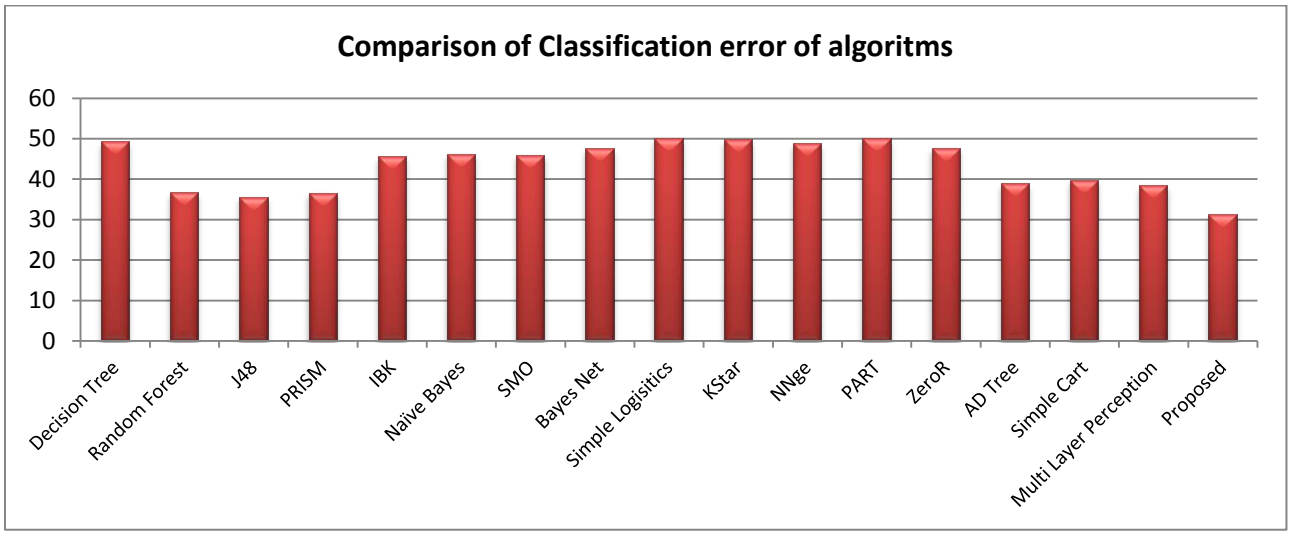

Figure 4. Comparison of Classification error in between the seventeen algorithms.

The performance obtained using Proposed Fast Boost Decision Tree classifier was found to be higher than the results obtained by our et.al as described in the Table 2 which depicts that Proposed Fast Boost Decision Tree algorithm performs better than that Decision tree.

In wekaProposed Fast Boost Decision Tree classifier algorithm shows only the number of instances is correctly clustered and incorrectly clustered. From this we are able to know that which algorithm is best. Table show the results that the Proposed Fast Boost Decision Tree classifiercorrectly clustered more instances than other algorithm.

V. CONCLUSION

This study focuses on finding the right algorithm for classification of data that works better on diverse data sets. However, it is observed that the accuracies of the tools vary depending on the data set used. It should also be noted that classifiers of a particular group also did not perform with similar accuracies. Overall, the results indicate that the performance of a classifier depends on the data set, especially on the number of attributes used in the data set and one should not rely completely on a particular algorithm for their study. So, we recommend that users should try their data set on a set of classifiers and choose the best one. Here we discussed few data mining algorithms which are used to perform data analysis tasks in different fields. Our Proposed Fast Boost Decision Tree classifieralgorithms has higher accuracy that other classifiers. This algorithms employed in fraud detection, intrusion detection, BPO Industry,Finance and Health for extraction of useful information.

VI. FUTURE WORK

We would like to develop web based software for performance evaluation of various classifiers (including our proposed)where the users can just submit their data set and evaluate the results on the fly.

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