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An Association Rule Based Model for Discovery of Eligibility Criteria for Jobs

P. K. Deva Sarma

Department of Computer Science, Assam University, Silchar, India, PIN 788 011

*Corresponding Author: pankajgr@rediffmail.com, Tel.: +91-9957496261

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Abstract: Association rule mining is a data mining technique in which pattern of occurrences of one set of items with another set of items in databases of transactions are discovered as rules of implications with certain measures of interestingness. Support or the frequency of occurrences of sets of items and confidence are the most widely used measures of interestingness of association rules of the form X→Y where X and Y are disjoint sets of items. Though the problem of association rule mining emerged from analysis of market basket data in supermarket there are numerous areas of applications of association rule mining technique. In this paper, an association rule based model for discovery of eligibility criteria for jobs is proposed. For this the eligibility requirements of jobs are converted to a set of transactions and then a data base of such transactions is prepared for discovering the association rules in such a way that the antecedent of a rule represents the eligibility requirements and the consequent represents the concerned job. Such rules once discovered can be used for various purposes by the employers, job seekers and the policy makers for proper planning related to recruitment, employment and creation of need based vacancies respectively.

Keywords— Data mining, big data, association rule, support, confidence, classification

I. INTRODUCTION

In present day world there are plenty of opportunities for career and jobs and information regarding this are widely available on the internet, news paper, social media and elsewhere. Tremendous amount of data are generated in this respect and are available in public domain. These data are unstructured and varying in nature and in the context of big data there are enormous complexities in such data. It is important for professionals and students who are looking for better and prosperous career options to judiciously analyse such data before choosing their career path. The idea is to find mechanism to maximize the scope and growth of career option of people based on academic and professional back ground. It is observed frequently that different persons with similar or in some cases even identical academic qualifications do not have careers of similar or even comparable level. Some have excellent career with continuous scope for further growth while some others with identical background have average or below average career with hardly any option of growth and prosperity. There can be multiple reasons for this including social and economic background of the people. But one prominent reason for such an outcome is lack of wide knowledge about extending and maximizing the career opportunities at a very early stage of their lives due to non availability and ineffective dissemination of information in a suitable manner. As a result various career options could not be evaluated by the stake holders in relation to their future scope, mobility and growth in a futuristic sense before taking up a particular option. This is recognized as a very critical need in the context of the present day as there are diverge and wide ranging career opportunities.

Since the data in this context are huge, unstructured, varying and growing continuously, therefore a data mining approach for analysing and mining the patterns from the data related to requirements of various qualifications for jobs and careers shall be not only helpful for choosing a better career path but also to sustain and grow in such career as the patterns discovered from the actual data are proofs for sustainable bright careers of various people. Prospective candidates can guide themselves by using such a technique for their betterment. This innovation for providing information services is essential in shaping the lives and careers of youth. Since innovative ideas in thought and action are prerequisite for success in present day world.

Presently observational and heuristics based approach is used for such purposes but there is need for more meticulous techniques based on analytics. This approach based on data mining proposed in this work can be used to establish information services for the purpose of ascertaining the requirements in various skill domains for the present and the future.

In this paper a technological model is designed for augmenting the techniques for searching for appropriate career and job opportunities including those in research and development. The

proposed model is designed based on association rule mining technique to determine the associations among the academic and skill background with prospective career or job opportunities. Out of various data mining techniques association rule mining method is used in this model for finding the association pattern among various academic qualifications, skill set and career opportunities. However, possibility of applying other models namely classification and clustering is also discussed.

A sample dataset is prepared for analyzing the proposed model for mining the association rules as described above. In essence, in this paper, the relationship between academic, professional skill background and the prospective carrier opportunities are conceived as if - then rules and it is observed that having a certain set of background qualifications leads to having certain career opportunities with specified rule strength in terms of certain support and confidence.

The rest of the paper is organized as follows. In section 2, related works about application of data mining techniques for finding job opportunities are discussed. In section 3 the association rule mining technique is discussed. In section 4, the proposed model for discovery of eligibility criteria for jobs as association rule is presented. The importance of such association rules is discussed in section 5. The paper is concluded with a discussion about the scope for the future work.

II. RELATED WORK

For mining employment opportunities, career options and in various other related activities data mining techniques are applied in various recent works. Classification technique is used for mining employment and job opportunities in [1]. A decision tree based classification is used to propose a job recommender system for considering candidate job preferences in [1]. An approach based on application of association rule mining for employment guidance and employment opportunities is published in [2]. But no experimental results are reported.

Data mining techniques are also applied to improve personnel selection and enhance human capital in high technology industry [3]. Models based on classification are proposed for predicting graduate/students' employment in [4] [5]. Classification techniques like Bayesian methods, Multilayer Perceptron and Sequential Minimal Optimization (SMO), Ensemble Methods and Decision Trees, are used to predict the employability of students and to find the most suitable algorithm for the problem [5]. An employability model for graduates based on data mining is proposed in [6]. Data mining techniques namely classification with k-NN and information extraction methods from a textual dataset are applied with Rapid Miner and R, to determine effective ways of discovering knowledge from a given collection of vacancies for skills and vacancy analysis in [7]. Classification Technique is also used for Appraisal Management System [8].

III. ASSOCIATION RULE MINING

Data Mining concerns with design and development of computational algorithms and techniques for discovering hidden patterns and rules which are nontrivial, interesting, previously unknown and potentially useful from data in databases [9] [10]. The problem of association rule mining is to discover a set of attributes or items shared among a large number of transactions in a given database [11]. In association rule discovery, it is found how the presence of a set of items in a transaction influences the presence of another set of items in the same transaction and how regularly it happens in the whole database.

A. Definitions of Association Rule and related Terminology

A set of items is called an *itemset*. An itemset with k-items is called a *k-itemset*. The support count or frequency of occurrence of an itemset X is denoted by $\sigma(X)$. An itemset X is said to be *large* or *frequent* if its support is not less than a pre specified minimum support (minsup). A set of frequent-k itemsets is denoted by F_k. The problem of mining Association Rules was first introduced in [11] [12] [13]. It is described as below.

Let $I = \{i_1, i_2, i_3, \ldots \ldots \ldots i_m\}$ be a set of literals called items. D be a database of transactions, where each transaction T is a set of items such that $T \subseteq I$. Given an itemset $X \subseteq I$, a transaction T contains X if and only if $X \subseteq T$. An association rule is an implication of the form X => Y such that $X \subseteq I$, $Y \subseteq I$ and $X \cap Y = \Phi$. The rule X=>Y holds in the transaction database D with confidence c if c% of the transactions in D that contain X also contain Y. The rule X=>Y has support s in the transaction database D if s% of transactions in D contains X U Y.

The quality of the association rules are expressed by various measures of interestingness. Support and confidence are most widely used measures of interestingness [11] [12]. Rules with high confidence and strong support are called strong rules.

Machine learning techniques can also be incorporated to discover efficient patterns from large data related to employment [14].

IV. PROPOSED MODEL FOR MINING ELIGIBILITY FOR JOBS

In this work association rule mining technique is applied for mining of eligibility for jobs in sets of data about employment. The proposed model for applying association rule mining technique is described below.

The data regarding the eligibility conditions for various jobs is represented as transactions in such a way that the last attribute in each transaction represents a job title or designation or name of a job and all the attributes preceding the last attribute represents various eligibility qualifications for the job. Then the frequent itemsets and the association rules of the form X→Y where X represents the set of qualifications for the job represented by Y are discovered with respect to the pre specified minimum confidence and minimum support. Thus the association rules are discovered in a selected manner with additional constraint on the consequents. The itemsets appearing in the antecedent represent the qualifications required for the job appearing in the consequent. The support for the corresponding association rule gives the frequency of occurrence of the rule containing the eligibility qualifications and the corresponding job in the whole database.

Significance of such association rule: Such an association rule means that out of all the employment records in the whole database how many people are engaged in doing a particular job specified in the consequent with the set of qualifications appearing in the antecedent. This in turn shows the popularity or the demand of that job and interest of people opting for that job. If the job discovered with the specified set of eligibility has high support and high confidence then this means that the job is a highly sought after one. The confidence of the rule means that the job appearing in the consequent of the rule occurs in as many fraction/times of all the occurrences of the set of eligibility qualifications on the left hand side of the rule in the entire dataset. This means with the same set of eligibility qualifications there can be various different jobs which people can do. But a high confidence of the rule implies that among all the jobs which are possible with the same eligibility qualifications, the job specified in the rule with high confidence is done by most of the people and hence it is the most popular job. Also such a rule gives the information on the requirement of personnels for different kinds of jobs with the same set of qualifications. This approach is also found to be useful in the sense that most of the jobs at present require a set of relevant qualification and training. Therefore, for finding the suitability, appropriateness and requirements of relevant set of qualifications for different kinds of jobs such an approach based on association rule mining is necessary. The information thus obtained by using such data mining technique can, in turn help the educational policy planners to plan for creating the required number of qualified personnels for different jobs by allocation of funds, seats and vacancies in the universities, colleges and institutions of the country. The projections for the future requirements can also be made by such mining technique using the association rule mining approach.

In the following the discovery of the association rules are shown with the eligibility criteria on the antecedents and the corresponding job on the consequents of the rules. A sample data set is prepared by using the list of eligibility qualifications and names of jobs with codes shown in table 1 and table 2 respectively. The sample data set is shown in table 3 below.

Table 1: List of Eligibility Qualifications with codes

Name of Educational Qualification	Code
H S Arts	1
H S Commerce	2
H S Science	3
B A	4
B Com	6
B Sc	8
M. Sc.	10
M. A.	11
M. Com	12
Degree in Civil Engineering	62
Degree in Chemical Engineering	64
M. Tech./M. E.	72
MBBS	73
B. Ed.	77
LLB	82

Table 2: List of Jobs with job code

Name of Job	Code
Teacher in High School	87
Teacher in Higher Secondary School	88
Doctor by Profession	92
Group C Post	93
Group B Post	94
Group A Post	95
Scientist	96
News Paper Editor	99
Engineer	108
Lawyer	132

Table 3: Sample data set

TID	Items/Attributes	TID	Items/Attributes
1	1 4 77 87	16	3 73 92
2	2 6 77 87	17	1 4 95
3	3 8 77 87	18	2 6 95
4	1 4 93	19	3 8 95
5	2 6 93	20	3 62 95
6	3 8 93	21	3 64 95
7	3 62 94	22	3 8 10 95
8	3 64 94	23	1 4 11 95
9	3 62 108	24	2 6 12 95
10	3 64 108	25	1 4 99
11	3 62 72 96	26	1 4 11 99
12	3 64 72 96	27	1 4 11 77 88
13	1 4 82 132	28	2 6 12 77 88
14	2 6 82 132	29	3 8 10 77 88
15	3 8 82 132	30	3 73 95

From the sample data set of table 3, some of the association rules which can be discovered are shown in table 4. The minimum support and the minimum confidence thresholds are considered to be 0.033% (i.e. minimum support count=1) and 10% respectively. Here in some cases the largest sized frequent itemsets which do not have any frequent itemset as its superset and its last element is a job code are also considered for generating the rules. The support and confidence of these rules can be calculated by counting the frequency of occurrence of the itemsets generating the rules.

For example consider the rule (1, 4, 77) → 87 that is, (HS Arts, BA, B. Ed.) → Teacher in High School) shown in table 4. The support count of the itemset (1, 4, 77, 87) is 1 and the support count of the itemset (1, 4, 77) is also 1. The confidence of the rule (1, 4, 77) → 87 is therefore given by [support count of (1, 4, 77, 87)/support count of (1, 4, 77)] =1/1 =1, i.e. 100%. Similarly the support and confidence of all the rules can be calculated.

From the association rules shown in Table 4, it is observed that the different sets of qualifications are appeared in the antecedent of different rules for a particular job. However, from the association rules shown in Table 4, it is difficult to find all the different sets of qualifications required for a particular job. But by grouping the discovered association rules for the same job, it is possible to find all the required sets of qualifications for a particular job. This requires classifying the discovered association rules based on the item(s) appearing in the consequent so that different sets of qualifications required for a particular job can be identified. This is done in this paper with a view to identify the different sets of qualifications required for the same job. For this, the discovered association rules are classified and shown in table 5.

Table 4: Some of the discovered association rules

Discovered Rules in Terms of Item Code	Meaning of the Discovered Rules in Terms of Item Names
(1, 4, 77) → 87	(HS Arts, BA, B. Ed.) → Teacher in High School
(1, 4) → 87	(HS Arts, BA.) → Teacher in High School
(2, 6, 77) → 87	(HS Commerce, B. Com, B. Ed.) → Teacher in High School
(2, 6) → 87	(HS Commerce, B. Com) → Teacher in High School
(3, 8, 77) → 87	(HS Science, B. Sc., B. Ed.) → Teacher in High School
(3, 8) → 87	(HS Science, B. Sc..) → Teacher in High School
(1, 4, 11, 77) → 88	(HS Arts, BA, MA, B. Ed.) → Teacher in Higher Secondary School
(1, 4, 11) → 88	(HS Arts, BA, MA) → Teacher in Higher Secondary School
(2, 6, 12, 77) → 88	(HS Commerce, B. Com, M. Com., B. Ed.) → Teacher in Higher Secondary School
(2, 6, 12) → 88	(HS Commerce, B. Com, M. Com.) → Teacher in Higher Secondary School
(3, 8, 10, 77) → 88	(HS Science, B. Sc., M. Sc., B. Ed.) → Teacher in Higher Secondary School
(3, 8, 10) → 88	(HS Science, B. Sc., M. Sc) → Teacher in Higher Secondary School
(3, 73) → 92	(HS Science, MBBS) → Doctor by Profession
(1, 4) → 93	(HS Arts, BA) → Group C Posts
(2, 6) → 93	(HS Commerce, B. Com) → Group C Posts
(3, 8) → 93	(HS Science, B. Sc.) → Group C Posts
(3, 62) → 94	(HS Science, Degree in Civil Engineering) → Group B Posts
(3, 64) → 94	(HS Science, Degree in Chemical Engineering) → Group B Posts
(3, 62) → 108	(HS Science, Degree in Civil Engineering) → Engineer
(3, 64) → 108	(HS Science, Degree in Chemical Engineering) → Engineer
(3, 62, 72) → 96	(HS Science, Degree in Civil Engineering, M.E./M. Tech.) → Scientist
(3, 64, 72) → 96	(HS Science, Degree in Chemical Engineering, M.E./M. Tech.) → Scientist
(1, 4, 82) → 132	(HS Arts, BA, LLB) → Lawyer
(2, 6, 82) → 132	(HS Commerce, B. Com, LLB) → Lawyer
(3, 8, 82) → 132	(HS Science, B. Sc., LLB) → Lawyer
(1, 4) → 95	(HS Arts, BA) → Group A Posts
(2, 6) → 95	(HS Commerce, B. Com) → Group A Posts

(3, 8) → 95	(HS Science, B. Sc.) → Group A Posts
(3, 62) → 95	(HS Science, Degree in Civil Engineering) → Group A Posts
(3, 64) → 95	(HS Science, Degree in Chemical Engineering) → Group A Posts
(3, 73) → 95	(HS Science, MBBS) → Group A Posts
(1, 4, 11) → 95	(HS Arts, BA, MA) → Group A Posts
(2, 6, 12) → 95	(HS Commerce, B. Com, M. Com.) → Group A Posts
(3, 8, 10) → 95	(HS Science, B. Sc., M. Sc.) → Group A Posts
(1, 4) → 99	(HS Arts, BA) → News Paper Editor
(1, 4, 11) → 99	(HS Arts, BA, MA) → News Paper Editor

Table 5: Different sets of qualifications required for a particular job

Name of job	Different sets of qualifications required	Name of job	Different sets of qualifications required
Teacher in High School	(HS Arts, BA, B. Ed.) (HS Arts, BA.) (HS Commerce, B. Com, B. Ed.) (HS Commerce, B. Com) (HS Science, B. Sc., B. Ed.) (HS Science, B. Sc..)	Teacher in Higher Secondary School	(HS Arts, BA, MA, B. Ed.) (HS Arts, BA, MA) (HS Commerce, B. Com, M. Com., B. Ed.) (HS Commerce, B. Com, M. Com.) (HS Science, B. Sc., M. Sc., B. Ed.) (HS Science, B. Sc., M. Sc)
Group B Posts	(HS Science, Degree in Civil Engineering) (HS Science, Degree in Chemical Engineering)	Group C Posts	(HS Arts, BA) → Group C Posts (HS Commerce, B. Com) → Group C Posts (HS Science, B. Sc.) → Group C Posts
Engineer	(HS Science, Degree in Civil Engineering) (HS Science, Degree in Chemical Engineering)	Lawyer	(HS Arts, BA, LLB) (HS Commerce, B. Com, LLB) (HS Science, B. Sc., LLB)
Group A Posts	(HS Arts, BA) (HS Commerce, B. Com) (HS Science, B. Sc.) (HS Science, Degree in Civil Engineering) (HS Science, Degree in Chemical Engineering) (HS Science, MBBS) (HS Arts, BA, MA) (HS Commerce, B. Com, M. Com.) (HS Science, B. Sc., M. Sc.)	Scientist	(HS Science, Degree in Civil Engineering, M.E./M. Tech.) (HS Science, Degree in Chemical Engineering, M.E./M. Tech.)
		News Paper Editor	(HS Arts, BA) (HS Arts, BA, MA)

Similarly there are different jobs for which the eligibility criteria are the same. In this case the discovered rules can be classified based on the identical antecedent and different consequents. These study helps in finding different career options for the candidates with a set of qualifications. These are shown in table 6 below.

Table 6: Different career options with a set of qualifications

Set of Qualifications	Name of Different Jobs	Set of Qualifications	Name of Different Jobs
(HS Science, B. Sc., B. Ed.)	Teacher in High School	(HS Science, B. Sc., M. Sc)	Teacher in Higher Secondary School , Group A Posts
(HS Arts, BA, MA)	Teacher in Higher Secondary School, Group A Posts, News Paper Editor	(HS Arts, BA, MA, B. Ed.)	Teacher in Higher Secondary School

(HS Commerce, B. Com, M. Com., B. Ed.)	Teacher in Higher Secondary School	(HS Commerce, B. Com, M. Com.)	Teacher in Higher Secondary School, Group A Posts
(HS Science, B. Sc., M. Sc., B. Ed.)	Teacher in Higher Secondary School	(HS Commerce, B. Com)	Teacher in High School, Group C Posts, Group A Posts
(HS Arts, BA.)	Teacher in High School, Group C Posts, Group A Posts, News Paper Editor	(HS Arts, BA, B. Ed.)	Teacher in High School
(HS Science, B. Sc.)	Teacher in High School, Group C Posts, Group A Posts	(HS Science, MBBS)	Group A Posts, Doctor by Profession
(HS Commerce, B. Com, B. Ed.)	Teacher in High School	(HS Arts, BA, LLB)	Lawyer
(HS Science, Degree in Civil Engineering)	Group A Posts , Group B Posts, Engineer	(HS Commerce, B. Com, LLB)	Lawyer
(HS Science, Degree in Chemical Engineering)	Group A Posts , Group B Posts, Engineer	(HS Science, B. Sc., LLB)	Lawyer
(HS Science, Degree in Civil Engineering, M.E./M. Tech.)	Scientist	(HS Science, Degree in Chemical Engineering, M.E./M. Tech.)	Scientist

V. IMPORTANCE OF JOB ELIGIBILITY AS ASSOCIATION RULES

The discovery of eligibility for jobs as association rules helps in finding different career options for the candidates with reference to their qualifications. Further, the work force required for national development needs to be remodelled based on education and training from time to time. This data mining approach can help people to take responsible decision relevant for seeking educational and career opportunities for fulfilling national and global need. The discovered information can also be utilized for expanding higher educational avenues to encompass conventional and possibly many unexplored fields for sustainable education system. This requires interaction of conventional academic and modern technological disciplines as well as academicians and practitioners without any geographical boundary. The data mining approach can deliver mechanisms for decision making for developing appropriate action plan so that prospective careers of the youth can be guided by giving them the opportunity to pursue appropriate career option for shaping their future. Such techniques based on analytics can be useful for planned engagement of the human resources. It is even required for guided public investments for higher education. This approach can be used to establishment of information services in the domain for ascertaining the requirements in various skill domains for the present and the future.

VI. FUTURE WORK AND CONCLUSION

In this paper, an association rule based model for discovering the eligibility criteria for jobs is proposed from related large datasets as part an information system based employment data analytics. The dataset for the job eligibility requirements are designed as transactions. The eligibility qualifications are represented in the antecedents of the association rules while the relevant job is represented in the consequent. Further, criteria for classification of rules are defined for analysing the discovered rules based on an input set of qualifications for finding different job options and also for finding people with different sets of qualifications doing the same job. The significance and importance of discovering such association rules are discussed.

As future work, on field data shall be collected through a survey and then the transaction data set shall be prepared for discovering the eligibility criteria for various kinds of jobs in the form of association rules by applying the apriori algorithm. Then out of a large number of rules discovered relevant rules shall be selected based on appropriate criterion and then interpreted for expressing the idea behind the approach. Further, association rules can be grouped together to find various kinds of jobs for which the same eligibility criteria are required. The reverse of this namely all the different sets of eligibility criteria which leads to doing the same job shall also be computed from the employment data set. In this case the rules with the same consequent but different antecedents are also grouped together. From these rules it is seen that how different sets of eligibility criteria leads to the same job.

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Author's Profile

Pankaj Kumar Deva Sarma is a Ph. D. in Computer Science from Gauhati University, India in Data Mining and Knowledge Discovery. He received the B.Sc (Honours) and M. Sc. Degrees in Physics from the University of Delhi, Delhi, India before receiving the Post Graduate Diploma in Computer Application and the M. Tech degree in Computer Science from New Delhi, India. He is currently an associate professor of Computer Science in the University Department of Computer Science at the Assam University, Silchar, India. His primary research interest is in algorithms, data base systems, data mining and knowledge discovery, parallel and distributed computing, artificial intelligence and neural network. He is life member of ISTE and IETE, New Delhi.

