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GRSFA: Recommending Course Grade for Improving Academic Performance of Students using Filtered Associator Algorithm in Education Sector

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Abstract— Recommendation system acts as a information filtering system that provide the suggestions to users based on many different factors. In the current study, a framework for recommendation system called CGRSFA is developed for recommending the grade of course. For this framework, semester-wise, year-wise and overall grade information of students' courses is stored in ten datasets. This framework uses real data gathered from university site related to Four Year Bachelor of Technology - Computer Science and Engineering Programme, counting on overall 11510 instances and 42 courses. Relevant rules which indicates courses dependencies and courses prerequisites for other courses are found using this framework for each dataset e.g. the meaning of the rule "System_Programming=A+ → Compiler_Construction=A+" is that if student receives 'A' grade in System Programming course then that student will received 'A' grade in Compiler Construction course also as System Programming course is the prerequisite to the course Compiler Construction. Rules which are not relevant are irrelevant rules and such rules are discarded. Result of four association rule algorithms such as Apriori Association Rule, Filtered Association algorithm, Predictive Apriori Association Rule and Tertius Association Rule algorithms are compared based on relevant and irrelevant rules for selecting the best association rule algorithm for the grade recommendation system. The algorithm Filtered Associator algorithm is selected among these algorithm for the grade recommendation system. Filtered Associator algorithm is used to find the correlation among the courses. In Filtered Associator algorithm, first the grade dataset is filtered using the filtering method - Reservoir sampling Algorithm to remove the data items from dataset that do not meet certain criteria and then Apriori association rule algorithm is applied on the filtered dataset. Association rules generated along with the support parameter value for one of the dataset D6 is given and explained in the current study. If the support parameter value of obtained association rules is increased then the most optimal association rules for maximum support value are generated using Filtered Associator algorithm for the grade recommendation system. Number of association rules generated for remaining nine datasets along with support parameter value is also presented in the experimental result.

This recommendation system is useful for instructor as well as students for improving academic performance. This system can also be used in MOOCs for recommending the course grade.

Keywords— Reservoir sampling Algorithm, Apriori association rule algorithm, Recommendation system, Support

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1. Introduction

Recommendation system suggests things to the user based on many different factors. This recommendation system is used on many popular platforms such as Amazon, Netflix, etc. The recommendation system for Amazon uses a combination of collaborative filtering and content-based algorithms e.g. if you purchase mobile then Amazon site will recommend you to buy screen guard and cover for the mobile. This recommendation system is also used in education sector for finding correlation among courses [26], recommending courses in MOOCs (Wu, 2019), recommending courses to students based on profile (Emon, 2021), interactive teaching for English course (Nie, 2021), to identify the correlation among students' educational bahaviour (Raihan, 2020), etc. There are three types of recommendation system –

- Content-based recommendation: Recommendations are made based on the similarity between data items.
- Collaborative filtering based recommendation: In this case, recommendations are made based on the past behaviour of other users. In this case, machine learning algorithms are used for making recommendations.
- Hybrid recommender system: This type combines both content-based and collaborative filtering approaches.

In this research article, we consider collaborative filtering approach and designed the framework called CGRSFA for recommending the course grade to students based on courses dependencies and prerequisites. For this framework, ten datasets which contains the grade information of students 'courses are used to recommend the course grade to the students. This framework will be useful to instructor/ teacher to improve teaching-learning process and students/ learners to improve their academic performance.

Remaining part of this research article is arranged as follows: Section II presents the literature survey related to the recommendation system while Section III discusses about the framework for CGRSFA and phases of this framework for recommending the course grade to students. Section IV explains the algorithm designed using association rule algorithm for this framework whereas results obtained using Filtered Associator algorithm is discussed in Section V. This research article is concluded in Section VI followed by References used to prepare this research article.

2. Literature Review

This section presents the literature review related to the recommendation system in education sector and research gap found in it. The research article (Naren, 2020) used data mining and natural language processing technique to build the model for helping students to choose the elective course as per capability of students while authors of research article (Li, 2020) considered the combination of two techniques such as item-based collaborative filtering and Bayesian Personalized Ranking to recommend the course to the students. Recommendation system based on semantic analysis using Ontology is developed to provide high school recommendations (Vu, 2020). Deep learning techniques (Dien, 2020; Sakboonyarat, 2019) and Classification algorithms (Fernández-García , 2020; Yanes, 2020; Kamila, 2019; Chao, 2019) are used to design the recommendation system. Collaborative filtering based recommendation system is suggested in the research articles (Stein, 2020; Zhang, 2018). The web-based online tutor system (Muangprathub, 2020) is illustrated to develop a learning recommendation component to dynamically predict learners' style. The hybrid recommendation system that combines content-based and collaborative filtering with the help of Genetic algorithm is developed to choose elective courses (Esteban, 2020) while the Non-negative Matrix Factorization method followed by content-based filtering technique is used to recommend best module or courses to students (Campos, 2020). The research article (Hajri, 2019) describes the process to calculate recommendations for OER metadata which follow the Linked Open Data (LOD) principles. The research article (Li, 2019) combined the collaborative filtering and clustering algorithm to recommend courses to students while in the research article (Manzan, 2019), 35 Cyber security online courses were analyzed to recommend topics while preparing this course. The research article (Guan, 2019) designed the recommendation system that consists of two modules - the talent module and enterprise module which will help job seekers and enterprise to find more suitable talents. The personalized recommendation system is proposed in the research article (Ndiyae, 2019) which is based on the analysis of learners' response in

knowledge test. Recommendation system is developed to provide well evaluated learning content to students to improve teaching evaluation (Mehta, 2018).

From above discussion, following research gap is found:

- Collaborative filtering is used for the recommendation system.
- Hybrid recommendation system approach is used for building the framework.
- Developed recommendation model is tested on only one dataset.
- Classification techniques or deep learning techniques are used for making recommendations.
- Clustering technique and collaborative filtering technique is combined to build the recommendation system.

There is no research article which uses the filtering and association rule algorithm for recommendation system based on collaborative filtering. In this study, a collaborative filtering approach based framework CGRSFA is developed with the help Filtered Associator algorithm and tested on ten datasets.

3. Framework For Recommendation System In Education Sector

A framework for the course-wise grade recommendation system called CGRSFA using Filtered Associator algorithm is shown in Figure 1. Following are steps in the recommendation system-

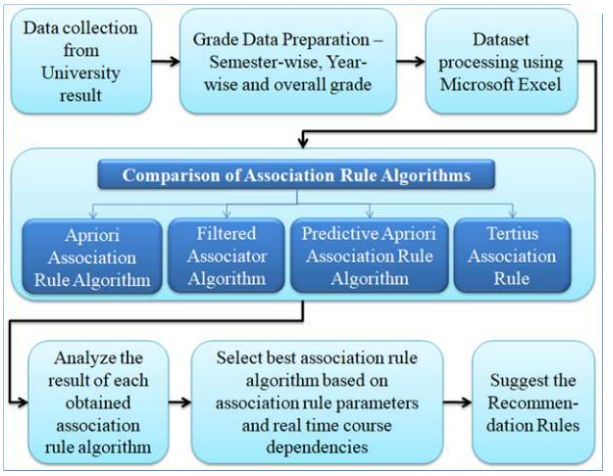

Fig.1 : Framework for CGRSFA Course Grade Recommendation System

A. Data collection from University result

Data for the grade recommendation system is collected from university site http://www.sus.ac.in/examination/Online-Result-(Ledger) or https://su.digitaluniversity.ac/Content.aspx ?ID =29445 related to the result analysis of four year Bachelor of Technology (B.Tech.) - Computer Science and Engineering Programme for the Academic Year 2014-15 and 2015-16. The result analysis of Second Year (SY), Third Year (TY), and Final Year (BE) is considered to prepare the dataset for the grade recommendation system. Table 1 represents data collection and processing for the recommendation system.

So this table contains

- No. of Students' data collected for two Academic Years (2014-15 and 2015-16) - Data for the recommendation system consist of semester-wise and year-wise number of students available in those two Academic Years e.g. Number of students considered for BE Semester VII Result is 1408.
- No. of Students' data after initial processing and mapping of Permanent Registration Number (PRN) - Since the result analysis data was available in PDF form, so Microsoft Excel is used for initial processing of data. In initial processing, student-wise result analysis data of each semester is prepared. After preparing semester-wise students' data, PRN of each semester result sheet may not be same, so mapping of PRN of all semester data is done. So number of Students' data after initial processing and mapping of Permanent Registration Number (PRN) numbers is given in Table 1 e.g. such number of Students' data for each semester is 1383.
- No. of Students' data after checking the result of failed courses – After initial processing and mapping of Permanent Registration Number (PRN), students' data is checked for failed courses. If the particular student is passed in the particular course of particular semester then the updated marks of that student in that course is changed. Such number of Students' data after checking the result of failed courses is also given

Table 1:
Data Collection and Processing For Recommendation System

Sr. No.	Semester	No. of Students' data collected for Academic Year 2014-15 and 2015-16	No. of Students' data after initial processing and mapping of PRN numbers	No. of Students' data after checking the result of failed courses
1	SY Semester III Result	1768	1383	1151
2	SY Semester IV Result	1724	1383	1151
3	SY Semester III and IV Result		1383	1151
4	TY Semester V Result	1438	1383	1151
5	TY Semester VI Result	1461	1383	1151
6	TY Semester V and VI Result		1383	1151
7	BE Semester VII Result	1408	1383	1151
8	BE Semester VIII Result	1438	1383	1151
9	BE Semester VII and VIII Result		1383	1151

in Table 1 e.g. such number of Students' data for each semester is 1151.

B. Grade Data Preparation

For grade recommendation system, since dataset should consists of grades for all courses depending on the marks obtained by students in that particular course in university examination, we use Microsoft excel to prepare the data. Excel sheet contains the marks of students obtained by students in the university exam for all courses of all semester of B.Tech. The grades for marks range are given as follows:

- Grade O for the marks range 80-100,
- Grade A+ for the marks range 70-79.99,
- Grade A for the marks range 60-69.99,
- Grade B+ for the marks range 55-59.99,
- Grade B for the marks range 50-54.99,
- Grade C+ for the marks range 45-49.99,
- Grade C for the marks range 40-44.99, and
- Grade F for the marks range 0-39.99.

C. Prepared Datasets

After data collection and preparation stage, datasets are prepared which consists of grades of semester-wise courses, year-wise courses and overall courses grade dataset. Table 2 represents datasets, dataset name and number attributes in each datasets. In this table, number of attributes for particular semester/s represents the number of courses in that particular semester/s.

The semester-wise courses considered are given below –

- SY Semester III Result – Applied Mathematics-I, Discrete Mathematical Structures, Advanced C Concepts, Digital Techniques, Computer Graphics,Lab-Visual Basic
- SY Semester IV Result - Applied Mathematics-II, Theory of Computation, Microprocessors, Data Communication, Data Structures, Lab-Object Oriented Design & Programming Through C++
- SY Semester III and IV Result - Semester III and IV courses given above.
- TY Semester V Result – Operating System Concepts, Computer Networks, System

Table 2:
Datasets Used For Recommendation System

Sr. No.	Dataset	Dataset Name	Number of attributes (Number of courses available in that particular semester/s)	Size of dataset
1	SY Semester III Result	D1	6	1151
2	SY Semester IV Result	D2	6	1151
3	SY Semester III and IV Result	D3	12	1151
4	TY Semester V Result	D4	7	1151
5	TY Semester VI Result	D5	8	1151
6	TY Semester V and VI Result	D6	15	1151
7	BE Semester VII Result	D7	8	1151
8	BE Semester VIII Result	D8	7	1151
9	BE Semester VII and VIII Result	D9	15	1151
10	Overall Grade	D10	42	1151

Programming, Design and Analysis of Algorithm, Computer Organization, Lab-Java Programming, Self Learning-I

- TY Semester VI Result – Database Engineering, Compiler Construction, Unix Operating System, Mobile Computing, Software Engineering, Lab-Programming in C#.net, Mini Project, Self Learning -II

- TY Semester V and VI Result - Semester V and VI courses given above.

- BE Semester VII Result - Advanced Computer Architecture, Distributed System, Modern Database System, Project Phase-I, Python, Vocational Training, Elective-I, Elective-II.

- BE Semester VIII Result - Management Information System, Information & Cyber Security, Lab-I (Web Technology), Lab-II (Project Phase-II), Lab-III (Open Source Technology), Elective-III, Elective-IV

- BE Semester VII and VIII Result - Semester VII and VIII courses given above.

Table 3 :
Sample Grade Dataset Used Of Sy Semester Vii Result For Recommendation System

ACA(70444101) Grade	DSys(70444102) Grade	MDS(70444103) Grade	PP-I(70444104) Grade	Py(70444105) Grade	VT(70444106) Grade	Ele-I Grade	Ele-II Grade
A	A	A	O	O	O	A	A
A	A	A	O	O	O	A	A+
A+	A+	O	O	O	O	O	A+
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
O	A	O	O	O	O	O	A+
A	A	A	O	O	O	A	A+

Table 3 shows the sample grade dataset for Final Year Semester-VII that is Dataset D7. This semester consists of 8 courses such as Advanced Computer Architecture (ACA), Distributed System (DSys), Modern Database System (MDS), Project Phase-I (PP-I), Python (Py), Vocational Training (VT), Elective-I (Ele-I) and Elective-II (Ele-II) course. In this Table 2, grade (O, A+, A, B+, B, C+, C, and F) for each course of semester-VII is shown.

D. Comparison of Association Rule Algorithms

Association rule algorithms are used to find the relationship among data items that is to find dependency of one data item on another data item and used in various applications [21, 22]. This section discusses the comparison of four association rule algorithms such as Apriori Association Rule, Filtered Association algorithm, Predictive Apriori Association Rule and Tertius Association Rule algorithms to select the best association rule algorithm for the grade recommendation system. In this section, we define two types of association rules applicable to recommendation system -

- Relevant Rules – Relevant rules are those rules in which one course is dependent on other course or one course is prerequisite to another course.

  1. Example: Consider the rule, "Java_Programming=O Programming_in_C#=O → Mini_Project=O". The meaning of the rule is that if students received 'O' grade in Java Programming and Programming-in-C# then those students will also get 'O' grade in Mini_Project as for implementing any real-time application for Mini-Project, we should have the knowledge of programming languages such as Java Programming, Programming-in-C#, etc. So Mini-Project lab course is dependent on programming languages.

  2. Example: Consider the rule, "Discrete_Mathematical_Structure=A Data_Structure=A → Database_Engineering=A". In this rule, these two courses Discrete Mathematical Structure and Data Structure are prerequisite to Database Engineering course.

Above two examples are examples of relevant rules.

- Irrelevant Rules - Irrelevant rules are those rules in which one course is neither dependent nor prerequisite to another course.

  Example: Consider the rule, "Theory_of_Computation=A → Mobile_Computing=A". This rule is irrelevant rule as the course Theory of Computation is neither prerequisite nor dependent on Mobile Computing.

1. Apriori Association Rule Algorithm

Apriori association rule algorithm also known as frequent pattern mining is a bottom up approach used to find the most frequent itemsets iteratively in the dataset. Performance parameters support are used to evaluate this association rule algorithm. Table 4 represents the result of application of Apriori association rule algorithm on dataset D6. For minimum support value 0.35, ten rules are obtained.

Table 4 :
Result of Apriori Association Rule Algorithm For Dataset D6

Minimum Support	No. of Rules	Rules
0.35	10	1. Software_Engineering=A+ Programming_in_C#=O → Mini_Project=O 2. Programming_in_C#=O → Mini_Project=O 3. Software_Engineering=A+ → Mini_Project=O 4. Java_Programming=O Programming_in_C#=O → Mini_Project=O 5. Operating_System_Concepts=A+ →Mini_Project=O 6. System_Programming=A → Mini_Project=O 7. Computer_Organization=A → Mini_Project=O 8. Database_Engineering=A+ → Mini_Project=O 9. Java_Programming=O → Mini_Project=O 10. Compiler_Construction=A → Mini_Project=O
0.38	8	1. Programming_in_C#=O → Mini_Project=O 2. Software_Engineering=A+ → Mini_Project=O 3. Java_Programming=O Programming_in_C#=O → Mini_Project=O 4. System_Programming=A → Mini_Project=O 5. Database_Engineering=A+ → Mini_Project=O 6. Java_Programming=O → Mini_Project=O 7. Compiler_Construction=A → Mini_Project=O 8. Computer_Networks=A+ → Mini_Project=O
0.4	5	1. Programming_in_C#=O → Mini_Project=O 2. Software_Engineering=A+ → Mini_Project=O 3. Java_Programming=O Programming_in_C#=O → Mini_Project=O
0.45	3	4. Java_Programming=O → Mini_Project=O 5. Computer_Networks=A+ → Mini_Project=O 1. Programming_in_C#=O → Mini_Project=O 2. Java_Programming=O Programming_in_C#=O → Mini_Project=O 3. Java_Programming=O → Mini_Project=O
0.65	2	1. Programming_in_C#=O → Mini_Project=O 2. Java_Programming=O → Mini_Project=O
0.7	1	1. Programming_in_C#=O → Mini_Project=O

From Table 4, it is observed that when we increase the value of minimum support then we get the best rules for maximum support value.

2. Filtered Associator Algorithm

The Filtered Associator algorithm is an association rule algorithm which is used to find association between data items in a dataset. In this algorithm, we first apply a filter to the dataset that remove data items which do not meet certain criteria. After applying filtering method on the dataset, this Filtered Associator algorithm uses association rule algorithm to find association rules on filtered dataset. In this Filtered Associator algorithm, we use Apriori association rule algorithm as association rule algorithm. This Apriori association rule algorithm is used in various applications such as sales [23], cyberspace security [24], medical field [25], etc.

Table 5 :
Result of Filtered Associator Algorithm For Dataset D6

Minimum Support	No. of Rules	Rules
0.4	10	1. Programming_in_C#=O → Mini_Project=O 2. Java_Programming=O Programming_in_C#=O →Mini_Project=O 3. Software_Engineering=A+ Programming_in_C#=O → Mini_Project=O 4. Database_Engineering=A+ Programming_in_C#=O → Mini_Project=O 5. Software_Engineering=A+ Mini_Project=O → Programming_in_C#=O 6. Java_Programming=O → Mini_Project=O 7. Computer_Networks=A+ → Mini_Project=O 8. Software_Engineering=A+ → Mini_Project=O 9. Database_Engineering=A+ Mini_Project=O → Programming_in_C#=O 10. Database_Engineering=A+ → Mini_Project=O
0.43	8	1. Programming_in_C#=O → Mini_Project=O 2. Java_Programming=O Programming_in_C#=O → Mini_Project=O 3. Java_Programming=O → Mini_Project=O 4. Computer_Networks=A+ → Mini_Project=O 5. Software_Engineering=A+ → Mini_Project=O 6. Java_Programming=O Mini_Project=O → Programming_in_C#=O 7. Java_Programming=O → Programming_in_C#=O 8. Java_Programming=O → Programming_in_C#=O Mini_Project=O
0.65	6	1. Programming_in_C#=O → Mini_Project=O 2. Java_Programming=O Programming_in_C#=O → Mini_Project=O 3. Java_Programming=O → Mini_Project=O 4. Java_Programming=O Mini_Project=O → Programming_in_C#=O 5. Java_Programming=O → Programming_in_C#=O 6. Java_Programming=O → Programming_in_C#=O Mini_Project=O
0.7	2	1. Programming_in_C#=O → Mini_Project=O 2. Java_Programming=O → Mini_Project=O
0.75	1	1. Programming_in_C#=O → Mini_Project=O

The filtering method used in this Filtered Associator algorithm is Reservoir sampling Algorithm. Reservoir sampling Algorithm is the filtering method used to select a simple random sample of k data items without replacement from size n population in a single pass over data items.

Table 5 illustrates the result of application of Filtered Associator algorithm on the dataset D6. From Table 5, it is noted that for minimum support value 0.4, ten relevant rules are obtained as compared to the result of Apriori association rule algorithm in which ten rules are obtained for minimum support value 0.3. Table 5, it is found that if we increase the minimum support value then we get the optimal association rules for maximum support value. Even all association rules generated are matched with the real-time course dependencies and course prerequisites. Hence we considered this algorithm for the course grade recommendation system.

3. Predictive Apriori Association Rule Algorithm

Predictive Apriori association rule algorithm is the extension of Apriori association rule algorithm by adding the performance parameter predictive accuracy measure into rule mining process. Table 6 shows the result of application of Predictive Apriori association rule algorithm on the Dataset D6. From Table 6, it is noted that the rule "Software_Engineering=A+ Self_Learning-II=A → Mini_Project=O " is irrelevant as whether Self Learning-II course is dependent or prerequisite to Software Engineering and Mini Project is dependent on the selection of course as Self Learning-II course by students.

As using this association rule algorithm, we obtained association rules which are irrelevant; hence this algorithm is not used for the course grade recommendation system.

Table 6 :
Result of Predictive Apriori Association Rule Algorithm for Dataset D6

1. Software_Engineering=A+ Programming_in_C#=O → Mini_Project=O
2. Database_Engineering=A+ Programming_in_C#=O → Mini_Project=O
3. Java_Programming=O Software_Engineering=A+ → Mini_Project=O
4. Operating_System_Concepts=A+ Programming_in_C#=O → Mini_Project=O
5. Operating_System_Concepts=A+ Java_Programming=O → Mini_Project=O
6. Computer_Networks=O → Mini_Project=O
7. Java_Programming=O Self_Learning-II=A → Mini_Project=O
8. Operating_System_Concepts=O → Mini_Project=O
9. Compiler_Construction=A+ → Mini_Project=O
10. Software_Engineering=A+ Self_Learning-II=A → Mini_Project=O

4. TertiusAssociation Rule Algorithm

TertiusAssociation Rule Algorithm is used to find association rules that satisfy user-specified minimum support and confidence. Table 6 represents the result of application of Tertius association rule algorithm on Dataset D6. From Table 7 it is found that the rule "Computer_Networks = O → Computer_Organization = A+ or Software_Engineering = O" is irrelevant as these courses is neither prerequisite nor dependent on each other.

After application of this algorithm on dataset, we obtained association rules which are irrelevant; hence this algorithm cannot be used for the course grade recommendation system.

Table 7 :
Result of Tertius Association Rule Algorithm For Dataset D6

1. Computer_Networks = O → System_Programming = A+ or Database_Engineering = O
2. Computer_Networks = O → Computer_Organization = A+ or Database_Engineering = O
3. Computer_Networks = O → Computer_Organization = A+ or Operating_System_Concepts = O
4. Computer_Networks = O → System_Programming = A+ or Operating_System_Concepts = O
5. Computer_Organization = A+ → System_Programming = A+ or Compiler_Construction = A+
6. Computer_Networks = O → Database_Engineering = O or Operating_System_Concepts = O
7. Computer_Networks = O → Unix_Operating_System = A+ or Operating_System_Concepts = O
8. Operating_System_Concepts = O → Computer_Networks = O or Database_Engineering = O
9. Computer_Networks = O → Computer_Organization = A+ or Software_Engineering = O
10. System_Programming = A+ → Computer_Organization = A+ or Unix_Operating_System = A+

E. Select best association rule algorithm based on association rule parameters and real time course dependencies

As discussed in subsection D, Filtered Associator algorithm is used for the course grade recommendation system based on courses dependencies or courses prerequisites. Support parameter value is also used for the evaluation of these association rules.

F. Suggestion and Recommendation Rules

In this phase of CGRSFA framework, we recommend suggestions and rules to students based on courses dependencies or courses prerequisites.

4. Algorithm Using Filtered Associator Algorithm

Algorithm 1 presents the algorithm considered for CGRSFA Framework using Filtered Associator algorithm. It consists of four steps:

1. Selection of the best association rule algorithm for CGRSFA Framework: In this step, the result of four association rule algorithms such as Apriori Association Rule, Filtered Association algorithm, Predictive Apriori Association Rule and Tertius Association Rule algorithms are compared based on relevant and irrelevant rules to select the best algorithm for the grade recommendation system. The best association rule algorithm - Filtered Associator algorithm for CGRSFA Framework is selected.
2. Initialize dataset file number DATASET_N = 1: Dataset number is initialized to first dataset for checking the result of Filtered Association algorithm on it.
3. Saving the result of application of Filtered Associator algorithm on ten datasets in a file: In this step, Filtered Association algorithm is applied on each dataset and the following things are noted for each dataset

   a.Number of rules (A_N_RULES) generated

   b.Minimum support value (A_MIN_SUP)

   c. Most optimal rules (A_OPT_RULES)

Algorithm 1 : Algorithm for $CGRS_{FA}$ Framework
Input: ARFF file containing students' grade obtained in each course of semester or year
Output: Course grade recommendation Rules for students

Method:

1. Selection of the best association rule algorithm for $CGRS_{FA}$ Framework;
   - a Apply Apriori association rule algorithm (ASS_ALGO = 1), Filtered Associator algorithm (ASS_ALGO = 2), Predictive Apriori association rule algorithm (ASS_ALGO = 3) and Tertius association rule algorithm (ASS_ALGO = 4) on any dataset (Consider dataset D4);
   - b Check the rules generated using these four association rule algorithms.
   - c For ASS_ALGO = 1 to 4
     - i. If the rules obtained using ASS_ALGO are relevant rules then
       the result of association rule algorithm for $CGRS_{FA}$ framework is considered
       else /* the rules obtained using ASS_ALGO are irrelevant rules */
       the result of association rule algorithm for $CGRS_{FA}$ framework is discarded
     - ii. ASS_ALGO = ASS_ALGO + 1
   - d The best association rule algorithm that is Filtered Associator algorithm for $CGRS_{FA}$ Framework is selected
2. Dataset file number DATASET_N = 1;
3. For DATASET_N = 1 to 10
   - i. Read DATASET_N ARFF file;
   - ii. Apply Filtered Associator algorithm on ARFF file;
   - iii. **Repeat**
     - a. Check the number of rules (A_N_RULES) generated;
     - b. Save the result of algorithm along with minimum support value (A_MIN_SUP) and number of rules generated (A_N_RULES);
     - c. Increase the value of minimum support (A_MIN_SUP);

     Until A_N_RULES = 0.
   - iv. Note down the most optimal rules (A_OPT_RULES) for maximum support value (A_MAX_SUP);
   - v. DATASET_N = DATASET_N + 1;
   - vi. Goto step 3.
4. Display the course grade recommendation rules.

d. Maximum support value (A_MAX_SUP)

These values are stored in the table format for each dataset.

4. Display of the course grade recommendation rules: In this step, the recommendation rules generated using Filtered Association algorithm for each dataset is displayed.

Various variables used in the algorithm are explained below:

- ASS_ALGO – This variable indicate the association rule algorithm e.g. Apriori association rule algorithm (ASS_ALGO = 1), Filtered Associator algorithm (ASS_ALGO = 2), Predictive Apriori association rule algorithm (ASS_ALGO = 3) and Tertius association rule algorithm (ASS_ALGO = 4).

- DATASET_N – The association rule algorithm is applied on ten datasets so this variable represents the dataset number from 1 to 10.

- A_N_RULES – This variable is the number of rules generated after applying Filtered Associator algorithm.

- A_MIN_SUP – This variable indicates the minimum support parameter value for the generated association rules.

- A_OPT_RULES – If the support parameter value of Filtered Associator algorithm is increased then for the maximum support, the most optimal rules are generated. So the most optimal rules are denoted using this variable.

- A_MAX_SUP – This variable presents the support parameter value for which optimal rules are generated.

5. Results And Discussion

In this section, we discuss the result of application of Filtered Associator algorithm on ten datasets. Number of association rules, actual association rules generated, and support parameter value using Filtered Associator algorithm on the Dataset D6 is presented in Table V. Actual Association rules represeneted in the Table V match with the real-time coursedependencies and course prerequisites.

Table 8 :
Result of Filtered Associator Algorithm for Ten Dataset

Datasets →	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Support value	0.1	0.1	0.4	0.15	0.4	0.4	0.45	0.85	0.9	0.9
No. of rules	10	10	10	10	10	10	10	10	10	10
Support value	0.15	0.15	0.43	0.2	0.42	0.45	0.8	0.87	0.93	0.94
No. of rules	6	9	8	5	7	6	7	4	6	4
Support value	0.2	0.2	0.65	0.25	0.43	0.7	0.85	0.91	0.94	0.95
No. of rules	3	4	6	3	2	2	4	2	4	2
Support value	0.3	0.25	0.7	0.3	0.44	0.75	0.93	-	0.96	-
No. of rules	1	3	2	1	1	1	2	-	2	-
Support value	-	0.3	0.75	-	-	-	-	-	-	-
No. of rules	-	1	1	-	-	-	-	-	-	-

This section represents only the number of association rules along with support parameter value for all ten dataset which does not contain actual association rules generated for that particular dataset.

Table 8 represents application of Filtered Associator algorithm on ten datasets along with support value and number of rules obtained for each dataset. This table also represent the number of optimal rules generated for particular dataset for maximum support parameter value if the support parameter value is increased. From Table 8, it is found that for Dataset D1 and D2, ten rules are obtained for support value 0.1 and one optimal association rule out of 10 rules is obtained for support value 0.3. For dataset D3, D5, and D6, ten rules are generated using this association rule algorithm for support value 0.4.

Ten rules are observed for support value 0.9 for datasets D9 and D10 while support value 0.96 and 0.95 are observed for two rules obtained using datasets D9 and D10 respectively. For dataset D8, ten rules are generated for support value 0.85 while for two rules are obtained for 0.91 support value. Ten rules are noted for support value 0.15 for dataset D4 and for dataset D7; ten rules are generated for support value 0.5.

Figure 2 shows the graphical representation of number of rules generated for support values using Filtered Associator algorithm for ten datasets.

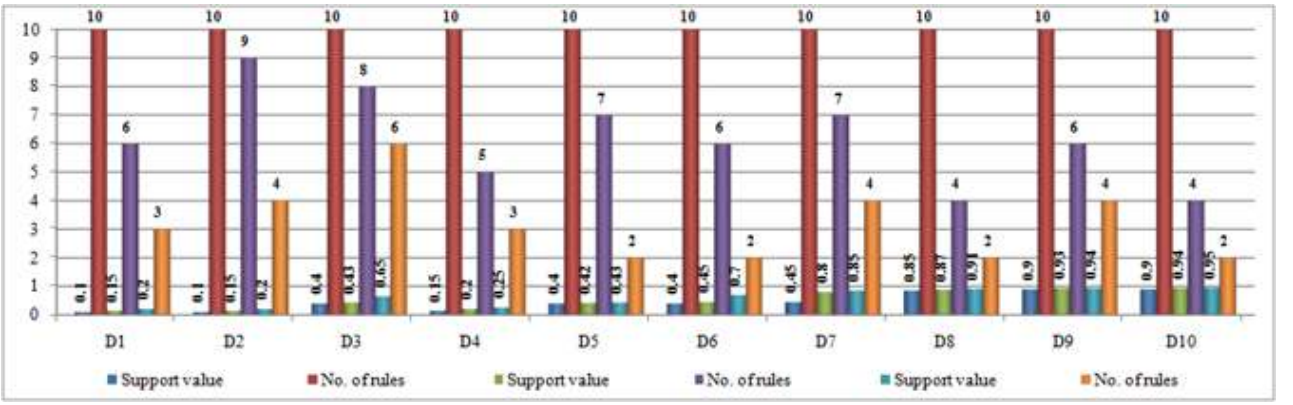

Fig.2 : Result analysis of Apriori association rule algorithm for all datasets

Conclusion

In current study, we designed the framework for course grade recommendation system using Filtered Associator rule algorithm and titled this framework as CGRSFA. For this framework, we used data generated using Four Year B.Tech. Computer Science and Engineering Programme result analysis ledgers collected from University. We processed data and prepared ten datasets with the help of Microsoft Excel. The best association rule algorithm - Filtered Associator algorithm is selected by comparing four algorithms - Apriori association rule algorithm, Filtered Associator algorithm, Predictive Apriori association rule algorithm and Tertius association rule algorithm on the basis of relevant and irrelevant rules as well as support parameter value. Actual association rules generated, number of rules and support parameter value for one of the dataset D6 is illustrated in this article. The optimal association rules are generated after increasing the support value. The result of application of the algorithm - Filtered Associator algorithm on remaining nine datasets are also preseneted with the help of number of association rules generated and support parameter value for each of the dataset.

In future, we will apply the combination of the clustering algorithm and the association rule algorithm. The result of this combination will be compared with the result of this study to check the effectiveness of combination of clustering and association rule algorithm with the Filtered Associator algorithm.

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