International Journal of Innovative Research in the Humanities
Vol.1, NO.1 , P: 29 - 42
Received : 23 January 2021
Accepted : 28 March 2021

Application of data mining in identifying and discovering hidden patterns of theft

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Abstract
Crime prevention has always been one of the basic and important issues in human life that have been applied in various ways throughout history. Due to the development of information and communication technologies and the launch of comprehensive information systems in the police force and the registration of criminals' information in databases, the use of data mining techniques and knowledge discovery to analyze and track down crimes, including theft, is one of the necessities of the Iranian police and the judiciary. The main purpose of this study is to develop and present a data mining model that, by using existing crime databases and data mining tools and algorithms, can identify and detect crime patterns so that the police can predict the occurrence of crime and prevent the occurrence of crimes by more precise control of the forces and their military arrangement in the crime area. In the proposed model, two coupling rules with the former probability algorithm and clustering with the Chi-mean algorithm are used to extract the patterns from a database with more than one hundred thousand theft records. This paper's novelty can be mentioned as the methodology and the databank volume, consisting of thousands of cases.

Keywords: data mining, relational rules, crime patterns, data mining process

Introduction
the problem of crime and how to control it. Their main focus and policy in crime control have been increasing and professionalizing the police and judicial system [1]. The performance of governments in dealing with the crime has been allocating more money to judicial and police organizations, which has led to a rapid increase in budgets and staff at that time [2]. Creating security and peace in the society is not achieved only by resorting to criminal methods after the crime, but the government has to take measures before the crime to eliminate the conditions for its realization[3]. Perhaps the best model for understanding crime prevention is the perspective of reducing the opportunity to commit a crime in society[4]. The theorists of this model suggest that criminal behaviors are due to the existence of a suitable opportunity to commit a crime in a particular place and time, and the elimination or reduction of these opportunities should lead to a reduction of crimes in that place. In this model, the clearest view is how opportunity is the most important factor in committing or preventing a crime[5]. This model suggests that crime occurs more in areas where offenders are provoked due to a suitable

target and victim, and there is no guard to prevent the crime[1]. Today, information technology can play an effective role in judicial and police organizations by providing systems based on the above theories, considering the main factors and basic variables in the decision-making process[6]. Among the introduced technologies, data mining as a powerful tool in crime data analysis has an effective role in discovering the crime database pattern and knowledge in the decision-making process to reduce the opportunity to commit crime and control crime [7]. Undoubtedly, human social conditions have made confrontation with a phenomenon called crime inevitable, and human beings always need crime analysis knowledge. Crime analysis uses a systematic method to identify, detect and predict crimes [8]. In the following, some of the basic concepts of data mining and some of its techniques, and the basic principles of crime analysis are discussed. Then, some global experiences in crime data mining are discussed, and then the use of data mining techniques such as cloning rules and clustering to extract the behavioral patterns of criminals in practical ways is examined[8].

Elements of a Paper

Coherent rules in data mining

Knowledge discovery in a database is a process of identifying accurate, simple, useful, and finally comprehensible patterns and models in data. Data mining is a stage of the knowledge discovery process and includes its algorithms to consider acceptance discovers patterns and data models [9]. What is meant by a useful model here is a model in data that describes the relationship between a subset of data while being valid, simple, understandable, and new. Data mining is one of the most important methods by which useful patterns in the data with minimal user intervention are identified, and information is provided to users and analysts to make important and vital decisions in organizations[10]. Connection rules are one of the most important methods of data mining. This method may be considered the most common form of pattern discovery in non-supervisory learning systems [11]. This data mining method is most similar to people's behavior at the beginning of data mining, that is, "searching for gold within a very large database." Gold, in this case, means a rule that says something about the database that was not previously understood and now that it has been discovered is of great interest [9]. These methods find all possible patterns in the database.

On the one hand, discovered rules can be a strength because nothing has been explored; on the other hand, it is a weakness because the user will face many rules whose performance analysis is time-consuming and costly. Criteria such as support coefficient and reliability are used to discover better quality rules. The view of an associative rule is as follows, in which A, AB, and B are subsets of a set of repetitive items [12].

$$A => B \qquad (1)$$

Support factor: is the percentage of a set of transactions that includes both subsets A and B [13]. Reliability factor: Expresses the dependence ratio of a subset of repetitive items to a subset of other repetitive items and is calculated using the following equation [14]:

$$(A) /(A, B) =(A=>B) \qquad (2)$$

Kai Average Method

The Kai means algorithm is one of the simplest and most common algorithms used for clustering large data sets. This algorithm, which uses the square rhyme criterion for clustering, starts assigning samples to clusters with an initial and random division [15]. The similarity criterion 5 between

samples and clusters repeats allocating samples and calculating the average distance until the convergence criterion is met. It is normal for the algorithm to stop if it is impossible to separate any instance from one cluster and assign it to another cluster to reduce the error squares [16]. So far, many criteria have been proposed to validate the clustering answer. Milligan et al., Paul, and Biswas have proposed several criteria for evaluating the quality of different clustering methods. Here, the Davis Boldin index, which is one of the most important indicators for evaluating clustering results, is used to evaluate the results of clustering solutions. The Davis-Boldin index is defined as follows [17]

$$DB_{nc} = \frac{1}{n_c}\sum_{i=1}^{n_c} R_i$$
$$R_i = \max_{i=1,\ldots,n_{c,i\neq j}} R_{ij} \qquad (3)$$

In the above definition, DBnc is clear that DBnc is the average similarity between each cluster C (i = 1, ..., n) and the most similar cluster. DBnc is desirable for each cluster to have the least possible similarity with other clusters. Clustering that minimizes DBnc is optimal for this clustering index [18]. The DBnc index does not directly use the number of clusters in its equations. But like the Dan index, by plotting the DBnc function for several different clusters, the optimal number of clusters can be found at the DBnc minimization location [19].

Application of data mining in crimes

The sheer volume of crime-related data and information in the police department, on the one hand, and the complexity of the relationship between these crimes, on the other, make traditional crime analysis methods often used by experienced detectives and crime scene inspectors [9]. Firstly, they need to spend a lot of human time and money, and secondly, due to the high level of human factors involved in decisions, they cannot take into account all the influential factors in a crime and the relationships between them. Such a situation highlights the need to employ an information technology-based intelligence system to detect and solve crimes [11]. The complex nature of crime-related data and the intangible relationships between the inputs have led to the growing acceptance of data mining knowledge among criminologists and crime analysts. The knowledge obtained from applying data mining methods in crime analysis provides a suitable platform for commanders' and managers' informational support to carry out future police activities [17]. As Colin McQue, Project Manager of the Crime Analysis Unit at the Virginia Police Department puts it: Provide an infinite array of variables, which is far superior to what an analyst alone or even an analytical team or a joint combat team can scrutinize "[9]. In some countries, data mining methods and techniques have been used to predict and prevent the occurrence of crime, which is briefly described below. A researcher[18] used regression to predict cybercrime. Based on the results, the number of hours of computer use and membership in groups and Internet networks increased the rate of cybercrime and were introduced as the main variables predicting crime rate. A researcher [19] reviewed the application of data mining techniques in this field by introducing data mining as one of the most effective tools in cybercrime. This study examines a case study in Taiwan and discusses cybercrime and related issues. Finally, suggestions for dealing with cybercrime are provided. Research [20] presented a decision support model based on the SOM fuzzy technique for identifying and analyzing patterns and trends in crime occurrence. This model is implemented in data related to Taiwan International Police. The results obtained have been useful for police force managers in formulating crime prevention strategies.

West Virginia Police Lab has used a software tool called (Criminal Information Management System) to analyze crime data and obtain logical results by applying the principles of statistics and data mining algorithms[21]. Northamptonshire Police used legal data (fingerprints or DNA) and crime for this pilot project. The findings show that investigators can act according to their ability to collect DNA and fingerprints from the crime scene. It also increased their ability to predict which crime scene would provide the best opportunity to collect legal samples, which would not have been possible without them and with their ability[22]. A research team at the University of Sunderland (Center for Adaptive Systems) was commissioned to implement "Intelligent Software for Decision Makers." As a result, those projects developed tools for the direct use of data mining processes. Police were interested in investigating the recurrence of the victim[23]. The concept of victimization was first coined by Sparks, which means that places, where a crime has occurred once are disproportionately likely to occur again. For example, the probability of being stolen again after 28 days was one of the first thefts, which should be reduced to normal (after six months). After preparing the Inglis software, Ewart and Wilbert demonstrated a reduction in the time interval between successive thefts and property re-victimization [24]. In the aftermath of the 9/11 attacks, the CIA, the FBI, and other federal agencies decided to gather internal and external security information to prevent terrorist attacks. These efforts motivated local authorities to more closely control judicial crimes in their area. The main challenge for all law enforcement and data collection organizations is the accuracy and effectiveness of the increasing crime data analysis. Solving complex conspiracies is often difficult because suspects' information can vary geographically and extensively over long periods. Detecting cybercrime can also be difficult [25]. Project Over Involve West Midland Police in 2000 The main purpose of this system was to help manage and control the burglary rate (BDH) using decision support systems [17]. The Kaplin 4 project was implemented by researchers at the University of Arizona in collaboration with the Tuscan and Fulani Police Organization after 1997. This project aimed to provide a general framework for identifying and detecting various types of crime with crime data mining techniques. Each category shows a set of techniques for use in the analysis of some crimes [9]. They believe that their framework is generally applicable in crime analysis and intelligence analysis because it encompasses all major crime types, such as traditional and new intelligent data mining techniques [11]. Usually, the criminal justice database only records structured data embedded in predefined fields. Data mining's first task is to extract specific entities from police descriptive (fictional) reports that are difficult to analyze using automated techniques [17]. The U.S. Phoenix Police Department received a modified version of the AI entity extraction system that uses a three-step process to identify individuals, places, and organizations in a document. Suspects often use names, dates of birth, or addresses. Wrongly give to police officers. Therefore, they have different entries in the database, making it difficult for officers to identify the correct information and report past incidents in which they are involved or trapped. Tuscan police law enforcement officers could retrieve a suspect's existing identity records in the database using the Deceptive Tracking Detection Technique [19]. Criminals often develop networks that consist of groups or teams that engage in various illegal activities. The Tucson Police Organization sought to develop an effective network disruption strategy by expanding data mining

techniques to identify subgroups and key members of such networks and then study interaction patterns [17].

Methodology

In this section, a new method is presented to reach the desired knowledge from the relevant data. Since CRISP-DM3 is a global standard used in data mining projects, the research's executive structure is examined on this basis. Has been stated. The proposed model is based on the CRISP-DM standard, as shown in Figure 1[25]. Understanding the business issue: In this phase of the process, the main business objectives were first determined. In this article, the business's main objective (Greater Tehran Awareness Police) is to find hidden relationships in the relevant database to identify and discover the rules and patterns of the crime of theft. This is based on discovering hidden patterns between the characteristics of thieves and theft cases, about which information is stored in the system[19]. Recognition of data: The study's statistical population consists of data related to 102273 robbers who committed the crime of theft during the years 2010 to the end of 2020, and in the system, information related to their crime has been recorded[26]. Data Preparation: In the preparation process, to clear and preprocess the data, two important data reduction three and changes in the form of data must be performed on the relational database. At this stage, the data reduction operation (data deletion) was done manually in the database in the following two ways [3, 27]: Deleting the record (thief) due to incomplete information of thieves (does not have the authority to enter the final model, because it does not include the basic variables such as what type of crime the thief has committed and in which category of theft). After the preprocessing stage, some fields have been removed to apply the algorithm to the database, some fields have been added, and some fields have been changed. Some variables (characteristics of thieves) were not influential in the behavior of thieves. These fields in the Greater Tehran database include[28]: Identity information (name, surname, father's name, case number, identity card number, and certificate number) is the unit of confession, the unit of arrest, the type of appointment issued, and the judge's name. These fields were practically and conceptually unrelated to the thief's behavior and should be removed from the database[9]. After performing the data preparation step, fourteen characteristics described in Table 1 were used for modeling: Different modeling methods are selected and used at this stage. Typically, there are several methods for one type of data mining problem. To build the model, it is necessary first to select the modeling method, which in this research, the two operations of the clustering rules and clustering have been used. In this research, two clustering techniques and relational rules have been used. In the initial model first, all data were converted into eight clusters, and the output clusters were analyzed as shown in table 1.

Table 1. Properties used as input to the algorithm

Title	FIELD NAME
Type of crime	FK_CRIME_TYPE_ID
Occurrence mode	OCCURRENCE_SITUATION_ID
Defendant's trick	FK_TECHNIQUE_TYPE_ID
Place of crime	FK_OCCURRENCE_PLACE_ID

Gender	FK_SEXUALITY_ID
Level of education	FK_EDUCATION_ID
Marital status	FK_MARRIAGE_STATUS_ID
Month of crime	OCCURRENCE_MONTH
Age group	AGE_ID
Season of occurrence	OCCURRENCE_FASL
Half-year	OCCURRENCE_NIMSAL
Job	JOB
The time of the crime	OCCURRENCE_TIME
The occasion of a crime	OCCASION_OCCURRENCE_CRIME

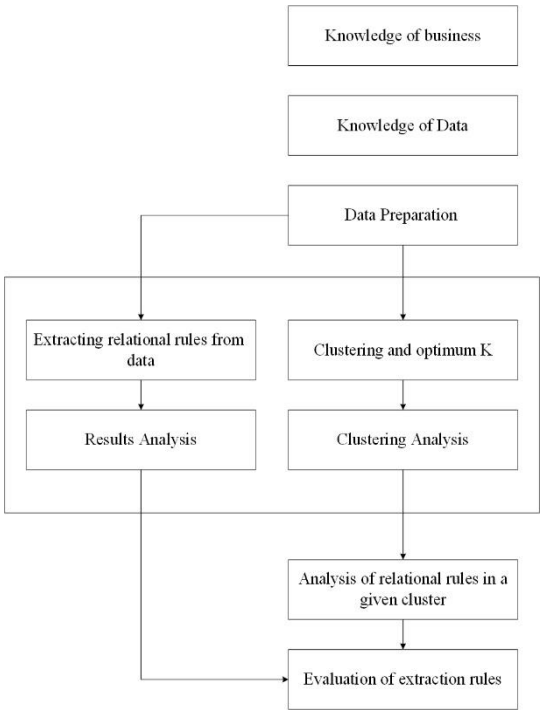

Figure 1. A data mining model is presented to identify the hidden rules of the crime of theft. Delete field (a feature of the thief or theft case)

Then, to extract the cluster rules, the previous probability operations were performed on the clusters. The initial model results in clustering all data and then executing the previous probability operations on each cluster[28]. The secondary model was built with the amount of support and the initial reliability. After the previous probability algorithm extracted the rules, the Greater Tehran Intelligence Police experts reported the results. These individuals identified among the extraction rules those that were beneficial to the organization. The third step is to compare the primary model's output results with the secondary model's output. Data were clustered using the mean chi-square method, and the following results were obtained. The Davis-Boldin index was used to evaluate the different clustering modes and select the best mode, and eight clusters were obtained as the best number of clusters for this data [29, 30].

Results and Discussion

The eight clusters obtained from the implementation of the Chi-mean algorithm are as shown in Table 2. According to Table 2, cluster one and cluster four are the same in all characteristics such as type of selected crime, gender, age group, occupation, time of year, year and occasion of the day of the crime, and crime technique [1]. The only difference between the people belonging to these two clusters is the thieves' marital status and the month of the crime in clusters one and four. Khusheh is a representative of two male thieves who committed theft in January 2005. Cluster five can be called pickpockets and pickpockets that steal in public on a public road [7]. Cluster Eight is for single, extortionate thieves who use violence, threatening and intimidating people, or sometimes causing beatings and injuries. Considering the two clusters of three and six, it can be seen that the only difference between these two clusters is the time of the crime and the marital status of the thieves. Cluster 7 includes male thieves who have committed robberies from government places such as banks, hospitals, shrines, and holy shrines under the cover of a water and electricity officer or a Basij force(see figure 2).

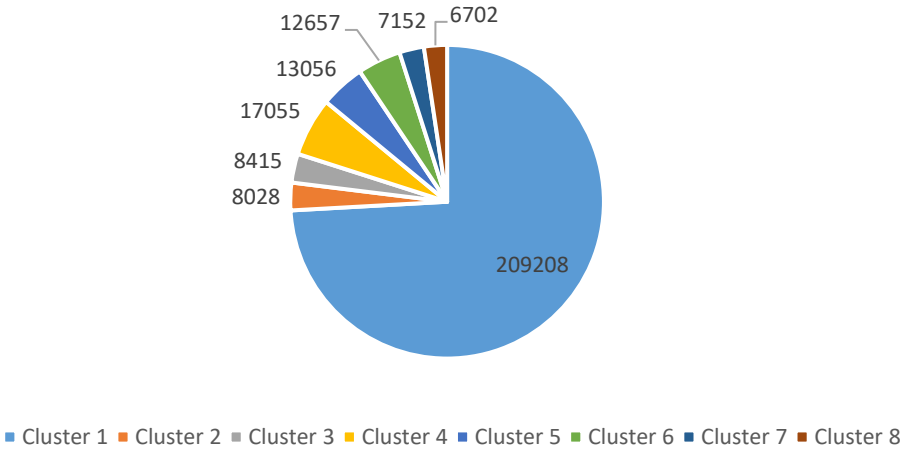

Figure 2. Records resulted from the Chi-mean method

Table 2. Eight clusters resulting from the implementation of the Chi-mean algorithm

Cluster name	Description of each cluster	A record number of information
Cluster 1	Single thieves of private places steal from private places such as workshops, warehouses, etc., in April.	209208
Cluster 2	Male thieves who committed a robbery in January 1984	8028
Cluster 3	Married house thieves who steal between 600 in the morning and 1200 at noon	8415
Cluster 4	Married thieves of private places who steal in May.	17055

Cluster 5	Pockets and briefcases that are stolen in public on a group basis.	13056
Cluster 6	Single burglars who steal between 1200 and 1600 hours.	12657
Cluster 7	Thieves of government places	7152
Cluster 8	Forced single thieves who rob by threatening or intimidating people or occasionally causing beatings and injuries	6702

In this section, the effect of combining two clustering algorithms and relational rules in improving the output results with the available data is investigated. For this purpose, at first, only a previous probabilistic algorithm 1, which is the coupling rules in data mining, models its data and examines the output rules, the accuracy, and validity of the rules [29]. Greater Tehran Awareness Police will be paid. The table below shows the extracted rules by specifying the minimum reliability coefficient and ten's support coefficient. According to the data in this table, the reliability coefficient in 26 rules of extraction rules is less than 50%, which means that the rules extracted by this method do not have very high validity. For this reason, in the next step, we are looking for another method that provides more valid rules. In this new integrated method, we use two methods of clustering and relational rules [30].

Table 3. Number and reliability of rules derived from the previous probability algorithm

Parameter	Value
Number of rules obtained	31
Number of rules with a confidence interval of 70 to 100%	2
Number of rules with a confidence interval of 50 to 70%	3
Number of rules with less than 50% confidence	26

According to the initial conditions, the same data of the first experiment is separated by one of the clustering techniques called the mean K, which was fully expressed in the previous step, and the resulting eight clusters are considered input for the previous probability algorithm [17]. Each cluster is executed with the previous probability algorithm, and the output rules of each cluster are analyzed, and its results are compared with the output of the previous probability algorithm alone. The table below shows combining the two algorithms of the previous probability and the mean K.

By comparing the two indices of reliability and support in the previous two cases, we find that in the first case, the coefficients of reliability and support in the extraction rules are low, and this is the opposite of the second case. Support is much higher than the first mode. The results are logical because in the first case, due to the heterogeneity of information records, the percentage of backups that the number of transactions in the database, which includes all precondition fields and results, is low compared to the total information records, as well as the percentage of certainty[20]. Prerequisite and result is the number of occurrences of a prerequisite part

in information records, which results in a lower percentage of reliability in this case. In the second case, using a clustering algorithm causes data segmentation in clusters where the similarity of information records within clusters is very large and different. There is a maximum between clusters, so the cluster data are more interconnected, which increases the percentage of reliability and the percentage of support in the latter case [21] (see figure 3).

Figure 3. Rules resulted from the method for each cluster

Table 4. Number and reliability of the rules resulting from the implementation of the previous probability algorithm on each of the clusters

Number of rules with less than 50% confidence	Number of rules with a confidence interval of 50 to 70%	Number of rules with a confidence interval of 70 to 100%	Number of rules obtained	Cluster number
121	5	39	165	1
13	5	29	47	2
25	--	41	66	3
129	--	22	151	4
60	11	130	201	5
37	10	30	77	6
29	6	30	65	7
20	52	29	101	8

Evaluation of results: At this stage of the project, a high-quality model from the point of view of data analysis is made. The rules extracted from the algorithm are considered as the knowledge extracted from the research. According to the extracted results, the experts' valid and useful rules were extracted from the algorithms and further studied.

Finally, the process is reviewed to ensure the accuracy of the operations performed. Using Model 1[19]: Creating a model is generally not the end of the project. Even if the model's goal is to enhance knowledge of the data; The acquired knowledge then needs to be organized and presented in a way that users can use. Depending on the job requirements, the deployment phase can be as simple as creating a report or as complex as running a reproducible data mining process.

In many cases, it is the operators who take steps to apply, not the data analysts. In this section, after obtaining the previous probability algorithm results, all the discovered rules were examined. In the following, some examples of its results will be examined. The effect of the building's shape on the commission of a burglary in burglary, identification, and selection of location is one of the most important and accurate tasks for the thief[22].

Table 5. The effect of building shape on home theft

Law	Factor
Villa houses burglary	Reliability=91.61% Support factor=18.99%
Apartment houses Home burglary	Reliability=11.67% Support factor=0.53%

In the above table, in the first law, the reliability coefficient of 91.64 percent means that 91.64 percent of burglaries have been in villa houses, and in the second law, which has a confidence coefficient of 11.67 percent, it shows that 11.67 percent of burglaries in apartment houses. It has been. What can be understood from the above table is that villa houses are more vulnerable to encroachment than apartments. According to home burglary experts, thieves usually choose southern homes for burglary because they enter the house immediately after removing the barrier. However, in northern homes, the status of entry and intrusion into the home is unknown to thieves, and there are more dangers for him. Apartment theft has its characteristics. Because of their closeness to each other, they are less likely to be robbed by professional thieves. Such places are mostly robbed by addicted thieves and so-called "thieves" who do not even hesitate to take a pair of shoes or clothes from the strap [30].

Table 6. The effect of gender on committing a gibberish crime

Law	Factor
Women pickpocket	Reliability=43.98% Support factor=3.31%
Men pickpocket	Reliability=26.57% Support factor=96.69%

The above table's first law's reliability coefficient is 43.98 percent, which means that 43.98 percent of women are pocket criminals in the available data. And this shows that the thieves are mostly women. The second law of the above table's reliability coefficient is 26.57%, which means that 26.57% of men are pickpockets in the available data. What can be seen from Table 6 is that the probability of pickpocketing by women is more than 1.5 times that of men. Pocket thieves are mostly women, and their prey is usually women who shop in stores or stand in different ranks [9]. On the other hand, due to police women's poor performance in Iran, the chances of arresting and trapping Berhizan's pocket are very low. This law was not already specified for the Greater Tehran Intelligence Police experts, but it did not contain any knowledge in this law and left an important point, seriously evaluated by them [11].

Table 7. The effect of the chapter on the crime of stealing car parts and contents

Law	Factor
Spring Stealing car parts and contents	Reliability=18.95% Support factor=27.71%
Winter Stealing car parts and contents	Reliability=17.63% Support factor=29.93%

The first law shows that 18.95% of the spring violations are theft of car parts and contents. The second law also shows that 17.63% of winter violations are theft of car parts and contents. According to Table 7, car contents are more likely to be stolen in the spring than in the winter. The goals of car thieves and the contents inside the car, which is generally fun, are usually more in good weather seasons such as spring and summer to steal the car and its contents (recording and distribution, changer, etc.). According to experts and experts from the Anti-Car Theft Office, most stolen cars are discovered in the north of the country, which usually young car thieves leave in those areas after satisfying their desires[19].

Table 8. Rules extracted from the previous probability robbery algorithm

Law	Factor
Threats of cold-blooded robbery	Reliability=44.54% Support factor=11.58%

According to the table above, with a probability of 44.54%, thieves use the technique of threatening with cold steel. Professional thieves always carry a firearm or a firearm so that they do not try to use it, and the reason is that the purpose of stealing equipment is not to engage in conflict and quarrel, and only to avoid using it.

Conclusion

In this research, using data mining and its algorithms, an attempt has been made to perform an accurate analysis of the mass data

in the database and help the relevant managers make decisions using the data's hidden patterns. In this article, using the two methods of coordination rules and clustering method, an attempt has been made to discover and make available to these tribes the requirements of managers. For example, some of the extracted patterns show that villas are more vulnerable to encroachment than apartments or that some of these rules indicate that women are more likely to be robbed. These patterns also show that the car contents are more likely to be stolen in the spring than in the winter. In this article, four useful rules out of fifty rules that were interpreted and approved by experts were stated. Of course, what is clear is that crime data mining is far more extensive than can be comprehensively presented in an article. Security is a national and sometimes regional and global issue, so the perpetrators of crime data mining are generally the claimants of security (the judiciary, the Ministry of Intelligence, the National Security Council, the police, and other relevant organizations). Depending on the type of crime, crime data mining can be discussed in the following contexts. With his studies in the field of literature on research, the researcher has provided future research suggestions, which are described below. All these researches help the managers of the relevant organizations to make more accurate and precise decisions using the knowledge extracted from the historical data of the organization:

1- Using combined methods and models of data mining and artificial intelligence to identify thieves who have the longest history of committing a crime;

2- Designing and creating an intelligent expert system that uses data mining techniques to predict the crime situation for criminals in the future;

3- Using the clustering technique on the association rules derived from the database to reduce the number of coupling rules and integrate similar extraction rules in the crime database and investigate the differences in the displacement of these two data mining methods (clustering and association rules).

4- Identifying crime scenes in terms of committing various crimes and contaminated areas in terms of dealing with stolen property with the help of spatial mining;

5- Using data mining to discover hidden connections between thieves, thieves, and stolen property.

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