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Research paper

A Systematic Review of Recommender Systems in Education

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Abstract

Recommender system (RS)s are widely used in different walks of life. This research work is to explore the usage of RS in the field of education. This review is performed in five dimensions which includes, Purpose of RS in Education, various techniques to build RS, input parameters used in design of RS, type of students involved in design of RS and Modelling strategies for RS to represent the data. The outcome of the research work is to facilitate the efficient design of the recommender system in education which will help the students by generating the appropriate recommendations.

Keywords: *Recommender System, Modelling Strategy, Techniques, Input-Parameters*

1. Introduction

Recommender systems are widely used in various domains for its efficiency in recommending appropriate items for its users. Generally recommender systems are used to recommend movies, music, products, news articles etc based on the users historical data and requirements. Recommender systems can be beneficial in education sector as the students will have a dilemma in their selection of subjects, programs and courses. Various research has been done regarding the applications of Recommender systems in other domain where as its usage in education is comparatively less [3][9][24]. Thus this research work is to study about the usage of recommender systems in education.

Recommender system has three basic components namely users, items and ratings. Recommender engine is the core of the recommender system which works based on the design of user profile and item profile. There exists a variety of design techniques to build user profile and item profile. There are different types of recommender systems which include content based recommender system, collaborative recommender system, knowledge based recommender system, demographics based recommender system, and hybrid recommender system.

Recommender systems in education sector is designed by mapping students as users, courses / programs as items and student feedback about the course/program as ratings. This research work aims to provide a thorough review regarding the different purposes for generating recommendations in education sector, techniques involved in designing RS, parameters involved in building the user profile, different types of students who could require recommendations and the different modelling strategies for building user profile /item profile. The outcome of this work will enable the researcher to design the recommender system in an efficient way.

This paper is organized as different sections. Section 2 describes the various research work done in this filed. Section 3 elaborates the purpose of RS in education. Section 4 describes the techniques involved in building the Recommender system. Section 5 specifies the student attributes considered for designing the recommender system. Section 6 deals with different categories of students. Section 7 discusses the research gap section 8 provides an insight to the challenges involved in the design of Recommender system in the education sector.

2. Literature Review

Literature review is done in a systematic manner. First, Detailed survey of RS is done [3][29]. The second step is to survey about the various types of RS such as Knowledge based Recommender system [55][59], constraint based recommendation [22] [47] and context aware recommender systems [4]. The next step is to list of applications of RS as mentioned in [10][24]. Then, the next step is to identify the various attributes of students/learners using Educational Data miningprocess [16][20]. The next step is to learn about the tools for designing RS is elaborated in [1][50]. The design of RS using machine learning algorithms [9] is studied. Finally, various evaluation strategies to evaluate RS is elaborated in [36]. Based on the systematic review, this research work is based on five dimensions which include, Purpose of RS in Education, various techniques to build RS, input parameters used in design of RS, type of students involved in design of RS and Modelling strategies for RS to represent the data.

3. Purpose

The outcomes of recommendations are varied in nature. Depending upon the students requirements, RS is widely used to recommend appropriate courses (subjects). This is widely used in online class rooms to help the students to recommend courses. Depending upon the participation of students in virtual class rooms, RS is used to recommend study plan which details about the course sequences which will help the students to score better grades. RS play a crucial role for providing personalized curriculum depending upon the skill set of the students. There exists RS that recommend curriculum based on job market and other requirements. Also, for online students, RS is used to recommend learning re-

sources and contents. Some RS is available in the literature that recommends colleges / Universities for degree programs. Very few RS do exist in the literature that recommends degree programs for the students based on grades and interests. Thus the RS in education has different purposes which is summarized in the table.

Table 1: Purpose of RS in Education

Sl.no	Purpose	Literature
1	To recommend online courses	[32], [43], [17], [46], [6], [57], [53], [33], [42], [38], [21], [60], [54], [31], [7]
2	To recommend regular courses (subjects)	[23], [44], [30], [48], [19], [5], [40]
3	To recommend suitable degree programs for the students.	[49], [56]
4	To recommend the learning path / course sequences	[15], [26]
5	To recommend personalized curriculum	[51], [8],
6	To recommend colleges / universities	[52], [12],
7	To recommend curriculum for job market	[27]
8	To recommend learning resources	[18], [58], [61], [13], [34], [2]
9	Prediction	[14], [62], [11]
10	Recommendations to teachers	[39]

4. Techniques

Design of RS depends on the objective of the system. Therefore, there exists a wide variety of techniques being involved in the design of RS. A thorough analysis of the design of RS in three dimensions namely, the design of Recommender engine, the design of user/Item profile and the supporting mathematical model is done in this work. The literature shows that predominantly, content based and collaborative systems are used in this domain. The other types of RS like Knowledge based RS and constraint based RS are also designed in this domain. Classifiers based recommender systems are designed to help the students to recommend the learning path, to recommend courses etc. Decision tree, Neural networks based classification, Naïve Bayes, MLP, SVM , Linear regression models are used in the design of classifiers based RS. Clustering based recommendations using K-means clustering algorithm and Artificial immune system based clustering algorithm is used in the design of RS. Apriori based association rules are also used to design the RS where the recommendations are static in nature. The other techniques like agent programming is also used in the design of the RS. Fuzzy based RS are designed by using fuzzy inferences in knowledge base. Other data mining techniques like MF, BMF based recommendation are also designed. User profile and item profile design plays an important role in the design and performance of RS. Predominantly, by considering the variety of student data , 2D models are used in building the user profile and item profile. The other models like Graph based knowledge representation and Semantic web ontology based profile design is used in the design of RS. By mapping RS as a Constraint satisfaction problem, recommendations are generated which are static in nature. Logic of Plausible reasoning techniques and Fuzzy cognitive maps are also used in the design of RS. The various techniques used in the design of RS is summarized in the table 2.

Table 2: Techniques of RS in Education

Sl.no	Techniques	Literature
1	Content based filtering	[32], [5]
2	Collaborative filtering	[32], [18], [19], [53], [33], [38], [36], [31]
3	Rule based filtering Apriori based association rules	[44], [53], [42], [54],[60]
4	Agent systems	[43], [37]
5	Knowledge based approach	[15]
6	Decision tree based classification NN based classification Naïve bayes, ANN, MLP, SVM, Bayesian network based recommendations Linear regression models	[49], [8], [14], [6], [57], [26], [37], [41]
7	Clustering based recommendation K-means clustering Artificial immune system based clustering	[46], [30], [26], [53], [60]
8	MF, BMF based recommendation	[6]
9	Constraint based recommendation	[28], [22], [47]
10	Fuzzy inference engine	[17], [40]
11	Hybrid Approach to design RS	[43], [21],[52],[38]
12	Genetic Algorithms	[39]

5. Parameters

Various input parameters pertaining to the requirements of the learners are used in the design of RS. Predominantly, the performance based parameters like test score, Grade point average(GPA), other measures like GRE score and entrance score etc are used in recommending the courses for the learners. The design of the RS is also based on Career goal of the learners. RS is also designed based on Learners interest (personal / professional). Learning needs (audio/visual / interested subject etc) is considered to recommend the courses. Family details like Income, Dependants/family size/ number of siblings, Mothers qualification, Fathers qualification is considered in recommending appropriate courses for the students. The skill set of the student which includes Cognitive level, Learning style, Achievements / competitions won, previous Job experience is used in recommending the appropriate courses for the students. Some RS is designed based on ratings of courses / teachers/ institutions to recommend the courses. Web based RS is designed based on users Web history / navigations / clicks. Other parameters like gender, Age and previous Education type is used in course recommendation. The various parameters used in the design of RS is summarized in the table 3.

Table 3: Parameters used in design of RS

Sl.no	Input Parameters used in design of RS	Literature
1	Performance based parameters (test score, GPA, academic score, etc)	[32], [17], [14], [46], [6], [12], [30], [62], [34], [7], [31], [13]
2	Career goals	[23]
3	User interest (personal / professional)	[8], [56], [54], [31]
4	Job desire	[49],[27]
5	Learning needs	[15]
6	Income	[17], [62]
7	Dependants/family size/ number of siblings	[17],[62]
8	Education type	[14]
9	Achievements/competitions	[14]
10	Gender	[14], [12], [62]
11	Age	[14]
12	Major applied	[14]
13	University applied	[12]
14	Job experience	[12]
15	Ratings (course/teacher)	[30]
16	Mothers qualification	[62]
17	Fathers qualification	[62]
18	Cognitive level	[45],[7]
19	Learning style	[45]
20	Web history / navigations / clicks	[43],[37]

6. Types of Students

Majority of the research work is focused for virtual classrooms and online students. Some research experiments also involve regular university / college students. The research activities for the school students is comparatively less. The various type of students involved in the design of RS is summarized in the table 4.

Table 4: Students involved in design of RS

Sl.no	Type of Students	Literature
1	Online students	[32], [43], [51], [18], [42], [46], [58], [39], [26], [38], [61], [21], [37], [34]
2	Regular university/college students	[23], [49], [15], [8], [17], [52]

7. Modeling Strategies

To model course recommendation as a RS, user profile design and item profile design plays a crucial role in measuring the efficiency of the system. User profile is designed as vector based model, graph based model and ontology based model. Item profile is designed as rule based model. Recommendations are generated based on classifiers. Clustering based RS do exist in the literature. The design of RS is also based on Mathematical strategies like linear programming problem, constraint satisfaction problem. Fuzzy based modelling using Fuzzy cognitive maps is also used to recommend courses. The different mapping strategies to solve the course recommendation problem is listed in table 5.

Table 5: Modelling strategies

Sl.no	Modelling Strategies	Literature
1	User profile as graph	[15], [28], [25], [2]
2	Course details as rules	[49],[53]
3	Knowledge base design using Logic of plausible reasoning (LPR)	[35]
4	Knowledge base design using Fuzzy cognitive Maps	[2]
5	Linear programming problem	[28]
6	Constraint satisfaction problem	[15], [45]
7	Ontology	[51], [27], [58]

8. Challenges

The major challenges involved in designing the RS is listed in this section. The first and foremost challenge is to design a course advisory system to satisfy multiple users and their requirements. As there is a rapid change in the courses being introduced in each academic year, the course advisory systems should be designed as intelligent and adaptive systems to incorporate the dynamic changes in the education system. It is very difficult to identify the appropriate machine learning algorithms that suit the current situation. Because of the internet era, the issues related with the compatibility of the web based course advisory systems using machine learning algorithms are to be considered during the implementation stage of the system. Now a days, the curriculum designers have adopted open ended electives, choice-based credit system, interdisciplinary courses, and certification courses and therefore, course advisory systems should adopt to the changes incorporated in the education system.

9. Inferences

The inferences from the literature helped us to identify the research gap. It is noted that research work towards Program selection in Indian universities is minimum. Program recommendation after completing class XII needs a major focus. In the existing RS, recommendations are generated based on few parameters like goals, user navigation, grades and learning needs. But the Input parameters related to adaption and intelligence are not considered. Lots of research work in RS was targeted for online students and LMS data is used for building profile. As efficient user profile design will improve the performance of RS, multiple parameters could be considered. Also it is noted that research work towards generating recommendations for regular students is less. Very few researchers work towards the design of RS for Program selection before joining an educational institute. Course selection as Subject level for a particular program is considered. These generic applications revolve around the design of user feedback as ratings. Ratings are commonly used for generating recommendations. Content based and collaborative based RE are designed predominantly whereas KBRS is very less in this application.

10. Conclusion

The systematic survey has helped to identify the usage of recommender systems in five aspects like Purpose of RS, techniques to build RS, input parameters to design of RS, type of students involved in design of RS and Modelling strategies for RS. This research work has identified some of the challenges that exists in this field. Also, the paper also listed various research openings which will facilitate the researchers to carry further research activities in this domain

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