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A Survey on Association Rule Mining Algorithms for Frequent Itemsets

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***Abstract*— These days many current data mining tasks are accomplished successfully only in discovery of Association rule. It appeals more attention in frequent pattern mining because of its wide applicability. Many researchers successfully presented several efficient algorithms with its performances in the area of rule generation. This paper mainly assembles a theoretical survey of the existing algorithms. Here author provides the considered Association rule mining algorithms by beginning an overview of some of the latest research works done on this area. Finally, discusses and concludes the merits and limitation.**

Keywords-Data Mining; Association rule; frequent pattern; algorithm

I. INTRODUCTION

One of the reasons behind maintaining any database is the Extensive amounts of knowledge and data stored to find interesting patterns and trends in the data. Since the increase in data volume causes difficulties in extracting useful information for decision support, databases demand the development of specialized tools for accessing the data, data analysis, knowledge discovery, and effective use of stored knowledge and data. The technologies developed in the area of Data Mining and knowledge discovery in databases are primarily behind and make the traditional manual data analysis become insufficient. It drives inventing innovative methods for efficient computer-based analysis.

Data mining involves the use of sophisticated data analysis tools to discover previously unknown, valid patterns and relationships in large data sets. These tools include statistical models, mathematical algorithms, and machine learning methods (algorithms that improve their performance automatically through experience, such as neural networks or decision trees). Consequently, data mining consists of more than collecting and managing data and also includes analysis and prediction.

Most of them frequently define the state of knowledge discovery in databases as a execution, that consists of: recognizing the domain, establishing the data set and cleaning the data, extracting the hidden data of regularities in thus formulating knowledge in the form of models or patterns, post processing of discovered knowledge, and finally exploiting the results.

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Data mining is used for a variety of purposes in both the private and public sectors. Industries such as banking, insurance, medicine, and retailing commonly use data mining to reduce costs, enhance research, and increase sales. For example, in a supermarket, the user can figure out which items are being sold most frequently. But this is not the only type of `trend' which one can possibly think of. The goal of database mining is to automate this process of finding interesting patterns and trends. Once this information is available, we can perhaps get rid of the original database. The output of the data-mining process should be a "summary" of the database. This goal is difficult to achieve due to the vagueness associated with the term `interesting'. The solution is to define various types of trends and to look for only those trends in the database. One such type constitutes the association rule.

Association rule mining is a very important research topic in the data mining field, it's problem in large databases is to generate all association rules [1], of the form X =>Y, that will produce strong association rules which satisfy both minimum support degree (min_sup) and the minimum confidence degree (min_conf) greater than the user defined minimum support and minimum confidence [2, 3, 4].

Definition 1: Let X={x1, x2 ….. xn} be a set of items, then $D = \{< T_{id}, T > | T \subseteq X\}$ is a transaction database, where T_{id} is an identifier which be associated with each transaction.

Definition 2: Let $A \subseteq X, B \subseteq X, and A \cap B = \phi$, we called $A \Rightarrow B$ as association rule.

Most of the algorithm generally has two steps execution. First, to find all sets of items that have support above the given minimum, and then generating the desired rules from these item sets. The apriori algorithm has come first, to find

all frequent itemsets, the other is generate strong association rules from frequent item sets during pruning [5].

The rest of the paper discusses as follows. Section 2 organizes basic concepts of data mining. Section 3 discusses different types and performance of Association Rules. It also discusses improved apriori algorithms in section 4. Section 5 organizes Fuzzy based association rule. Section 6 shows the finding of existing systems. Finally in Section 7, it comes to a conclusion by pointing out some related open problems.

II. DATA MINING

Data mining encompasses a broad set of technologies, including data warehousing, database management, data analysis algorithms, and visualization. The crux of the appeal for this new technology lies in the data analysis algorithms, since they provide automated mechanisms for sifting data and extracting useful information [6].

Hussain et al. (2000) presented a method for mining exception rules based on a new measure which estimates interestingness relative to its corresponding common sense rule and reference rule [7].

Liu et al. (1999) addressed the problem of finding weak patterns (i.e., reliable exceptions) from databases and proposed simple and efficient approach. Using deviation analysis to identify interesting exceptions and explore reliable ones, this is flexible in handling both subjective and objective exceptions [8].

CHEN Ning et al introduced an algorithm which is not only effective but also fast for discovering sequential knowledge based on set operations, avoiding multiple scans of the original databases. We use vertical database layout which stores transactions (customers) containing an itemset (sequence) into tidlists[3].

III. ASSOCIATION RULES

Association rule mining has attracted a great amount of interest since it is a hot area of data mining. A considerable number of algorithms for discovering association rules were proposed earlier.

HUANG Liusheng proposed a new algorithm BitMatrix that presented for discovering all significant association rules between items in a large database of transactions. Also it compared with the previously known algorithms, the Apriori and AprioriTid algorithms [2].

Jian Hu1 et al proposed in F-Forest, i.e suitable to parallel algorithm. A parallel mining model and parallel association rules mining algorithm, namely F-FDPM, are designed to accelerate association rules mining [4].

LIU Jun-qiang and PAN Yun-he et al proposed a hybrid approach that adapts search strategies, representations of projected transaction subsets, and projecting methods to the characteristics of the dataset. Efficient local pruning, global checking, and fast hashing methods are detailed in this research paper [9].

ZHOU Haofeng et al used the domain knowledge through the concept hierarchy, which displayed its flexibility. It also introduced the interestingness and algorithm that mines the rules with negative items, making the semantics of the association rules more complete than ever [10].

Assaf Schuster et al proposed to D-ARM algorithm that used the communication efficiency of the DDM algorithm to parallelize the single-scan sampling algorithm, its performance is unmatched by any previous algorithm. Scale-up experiments over standard synthetic benchmarks demonstrate stable run time regardless of the number of computers. [11].

Stephane Lallich et al proposed an innovating framework from which a unified view of a large number of interestingness measures can be constructed, and which clarifies some of the links between these measures [12].

Agrawal R et al proposed the sets of association rules are simple text lists. Each rule consists of a set of items for the antecedent, a set of items for the consequent, and the numerical values of two interestingness measures, support and confidence. Support is the proportion of records which verify a rule in the database; it evaluates the generality of the rule. Confidence (or conditional probability) is the proportion of records which verify the consequent among those which verify the antecedent; it evaluates the validity of the rule (success rate) [13].

V. Palanisamy et al proposed association rules of the form X → Y where X and Y are sets of items. The intuitive meaning of the rule X → Y is that transactions (e.g. supermarket baskets) containing set X of items tend to contain set Y of items [14].

V Kivi et al illustrated the relative information content between terms and locations by inspecting the principal associations that appear well aligned with neuroscience consensus. Meaningful relations between single terms and single locations appear from the many-to-many relationship between abstracts and sets of Talairach coordinates. The utility of this form of data mining is presently limited by the relatively small databases available [15].

Daniel Kunkle et al proposed in MFGI class and EGR class are both based on a conceptual classification tree (of g-itemsets or g-rules). The key to these approaches is the efficient dynamic generation and pruning of the classification trees [16].

Srikant and Agrawal (1996) proposed a method to mine association rules with quantitative and categorical attributes. This method deals with quantitative attribute by partitioning the values of the attribute and combining adjacent partitions as necessary. In addition, they introduced measures of partial completeness which quantify the information lost due to partitioning [17].

Brin et al. (1997) studied the correlations of association rules and proposed measuring significance of associations via the cm-squared test for correlation from classical statistics. Also enabling a measure that is upward closed in the itemsets lattice. This helps to narrow down the mining problem between correlated and uncorrelated itemsets in the lattice [18].

Yun et al. (2003) studied the tools discovering the association rules and proposed a technique discovering the association rules for significant rare data. It appeared infrequently in the database but highly associated with specific data. With the rapid development of data mining techniques and tools, many researchers become more focused on finding alternative patterns [1].

Padmanabhan and Tuzhilin proposed methods that could discover unexpected patterns in data by using domain knowledge in a systematic manner. They proposed new methods for revealing a minimal set of unexpected patterns that discover orders of magnitude fewer patterns and yet retain most of the truly interesting ones [5, 19, 20]

Zhou and Yau (2007) proposed two simple, practical and effective schemes to mine association rules among rare items. The algorithm can also be applied to frequent items with bounded length [21].

Wu et al. (2004) presented an efficient method for mining both positive and negative association rules in databases [22]. Yuan et al. (2002) studied negative association rules, respectively. He presented a rule discovery algorithm that found a useful subset of valid negative rules and employed a hierarchical graph-structured taxonomy of domain terms in generating negative rules. Also, quite a few researchers proposed fuzzy mining algorithms based on fuzzy set theory in recent years [23].

W. M. Ma et al.123 method extends traditional associations to include association rules, which indicate negative associations between itemsets. Hong et al. (1999) proposed a new data-mining algorithm for extracting interesting knowledge from transactions stored as quantitative values [24].

Zhang Tiejun et al presented and evaluated an efficient algorithm for mining frequent closed itemsets in transaction database. FCI-Miner adopts a novel data structure for compressing crucial information about frequent itemsets, which reduce the database greatly, and also uses an effective method to generate candidate itemsets and count their support without generating conditional FP-Trees [25].

Peng Gong et al introduce an improved Data Mining Association Rules Apriori Algorithm and its deployment to Shanhua group Cross-selling analysis. The deployment of the Apriori algorithm deletes lots of invalid business, reduces the records for the following scanning, which raises the efficiency of data mining. At the same time the scale of database also decrease. Consequently, the scanning time is saved and the processing efficiency is enhanced [26].

N.Balajiraja proposed a novel approach to integrate data mining model into multidimensional models in order to accomplish the conceptual design of Data Warehouse with Association Rules (AR). The main advantage is that the Association Rules rely on the goals and user requirements of the Data Warehouse, instead of the traditional method of specifying Association Rules by considering only the final database implementation structures such as tables, rows or columns [27].

Aruna J. Chamatkar and P.K. Butey provided a resultant table by evaluating four different algorithms and presented the performance analysis. The proposed Association rule mining algorithms such as IARM, GCBARM, MMLFAR, MFCBARM are considered as the improved methods with significant progress in performance evaluation [28].

N.Balajiraja and G.Balakrishnan proposed paper as a improved version of apriori algorithm that is focused on four features namely: 1) Data preparation and select the required data, 2) Generate itemsets that determines the rule constraints for knowledge, 3) Mine k-frequent itemsets using the new database and 4) Generate the proposed association rule that establishes the knowledge base and provide better results compared to existing method [29].

Monali Dey and Siddharth Swarup Rautaray, study the performance of the existing approaches for mining frequent closed itemsets and developed an algorithm, called FCFIA. It integrates two techniques in order to improve the efficiency of mining frequent closed itemsets [30].

M Patel et al proposed through in-depth study of the existing Apriori algorithm and its improved version, an Apriori optimization program is proposed [31].

Mohammed M. Mazid et al compared the performance of three popular Association Rule Mining algorithms: Apriori, Predictive Apriori and Tertius based on data characteristics. The accuracy measure is used as the performance measure for ranking the algorithms. A wide variety of Association Rule Mining algorithms can create a time consuming problem for choosing the most suitable one for performing the rule mining task [32].

IV. IMPROVED APRIORI ALGORITHM

LI Pingxiang CHEN et al proposed a method for mining association rules in large databases with association analysis and probability evaluation. This method explores efficient mining of association rules by probability evaluation. It scans the database again to refine the candidate frequent itemsets to the frequent itemsets [33].

WEI Yong-qing et al presented an improved algorithm in process of seeking the maximal frequent itemsets. It only needs to scan the database to complete the separation and statistics of the entire database [34]. After the scanning and counting the entire database, the system gets the candidate itemsets of all the business itemset {C1 C 2…… Ck}. Then

prune all the candidate itemsets according to the least supporting degree and the confident degree.

Huan Wu et al proposed an improved algorithm IAA is proposed based on the original Apriori algorithm. IAA adopts a new count-based method to prune candidate itemsets and uses generation record to reduce total data scan amount [35].

Parvinder S et al proposed an efficient approach based on weight factor and utility for effectual mining of significant association rules. The proposed approach exploits the anti-monotone property of the Apriori algorithm, which states that for a k-itemset to be frequent all (k-1) subsets of this itemset also have to be frequent. Subsequently, the set of association rules mined are subjected to weightage (W-gain) and utility (U-gain) constraints. For every association rule mined, a combined Utility Weighted Score (UW-Score) is computed. Ultimately, we determine a subset of valuable association rules based on the UW-Score computed [36].

V. FUZZY BASED ASSOCIATION RULES

Authors Hamid Mohamadlou Reza Ghodsi and Jafar Razmi' used fuzzy clustering to mining data in datasets. First cluster all transactions. Then each quantitative attributes is partitioned into fuzzy intervals, and a proposed algorithm is used to mining rules. This algorithm can be applied on the transformed fuzzy discrete datasets [37].

Wei-Min Ma et al proposed in addition to the support and confidence, a measure named dependence is employed as the third criterion to indicate that how interesting an association rule may be. The interest is measured based on the membership values of it belonging to the fuzzy stronger rule set and weaker rule set. With this fuzzy interest measure, the new framework provides much more flexibility than traditional methods to discover some potentially more interesting association rules [38]

Yue et al (2000) proposed a method to mine fuzzy association rules with weighted items. They introduced two new algorithms which made use of a metric called the k-support bound in the mining process to handle the problem. However, the downward closure property of the support measure in the unweighted case no longer existed [39].

Au and Chan (2005) presented the problem of mining changes in association rules and proposed to perform data mining in the discovered association rules so as to reveal the regularities governing how the rules change in different time periods and to use linguistic variables and linguistic terms to represent the changes in the discovered association rules [40].

Hu et al. (2003) proposed a new algorithm, named fuzzy grids-based rules mining algorithm, to generate fuzzy association rules from a relational database [41]. The algorithm consists of two phases: one to generate the large fuzzy grids and the other to generate the fuzzy association rules.

N.Balajiraja and G.Balakrishnan applied fuzzy concepts. First, basic need of valuable analysis for finding their inter relations of dataset, using the traditional graph theory approach and geometric characteristics of the underlying entities represent the vertices and edges. This method reprocess huge amount of date sets. The proposed algorithm named Graph and Cluster Based Association Rule Mining (GCBARM) [42].

N.Balajiraja and G.Balakrishnan adds that the raw text transaction dataset are converted into numeric sequence value, and is assigned for each attribute and removes noise and missing values. Then the converted sequence values are split and grouped equally. Each group has individual transaction ID. The MFCBARM method is scanning the transaction group dataset once and then creates a cluster table. After this process, it prunes and finds out minimum support for multiple level frequent item sets using encryption catalog table [43].

VI. FINDINGS OF EXISTING ALGORITHMS

The weak areas of these algorithms are identified as:

- Number of reads the database transaction n time data scans where n is the size of large nonempty itemset,
- It is not competent in utilizing the memory.
- The number of discovered rules is huge while most of them are uninteresting.

VII. CONCLUSION

In this paper, we provide a survey of research on mining data streams. This article focuses on how to improve the efficiency of association rule mining algorithm and have tried to cover both early and recent literature related to mining. This paper has said very limited, and many issues yet to be studied further. Moreover, we have addressed the merits and limitations and presented an overall analysis of the algorithms. It provides insights for end-users in applying or developing an appropriate algorithm for different streaming environments and various applications. We have also identified possible future research issues on mining algorithms. Mining techniques will then be very significant in order to conduct advanced analysis, such as determining trends and finding interesting patterns on streaming data. It is our intention to present this survey to simulate interests in utilizing and developing the previous studies into emerging applications.

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