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Association Rule Mining and Frequent Pattern Mining Applications on Crime Pattern Mining: A Comprehensive Survey

V R Sadasivam¹, Dr K Duraisamy², R Mani Bharathi³

Associate Professor, Department of IT, K.S.Rangasamy College of Technology, Tiruchengode, India¹

Dean, Academic Affairs, K.S.Rangasamy College of Technology, Tiruchengode, India²

P.G. Scholar, Department of IT, K.S.Rangasamy College of Technology, Tiruchengode India,³

ABSTRACT: Frequent pattern mining is a very big researched area in the area of data mining with wide range of application. Frequent itemset mining plays an important role in several data mining fields as association rules, correlations, classification, clustering, and warehousing. The Apriori and FP-growth algorithms are the most famous algorithms which is used in frequent pattern mining. Apriori algorithm is the classical and an important algorithm for mining frequent itemsets. Apriori is used to find all the frequent itemsets in a given database. This survey paper highlights the various frequent pattern mining and association rule mining application on crime pattern mining. Mining of the frequent patterns can be classified into two categories. The first category is the candidate generation; second category is without candidate generation and vertical layout approach. It also explains various pattern mining algorithms and how it can be applied to the various areas particularly in the field of crime pattern detection.

KEYWORDS: Association Rule Mining, Apriori, Crime Pattern mining, FPgrowth, Frequent Pattern Mining.

I. INTRODUCTION

Mining frequent patterns is an important aspect of data mining, which tries to identify patterns that appear frequently in data. Frequent pattern mining is a very big researched area in the area of data mining with wide range of application. Frequent itemset mining plays an important role in several data mining fields as association rules, correlations, classification, clustering, and warehousing. This chapter details about frequent pattern mining algorithm, types and extensions of frequent pattern mining, association rule mining algorithm, rule generation, suitable measures for rule generation. This chapter describes about various existing FPM algorithms, data mining algorithm for crime pattern. By applying frequent pattern mining algorithm and suitable measures, the proposed new algorithm is applied to crime dataset in order to find out the suspects in the short span of time.

Frequent pattern mining is the process of mining data in a set of items or some patterns from a large database. The resulted frequent set data supports the minimum support threshold. A frequent pattern is a pattern that occurs frequently in a dataset. A frequent item set should appear in all the transaction of that data base. Frequent pattern mining was first proposed by Agarwal et. al. [25] for market basket analysis in the form of association rule mining. Frequent Itemset mining came into existence where it is needed to discover useful patterns in customer's transaction database. A customer's transaction database is a sequence of transactions ($T=t_1\dots t_n$), where each transaction is an itemset ($t_i \subseteq I$). An itemset with k elements is called a k -itemset. An itemset is frequent if its support is greater than a support threshold, denoted by min supp. The frequent itemset problem is to find all frequent itemset in a given transaction database. The first and most important solution for finding frequent itemsets, is the Apriori algorithm. The fundamental frequent pattern algorithms are classified into three ways as follows:

1. Candidate generation approach (E.g. Apriori algorithm)
2. Without candidate generation approach (E.g. FPgrowth algorithm)

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3. Vertical layout approach (E.g. Eclat algorithm)

CANDIDATE GENERATION APPROACH

APRIORI ALGORITHM

Agrawal and Srikant (1994) developed the classical Apriori algorithm. Apriori algorithm is the most classical and important algorithm for mining frequent itemsets. This algorithm relies on generate and test approach and an important property: the Apriori property. This property is also known as anti-monotone property, and it is a basic pillar of the Apriori algorithm. It states that all non-empty subsets of a frequent itemset must be frequent. For example, if itemset 1,2,3 is a frequent itemset, then all of its subsets 1,2,3,1-2,2-3 and 1-3 must be frequent. In the other view, if an itemset is not frequent, then none of its supersets can be frequent. As a result, the list of potential frequent itemsets eventually gets smaller as mining progresses.

- Apriori property [14]: “All nonempty subsets of a frequent itemset must also be frequent”.

FREQUENT ITEMSETS WITH APRIORI

- Apriori algorithm is
 - A basic algorithm for finding frequent itemsets for boolean association rules
 - Based on levelwise search
 - o iteratively find frequent itemsets with size from 1 to k (k -itemset)
- Basic idea is to reduce the search space by using the Apriori principle:
 - any subset of a frequent itemset must be frequent
 - that is, if $\{AB\}$ is a frequent itemset, both $\{A\}$ and $\{B\}$ should be frequent itemsets
 -

WITHOUT CANDIDATE GENERATION APPROACH

FP GROWTH

The algorithm does not subscribe to the generate-and-test paradigms of Aprori. Instead, it encodes the data set using a compact data structure called FP-tree and extracts frequent itemsets directly from this structure. This algorithm is based upon the recursively divide and conquers strategy; first the set of frequent 1-itemset and their counts are discovered. Starting from each frequent pattern, construct the conditional pattern base, then its conditional FP-tree is constructed (which is a prefix tree.). Until the resulting FP-tree is empty, or contains only one single path. (Single path will generate all the combinations of its sub-paths, each of which is a frequent pattern). The items in each transaction are processed in L order. (i.e. items in the set were sorted based on their frequencies in the descending order to form a list).

WHY IS FREQUENT PATTERN GROWTH FAST?

- Performance study shows
 - FP-growth is an order of magnitude faster than Apriori, and is also faster than tree-projection
- Reasoning
 - No candidate generation, no candidate test
 - Use compact data structure
 - Eliminate repeated database scan
 - Basic operation is counting and FP-tree building

VERTICAL LAYOUT APPROACH

ECLAT ALGORITHM

Equivalence Class Clustering and bottom up Lattice Traversal is known as ECLAT algorithm. This ECLAT is also used in performing item set mining. It uses TID set intersection that is transaction id intersection to compute the support of a candidate item set for avoiding the generation of subsets that does not exist in the prefix tree. For each item store a list of transaction id. In this type of algorithm, for each frequent itemset i new database is created D_i . This can be done by finding “j” which is frequent corresponding to “I” together as a set then j is also added to the created database i.e. each frequent item is added to the output set. It uses the join step like the Apriori only for generating the

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candidate sets but as the items are arranged in ascending order of their support thus less amount of intersection is needed between the sets.

ECLAT PROPERTIES

- Candidate itemsets partitioned
- After partitioning, no communication
- Atmost 3 scans of the local database
- Intersection is more efficient than hash-tree
 - only necessary transactions are processed
 - locality
- Pipelined counting for frequent itemsets

II. ASSOCIATION RULE MINING

An association rule has two parts, an antecedent (if) and a consequent (then). An antecedent is an item found in the data. A consequent is an item that is found in combination with the antecedent. Association rules are created by analyzing data for frequent if/then patterns and using the criteria support and confidence to identify the most important relationships. Support is an indication of how frequently the items appear in the database. Confidence indicates the number of times the if/then statements have been found to be true.

In data mining, association rules are useful for analysing and predicting customer behavior. They play an important part in shopping basket data analysis, product clustering, catalog design and store layout. Programmers use association rules to build programs capable of machine learning. Machine learning is a type of artificial intelligence (AI) that seeks to build programs with the ability to become more efficient without being explicitly programmed.

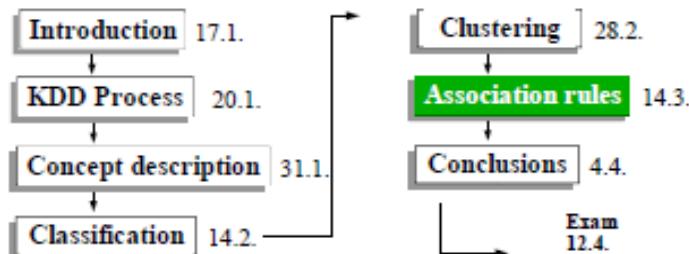


Fig. 1 Association Rules

ASSOCIATION RULE GENERATION

Association rule mining is a two-step process:

1. Find the frequent itemsets, i.e., the sets of items that have at least the minimum support s.
2. Use the frequent itemsets to generate (strong) association rules that satisfy the minimum support s and minimum confidence g.

TYPES OF ASSOCIATION RULE MINING

1. Positive Association Rule
2. Negative Association Rule
3. Constraint Based Association Rule

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III. APPLICATIONS OF FREQUENT PATTERN MINING & ASSOCIATION RULE GENERATION

Application includes market basket analysis and risk analysis in commercial environments, cross-marketing, catalog design, sale campaign analysis, Web log (click stream) analysis, DNA sequence analysis, loss-leader analysis, clustering, classification epidemiology, clinical medicine, fluid dynamics, astrophysics, crime prevention, and counter-terrorism.

DATA MINING AND CRIME PATTERNS

Crimes are a social nuisance and cost our society dearly in several ways. Any research that can help in solving crimes faster will pay for itself. About 10% of the criminals commit about 50% of the crimes. Data mining technology to design proactive services to reduce crime incidences in the police stations jurisdiction. Crime investigation has very significant role of police system in any country. Crime analysis can occur at various levels, including operational, and strategic tactical. Crime analysis study crime reports, arrests reports, and police calls for service to identify emerging patterns, series, and trends as quickly as possible. Crime analysis should be able to identify crime patterns quickly and in an efficient manner for future crime pattern detection and action. Crime information that has to be stored and analyzed, Problem of identifying techniques that can accurately analyse this growing volumes of crime data, Different structures used for recording crime data. Crime analysis employs data mining, crime mapping, statistics, research methods, desktop publishing, charting, presentation skills, critical thinking, and a solid understanding of criminal behavior. In this sense, a crime analyst serves as a combination of an information systems specialist, a statistician, a researcher, a criminologist, a journalist, and a planner for a local police department

CRIME PREVENTION THEORY

The traditional approach to crime prevention has been to try to identify the psychological and social causes of crime and to attempt to remedy these deficiencies by treating the individual offender and/or designing special educational, recreational and employment services for groups regarded as being at risk. The escalating crime rate suggests that this approach is not working. An alternative is 'situational crime prevention'. It rests on two assumptions: that the criminal is a rational decision maker who only goes ahead with a crime where the benefits outweigh the costs or risks; and that the 'opportunity' to commit a crime must be there. Situational crime prevention aims to remove the opportunity, and make the costs of a crime greater than the benefits. It includes various forms of target hardening to make the objects of crime less vulnerable (e.g. car steering column locks, deadlocks on dwelling doors, passenger and baggage screening at airports); Situational crime prevention places more responsibility on the individual for ensuring his or her own safety than does traditional law enforcement, but to succeed, it needs the co-operation of the police, public and private organisations and members of the community

IV. LITERATURE SURVEY

P.Dhakshinamoorthy, T.Kalaiselvan [1] states that main objective of the paper is to analyse the approach between the police department computer science department. Author implements pattern detection technique to solve the crimes faster in order to help the policemen. Author quoted the Jiawei Han and Michelin Kamber words as "Need is the mother of invention". The most three important needs of the police department are 1) Finding the solution for the unsolved crimes, 2) Solve the crimes at present in faster manner, 3) Predicting the future crimes. As a conclusion, data mining

Kadhim B. Swadi Al-Janabi [2] presents a proposed framework for the crime and criminal data analysis and detection using Decision tree Algorithms for data classification and simple KMeans algorithm for data clustering. The paper tends to help specialists in discovering patterns and trends, making forecasts, finding relationships and possible explanations, mapping criminal networks and identifying possible suspects. The classification technique is based mainly on grouping the crimes according to the type, location, time and other attributes and clustering is based on finding relationships between different Crime and Criminal attributes having some previously unknown common

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characteristics. The results of both classifications and Clustering are used for prediction of trends and behavior of the Crimes and Criminals.

Dawei Wang et. al. [3] proposed a spatial data mining framework to study crime hotspots through their related variables. Author used Geospatial Discriminative Patterns (GDPatterns) to capture the significant difference between two classes (hotspots and normal areas) in a geo-spatial dataset. Utilizing GDPatterns, a novel model was developed Hotspot Optimization Tool (HOT)—to improve the identification of crime hotspots. Finally, based on a similarity measure, GDPattern clusters were grouped and visualize the distribution and characteristics of crime related variables. The results of this approach was evaluated using a real world dataset collected

Javad Hosseinkhani et. al. [4] provides a review about mining useful information by means of Data mining. Author specified even though data mining can be applied to various fields, one of the crucial field is criminology where data mining utilized for identifying crime characteristics. Detecting and exploring crimes and investigating their relationship with criminals are involved in the analyzing crime process. Author reveals that criminology is a suitable field for using data mining techniques which shows the high volume and the complexity of relationships between crime datasets. The paper aims to provide useful information by means of Data Mining, so that crime hot spots are identified and crime trends are predicted.

S.Yamuna, N.Sudha Bhuvaneswari [5] proposed data mining techniques to analyze and predict the future crime. The prediction of future crime trends involves tracking crime rate changes from one year to the next and used data mining to project those changes into the future. The basic method involves cluster the states having the same crime trend and then using "next year" cluster information to classify records. This is combined with the state poverty data to create a classifier that will predict future crime trends. To the clustered results, a classification algorithm was applied to predict the future crime pattern. The classification was performed to find in which category a cluster would be in the next year. This allows us to build a predictive model on predicting next year's records using this year's data. The decision tree algorithm was used for this purpose. The generalized tree was used to predict the unknown crime trend for the next year. The experimental results proved that the technique used for prediction is accurate and fast.

Malathi. A, Lt. Dr. S. Santhosh Baboo [6] concerned that national security has been increased after Mumbai Taj Hotel attack on 26.11.2008. This was happened as a criminal and terrorist activities. So, to analyze and solve such kind of issues author applied data mining in the context of law enforcement and intelligence analysis. Author used clustering/classification based model to anticipate crime trends. The paper also carry various data mining approaches and techniques which can be applied for crime pattern and various analysis of city crime such as propertycrime, violent crime, crime against women and other crimes. The results of this data mining could potentially be used to lessen and even prevent crime for the forth coming years.

Goswami D.N., Chaturvedi Anshu., Raghuvanshi C.S. [7] proposed three different frequent pattern mining approaches that is Record filter, Intersection and Proposed algorithm which is based on classical Apriori algorithm. Author made comparative study by keeping dataset of 2000 transactions and as a result Record filter proved better than classical Apriori algorithm, Intersection approach proved better than Record filter approach and finally proposed algorithm proved that it is much better than other frequent pattern mining algorithm.

Revathy Krishnamurthy, J. Satheesh Kumar [8] present a detailed study on clustering techniques and its role on crime applications. Authors presents clustering one of the datamining technique to combine data objects into groups. The data objects within the group are very similar and very dissimilar as well when compared to objects to other groups. Authors whole ideas is this study will surely help the crime branch for better prediction and classification of crimes. It also helps the crime analysts and law enforcers to precede the case in the investigation and help solving unsolved crimes faster. Authors also presents partition clustering algorithm one of the best method for finding similarity measures.

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Dr. M. VijayaKumar 1, Dr. S. Karthick 2 and N.Prakash [8] proposed GIS system to grasp spatial and temporal patterns of crime offenses. GIS makes possible to reduce the crime and extend the security of residents. It offers a vital method that is identification of crime hotspots with a high crime rate. Spatial-Temporal crime analysis plays a fundamental role in lots of security related crime forecasting applications. Authors carried out the research by efficiently connecting spatial and temporal crime factors for repeated events in particular high density crime area. The main objective of the paper is to explore a combined approach of the spatial and temporal patterns of particular crimes and forecasting the results through simulation. Input has given from Tamil Nadu cases which is gathered from Chennai City.

Donald E. Brown [9] provides two technologies to turn data into information in order help the law enforcement agencies for handling large amount data and processed those data into useful information. Data fusion is the first technique which is used for organizing, combining and interpreting information from multiple sources and it also overcomes confusion from problematic reports, noisy backgrounds etc. Data mining is used to discover patterns and relationships with large databases.

Robin Singh Bhadaria, Rohit Bansal, Henry Alexander [10] developed a hyper structure based pattern growth method for frequent itemset mining from uncertain data and also developed a maximal clique based candidate pruning method for uncertain data. Author implemented and analyzed the performance of the well known algorithms for frequent itemset mining for both binary and uncertain data model. The outcome shows that in case of dense binary datasets, FP-growth outperforms all other algorithms, whereas in case of sparse data hyper structure based algorithm P-Hmin outperforms other algorithms.

M Suman , T Anuradha , K Gowtham, A Ramakrishna [11] proposed Apriori-Growth algorithm which is based on Apriori algorithm and FP-Growth algorithm. The advantage of the Apriori-Growth algorithm is that it doesn't need to generate conditional pattern bases and subconditional pattern tree recursively. The proposed Apriori Growth algorithm overcome the disadvantages of Apriori algorithm and efficiently mine association rules without generating candidate itemsets, and also the disadvantage of FP-Growth i.e. consumes more memory and performs badly with long pattern data sets.

Jian Pei, Jiawei Han, Hongjun Lu, Shojiro Nishio, Shiwei Tang, Dongqing Yang [12] proposed a simple and novel hyperlinked data structure, H-struct which overcomes some performance bottlenecks of the existing algorithm when mining databases with different data characteristics, such as dense vs. sparse, long vs. short, memory-based vs. disk-based, etc. The new mining algorithm, H-mine, works in a very limited and precisely predictable space overhead and runs really fast in memory-based setting. So, as a result the study shows that Hmine has high performance in various kinds of data, outperforms the previously developed algorithms in different settings, and is highly scalable in mining large databases.

Shyam Varan Nath [13] proposed an idea to solve crime detection problems using Data mining. Crimes are a social nuisance and cost our society dearly in several ways. Author look at the use of clustering algorithm (k-means clustering) to detect the crimes patterns and speed up the process of solving crimes. This clustering technique are applied to real crime data to validate the results. Author also used semi-supervised learning technique for knowledge discovery from the crime records to increase the predictive accuracy.

Anna L. Buczak , Christopher M. Gifford [14] are applied fuzzy association rule mining for community crime pattern discovery. Discovered rules are presented and considered at regional and national levels. To extract rare and novel rules from thousands of discovered rules, support metric was defined. It helps the law enforcement personnel to find out interesting and meaningful crime patterns rather than wasting time in uninteresting and rare (rules) patterns.

Divya Bansal, Lekha Bhambaru [15] explains the use of association rule mining in extracting pattern that occur frequently within a dataset. Association algorithm can be applied to the conversion of quantitative data into qualitative data. Author considers two Association Rule algorithms namely Apriori algorithm and Predictive Apriori algorithm.

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They implement Apriori algorithm in mining association rules from dataset of crime against women collected from session court and compares the result of both the algorithms using data mining tool called WEKA.

Aniruddha Kshirsagar, Lalit Dole [16] are used data mining methods to identify crime detection in both transaction domain and in application domain. Outlier detection is used which deviates from other observations. The authors gives the summary on how to find out and overcome fraud identity by using data mining techniques which helps in both transaction and credit card application domain in financial field.

Yagnik Ankur N., Dr .Ajay Shanker Singh [17] are presented a new method to detect outliers by discovering frequent pattern from the data set. The outliers are defined as the data transactions that contain less frequent pattern in their item sets. It can be applied to law enforcement to discover unusual patterns from multiple actions of an criminal entity, especially fraud committed in financial transactions, trading activity or insurance claims.

Malathi, Dr. S. Santhosh Baboo [18] are used missing values and clustering algorithm for crime data. They also concentrate on MV algorithm and Apriori algorithm with some enhancements in the process of filling missing value and to indentify crime patterns. They applied the above techniques to real crime data collected from city police department. They also used semi-supervised learning technique for knowledge discovery from the crime records in order to increase the accurate prediction.

V. OTHER AREAS

DIGITAL FORENSIC

K. K. Sindhu, B. B. Meshram [22] states about forensic analysis steps in the storage media, hidden data analysis in the file system, network forensic methods and cyber crime data mining Author proposes a new tool which is combination of digital forensic investigation and crime data mining. The proposed system is designed for finding motive, pattern of cyber attacks and counts of attack types happened during a period. The proposed tool enables the system administrators to minimize the system vulnerability.

CYBER ATTACKS

S.S.Garasia, D.P.Rana, R.G.Mehta [21] mentions about Botnet is one of the most widespread and serious threat in cyber-attacks. A botnet is a group of compromised computers which are remotely controlled by hackers to launch the various network attacks, such as DDoS attack, spam, click fraud, identity theft and information phishing. Recently malicious botnets evolve into HTTP botnets out of typical IRC botnets. Data mining algorithms can be used to automate detecting characteristics from large amount of data, which the conventional heuristics and signature based methods could not apply. Here, author presents a new technique for botnet detection that makes use of Timestamp and frequent pattern set generated by the Apriori algorithm. The main advantage of the proposed technique is that prior knowledge of Botnets like Botnet signature is not required to detect the malicious botnets.

NETWORK FORENSIC ANALYSIS

XIUYU ZHONG [20] proposed network forensic analysis by applying Apriori algorithm. To secure the products in the network against intrusion methods, network forensic is needed. The large number of data are captured and analyzed in network forensics and after capturing and filtering network data package, the Apriori algorithm is used to mine the association rules according to the evidence relevance to build and update signature database of offense, and further it reduce the number of matching times greatly and improve the efficiency of crime detection. Simulation results show that the application of Apriori algorithm can raise the speed, exactitude and intelligence of data analysis for network forensics, the application can help to resolve the real-time, efficient and adaptable problems in network forensics

BANKING SECTOR

Dr. K. Chitra, B. Subashini [24] presents data mining techniques and its applications in banking sectors like fraud prevention and detection, customer retention, marketing and risk management. Early data analysis techniques were oriented towards extracting quantitative and statistical data. These techniques facilitate useful data interpretations for the banking sector to avoid customer attrition. Customer retention is the most important factor to be analysed in today's

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competitive business environment. Fraud is a significant problem in banking sector. Also detecting and preventing fraud is difficult. With the help of data mining algorithms, it is able to detect suspicious activity within the data in a non prescriptive way. While the system observes the user's transactions, it discovers common behaviour patterns by the way of clustering. In order to discover anomalous transactions, new transactions are compared with the user's common behavior patterns. A transaction that does not correspond with one will be treated as a suspicious activity and thus precautionary steps can be taken in advance.

EDUCATIONAL AREA

Dr.Vijayalakshmi M N, S.Anupama Kumar, Kavyashree BN [23] presents the application of association mining on educational data to understand the knowledge and performance of students. Author implemented Apriori algorithm on student log data to bring out the interesting rules. Those rules can be used to infer the performance of the students and to impart the quality of education in the educational institutions. The algorithm generated frequent item sets using support measure in order to understand the interest of the students in the course. Interesting rules are generated based on frequent item sets using confidence factor of the dataset. The rule helps the tutor to understand the knowledge and performance of the students in answering the questionnaire and hence understand the interest of the students in the course.

VI. CONCLUSION

This paper presents the review on various research papers pertaining to applications of frequent patterns mining and association rule mining in the field of crime pattern detection. It gives knowledge about various frequent pattern mining algorithm and extensions of the same. It also explains about the different application areas where these frequent patterns can be used other than crime pattern. We sure that this paper will help the researches and data miners to obtain knowledge and reveals the advantages of applying frequent pattern mining algorithm along with rule mining in various fields.

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