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A Classification Model for Predicting Web Users Satisfaction with Information Systems Success using Data Mining Techniques

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ABSTRACT

A very few research studies discussed the employment of data mining techniques in the field of IS success/effectiveness assessment. For this reason, the purpose of this study is to employ data mining techniques in the evaluation of Information System (IS) effectiveness, particularly classification method. This important issue helps and supports decision makers and IT managers towards the development of information system quality in order to be consistent with user needs and expectations. A reasonable data set of 255 subjects are collected through using a questionnaire of six dimensions including five quality factors (system quality, information quality, service quality, user interface quality and communication quality) and user satisfaction. This study attempts to employ the data mining techniques to develop a model for supporting the prediction of the user satisfaction with IS inside the international organizations. To validate the generated model, several experiments were performed based on real data collected from the international organization employees. The encouraging results of experiments show that this model has a sound prediction to decide regarding the level of user satisfaction toward the employed IS. Also the results indicate that the tree classification algorithm J48 is the best in doing classification in case of supervised target of two values. It is important to mention that the results consistent with the regression analysis and could contribute to the related empirical studies.

Key words: Data mining, classification, prediction, Information System (IS), effectiveness, user satisfaction

INTRODUCTION

As the amount of data kept in computer files and databases is growing at an extraordinary rate and at the same time, the user of this data excepting more sophisticated information from the files and databases which are rapidly becoming bigger day by day (Ngai *et al*., 2009; Lopez *et al*., 2012).

Data mining came to solve these sorts of problem and also, it helps the top management and IS managers in the decision making process through finding the hidden information in a database (Kantardzic, 2011; Lopez *et al*., 2012). Also, data mining aims at capturing the characteristics of data through different models such as clustering and classification models. Clustering is to explore the groups that are different from each others. It is also known as unsupervised classification as the object function is not predetermined (Kantardzic, 2011; Al-Radaideh and Al Nagi, 2012). However, classification is to create and utilizes a model to predict the categorical labels of unknown objects in order to differentiate between objects of different classes (Ngai *et al*., 2011).

To improve the decision making and support, it is important to give insight into what is happening in business through assisting managers in the prediction of what will happen tomorrow (Al-Radaideh and Al Nagi, 2012). Practically, the prediction can be done through classification as the value of the target object (user satisfaction) is predetermined or supervised (Ngai *et al*., 2011).

Nowadays, as the top level of management and IS mangers spent too much of their budget in IT development, the assessment of WBIS is greatly needed in order to justify the IT investment in terms of its impacts on user satisfaction (Balaban *et al*., 2013; Alhendawi and Baharudin, 2013a-d). Despite the importance of data mining techniques to information system management and assessment, the previous studies did not discuss the employment of the data mining in the prediction of IS effectiveness in terms of IS quality factors and user satisfaction (Lopez *et al*., 2012; Al-Radaideh and Al Nagi, 2012; Ngai *et al*., 2009, 2011). This means that very little research has been conducted to assess and predict the two critical issues including quality factors and user satisfaction with IS.

Thus, this study employ the data mining techniques in the prediction of the user satisfaction with IS in the international organizations which in significantly influence the decision regarding the IT investment and IS development. Section two discusses the literature review through which the needed features are determined and also it presents the related data mining concepts. Section three presents the methodology followed by the researcher. Section four discusses the development of the classification model which is used in the prediction of user satisfaction. Section five discusses the findings of the study. Section six provides a discussion regarding the implications of this research. Finally, the main points and future suggestions are concluded in section seven.

INFORMATION SYSTEM ASSESSMENT AND DATA MINING

This study is one of the fewest that aims at employing data mining techniques in the evaluation of Information System (IS) effectiveness in order to toward supporting decision makers and IT managers. Therefore, this section shows the related studies through which the data attributes are extracted. Also, it discusses the data mining concepts and techniques which are employed in the prediction of the electronic user satisfaction (e-Satisfaction) of IS users.

IS effectiveness: It is pointed by the researchers that IS could be considered an effective system if it assists the organization in achieving its goals (Malik, 2001). In that respect, Goodhue and Thompson (1995) explored relationship between IT usage and individual performance. Ozkan (2003) suggested that information system should meet the user expectation for being a quality information system and then it could be considered as an effective IS. Delone and Mclean (2003) indicated that IS effectiveness is the final outcome which is fully dependent on the quality factors, satisfaction and net impact dimensions. In the same direction, Petter *et al*. (2008) and Petter and Mclean (2009) considered the effectiveness as a dependent variable affected by multi constructs: system quality, information quality, service quality, satisfaction and net benefits.

Regarding user satisfaction, user satisfaction is considered as one of the most widely used measure of IS effectiveness of information system (Petter *et al*., 2012; Gable *et al*., 2008; Pikkarainen *et al*., 2006; Delone and Mclean, 2003). Also, Powers and Dickson (1973) mentioned that user satisfaction is the most significant criterion in assessing both IS success and failure. Thus, the conceptualizing user satisfaction is highly important in order to assess the satisfaction with the system and proceeds toward the improvement of the effectiveness of information systems. With

regard to D and M assessment models, Delone and McLean models are considered the most commonly used models for assessing the IS success or effectiveness (Petter *et al*., 2008; Petter and Mclean, 2009), where these two models are mainly concerned with six success dimensions. However, based on the nature of usage and dimensions, there are some differences between the two models. In the context of (Delone and McLean 1992), it is practically measure the IS success based on six dimensions including, first, two quality dimensions consisting information quality and system quality. Second, user satisfaction, frequent use, individual impact and organizational impact are considered as the remaining four success dimensions of D and M 1992. Fig. 1 shows the six dimensions of D and M92.

Many IS researchers typically validate the D and M92 model while others suggested modifying the model by adding new dimensions such as service quality (Pitt *et al*., 1995; Myers *et al*., 1997). In the survey study of Delone and McLean entitled with 10-year update study, the authors evaluated the arguments against their IS model and thus, D and M03 model is developed to include the service quality as a new dimension. The main two differences between D and M 2003 (D and M03) and original model D and M92 is the inclusion of service quality as well as D and M03 groups the individual impact and organizational impact into net benefits. The involvement of the net benefits as a single measure strengthens the model because this makes the model more easily with less measures and also responds to the negative and positive impacts as a whole (Petter *et al*., 2008). However, an interesting research made a review for D and M03 and eliminated the use construct (Gable *et al*., 2003; Sedera and Gable, 2004). Figure 2 shows the IS dimensions included with in D and M03.

Based on (Alhendawi and Baharudin, 2013a, b; Petter *et al*., 2012), it is found that there are several additional factors such as user interface quality and online communication quality could affect the user satisfaction. Accordingly this study, extract the most commonly used features that affect the user satisfaction with IS.

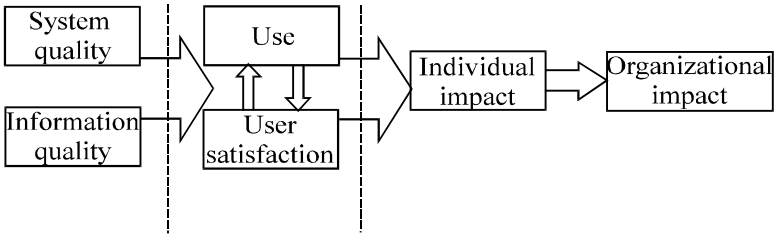

Fig. 1: IS success model (Delone and McLean, 1992)

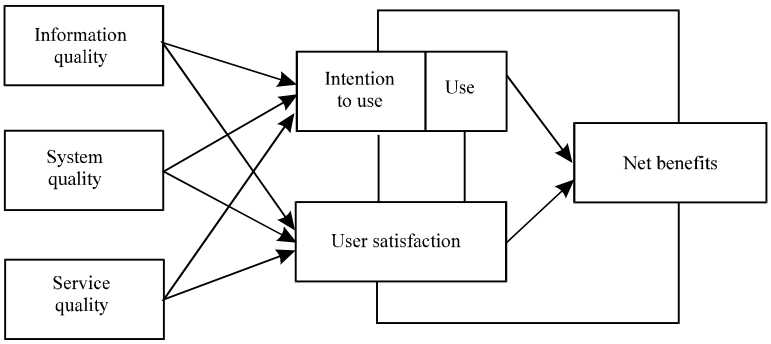

Fig. 2: IS success model (Delone and McLean 2003)

Data mining concepts and techniques: As this study employ the data mining in the prediction of the user satisfaction with IS, it seems that it is more appropriate to discuss the related data mining concepts and techniques. Data mining is sometimes called knowledge discovery because it is the process of analyzing data from various perceptions and summarizing it into useful information (i.e., patterns, models and rules). This information can be used to minimize costs and increase revenue, or for both (Ngai *et al*., 2011). Generally, a data mining or data discovery process includes an iterative sequence of the following steps (Kantardzic, 2011; Han and Kamber, 2001): Data cleaning, data selection, knowledge presentation, data transformation and data integration. Figure 3 shows the essential steps of data mining process.

Regarding the data mining techniques, there are several methods such as classification and clustering. The classification method supports the supervised learning in which the training data are accompanied by labels indicating the class of the observations or subjects. Further, the new data is classified based on the training set. However, in case of clustering (unsupervised learning), the class labels of training data is unknown and the classes or clusters are established based on the similarity of features.

Based on review (Ahmed, 2004; Giraud-Carrier and Povel, 2003; Turban *et al*., 2007; Ngai *et al*., 2009), there are several data mining model that could be provided by data mining techniques. Classification, clustering, regressions and forecasting are examples on the data mining models. There are many data mining algorithms that could be used in classification: Decision tree, Bayesian networks, regression and neural, networks. Concerning the decision tree, the classifiers are quite common methods as the construction of the tree does not need any expert knowledge or parameter setting where it is suitable for exploratory knowledge discovery (Al-Radaideh and Al Nagi, 2012). The decision tree can provide a model with rules that can be are easily read and interpreted by the system users. There are several tree classifiers such as decision tree and J48 classifiers are among the most popular and dominant decision tree classifiers (Han *et al*., 2011). With regard to Bayesian Network (BN), it is a relatively new tool identifying the probabilistic

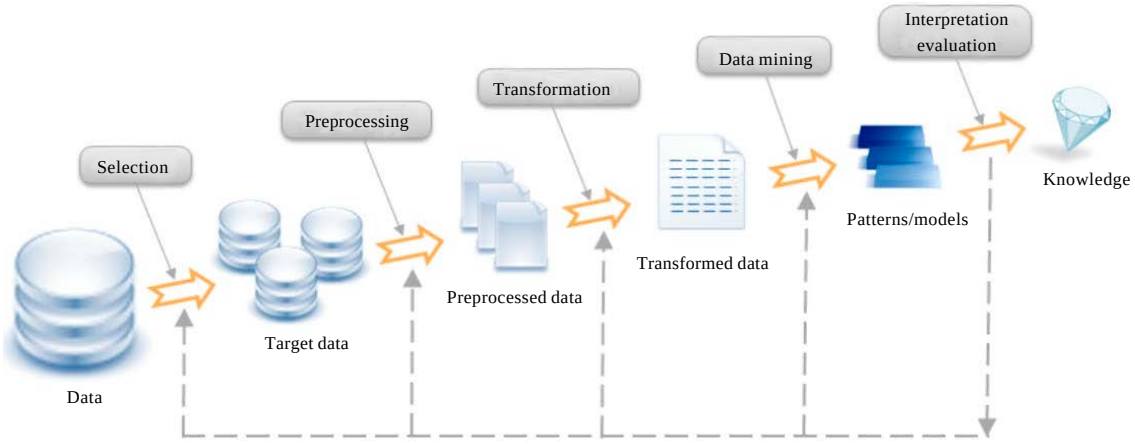

Fig. 3: Steps of transition from row data to knowledge

correlations between nodes to make predictions of class membership (Srinivas *et al*., 2010). In the context of regression, it is a statistical analysis tool through which the relationships among classifiers are specified are exlore in order to predict whether the observations of subject belong the class or not (Kantardzic, 2011; Ngai *et al*., 2009).

In terms of software packages, Weka is a broadly used toolkit for data mining and it is developed by University of Waikato in New Zealand (Witten *et al*., 2011). It includes a large set of data mining algorithms including implemented by JAVA. Weka also provides a collection of tools for data pre-processing, regression, association rules, visualization, classification and clustering. Consequently, it is considered as one of the most popular toolkit as it is actually includes the most commonly data mining algorithms and techniques.

CLASSIFICATION MODEL DEVELOPMENT

It can be concluded that quality factors such as system quality, information quality and service quality are the most important features in specifying the user satisfaction. Also, the classification method is considered as the most suitable technique in the prediction of user satisfaction. Consequently, the classification model should include the quality factors as features or determinants while the satisfaction should be received as a supervised object function. Figure 4 reveals that the proposed classification model used in the prediction of the user satisfaction with IS.

An extensive literature review was conducted to ensure that a comprehensive list of items was generated to assess the study variables included in the proposed model. Based on this review, the researcher generated a scale of seventy one items, where these items are adapted from standard scales. Therefore there is an essentiality for developing an instrument (i.e., questionnaire) to include the seventy one items which are generated based on literature survey. The questionnaire has six dimensions: Five quality factors as independent variables and user satisfaction as a dependent variable. Accordingly, there are five classifiers and one target. Regarding the values of object functions (i.e., whether it is effective of not) it depends on the mean of user satisfaction whether it is greater than 4.5 or not because the scale used in the data collection is 7-point Likert scale. Therefore, if the value of user satisfaction greater than 4.5 this means "the system somewhat accepted" which means the system is somewhat effective. Otherwise the system is ineffective.

In this study, it is more appropriate to use the classification method (i.e., supervised learning) as the measurement and the observation of the target function are known. The user satisfaction is suggested to be the target function and it has two values including "effective" or "ineffective".

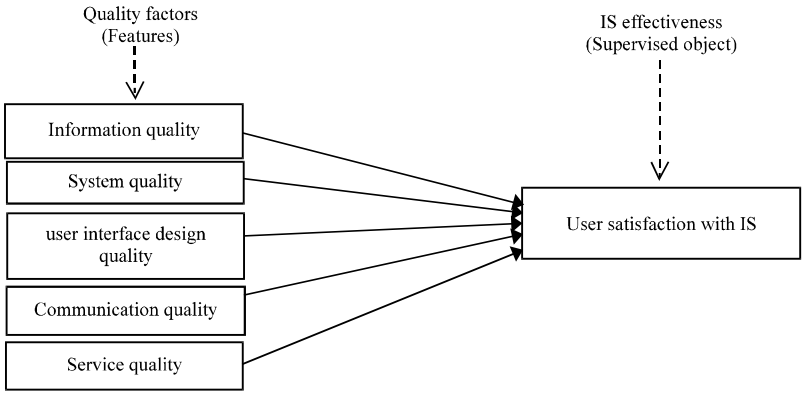

Fig. 4: Proposed theoretical framework for predicting user satisfaction

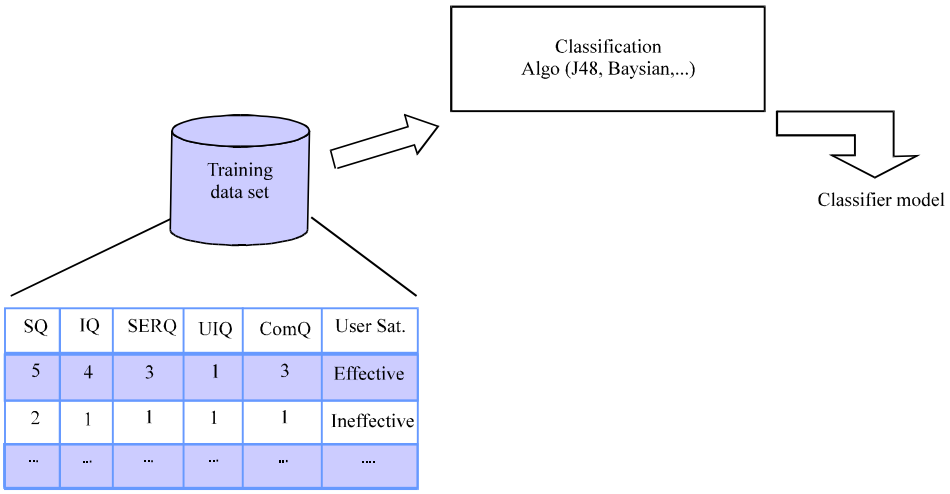

Fig. 5: First step of classification: Model construction

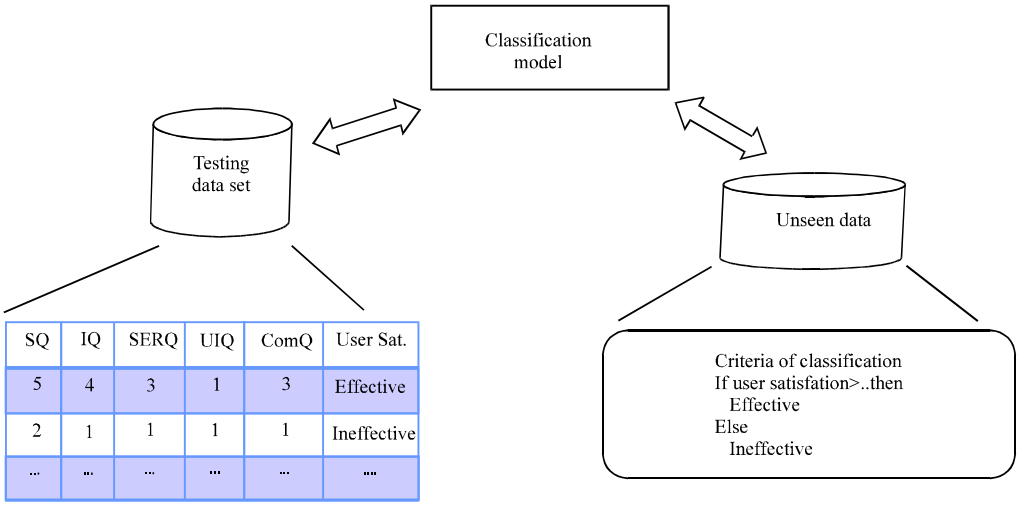

Fig. 6: Second step of classification: The prediction of satisfaction

Basically, the aspect of data mining is to build a model from data during the learning process (Giraud-Carrier and Povel, 2003). Generally, the data classification consists of two steps which are learning and testing steps. In the learning step, a model describing a predetermined set of concepts and classes is created through analyzing a set of database subjects or instances. An instance is supposed to be belong some predetermined class. Figure 5 reveals the model construction of the classification process.

In the second step, the constructed classification model is evaluated using different dataset in order to estimate the accuracy of the classification model. Figure 6 illustrates the second step used in the prediction of user satisfaction after building classifier model. In this step, the testing dataset is used to ensure the accuracy of the built classification model.

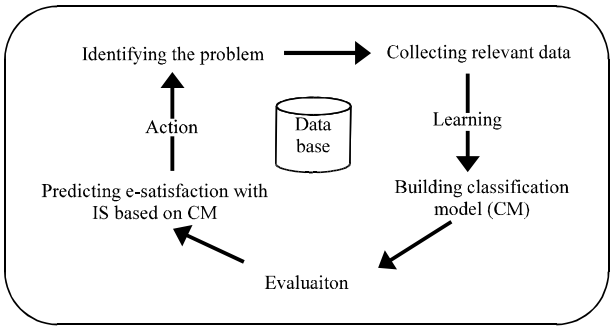

Fig. 7: Methodology of user satisfaction prediction

Table 1: The description of dataset

Attribute	Scale/ value
System Quality (SQ)	7-point Likert Scale (1-7)
Information Quality (IQ)	7-point Likert Scale (1-7)
Service Quality (SERQ)	7-point Likert Scale (1-7)
User Interface Quality (UIQ)	7-point Likert Scale (1-7)
Communication Quality (ComQ)	7-point Likert Scale (1-7)
User Satisfaction (US)	(Effective/Ineffective)

METHODOLOGY

Data set of 255 records is used in the training and testing phases. 70% of these records are used as a training data set in order to proceed toward the development of classification model. However, 30% of data set are used as a testing data set in order to test the capability of classification model or data mining technique in predicting user satisfaction. Considering the methodological steps followed in this study, Fig. 7 illustrates the steps that are utilized in the data mining cycle.

DESCRIPTION OF THE USED DATASET

The data set used is collected from the users of the Web IS. The attributes of dataset (System quality, information quality, service quality, user interface quality, communication quality and user satisfaction) are ranged from 1 to 7 as they are assessed based on the 7-point Likert Scale. Table 1 shows the description of these attributes.

The class or attribute to be predicted in this study is user satisfaction, that is, the user satisfaction level obtained after collecting user perceptions. It has two possible values or labels: Effective and ineffective.

FINDINGS

Weka is used to conduct the experiments on the data described in the previous section (Witten *et al*., 2011). To test the accuracy of the proposed classification model, 10 fold cross validation is used. The classification model is built during the training step. In the experiment, the accuracy of different classification including tree-based algorithm (J48), Bayes-based algorithm (Bayesian Net) and regression are compared. In the context of attributes used for classification, there are two sets: (1) set A includes all of the five attributes SQ, IQ, SERQ, UIQ and ComQ (2) set B includes all of set A except the UIQ and SQ.

Regression analysis method: The results of regression analysis indicate that UIQ and SQ are not significantly related to the user satisfaction. Table 2 shows the result of regression analysis.

Regarding the results of regression analysis of user satisfaction on quality factors, Table 2 demonstrates the degree to which the independent variables contributed to the dependent variable (i.e., user satisfaction). It presents the **β**-values which indicate how much each independent variable contributes on predicting dependent variable. It is clearly seen that information, service and communication quality have a positive significant relationship with user satisfaction at **β**-values (0.360, 0.325 and 0.165, respectively) and high significance level (significant < 0.01). In contrast the relationship between system quality and interface quality are insignificantly related with user satisfaction. Moreover, the multiple regression analysis showed that the above five quality factors predict a percentage of 62% of total variance explained in user satisfaction. Accordingly the attributes SQ and UIQ do not contribute to the user satisfaction.

Experiment (1): Decision tree and bayes network algorithms (using set a): The results show the percentages of classification accuracy for decision tree and Bayesian Net before removing UID and SQ. Table 3 reveals the accuracy of classification for decision tree algorithm.

Also the results of decision tree algorithm indicate that 255 are classified into two categories a and b where a and b denote the expected user satisfaction values effective and ineffective, respectively. The classification as follows: 79 are classified as effective and 120 are classified as ineffective while 56 out of 255 are not correctly classified.

Therefore, based Table 3, the Bayesian network algorithm will be the best algorithm as the accuracy of correct classification is 80.784% and the incorrect classification is 19.216%. However,

Table 2: Regression analysis of quality factors on user satisfaction

	User satisfaction	
Independent variables	β	p
System quality	0.042	0.378
Information quality	0.360***	0.000
Service quality	0.325***	0.000
User interface quality	0.054	0.207
Communication quality	0.165***	0.000
R	0.788	
R^2	0.620	
Adjusted R^2	0.615	
F-Value	117.306	

***ρ<0.001, **ρ<0.01, *ρ<0.05

Table 3: Accuracy of classification via decision tree and Bayesian network (attributes set A)

	Decision tree algorithm	Bayesian net algorithm	J48
Correctly classified instances	199	206.0	194
Percentage of correct classification (%)	78.034	80.784	76.0784
Incorrectly classified instances	56.0	49.0	61.0
Percentage of incorrect classification (%)	21.96	19.216	23.9216
Mean absolute error	0.289	0.199	0.2767
Test mode	10-fold	10-fold	10-fold
Total No. of instances	255	255.0	255

the worst values are for decision tree and J48 algorithms where the correct classification percentages are (78.034 and 76.0784%, respectively). Figure 8 shows the classification matrix of decision tree, J48 and Bayesian Net.

Experiment (2): Decision tree and Bayes network algorithms (using set b): If the classification model using set B which represent the 3 attributes (SQ, IQ and SERQ) that have a significant relationship with satisfaction, the results indicate that J48 is the best algorithm. Table 4 shows the percentages of correct and incorrect classification of the three algorithms including decision tree, Bayesian network and J48.

Therefore, based Table 3, J48 tree algorithm will be the best algorithm as the accuracy of correct classification is 93.333% and the incorrect classification is 6.667%. The classification percentages of the remaining two algorithms (Bayesian network and decision tree Algorithms) have the correct classification percentages of (90.980 and 92.549%, respectively). Consequently, the algorithm with the lowest classification is Bayesian algorithm. Figure 9 shows the classification matrix of decision tree, J48 and Bayesian Net after using the attributes set B (IQ, SERQ and ComQ).

Comparing the accuracy of the classification algorithms: Based on the findings obtained from the classification algorithms, it is important to highlight that the existence of the insignificant attributes has a negative effect on the classification process. Therefore, the findings emphasize the positive role of data cleaning on the accuracy of the classification model. Figure 4 reveals the efficiency of the three classification algorithms including J48, decision tree and Bayesian Net.

Table 4: Accuracy of classification via decision tree and Bayesian network (Attributes Set B)

	Decision tree algorithm	Bayesian net algorithm	J48
Correctly classified instances	236	232	238
Percentage of correct classification	92.549	90.980	93.333
Incorrectly classified instances	19.0	23.0	17.0
Percentage of incorrect classification	7.451	9.019	6.667
Mean absolute error	0.1347	0.1118	0.0911
Test mode	10-fold	10-fold	10-fold
Total No. of instances	255	255	255

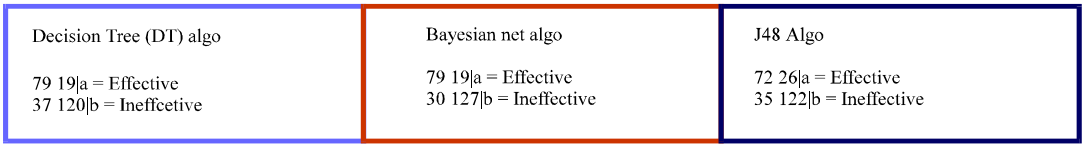

Fig. 8: Classification matrix of the classification algorithms

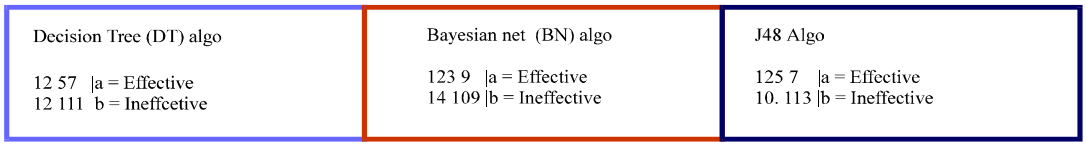

Fig. 9: Classification matrix of the classification algorithms (using attributes set B)

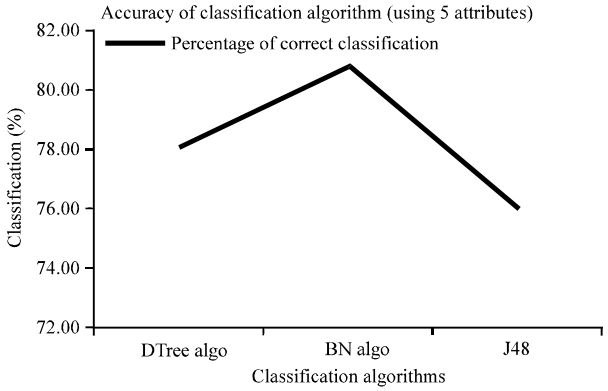

Fig. 10: Accuracy of classification using attributes set A

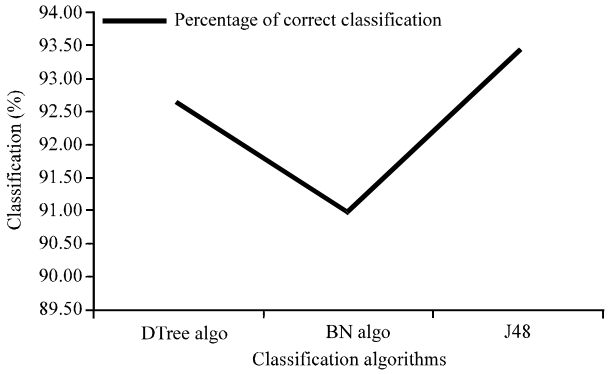

Fig. 11: Accuracy of classification using attributes set A

Figure 10 shows the difference in the accuracy of the classification algorithms before removing the insignificant attributes (SQ, UIQ).

With regard to Fig. 11, it illustrates the accuracy of the classification algorithm after eliminating the insignificant attributes.

DISCUSSION

As this study attempts to employ the data mining approaches in the field of information system effectiveness and measures, there are several implications that could be drawn in the light of the obtained findings. First, the data mining approaches including classification algorithms have correctly classified the attributes of the information systems (SQ, IQ, SERQ, UIQ and ComQ) with reasonable classification percentage (80.784%) for the user satisfaction with IS. Therefore, the proposed classification model has an acceptable number of classifiers to identify the user satisfaction as a supervised target and this is in agreement with many IS researchers (Balaban *et al*., 2013; Alhendawi and Baharudin, 2013a-c).

Second, for the data which has not preprocessed using regression (i.e., data includes the five attributes), the Bayesian network classification algorithm is the best for making classification as there is a possibility to have a considerable percentage of incorrectly classified occurrences. However, after removing the insignificant attributes (SQ and UIQ), the accuracy of percentage increased to be (93.333%) and the tree classification algorithm J48 is found the best amongst classification algorithms.

Third, the findings of this research indicate the suitability of J48 classification algorithm in building the classification model for a supervised target (user satisfaction) with two values (effective and ineffective). On the other hand, Bayesian network algorithm is effective for predicting the user satisfaction whenever the user satisfaction has more than two options.

Fourth, this study emphasizes the role of data preprocessing and cleaning on the accuracy of predication and classification as the correctly classified percentage is considerable increased whenever the insignificant attributes are removed. Therefore, there is integrity between the regression method and other classification methods as the regression helps and contributes in the preprocessing stage.

Accordingly, the encouraging results provide a strong evidence on the ability of using data mining approaches in predicting the IS effectiveness measures such as satisfaction. Thus it is suggested to use the classification and clustering approaches in the prediction of other IS measures such as IS value and the impact of IS on the individuals and groups within organizations.

In terms of limitation, even data mining reveals the data pattern and associations between attributes or study variables; it does not sufficiently identify the causality relationship between them. Therefore, it is important to use regression statistical analysis for showing the dependency between variables and also, using the decision support models such as expert system to be integrated with data mining models for optimization purposes.

CONCLUSION

This study discusses the potential of the data mining approaches, specially classification algorithms in the information system management and assessment. Based on the results, it is obvious that data mining techniques including several classification algorithms could be used in the prediction of user satisfaction. Therefore, the trained classification algorithm can be employed as an alternative resource for collecting data regarding user satisfaction. Additionally, this study found that using regression analysis helps in the improvement of the classification algorithms through performing data cleaning and preprocessing. Finally, the results indicate that the tree classification algorithm J48 is the best in doing classification in case of supervised target with two values and having some insignificant, however, the Bayesian network is found the best in case of having some insignificant attributes. Accordingly, the proposed significant attributes are correctly classified with high classification percentage and the classification algorithms could be employed in the prediction and development of IS performance.

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