

Research Article

Data Mining in the Application of Criminal Cases Based on Decision Tree

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Abstract: A briefing on data mining technology used in criminal investigation work and the importance of using ID3 decision tree to structure the Decision Tree algorithm method is given by this paper. It makes a combination of criminal cases criminal suspects training data sets, using its decision tree analysis of the classification and uses Microsoft SQL Server 2005 Office 2007 Add to the data mining of Visio 2007 graphics. It shows and shares the form of mining model.

Keywords: data mining; decision tree; ID3 algorithm; Visio 2007

INTRODUCTION

With the rapid development of politics, economy and scientific technology, modern crime shows its high-speed, intelligent and high-tech features. Judging from the overall trend of crime, we can observe that the crime case number increases significantly. Since 1949, there have been five peaks of crime. Particularly in the fifth peak, which emerged after the reform and opening up policy coming out. What's more, every crime wave brought new kinds of sins [1]. The rate of economic crimes, financial crimes and intelligent high-tech crimes rose dramatically – the high rising speed surpassed a vicious, primitive, human instinct of crime, while the proportion of major cases also has increased. Under such circumstances, it is an urgent problem for the police department to figure out how to employ the data mining technology in criminal investigation work, to discover new rules to improve efficiency and rapid responding capability of law enforcement, and to prevent and strike criminal actions in time [2]. Data mining will serve as a tool for the leaders and police officers of basic unit to find the hidden information.

Data Mining

Data Mining (DM) is the process of extracting useful information and knowledge from large quantities of structured and unstructured data, which is also an effective means of discovering knowledge [3]. Data mining sometimes is also known as knowledge discovering or knowledge extracting. Data mining sometimes can be defined as the process of extracting implicit, previously unknown and useful information and knowledge from large quantities of incomplete, noisy, ambiguous, random data for practical application. This definition includes the following layers of meanings: the data source must be real in large quantity; the information that is discovered must arouse the users' interests; the knowledge must be acceptable, understandable and applicable; the knowledge that is

discovered is required only to cover specific business problem.

In the process of data mining, the most important step is the data preprocessing, because there exist such bad data as noisy data, void data and inconsistent data due to the diversity and heterogeneity of historical data. The bad data must be cleaned up because they will affect the accuracy of data mining. And the secondary process is the correlation analysis since many properties of data may concern themselves with the data classification and mission prediction. For example, the height of the suspect may indicate the irrelevance with certain cases. Therefore, the relevance analysis can be conducted to delete irrelevant or redundant properties during the studying process. And at last, the process of data exchanging, which may generalize the data onto a higher level of concept. And the concept hierarchy can be used for this purpose. This step is very important for the property with continuous values. For example, the numeral value of the attribute of age may be generalized to the discrete intervals such as youth, middle-aged and old-aged. Similarly, the nominal values, such as domicile, can be generalized to high-level concepts, such as city.

ID3 decision tree algorithm

The basic algorithm of decision tree is greedy algorithm which makes use of recursion from the top down to construct the decision tree. In decision tree learning, ID3 (Iterative Dichotomiser 3) is a well-known algorithm used to generate a decision tree invented by Ross Quinlan. The ID3 algorithm can be summarized as follows [4]:

Algorithm: Generate_decision_tree. Generate a decision tree by given training data.

Input: samples (training samples) which are indicated by discrete attributes. attribute list which is the set of attributes.

Output: a decision tree.

METHOD

- Create a root node for the tree.
- If all samples are in the same class C ,then
- Return N as a leaf node and mark by class C.
- If attribute_list is null then
- Return N as a leaf node and mark by the commonest class of samples.// majority vote
- Set $GainMax = \max(Gain1, Gain2 \dots Gainm)$
if $(GainMax) < Criticality$ threshold (e.g.0.001).
- Return N as a leaf node and mark by the commonest class of samples.
- Select test_ attribute having the most information gain of the attribute_list.
- Make node N as test_ attribute.
- For each known value a_i of test_ attribute.//to divide samples
- Grow a branch by node N which meet test_ attribute= a_i .
- Set s_i a sample set of test_ attribute= a_i .
- If s_i is null then
- Add a leaf, mark by the commonest class of samples.
- Else add a return node by `Generate_decision_tree(s_i , attribute_list, test_ attribute)`.
End for
- Return N.

Make use of the attribute of the most information gain as the test_ attribute of current node in each node of the tree. The expression of information gain which is a measure of information in attributes is information entropy. The higher the information gain is, the larger the differences among the attributes are, and the stronger the capability of distinguishment is.

The method of information gain is as follows [5]

Set S be a set of s data samples. Suppose the attribute having m different values and define m different classes $C_i(i=1,2,\dots,m)$. S_i is the number of samples in C_i . The needing expected information of a giving sample can be given by formula (1) [6]

$$I(S_1, S_2, \dots, S_m) = - \sum_{i=1}^m P_i * \log(P_i) \quad (1)$$

In formula (1), P_i is probability that any sample belong to C_i . $P_i = |S_i|/|S|$, and 2 is the bottom of the logarithm because we use binary system to code the information.

The entropy of the subsets divided by A is as follows [7]

Set attribute A having V different values (a_1, a_2, \dots, a_v). Divide S into V subsets (S_1, S_2, \dots, S_v) among which S_j contains the samples of S while their values are a_j of A. If A is test attribute, the subsets correspond to the branch growing by nodes of set S. Suppose S_{ij} be the number of samples that are the subset s_j in class C_i . The entropy or the expected information of the subsets divided by A is:

$$E(A) = \sum((S_{1j} + \dots + S_{mj}) / S) * I(S_{1j}, \dots, S_{mj}) \quad (2)$$

In formula (2), $(S_{1j} + \dots + S_{mj}) / S$ serves as the authority of the j th subset, and equals to the number of the samples in subsets dividing the total of samples in S. The smaller the entropy is, the higher the pureness of divided subsets is.

$$I(S_{1j}, \dots, S_{mj}) = - \sum_{i=1}^m P_{ij} * \log(P_{ij}) \quad (3)$$

In formula (3), $P_{ij} = S_{ij}/|S_j|$ is probability that samples in S_j belong to C_i .

Information gain:

$$Gain(A) = I(S_1, S_2, \dots, S_m) - E(A) \quad (4)$$

ID3 algorithm in the work of criminal cases

Here is an example of decision tree classification algorithm. A certain area criminal cases training data sets listed as table 1.

From table 1, the attribute of the sample sets is “criminal level” which has two values as light and serious. Set C1 corresponding to light and C2 corresponding to serious. There are 9 samples in C1 while 6 samples in C2. To compute the information gain of each attribute, we should compute the needing expected information of the given sample classes.

$$I(S_1, S_2) = I(9, 6) = -(9/15) * \log(9/15) - (6/15) * \log(6/15) = 0.971$$

Table 1: A certain area criminal cases training data sets

No.	Family background	Criminal experience	Specialty	Foreigner	Criminal level
R01	middle	yes	yes	yes	light
R02	poor	no	yes	yes	serious
R03	poor	no	yes	yes	serious
R04	middle	yes	no	yes	light
R05	poor	no	no	no	serious
R06	poor	no	no	yes	light
R07	middle	no	yes	no	light
R08	poor	yes	yes	no	serious
R09	middle	yes	no	yes	light
R10	middle	no	no	yes	light
R11	poor	no	yes	no	serious
R12	poor	yes	no	yes	light
R13	poor	yes	no	yes	light
R14	poor	no	no	no	serious
R15	middle	no	no	yes	light

Next, compute information entropy of each attribute. Let's begin at "family background" and observe the distributions of light and serious. Then compute the expected information in connection with each distribution.

Family background = "middle", S11=6, S21=0, $I(S11,S21)=0$

Family background = "poor", S12=3, S22=6, $I(S12,S22)=0.918$

If samples are divided according to family background, the needing expected information of the given sample classes is:

$$E(\text{family background}) = (0/15)*I(S11,S21) + (9/15)*I(S12,S22) = 0.551$$

The information gain:

$$\text{Gain}(\text{family background}) = I(S1,S2) - E(\text{family background}) = 0.420$$

The similar computation:

$$\text{Gain}(\text{criminal experiences or not}) = 0.116$$

$$\text{Gain}(\text{specialty or not}) = 0.146$$

$$\text{Gain}(\text{foreigner or not}) = 0.249$$

In this way, Gain ("family background") has the largest value. It shows this attribution perform an important function in composing data to subclasses. We can create the first node "family background" and divide it to two parts, and so forth, we can get fig. 1 as follows.

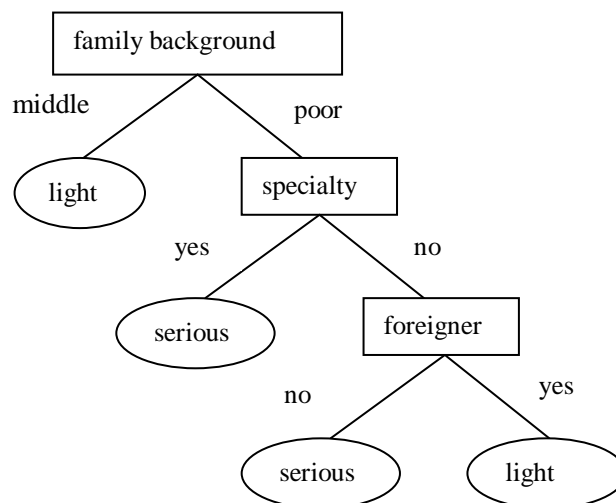


Fig. 1: criminal cases based on Decision Tree

From fig. 1, we can see one rule created in each route from root to leaf. When the family background is good, the criminal level of the suspect is light; when the family background is poor and he is foreigner having no specialty, the criminal level of the suspect is light; when the family background is poor and he has specialty, the criminal level of the suspect is serious; when one has specialty and he is native, the criminal level of the suspect is serious too.

RESULTS

Office 2007 Visio is data mining template which has the function of prediction and analysis. Using Microsoft SQL Server 2005 Office 2007 data mining external connection program and the draw form of Office Visio 2007, the results of DM based on decision tree can be appeared and shared as Fig. 2 below [8]

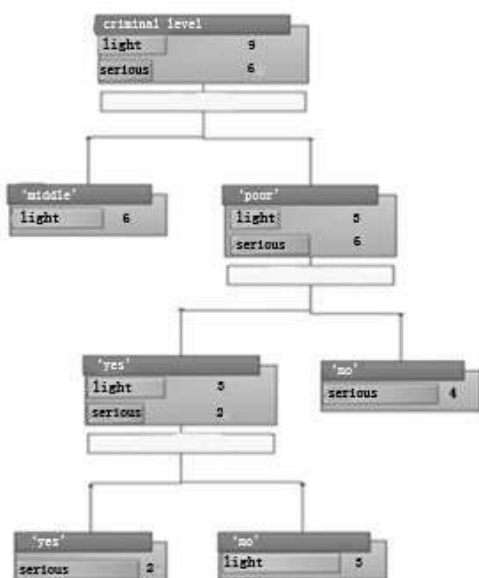


Fig. 2: Results of DM based on Decision Tree

CONCLUSION

Data mining technology is a new kind of science. Its effective application in the criminal investigation is the trend of times and the necessity of the public security work. In face of information sea, Data mining application in criminal cases can help to pick out the intelligence that reflects the security situation timely, comprehensively and accurately, and the intelligent staff will be freed from the massive statistic work, so they can devote more energy and time to focusing on information analysis, which will bring much more improvement to the judgment and efficiency.

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