Mutiple Driving Behavior Analysis

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Abstract—this article hopes to learn rules of driver behavior habit, which is useful for early warning. Those rules are divided into single behavior rules and multiple behavior rules. C4.5 is used to learn single behavior rules; resolution principle and correlation principle are combined and used to learn multiple behavior rules. At last rules that have conflict are filtered by a multi-attribute compositional method. Experiments show that the obtained rules are both efficient and comprehensive.

Keywords-C4.5;resolution principle; correlation principle; filtering rules

I. INTRODUCTION


This paper divides driving behavior into single behavior and multi-behavior. Firstly, we use resolution principle to extract multi-behavior rules. Then, we use C4.5 to extract the single behavior rule. At last, conflict resolution is solved in a multi-attribute compositional method. By this way, we can study driver’s usual behavior, and warn him when his behavior is unusual.

II. REALIZE METHOD AND DATA STRUCTURE

Driving Simulator is used in our experiment which can set the experiment condition and safer. Data structure is as followed: 5 behavior attributes are used to describe driver’s behavior. 10 status attributes describe driver’s behavior. 10 status attributes describe driver’s behavior.

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**TABLE I** RAW DATA SET

<table>
<thead>
<tr>
<th>No.</th>
<th>x1</th>
<th>x2</th>
<th>x3</th>
<th>x4</th>
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<th>x8</th>
<th>x9</th>
<th>y1</th>
<th>y2</th>
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</table>

1) Table I is raw data set, for us to get combination of behavior. For example, if we should definite combination behavior of y1 and y3, we select sub-column y1 and y3.

2) Using formula (1) to calculate the most relative attributes. As result, we get a result that x2, x3, x6, x7, x8, x9 are relative to y1 and y3.

3) Get column x2, x3, x6, x7, x8, x9, y1, y3 to create new table T'. where y1=1, y3=1, we get sub-table T'' (TABLE II)

**TABLE II** T'' IS SINGLE BEHAVIOR SUB-TABLE OF T'

<table>
<thead>
<tr>
<th>No.</th>
<th>x2</th>
<th>x3</th>
<th>x6</th>
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</table>

4) Attribute x2 value in row 1 and row 3 is different, this mean no matter what the value of x2 is, y1=1, y3=1 always set up. By the same way, attribute x3 and x6 can be filtered. The result rule is: if (x2=1) and (x3=1) and (x6=1) then (y1=1) and (y3=1) 

IV. USING C4.5 TO CALCULATE SINGLE BEHAVIOR

C4.5 gains ratio from information to calculate the decision tree and then turn the tree into rules. ID3 can lead to decision tree too, but in ID3, the attribute which has multiple values has much bigger entropy. In our case, because attribute x5-x10 has multiple value, we use C4.5 instead of ID3. In this way we can get trees about y1-y4 more accurately.

The step is as followed:

1. T is training set, attribute C has m value, C=C1,C2,...,Cm.
2. If the frequency of C is p1, p2,...,pm, then entropy of set T is
   \[ \text{Entropy} (S) = \sum_{i=1}^{m} p_i \log_2 p_i \]  
   (3)

3. If we divide the training set T with attribute A, information gain ratio based on A is calculated as follows:
   a) If attribute A has K different values, then A will divide set S into K sub-set \( S_1, S_2, ..., S_K \), information entropy of A is
   \[ \text{Entropy}_A (S) = \sum_{i=1}^{K} \left| S_i \right| \frac{\text{Entropy} (S_i)}{|S|} \]  
   (4)

   Here \( |S_i| \) and \( |S| \) is the count of set \( S_i \) and S.

   b) Information gain of A is:
   \[ \text{Gain}(A) = \text{Entropy}(S) - \text{Entropy}_A(S) \]  
   (5)

   c) Split information of A is:
   \[ \text{SplitInfo}(S) = \sum_{i=1}^{K} \left| S_i \right| \log_2 \left( \frac{|S_i|}{|S|} \right) \]  
   (6)

   d) Information gain ratio is:
   \[ \text{GainRatio}(A) = \frac{\text{Gain}(A)}{\text{SplitInfo}(A)} \]  
   (7)

4. After calculating information gain ratio of each attribute, we select the attribute that has biggest information gain ratio as the root of decision tree. Then divide the tree by this attribute value. By this way, set T is divided to sub-set \( T_1, T_2, ..., T_m \) for each sub-set repeat 2)-4), till every attribute don’t have any child in this sub-set.

For example, we get Figure 1 decision tree of y4: The tree in Figure 1 can be changed to rules.

Figure 1: decision tree

- If (x3=0) and (x9=0) then y4=0
- If (x3=0) and (x9=1) then y4=1
- If (x3=1) and (x4=0) then y4=1
- If (x3=1) and (x4=1) and (x8=0) then y4=1
- If (x3=1) and (x4=1) and (x8=1) the y4=0
- If (x3=1) and (x4=1) and (x8=0) the y4=0

V. RULE CONFLICT RESOLUTION

In the experiment we find some conflicts between rules.

1) Decision tree some time become partly best instead of overall best, we call this overfitting. The rules fit better in training set than in test set.

2) Rules got from different method perhaps conflict.
   a) When the rule has same conclusion, as it’s
   b) When the rule has different conclusion, as it’s
prerequisite is different, such as: “if p and q then r”; “if p and ~q then r”, we can get rule “if p then r”.

b) “if p then q” and “if p then ~q”, there is contradiction.

c) If two rules have same conclusion, but one’s prerequisite is included in the other’s, we call rule 1 is sub-rule of rule 2.

We show the way to solve the problem in 1), b) and c) through an example. We use the method based on multi-attribute compositional as in Table 4 shows: There are 10 records in test set in table 4, and now we get a rule: if x1=0 and x3=1 and x4=1 then y1=1; in table 4,”+” represent positive record (record fitting this rule), “-” represent negative record, there are 3 positive records, and 2 negative records, so the rule’s precision is 3/5, if we put off x1 from the rule, the rule becomes”if x3=1 and x4=1 then y1=1”, the new rule’s precision turns to 4/7. In table III, after putting off x3 and x4, we get the best precision (5/7), then at last the rule become “if x1 then y1”.

VI. EXPERIMENTAL RESULTS

We have collected 100-1000 action and status records from drivers and divide them equally to a train set and a test set. Experiment result base on ID3, Bayes and our method shows as Figure 2.

![Figure 2. accuracy rate](image)

The accuracy of Bayes is lower when there are less test records. But its curve is smoothing, and the accuracy increases rapidly.

ID3’s curve fluctuates. And with the train set increase, accuracy increases.

Although our method also curve fluctuates, it is better than ID3 on precision. It performs better than Bays when there is less data. Our method is the best overall.

VII. CONCLUSION

The innovations of this paper are:

1) Using C4.5 to solve attribute problem, this method is more accurate than ID3.

2) Using resolution principle to extract multi-behavior rules

3) Use method based on multi-attribute compositional to solve conflict between rules.

ACKNOWLEDGMENT

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REFERENCES


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