Comparison of Decision Tree and SVM Methods in Classification of Researcher's Cognitive Styles in Academic Environment

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Abstract

Recently, by development of internet, it is user's right to achieve the best answer based on what they demand. Also, classification is the task which is essential in data mining. Nowadays, there are many classification techniques to eliminate the classification problems such as Decision tree, SVM, Genetic Algorithm, Bayesian and others. In this paper, the researchers are classified to "Expert" and "Novice" based on cognitive style factors to have the best practicable answers. Academic environment has been chosen as a domain of this research. An important aim of this research is to classify the researchers based on Decision tree and Support Vector Machine techniques and finally according to the highest accuracy, choose the best technique to help the researchers to have the best answer based on their request in digital libraries.

Background/Objectives:

The main concepts of cognitive styles and specifications of Decision tree, and SVM methods are investigated. The implementation for classification of Decision tree and SVM methods are developed, finally, the classification based on the accuracy of the results are compared.

Methods/Statistical analysis:

Two methods of classification are used in this paper which are Decision tree and Support vector machine. There are various methods in Decision tree, but only 6 of them are used here which includes J48, LMT, RandomForest, REPtree and DecisionStump. Also, the experiment in SVM was based on 10-fold cross validation. To strengthen the analysis in SVM two experiments are done. The new experiment is based on 5-fold cross validation.

Results:

Based on the achieved values, if these two methods compare with accuracy and average accuracy values, SVM is the best method in comparison with Decision tree. Moreover, it can be concluded that, SVM can classify more precisely than Decision tree, because it categorizes using separating hyperlanes and margins. However, Decision tree does not use hyperlane, so may have some errors in classification.

Conclusion/Application:

Based on the SVM method, researchers can be classified to "Expert" and "Novice" based on cognitive style factors in order to have as best as possible answers. So, researchers will have the best feedback based on their demands in the digital libraries.

Keywords: Data mining, Classification, Cognitive styles, Decision tree, SVM, Academic environment

1. Introduction

Since , users have various requests in internet environments such as Digital Libraries, the information services are prepared to help them, therefore; there is a clear way for various users to represent their preferences obviously which is personalized digital libraries. Using this method will cause a problem for users. The problem is that users will not notice to their preferences so they cannot have a satisfactory research. To solve

this problem, this paper considers a way that achieves user preference based on cognitive styles and identifies related specification for information seeking and then classifies the researchers to "Expert" and "Novice".

Data mining is a machine learning approach which consists of many tasks such as cluster analysis; trend and evaluation analysis; statistical analysis; concept description; classification and prediction; outlier analysis and others. Classification and prediction techniques are the most essential tasks in data mining. Since, the classification target and the class level are already recognized; the classification methods are recognized as supervised learning. Several methods are recognized in classification especially in data mining, for example, Decision Tree, Bayesian, Fuzzy Logic, Support Vector Machine (SVM), Genetic Algorithm, Rough Set Theory, Nearest Neighbor and Neural Network. According to two criterions, an appropriate technique will be selected. These criterions are dataset and the accuracy of model advanced by the techniques [1].

2. Classification

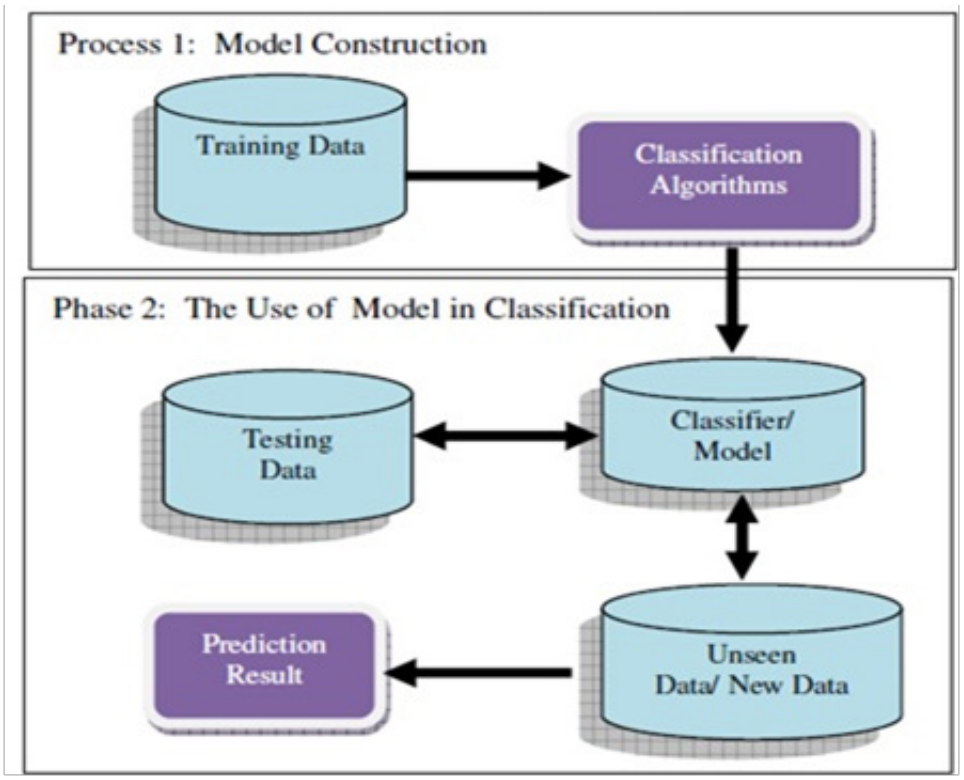
Nowadays, there are various classification methods which are presented by researchers in machine learning, statistics and pattern recognition. The main categories in data mining are Clustering, association, classification and prediction [2].

By passing the years, data mining developed many different techniques [3]. These techniques run the tasks which encompasses database oriented techniques, statistic, machine learning, pattern recognition, neural networks, rough set and the others. Also, there are various hidden information in data mining and data ware house. This hidden information can be applied in intelligent decision making which is similar with human decision.

Also prediction and classification are two techniques which can provide an intelligent decision making. The can be applied to extracts patterns which presenting significant data classes or to predict future data modes [4].

Furthermore, classification includes two phases. Learning process is the first phase. Based on this phase, classification algorithm will analyze the training data and then rules and patterns will be created which are based on learned model or classifier. According to the second phase which is testing process, the model will be used for classification. Test data are used for achieving the accuracy of classification patterns. And finally, based on the best accuracy, the rules can be applied for classification of new data or unseen data [Figure 1][1].

Fig.1. *The process of classification*



2.1 Decision Tree

Decision trees are widely used in the classification process. Decision trees are powerful and popular tools for classification and prediction. Decision trees represent rules, which can be understood by humans and used in knowledge system such as database. This method is intended to build knowledge structures based on the data set. This method consists of a set of rules that will divide the large group to different smaller and standardized groups based on the targets defined variable. The decision tree usually results in the form of categories and decision tree model is used either to calculate the probability that the existing data set is categorized into the appropriate category. There are various methods in Decision tree, but only 6 of them are used here which includes J48, LMT, RandomForest, REPtree and DecisionStump [5].

In general, Decision Tree performs the classification process without involving many aspects of computation and complexity. Decision Tree is also able to generate rules that are easily understood and even easier to use the database. Decision Tree is the good method for providing guidance to determine the appropriate and most importantly parameters for classification or prediction. In terms of data processing, the Decision Tree does not require the data processor for doing processing for its own data. In fact, if the data is lost, Decision Tree will interpret the data by replacing missing data with new data randomly. In addition, the most important advantage of Decision Tree is to have a very high execution time and still produce a fairly accurate classification results when compared with other classification methods [6].

There is a statistical property which is a good measure for the value of an attribute which is called information gain. It is applicable for selecting the most useful attribute for classifying and it is also useful for measuring how well an existed attribute divides the training examples based on their target classification. This estimation is used to choose between the candidate features at each step during growing the tree.

It is needed to explain a measure which is used in information theory, named entropy for defining information gain accurately. Entropy describes the impurity of a collection of examples. The entropy of set S which includes positive and negative examples of some target concept (a two class problem) is presented below; where p_p is the proportion of positive examples in S and p_n is the proportion of negative examples in S [7].

$$\text{Entropy}(S) = - p_p \log_2 p_p - p_n \log_2 p_n \quad (1)$$

The effectiveness of an attribute in classifying the training data can explain by having entropy which is a measure of the impurity in a set of training samples. This measure is the expected reduction in entropy and is happened by dividing the samples based on this attribute and is called information gain. In information gain, Gain (S, A), A refers to an attribute A and S represents a collection of examples and Values(A) is the set of all possible values for attribute A and S_υ is the subset of S for which attribute A has value υ [7].The formula is represented as formula 2.9:

$$Gain(S, A) \equiv Entropy(s) - \sum_{\upsilon \in Values(A)} \frac{|S_\upsilon|}{|S|} Entropy(S_\upsilon \quad (2)$$

2.2 Support Vector Machine (SVM)

Support vector machines are one of the developed and important machine learning technology which was introduced by Vapnik [8] and was originally based on statistical learning theory [9]. This method has been applied in various fields such as medical / healthcare, manufacturing, and text classification. According to Hua Li and danYongXin Zhang in [10] SVM method has a high ability to solve the problems which are related to over fitting, a small sample of data, data that is not linear (nonlinearity) and high dimensional data [11].

SVM used for binary classification and can find a hyperlane which divides the d-dimensional data into two classes completely. In non-linearly separable data, SVM put the data into a higher dimensional space to separate the data by proposing the "kernel induced feature space" concept [12]. SVM classifies data by mapping the training data into a higher dimensional feature space by placing a divider that can separate the positive model

from the negative model in the space [13]. In SVM, there is border that separates the set of positive data from negative data set with maximum margin in the feature space. Figure 2 provides an overview of SVM [14].

According to this method each document represents as a vector and tries to find a decision boundary which is called as a decision surface. The boundary displays the distinction between sets of vectors. Positive and negative instances for each category are used for training the system and the boundaries between categories are measured. In this method, classification can be done by calculating vector of a new document and determining the partition of the space, which the vector is, belongs to. [Figure 2]

Fig.2. *An over view of SVM*

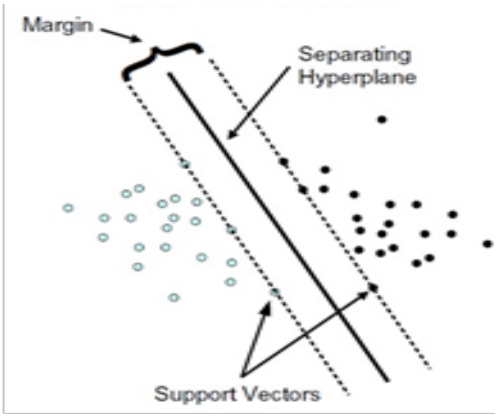
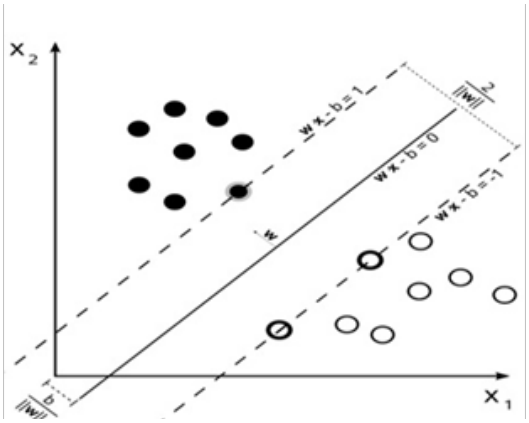


Fig.3. *Support Vector Machine*



The basic formula of SVM is shown in formula (3), y refers to the scalar output; w refers to the weight; x represents the input and b is biased.

$$y = f(x) = \omega.x - b \quad (3)$$

In SVM, margins and maximum-margin hyperplane will be trained by the samples of two categories. These samples of the margins are known as support vectors. For maximizing, the margin or the distance between the parallel hyperlanes, which are in the farthest possible point, that divide the data, w and b should be selected.

The hyperlanes is described by the formula (4) and (5):

$w.x - b = 1$ (4) or $w.x - b = -1$ (5)

It is important to consider that if the training data are linearly separable, the both hyperlanes of the margins should be under conditions with no points between them and large distance between them. In order to obtain the distance between two hyperlanes by, $\frac{2}{\|W\|}$ the ||w|| should be minimized (Figure 3). For preventing falling data points into the margins, the following constraint should be added, for each i [15] :

$$w.x_i - b \geq 1 \quad (6) \quad \text{for } x_i \text{ of the first class}$$

$$w.x_i - b \geq -1 \quad (7) \quad \text{for } x_i \text{ of the second class}$$

This can be presented as the following formula (8):

$$y_i(w.x_i - b) \geq 1 \quad (8) \quad \text{for all } 1 \leq i \leq n$$

The accuracy of the results by SVM classification is very high [16] and SVM can do and produce a complex classification model. It has no limitations to do the classification for data that has many attributes. If there is

missing data (missing values); SVM will automatically replace the value.

3. Data Set

The questionnaire was disseminated to 130 UTM research students but only 120 questionnaires were returned and 10 questionnaires were considered as incomplete data. So, this study is done based on 110 questionnaires. The domain of this research is an academic environment. The participants have been chosen from research students in University Technology Malaysia (UTM). They were 34 master research students and 76 PHD students from various faculties. The participants include: 40 computer science, 1 electrical engineering, 22 mechanical engineering, 21 civil engineering, 8 chemical engineering, 6 built environment and 12 management faculties.

Then, the questionnaire has been prepared based on cognitive style factors, which was based on Ford et al. (2002) [17]. The cognitive style instrument was selected in order to provide explanation of observed behavior of students when using web search engines. Since the tool was self-assessment, students were asked to respond to the questions in a cognitive style in a real life situation.

Based on the 130 disseminated questionnaires among UTM research students, only 120 questionnaires were returned and 10 questionnaires were recognized as incomplete data. So, this study is done based on 110 questionnaires. The analysis of this study is based on prediction of the student's status whether "Expert" or" Novice".

4. Researcher's Cognitive Styles Variables and Attributes

Data is collected based on researcher's Cognitive styles. The information was designed in questionnaire according to the cognitive style and information seeking variables. The questionnaire consists of 5 variables; where each variable is represented by several attributes. Table 1 shows the types of variables and attributes for data sets in general [18][19].

Table.1 *Variables and Attributes of Cognitive Styles*

Variable	Attribute
State of personal or internal knowledge	▪ Broad conceptual knowledge of the domain ▪ Specific knowledge or expertise of the problem ▪ Familiarity with the language or terminology used in the problem or domain

Information Seeking Behaviour	▪ Clarity and focus of thought
	▪ Kuhlthau's stages:
	  ▪ Initiation
	  ▪ Selection
	  ▪ Exploration
	  ▪ Collection

Information Seeking Activities	▪ Ellis's information-seeking activities:
	  ▪ Chaining
	  ▪ Browsing
	  ▪ Differentiating
	  ▪ Maintaining
	  ▪ Systematically working through
	  ▪ verifying

Uncertainty	▪ Recognizing a real problem to investigate; ▪ Defining the problem appropriately; ▪ Resolving the problem; ▪ Finding an effective way of presenting the results; ▪ Finding relevant information

5. Evaluating the Classification Methods

In this phase, the testing was done in order to do classification. Testing process was developed to select the appropriate classification method. Accuracy is the first factor for evaluating. The selection was based on the accuracy of each method. The classification method with the highest accuracy will be selected. Also the error value for each method is obtained which includes the Square Root Error of Mean (RMSE), Mean Absolute Error for (MAE). In the following formulas, (x) represents the predicted value, (y) represents the actual value, (n) represents the total number:

$$MAE = \frac{1}{n}\sum_{i=0}^{n} x - y \quad \textbf{(9)}$$

$$RMSE = \sqrt{\sum \frac{(x-y)^2}{n}} \quad \textbf{(10)}$$

The comparison on each of the methods is implemented. The results of each method are presented in table 2 to table 7. All the experiments are done in WEKA environment.

Table 2. *Results of J48*

J48		
Testing	**Number of correctly classified instances**	**Accuracy (%)**
1	11/11	100
2	10/11	90.9091
3	11/11	100
4	11/11	100
5	11/11	100
6	10/11	90.9091
7	11/11	100
8	7/11	63.6364
9	11/11	100
10	10/11	90.9091
Average Accuracy (%):		92.72728

Table 3. *Results of LMT*

LMT		
Testing	**Number of correctly classified instances**	**Accuracy (%)**
1	11/11	100
2	10/11	90.9091
3	10/11	90.9091
4	10/11	90.9091
5	11/11	100
6	10/11	90.9091
7	10/11	90.9091
8	7/11	63.6364
9	11/11	100
10	11/11	100
Average Accuracy (%) :		91.81819

Table 4. *Results of RandomForest*

RandomForest		
Testing	**Number of correctly classified instances**	**Accuracy (%)**
1	11/11	100
2	10/11	90.9091
3	11/11	100
4	10/11	90.9091
5	11/11	100
6	10/11	90.9091
7	11/11	100
8	8/11	72.7273
9	9/11	81.8182
10	11/11	100
Average Accuracy (%) : 92.72728		

Table 5. *Results of RandomTree*

RandomTree		
Testing	**Number of correctly classified instances**	**Accuracy (%)**
1	11/11	100
2	10/11	90.9091
3	10/11	90.9091
4	10/11	90.9091
5	11/11	100
6	10/11	90.9091
7	10/11	90.9091
8	8/11	72.7273
9	10/11	90.9091
10	10/11	90.9091
Average Accuracy (%): 90.9091		

Table 6. *Results of REPTree*

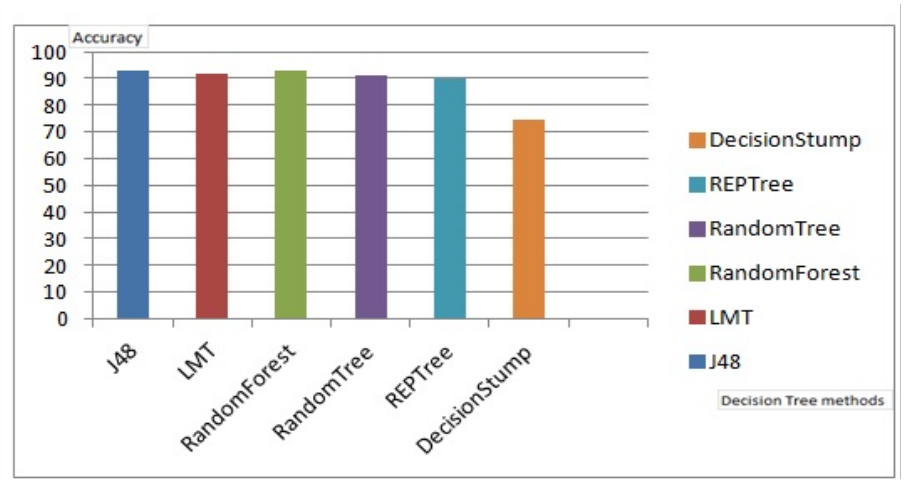
REPTree		
Testing	**Number of correctly classified instances**	**Accuracy (%)**
1	11/11	100
2	9/11	81.8182
3	11/11	100
4	9/11	81.8182
5	10/11	90.9091
6	10/11	90.9091
7	11/11	100
8	7/11	63.6364
9	11/11	100
10	10/11	90.9091
Average Accuracy (%): 90.00001		

Table 7. *Results of DecisionStump*

DecisionStump		
Testing	**Number of correctly classified instances**	**Accuracy (%)**
1	8/11	72.7273
2	9/11	81.8182
3	7/11	63.6364
4	9/11	81.8182
5	7/11	63.6364
6	10/11	90.9091
7	8/11	72.7273
8	7/11	63.6364
9	8/11	72.7273
10	9/11	81.8182
Average Accuracy (%): 74.54548		

Figure 4 shows the average accuracy of each method. Based on figure 4, it is clear that J48 and Random-Forest have the same average accuracy with 92.72728, therefore; the value of MAE and RMSE should be measured in order to find the best method.

Fig.4. *Average accuracy of 6 methods of decision tree*



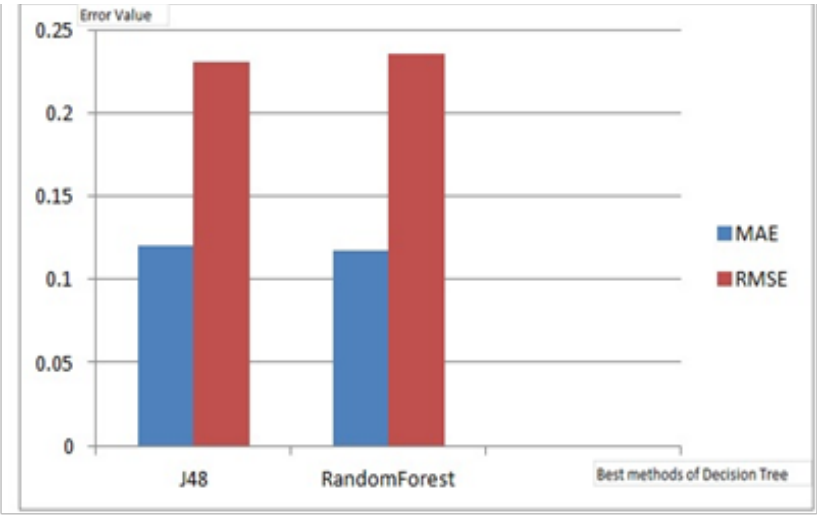
To choose the best method, if the values of the accuracy are same, then total value of the MAE will be measured. The classification method that produces the smallest MAE value will be selected. The next step is to determine the method of classification with the smallest MAE value among the best methods, if the values of MAE were same, the method with the largest RMSE value should be selected. Based on figure 2, it is clear that J48 and RandomForest have the same average accuracy with 92.72728. For choosing the best method among these two methods, it is necessary to find out the average value of MAE and RMSE error (table 8).

From table 2 and table 4 and also figure 4, although the accuracy value of J48 and RandomForest are the same, but in terms of average value of MAE in table 8, RandomForest method produces the smallest error (figure 5). So, in this case, it can be concluded that in the decision tree classification method, RandomForest, produces the highest accuracy with the smallest average value of MAE which is the best method.

Table 8. *Value of MAE, RMSE for J48 and RandomForest*

Number	J48		RandomForest	
	MAE	RMSE	MAE	RMSE
1	0.0642	0.1023	0.0439	0.1113
2	0.1166	0.2641	0.0909	0.246
3	0.0812	0.1217	0.0839	0.1733
4	0.1212	0.3178	0.1308	0.3178
5	0.1004	0.1217	0.0646	0.1273
6	0.0994	0.2612	0.1212	0.2701
7	0.1012	0.2249	0.0561	0.1475
8	0.3377	0.5347	0.3545	0.5568
9	0.061	0.1017	0.1686	0.2677
10	0.1221	0.2547	0.0582	0.1365
Average value	0.1205	0.23048	0.11727	0.23543

Fig.5. *Values of MAE and RMSE for J48 and random forest*



6. Results and Discussion on SVM

To strengthen the selection of SVM as a classifier of this analysis, one experiment was conducted using the SVM which was based on 10-fold cross validation. The purpose of this experiment carried out to prove that the value of using the SVM classification accuracy is higher. Although cross-validation using different values, but 10-fold cross validation generates more precise accuracy.

In 10-fold cross validation, all the 110 data set will be divided to 10 subsets. Each individual subset is known as test data and the rest data is considered as training data. Here, the training data set includes 99 data and test data includes 11 data. For achieving accuracy that is more accurate this process will be done 10 times. The experiment is done on the same train and test data which was used in Decision Tree. Data training and testing experiments conducted using LIBSVM environment. The following table shows the results of each process. [Table 9]

Table 9. *The results of SVM classification*

Cross Validation	Training		Testing	
	Number of correctly classified instances	Accuracy (%)	Number of correctly classified instances	Accuracy (%)
1	92/99	92.9293	11/11	100
2	92/99	92.9293	11/11	100
3	92/99	92.9293	10/11	90.9091
4	92/99	92.9293	11/11	100
5	93/99	93.9394	10/11	90.9091
6	94/99	94.9495	9/11	81.8182
7	92/99	92.9293	11/11	100
8	94/99	94.9495	9/11	81.8182
9	92/99	92.9993	11/11	100
10	93/99	93.9394	10/11	90.9091
Average Accuracy (%)	93.54236		93.63637	

The data is generated based on the learning model but the pattern of learning data is unknown. SVM implement the testing on the generated data based on the learning model. SVM will consider data patterns in the learning model to map data before testing. If the produced learning model is not accurate, then it would affect the results during testing later. The results for testing process and for training process are shown in table 9.

Table 10. *The results of SVM classification based on the new method of cross validation*

Experiment	Accuracy	Correctly classified instances	Incorrectly classified instances
1	100%	110	0
2	100%	110	0

Average classification results using SVM method are also presented in Table 9. Based on the table 9, the average accuracy of the training process is 93.54236 and the average accuracy of the testing process is 93.63637. According to the testing average accuracy, these experiments produce the high classification accuracy. This is because during the data learning process, the result of classification accuracy was also high.

The results of the Table 9 is based on k-folds cross validation, but besides these experiments, the new way of cross validation is done to prepare the training and testing data. In this technique, the original data is divided into k subsets. Among these k subsets, one subset is kept as the training data and the one data of this single subset is used as testing data. The cross-validation process is then repeated k times (the folds), until the number of testing data becomes equal with the number of original data. According to these new experiments, and to strengthen the analysis two experiments are done. In this case, 10-folds cross validation generates 1100 learning data and 5-folds cross validation generates 550 learning data. The results of the learning data stated in table 4.16. Through Table 10, it is known that the accuracy of the classification of the learning data experiments 1 and 2 are 100 %. For both experiments 1 and 2 SVM predict the total of 110 out of 110 research students with the correct data. Figure 6 shows the results of two experiments which are done in SVM.

7. Discussion on the Results

In this section the results produced with Decision Tree and SVM algorithms were compared and a brief discussion was given on the results. As the Table 11 shows, among these two methods decision tree had the worst results with the accuracy of 92.7278 and SVM with the accuracy of 93.63637 was the best. However, if we want to compare these two methods based on the average of accuracy of algorithms used in them then it can be concluded that SVM is the best with the average accuracy of the 96.818185% and Decision Tree with the average accuracy of 88.78789% is the worst.

Table 11. *Comparison of results of Decision Tree, SVM methods*

Method	Decision Tree	SVM
Best accuracy	92.72728	93.63637
Average accuracy	88.78789	96.818185

Finally, SVM has highest accuracy in comparison with decision tree methods. However, the proposed SVM technique in this research with the accuracy of 100% was either better than existing SVM classification method. In addition, under the best situation Decision Tree has the accuracy of the 92.72728 by using the method of RandomForest. This means that Decision Tree is the worst in comparison with SVM. Moreover, it can be concluded that, SVM can classify more precisely than Decision tree, because it categorizes using separating hyperlanes and margins. However, Decision tree does not use hyperlane, so it may have some errors in classification.

Fig.6. *The results of two experiments in SVM*

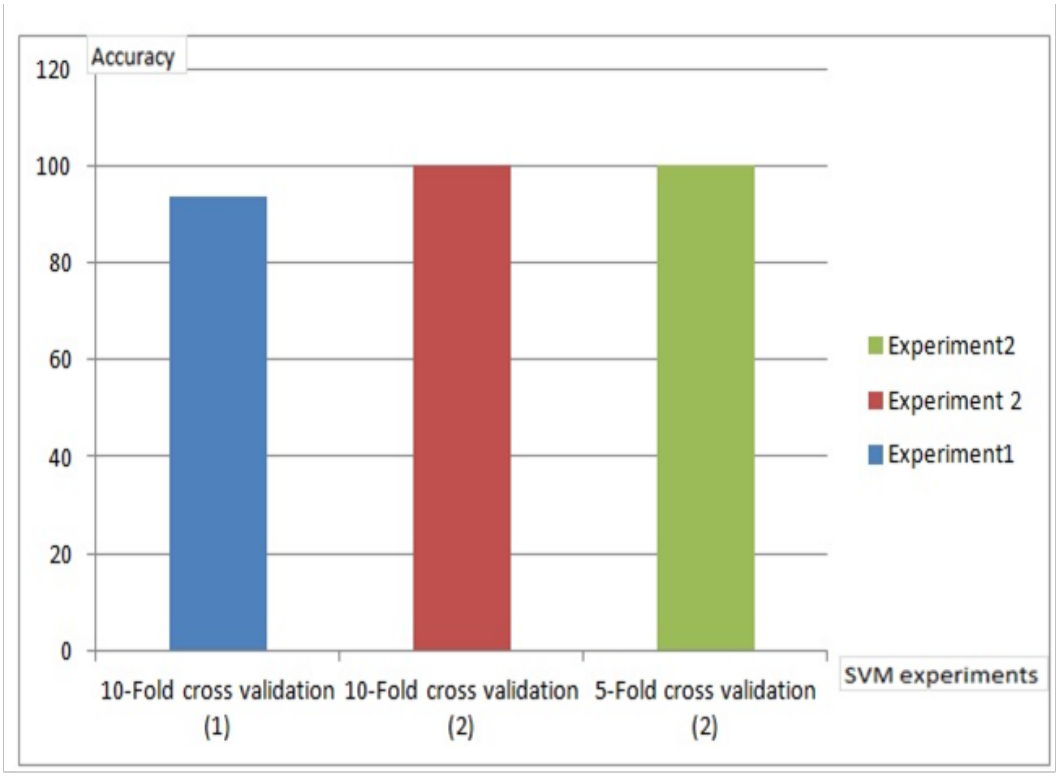
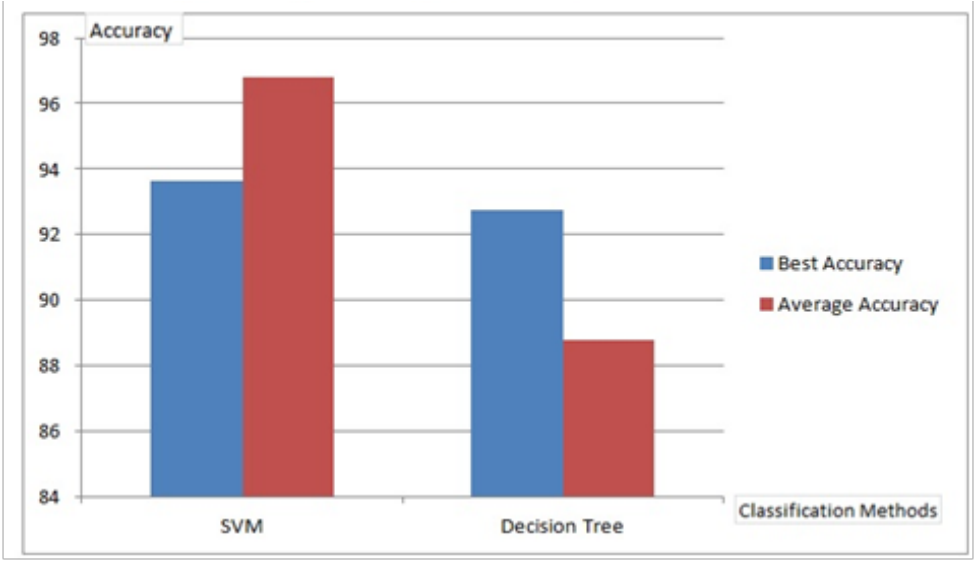


Fig.7. *Comparision of average and best accuracy of two methods*



Accuracy of experimental results (1 and 2) for SVM have been implemented for the case study and are compared with accuracy of other experimental results for SVM, as described in Table 12. This comparison includes results of experimental studies [20]. This comparison is only intended to show that SVM consistently produce high-precision values [16].However, there are restrictions on this comparison for each set of experiments using different data and parameters. Classification accuracy of SVM method is in the range of more than 80% to 90% and above. It is important to notice again that the comparison is done only to prove that even though different data sets and parameters used, the SVM is able to produce good accuracy.

Table 12. *Comparison of results between SVM in this case study and literature case study*

Researcher	Data set	Classification accuracy (%)
(Zheng and Song 2004)	Election Records	99.04
(Kumar and Gopal 2010)	UCI(experiment 7)	85.86
(Kumar and Gopal 2010)	UCI(experiment 8)	85.10

8. Conclusion

It can be concluded that SVM can produce more accurate result in comparison with Decision tree, because it categorizes using separating hyperlanes and margins. However, Decision tree does not use hyperlane, so it may have some errors in classification. Also, based on the SVM method, researchers can be classified to "Expert" and "Novice" based on cognitive style factors in order to have as best as possible answers. So, researchers will have the best feedback based on their demands in the digital libraries.

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