Selecting the Best Supervised Learning Algorithm for Recommending the Course in E-Learning System

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ABSTRACT
Now a day E-learning is becoming popular as it helps to fulfil the necessities of remote students and helps the teaching-learning process in Education system. Course Recommender System in E-Learning is a system which recommend the course to the student based on the choice of various student collected from huge amount of data of courses offered through Moodle package of the college. Here in this paper we compare the seven classification algorithm to choose the best classification algorithm for Course Recommendation system. Theses seven classification algorithms are ADTree, Simple Cart, J48, ZeroR, Naive Bays, Decision Table & Random Forest Classification Algorithm. We compare these seven algorithms using open source data mining tool Weka & present the result. We found that ADTree classification algorithm works better for this Course Recommender System than other five classification algorithms.

Keywords
ADTree, Simple Cart, J48, ZeroR, Naive Bays, Decision Table, Random Forest Classification Algorithm, Weka

1. INTRODUCTION
Course Recommender System in E-Learning is a system which recommend the course to the student based on the choice of various student collected from huge amount of data of courses offered through Moodle package of the college e.g. If student is interested in course like Database System then he would like to learn the Advanced Database System.

Here we use Moodle for data collection & Weka to check the results. The data flow diagram for Course Recommender System is given in figure 1 & explained in [15].
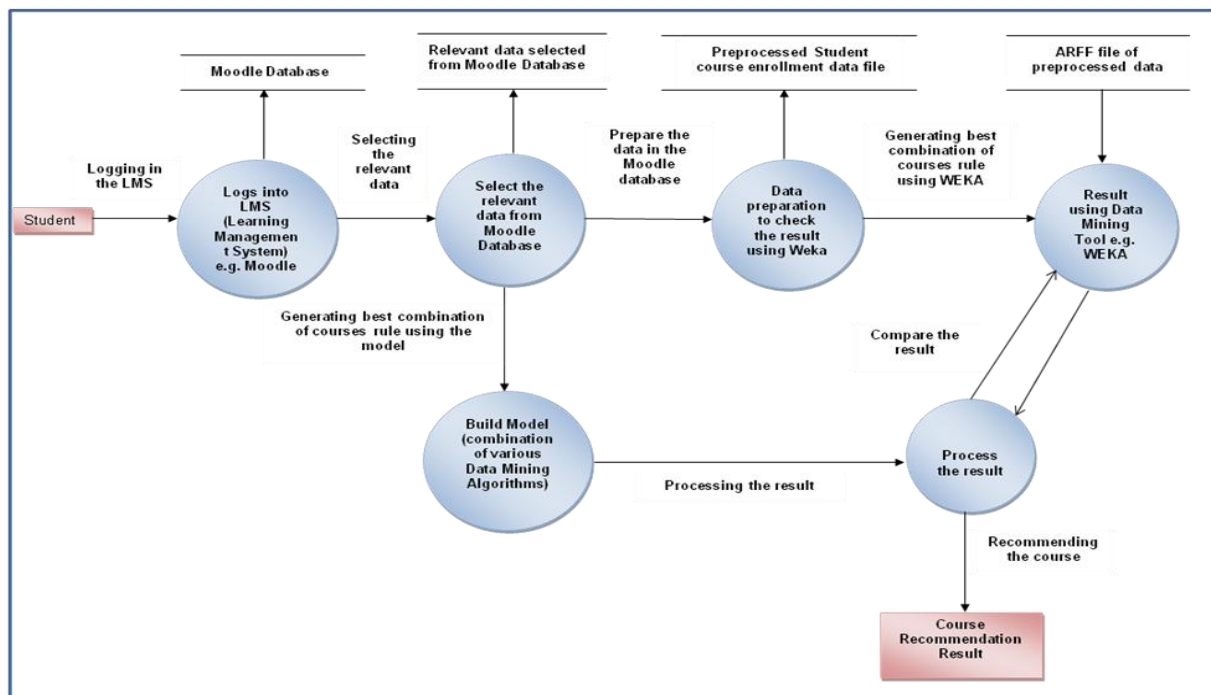

Figure 1: Data Flow Diagram for Course Recommendation System [15]

2. LITERATURE REVIEW

Hu H., Li J., Plank A., Wang H. and Daggard G. [1] conducted experimental comparison of LibSVMs, C4.5, BaggingC4.5, AdaBoostingC4.5, and Random Forest on seven Microarray cancer data sets. The experimental results showed that all ensemble methods outperformed C4.5. The experimental results also showed that all five methods benefited from data preprocessing, including gene selection and discretization, in classification accuracy. In addition to comparing the average accuracies of ten-fold cross validation tests on seven data sets, they used two statistical tests to validate findings.

Abdelghani Bellaachia, Erhan Guven [2] presented an analysis of the prediction of survivability rate of breast cancer patients using data mining techniques. The data used was the SEER Public-Use Data. The preprocessed data set consists of 151,886 records, which had all the available 16 fields from the SEER database. They have investigated three data mining techniques: the Naïve Bayes, the back-propagated neural network, and the C4.5 decision tree algorithms. Several experiments were conducted using these algorithms. The achieved prediction performances were comparable to existing techniques. However, they found out that C4.5 algorithm has a much better performance than the other two techniques.

My Chau Tu, Dongil Shin, Dongkyoo Shin [3] proposed the use of decision tree C4.5 algorithm, bagging with decision tree C4.5 algorithm and bagging with Naïve Bayes algorithm to identify the heart disease of a patient and compare the effectiveness, correction rate among them. The data they studied was collected from patients with coronary artery disease.

Aman Kumar Sharma, Suruchi Sahni [4] conducted experiment in the WEKA environment by using four algorithms namely ID3, J48, Simple CART and Alternating Decision Tree on the spam email dataset and later the four algorithms were compared in terms of classification accuracy. According to their simulation results, the J48 classifier outperforms the ID3, CART and ADTree in terms of classification accuracy.

Rich Caruana Alexandru Niculescu-Mizil [5] presented a large-scale empirical comparison between ten supervised learning methods: SVMs, neural nets, logistic regression, naive bayes, memory-based learning, random forests, decision trees, bagged trees, boosted trees, and boosted stumps. They also examined the effect that calibrating the models via Platt Scaling and Isotonic Regression has on their performance. An important aspect of their study was the use of a variety of performance criteria to evaluate the learning methods.

Eric Bauer, Ron Kohavi [6] provided a brief review of two families of voting algorithms: perturb and combine (e.g., Bagging), and boosting (e.g., AdaBoost, Arc-x4).

In research [7], twenty-two decision tree, nine statistical, and two neural network algorithms were compared on thirty-two datasets in terms of classification accuracy, training time, and (in the case of trees) number of leaves. Classification accuracy is measured by mean error rate and mean rank of error rate. Both criteria place a statistical, spline-based, algorithm called Polyclass at the top, although it is not statistically significantly different from twenty other algorithms. Another statistical algorithm, logistic regression, is second with respect to the two accuracy criteria. The most accurate decision tree algorithm is Quest with linear splits, which ranks fourth and fifth, respectively. Although spline-based statistical algorithms tend to have good accuracy, they also require relatively long training times. Polyclass, for example, is third last in terms of median training time. It often requires

hours of training compared to seconds for other algorithms. The Quest and logistic regression algorithms are substantially faster. Among decision tree algorithms with univariate splits, C4.5, Ind-Cart, and Quest have the best combinations of error rate and speed. But C4.5 tends to produce trees with twice as many leaves as those from Ind-Cart and Quest.

3. SUPERVISED CLASSIFICATION ALGORITHMS

Classification is a data mining task that maps the data into predefined groups & classes. It is also called as supervised learning. It consists of two steps. First step is the model construction which consists of set of predetermined classes. Each tuple /sample is assumed to belong to a predefined class. The set of tuple used for model construction is training set. The model is represented as classification rules, decision trees, or mathematical formulae. Second step is model usage which is used for classifying future or unknown objects. The known label of test sample is compared with the classified result from the model. Accuracy rate is the percentage of test set samples that are correctly classified by the model. Test set is independent of training set, otherwise over-fitting will occur [10]. Here we consider the brief introduction of each classification algorithm.

3.1 ADTree Classification Algorithm

An **alternating decision tree** (ADTree) is a machine learning method for classification which generalizes decision trees. An alternating decision tree consists of two nodes. Decision nodes specify a predicate condition. Prediction nodes contain a single number. ADTree always have prediction nodes as both root and leaves. An instance is classified by an ADTree by following all paths for which all decision nodes are true and summing any prediction nodes that are traversed.

The fundamental element of the ADTree algorithm is the rule as it comes under the tree category. A single rule consists of [16]:

- Condition: is a predicate of the form "attribute <comparison> value.
- Precondition: is simply a logical conjunction of conditions and
- Two scores.

    A precondition Evaluation of a rule involves a pair of nested if statements:

```
if(precondition)
    if(condition)
        return score_one
    else
        return score_minus_one
    end if
else
    return zero
end if
```

3.2 Simple Cart Classification Algorithm

Simple Cart (Classification & regression tree) is a classification technique that generates the binary decision tree. Since output is binary tree, it generates only two children. Entropy is used to choose the best splitting attribute. Simple Cart handles the missing data by ignoring that record. This algorithm is best for the training data.

3.3 J48 Classification Algorithm

A decision tree is a predictive machine-learning model that decides the target value (dependent variable) of a new sample based on various attribute values of the available data. The internal nodes of a decision tree denote the different attributes; the branches between the nodes tell us the possible values that these attributes can have in the observed samples, while the terminal nodes tell us the final value (classification) of the dependent variable. The attribute that is to be predicted is known as the dependent variable, since its value depends upon, or is decided by, the values of all the other attributes. The other attributes, which help in predicting the value of the dependent variable, are known as the independent variables in the dataset. [12].

3.4 ZeroR Classification algorithm

ZeroR classifier predicts the majority of class in training data. It predicts the mean for numeric value & mode for nominal class.

3.5 Naive Bays Classification Algorithm

Naïve Bays classification is based on Bays rule conditional probability. It makes use of all the attributes contained in the data, and analyses them individually as though they are equally important and independent of each other [12].

3.6 Random Forest Classification Algorithm

Random forest is a classifier that consists of many decision trees and outputs the class that is the mode of the classes output by individual trees. For many data sets, it produces a highly accurate classifier [13]. This algorithm handles the missing data & maintains the accuracy.

3.7 Decision Table

This is Class for building and using a simple decision table majority classifier (Ron Kohavi). In this algorithm, we have to set the number folds, display rule etc to get the proper result.

4. EXPERIMENTAL RESULT

Here we are considering the sample data extracted from Moodle database of a college after collection of data for course enrollment by student as shown in Table 1. In this table, we consider 45 student & 15 courses. Fifteen courses are C-programming (C), Visual Basic (VB), Active Server Pages (ASP), Computer Network (CN), Network Engineering (NE), Microprocessor (MP), Computer Organization (CO), Database Engineering (DBE), Advanced Database System (ADS), Operating System (OS), Distributed System (DS), Finite Automata System (FSA), Data Structure (DS-I), Software Engineering (SE), and Software Testing & Quality assurance (STQA). In this table yes represent that the student is interested in that particular course & no represent that student do not like that course.

Table 1: Sample Data from Moodle Database[11]

Courses→ Roll No↓	C	VB	ASP	CN	NE	MP	CO	DBE	ADS	OS	DS	FSA	DS-I	SE	STQA
1	yes	yes	yes	yes	yes	no	no	no	no	no	no	no	yes	no	no
2	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
3	yes	yes	yes	yes	yes	no	no	no	no	yes	yes	yes	yes	yes	yes
4	no	no	no	yes	yes	no	yes	no	no	no	no	no	no	no	no
5	yes	yes	yes	yes	yes	no	no	yes	no	yes	yes	no	yes	no	no
6	yes	yes	yes	no	no	no	no	no	no	yes	no	no	yes	no	no
7	no	no	no	yes	yes	yes	yes	no	no	no	no	no	no	yes	no
8	no	no	no	no	no	no	no	yes	yes	yes	yes	no	yes	no	no
9	no	no	no	yes	yes	yes	yes	no	no	no	no	yes	no	no	no
10	yes	no	no	no	no	no	no	no	no	no	no	no	no	no	no
11	yes	yes	yes	no	no	no	no	no	no	yes	yes	no	yes	no	no
12	yes	yes	yes	yes	yes	no	no	no	no	no	no	no	no	no	no
13	no	no	no	no	no	no	no	yes	yes	yes	yes	no	yes	yes	yes
14	yes	yes	yes	yes	yes	no	no	no	no	yes	yes	no	no	no	no
15	yes	yes	yes	no	no	no	no	no	no	no	no	no	yes	no	no
16	no	no	no	yes	yes	no	no	yes	yes	yes	yes	no	yes	no	no
17	yes	yes	yes	no	no	no	no	no	no	yes	yes	no	yes	yes	yes
18	yes	yes	yes	no	no	no	no	no	no	no	no	no	no	no	no
19	no	no	no	yes	yes	yes	yes	yes	yes	no	no	no	no	no	no
20	yes	no	no	no	no	no	no	no	no	yes	yes	no	yes	yes	yes
21	yes	no	yes	no	no	yes	yes	no	no	yes	yes	yes	no	no	no
22	no	no	no	no	no	no	no	yes	yes	yes	yes	no	yes	no	no
23	yes	yes	yes	yes	yes	yes	yes	no	no	yes	yes	no	yes	no	no
24	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
25	no	yes	yes	no	no	yes	yes	yes	yes	yes	yes	no	no	no	no
26	yes	yes	yes	no	no	no	no	no	no	yes	yes	no	yes	no	no
27	yes	yes	yes	yes	yes	no	no	no	no	no	no	no	no	no	no
28	no	no	no	yes	yes	no	no	no	no	yes	yes	no	yes	no	no
29	no	no	no	no	no	yes	yes	yes	yes	no	no	no	no	no	no
30	yes	yes	yes	yes	yes	no	no	no	no	no	no	no	no	yes	yes
31	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
32	yes	yes	yes	no	no	no	no	yes	yes	yes	yes	no	yes	no	no
33	no	no	no	yes	yes	no	no	no	no	yes	yes	no	yes	no	no

34	yes	yes	yes	no	no	no	no	no	no	no	no	no	no	no	no
35	no	no	no	no	no	no	no	no	no	yes	yes	no	no	no	no
36	no	no	no	yes	yes	no	no	no	no	no	no	no	yes	no	no
37	yes	yes	yes	yes	yes	yes	yes	yes	yes	no	no	no	no	no	no
38	no	no	no	no	no	no	no	no	no	yes	yes	yes	yes	yes	yes
39	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
40	no	no	no	no	no	no	no	no	no	no	no	no	no	yes	yes
41	yes	yes	yes	no	no	no	no	no	no	yes	yes	no	no	no	no
42	no	no	no	yes	yes	no	no	no	no	no	no	no	no	no	no
43	no	no	no	no	no	no	no	no	no	yes	yes	no	yes	no	no
44	no	no	no	no	no	no	no	no	no	no	no	no	no	no	yes
45	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no

In table 2, we are considering only those courses from table 1 for which the classification algorithm classifies this course as "yes". For remaining courses, the classification algorithm gives more percentage of "no" compare to the percentage of "yes". Table 3 gives the simulation errors that occurred in each classification algorithm.

From table 2, we can observe that ADTree has highest percentage of correctly classified instance & lowest percentage of incorrectly classified instances. ZeroR classification algorithm has lowest percentage of correctly classified instances & highest percentage of incorrectly classified instances. Naive Bays & Decision Table has the same percentage for correctly & incorrectly classified instances. Simple Cart, J48, & Random Forest classification algorithm has 91.66%, 93.33% & 87.22% correctly classified instances respectively & 8.44%, 6.77%, and 12.88% incorrectly classified instances. Ascending order of classification algorithm considering the classification accuracy into account is ADTree, J48, Naive Bays, Decision Table, Simple Cart, Random Forest, and ZeroR. So we consider the ADTree as classification algorithm for Course Recommender System as classification accuracy for ADTree is highest.

Table 2: Result using different classification algorithm

Classification algorithm → Courses↓		Naive Bays	Simple Cart	ZeroR	ADTree	Decision Table	J48	Random Forest
C-programming	Correctly classified instance	42	41	23	43	41	42	41
	Incorrectly classified instance	3	4	22	2	4	3	4
Operating System	Correctly classified instance	44	44	24	44	44	44	43
	Incorrectly classified instance	1	1	21	1	1	1	2
Distributed System	Correctly classified instance	43	44	23	44	44	44	43
	Incorrectly classified instance	2	1	22	1	1	1	2
Data Structure-I	Correctly classified instance	38	36	23	40	38	38	30
	Incorrectly classified instance	7	9	22	5	7	7	15
Overall result	Correctly classified instance	167 (92.77%)	165 (91.66%)	93 (51.66%)	172 (95.55%)	167 (92.77%)	168 (93.33%)	157 (87.22)
	Incorrectly classified instance	13 (7.23%)	15 (8.44%)	87 (48.44%)	9 (4.45%)	13 (7.33%)	12 (6.77%)	23 (12.88%)

Table 3: Simulation Errors in classification algorithm

Classification algorithm→ Courses↓		Naive Bays	Simple Cart	ZeroR	ADTree	Decision Table	J48	Random Forest
C-programming	Mean absolute error	0.1066	0.1478	0.5011	0.2168	0.1478	0.1478	0.1799
	Root mean squared error	0.2708	0.2997	0.5012	0.3274	0.2997	0.2997	0.319
	Relative absolute error	21.2766%	29.5017%	100%	43.2628%	29.5017%	29.5017%	35.9018%
	Root relative squared error	54.0313%	59.7928%	100%	65.3139%	59.7928%	59.7928%	63.6473%
Operating System	Mean absolute error	0.0937	0.0435	0.4989	0.0791	0.0435	0.0435	0.1207
	Root mean squared error	0.2036	0.1526	0.5	0.1929	0.1526	0.1526	0.2287
	Relative absolute error	18.7894%	8.7202 %	100%	15.8582%	8.7202 %	8.7202%	24.1994%
	Root relative squared error	40.7211%	30.5267%	100%	38.5807%	30.5267%	30.5267%	45.7326%
Distributed System	Mean absolute error	0.1056	0.0427	0.5011	0.1166	0.0427	0.0427	0.1456
	Root mean squared error	0.2202	0.1522	0.5012	0.2052	0.1522	0.1522	0.2441
	Relative absolute error	21.0675%	8.5245 %	100%	23.2764%	8.5245%	8.5245%	29.0618%
	Root relative squared error	43.93 %	30.3662%	100%	40.9439%	30.3662%	30.3662%	48.6894%
Data Structure-I	Mean absolute error	0.2364	0.286	0.5011	0.3714	0.2734	0.2825	0.3286
	Root mean squared error	0.4071	0.3959	0.5012	0.4427	0.4127	0.4026	0.4863
	Relative absolute error	47.1806%	57.0873%	100%	74.1151%	54.5589%	56.3758%	65.5755%
	Root relative squared error	81.2174%	78.9805%	100%	88.3127%	82.3421%	80.3289%	97.0259%

The graph for correctly classified instances is shown in figure 2 while the graph for incorrectly classified instance is shown in figure 3. From these two graphs, we can observe that ADTree classification algorithm is best for Course Recommender System.

In this graphs X-axis represent the seven classification algorithm while Y-axis represents correctly & incorrectly classified instances.
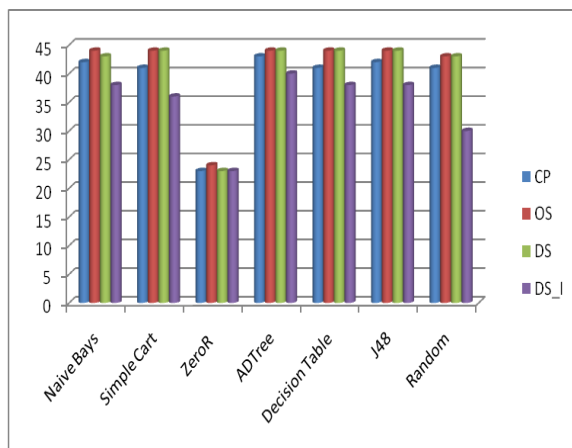

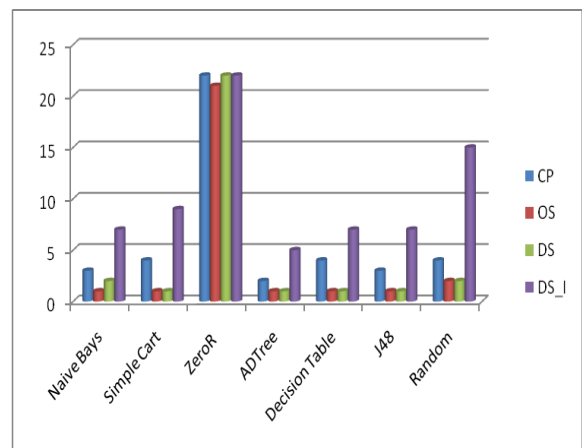**Figure 2: Graph for correctly classified instance in various classification algorithms**

Figure 3: Graph for incorrectly classified instance in various classification algorithms

Figure 4 shows the graph for comparison of these seven classification algorithm. In this graph, X-axis represents courses considered for comparison of classification algorithm & Y-axis represent the correctly classified & incorrectly classified instances. The result of application after application of ADTree classification algorithm to table 1 is shown in table 4.
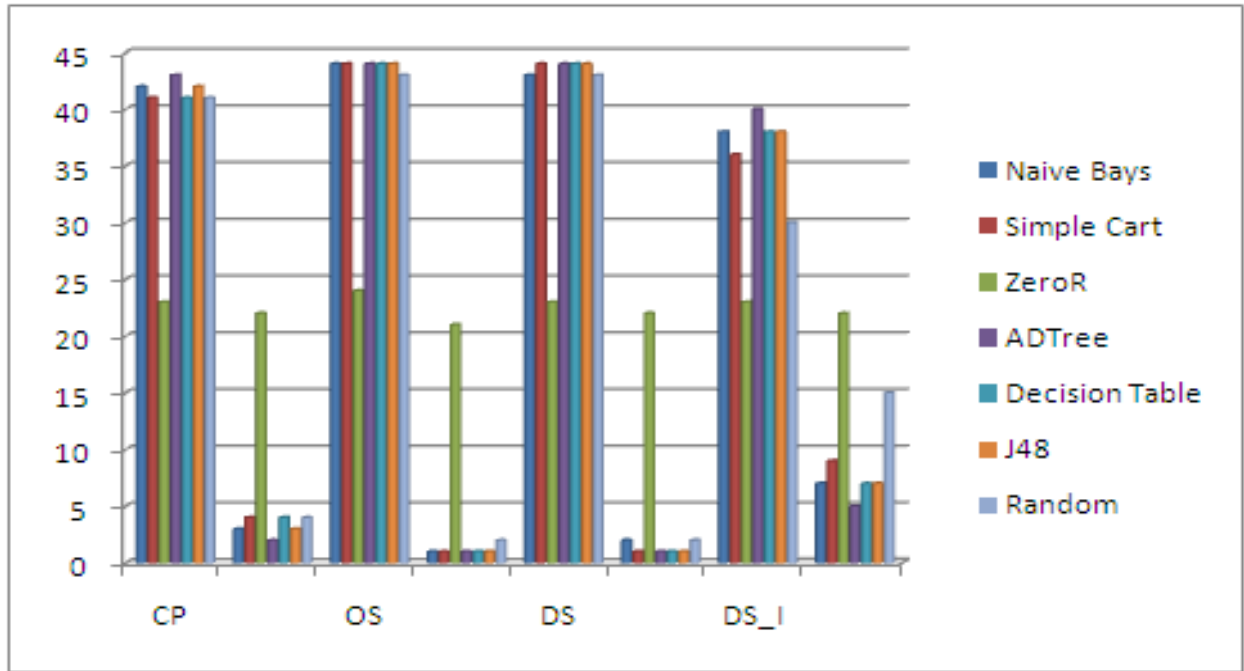

Figure 4: Comparison of classification algorithms in Course Recommendation System

Table 4: Table after application of classification algorithm-ADTree

Courses ➔ Roll_No | v	C	VB	ASP	CN	NE	MP	CO	DBE	ADS	OS	DS	FSA	DS-I	SE	STQA
3	yes	yes	yes	yes	yes	no	no	no	no	yes	yes	yes	yes	yes	yes
5	yes	yes	yes	yes	yes	no	no	yes	no	yes	yes	no	yes	no	no
11	yes	yes	yes	no	no	no	no	no	no	yes	yes	no	yes	no	no
17	yes	yes	yes	no	no	no	no	no	no	yes	yes	no	yes	yes	yes
20	yes	no	no	no	no	no	no	no	no	yes	yes	no	yes	yes	yes
23	yes	yes	yes	yes	yes	yes	yes	no	no	yes	yes	no	yes	no	no
24	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
26	yes	yes	yes	no	no	no	no	no	no	yes	yes	no	yes	no	no
32	yes	yes	yes	no	no	no	no	yes	yes	yes	yes	no	yes	no	no
39	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
41	yes	yes	yes	no	no	no	no	no	no	yes	yes	no	yes	no	no

After classifying the data, we apply the Apriori association rule to get the best combination of courses. Before preprocessing of data, we got the association rule containing "no" only which is shown in first row of table 5.

As we are recommending the course, we preprocess the data. The result after preprocessing of data is shown in second row of table 5. Now the association rule contains only "yes". The result of applying the Apriori association rule on classified data is shown in third row of table 5.

Table 5: Result for Course Recommender System [14]

Course considered	Parameter Considered	Results
Result of Apriori Association Rule before preprocessing & application of combination of Classification & Association Rule		
C, VB, ASP, CN, NE, MP, CO, DBE, ADS, OS, DS, FSA, DS-I, SE, STQA	Minimum support: 0.7 Minimum metric <confidence>: 0.9	Best rules found: 1. Computer_Organization=no → Microprocessor=no 2.Database_Engg=no → Advanced_Database_System=no 3. Computer_Organization =no Finite_State_Automata=no → Microprocessor=no 4. Microprocessor =no → Computer_Organization =no 5.Software_Testing_&_Quality_Assurance=no → Software_Engg=no 6. Software_Engg =no → Software_Testing_&_Quality_Assurance =no 7. Advanced_Database_System =no → Database_Engg =no 8. Microprocessor =no Finite_State_Automata =no → Computer_Organization =no 9. Finite_State_Automata =no Software_Testing_&_Quality_Assurance =no → Software_Engg =no 10. Finite_State_Automata =no Software_Engg =no → Software_Testing_&_Quality_Assurance =no
Result of Apriori Association Rule after preprocessing & before application of combination of Classification & Association Rule		
C, VB, ASP, CN, NE, OS, DS, DS-I	Minimum support: 0.5 Minimum metric <confidence>: 0.9	Best rules found: 1. Distributed_System=yes → Operating_System=yes 2. Visual_Basic=yes → Active_Server_Pages=yes 3. Network_Engg=yes → Computer_Network=yes 4. Computer_Network =yes → Network_Engg =yes 5. C_Programming=yes Visual_Basic =yes → Active_Server_Pages =yes 6. Distributed_System =yes Data_Sstructure_I=yes → Operating_System =yes 7. Operating_System =yes → Distributed_System =yes 8. Active_Server_Pages =yes → C_Programming =yes 9. C_Programming =yes → Active_Server_Pages =yes 10. Active_Server_Pages =yes → Visual_Basic =yes
	Minimum support: 0.6 Minimum metric <confidence>: 0.9	Best rules found: 1. Distributed_System =yes → Operating_System =yes 2. Operating_System =yes → Distributed_System =yes
After Application of Classification algorithm-ADTree & Association Rule-Apriori Association Rule		
C, VB, ASP, CN, NE, MP, CO, DBE, ADS, OS, DS, FSA, DS-I, SE, STQA	**Minimum support: 0.95** **Minimum metric <confidence> : 0.9**	Best rules found: 1. Operating_System =yes → C_Programming =yes 2. C_Programming =yes → Operating_System =yes 3. Distributed_System =yes → C_Programming =yes 4. C_Programming =yes → Distributed_System =yes 5. Data_Sstructure_I =yes → C_Programming =yes 6. C_Programming =yes → Data_Sstructure_I =yes 7. Distributed_System =yes → Operating_System =yes 8. Operating_System =yes → Distributed_System =yes 9. Data_Sstructure_I =yes → Operating_System =yes 10. Operating_System =yes → Data_Sstructure_I =yes

5. CONCLUSION AND FUTURE WORK

Here in this paper we compare the seven classification algorithm to choose the best classification algorithm for recommending the course to student based on various student choices. Theses seven classification algorithms, we consider for comparison, are ADTree, Simple Cart, J48, ZeroR, Naive Bays, Decision Table & Random Forest Classification Algorithm. We use the open source data mining tool Weka to check the result. We find that ADTree classification algorithm works better for this Course Recommender System as incorrectly classified instance for this algorithms are less than other five classification algorithms. Future works include the combination of other data mining algorithms to recommend the course to the student from the data obtained from the Moodle course of the college.

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