The Research of Method Situation Assessment in Robot-Soccer Games Based on Conditional Event Algebra

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Abstract—This paper mainly research on the situation assessment method. Since the situation assessment plays a key role in decision-making system, and the correct and effective intelligent decision has a direct decisive effect on winning in football matches. By using the Bayesian network framework to express the relation between events, and combining Conditional Event Algebra for logical reasoning, this paper firstly introduced the basic principle and property about CEA and product space conditional event algebra (PSCEA). And then a new situation assessment method is proposed in situation assessment module to address the incompatible problem between the probability and the logic. The experimental result shows that this new situation assessment method has more intelligent, efficient.

Index Terms—Conditional event algebra; Situation assessment.

I. INTRODUCTION

As the rapid development of Robot Soccer InTechnology, the demand of robots’ intelligence is more and more high. Situation assessment, which plays an important role in making an accurate and intelligent judgment on field, is an assessment processing for the arrangement of robots and the dynamic situation in the field by assessing and analyzing the activity of robots. Up to now, the domestic research departments haven’t an agreement in the definition of the Situation assessment. In this paper, we research the Situation Assessment based on Conditional Event Algebra (CEA). CEA has wide application prospects in the field of data fusion, for it can solve the incompatible problem between the probability and the logic. The paper firstly introduced the basic principle and property about CEA and product space conditional event algebra (PSCEA), then proposes method of situation assessment in Robot-Soccer Games based on CEA.

II. CEA

A. The Definition of CEA

Let \((\Omega, B, P)\) be a given probability space, \(\Omega\) a sample space, \(B\) a fixed event domain in the space \(\Omega\), and \(P\) a certain probability measure. For \(s \in B\), \(p(s)\) defined on the subsets of \(\Omega\), that satisfies the following properties[1-3]:

- \(p(\Phi) = 0\), \(p(\Omega) = 1\)
- \(p(s \cup \cdots \cup s_n) = p(s_1) + \cdots + p(s_n)\)
- The set of all conditional events is a Boolean algebra set with logic connectives \(\lor\), \(\land\) and \(\neg\).
- \((s | \Omega) = s\)
- Any probability measure \(P\) defined on the events of \(\Omega\) can be uniquely extended a probability measure \(P_0\) on conditional events such that \(P_0((S | X)) = p(S | X)\)
- \((S | X) \land X = (S | X)\)

B. The definition and properties of PSCEA

Let \((\Omega, B, P)\) be a given probability space. Given no condition events \(a, b, c, d \cdots\), then constructing an extended production probability measurable space \((\Omega, B_a, P_a)\) [4-5]

\[\Omega_a = \Omega \times \Omega \times K, P_0\] is probability measure in the space and \(B_a\) is a Boolean algebra or \(\sigma\)-algebra. So

\[(a | b) = ((a \land b) \times \Omega_a) \lor ((b' \land a \land b) \times \Omega_a) \lor (b' \lor a \land b) \times \Omega_a) \lor (b' \land b \land (a \land b) \times \Omega_a) \cdots (1)\]

Given a function \(f : B \times B \rightarrow B_a\), for all \(f\) are defined as[5]

\[f(a, b) = ab \lor (b' \land ab) \lor (b' \land b) \land ab) \lor \cdots\]

\[P_0(f(a, b)) = P_0(ab) + P(b')P(ab) + P(b')^2P(ab) + \cdots = P(ab) + \sum_{j \geq 1} P(b')^j\]

\[= P(ab) - \frac{1}{1 - P(b')} = P(ab) - \frac{P(ab)}{P(b)} = P(a | b)\] (2)

According to above definition, In \(R\), for any probability space
measure $P$, $P_0(a \mid b) = P(a \mid b) \cdot (\Omega_e, B_a, P_0)$ extends $(\Omega, B, P)$ and $P_0$ extends $P$ [6].

III. THE METHOD OF SITUATION ASSESSMENT BASED ON CEA

The higher-order condition event “if if $b_1$ then $a_1$ and if $b_2$ then $a_2$ then if $d$ then $c$ ” can be expressed as the scheme [7]

$$G = [(a \mid b)_1; (c \mid d)] \quad (3)$$

The $a_j, b_j, c, d$ in Eq.(3) are events under Boolean algebra, $(a \mid b)_j$ expresses $(a_j \mid b_j)$, and $P$ is a function denoted as $P: B \rightarrow [0,1]$. $(a \mid b)_j$ is a set of given rules or casual relations, $(c \mid d)$ is inferred condition from $(a \mid b)_j$. According to CEA, $G$ can be denoted as a set of conjunction events [7]:

$$A(G) = \bigcap \{a_j \mid b_j, a_j \times b_j, b_j\} \bigcap \{cd, c'd, d'\}$$

$$= \{w_{j1}, \cdots, w_{jm+1}\} \quad (4)$$

If no conjunction were null then $m = 3 \cdot \text{card}(J)+1 - 1, J$ is the collection of all $j$ in $(a_j \mid b_j)_{j \in J}$, card(J) is dimension of set $J$. According to Eq. (2),

$$G = [(a \mid b)_j; (c \mid d)]$$

$$= \{w_1, \cdots, w_m\}$$

Form Eq. (5), for any function $f$ in $A(G)$, there exists one and only index set $I(f)$ in $\{1, \cdots, m, m+1\}$. For any probability measure $P : B \rightarrow [0,1]$, and

$$p((a \mid b)_j; (c \mid d)) = P(A(G))$$

$$= P_0(f(a_j \mid b_j, c, d))$$

$$= \sum P(w_j), j \in I(f) \quad [8]$$

So, calculating the value of $G$ is equal to calculating the probability measure of $w_1, \cdots, w_{m+1}$ events in tradition probability space. We calculates the value of $P(w_1), \cdots, P(w_{m+1})$ [9] and sum up. Then we get the value of $P((a \mid b)_j; (c \mid d))$.

Given the scheme $G = [(a \mid b)_j; (c \mid d)]$ and corresponding Bias network, see from Fig. 1, then calculate the value of $p((a \mid b)_j; (c \mid d))$. This is the steps of Bayes Logic reasoning algorithm [10-12] based on CEA:

1. **Step1:** The question that we needed to solve is denoted by the higher-order condition event $G = [(a \mid b)_j; (c \mid d)]$.

2. **Step2:** Turn higher-order condition event $G$ into the joins among events $w_1, \cdots, w_{m+1}$ by applying the CEA properties.

3. **Step3:** Calculate the values of $P(w_1), \cdots, P(w_{m+1})$.

4. **Step4:** sum up $P(w_1), \cdots, P(w_{m+1})$.

In the algorithm mentioned above, step 3 is executed as following: Let $G_j = [(a \mid b)_j; (c \mid d)]$. According to Eq. (4),

$$A(G_j) = \{a_j \times b_j, a_j \times b_j, b_j\} \bigcap \{c'd, d'\}$$

$$= \{w_{j1}, \cdots, w_{j2}\} \quad (6)$$

So we need to calculate the value of $P(w_j)$. Take calculating the value of $P(w_1)$ for example.

$$P(w_j) = P(a_j, b_j, c, d)$$

So we can calculate the values of $P(a_j \mid b_j), P(d \mid a_j, b_j), P(c \mid a_j, b_j, d)$, then calculate the value of $P(A(G))$.

IV. THE APPLICATION OF THE METHOD OF SITUATION ASSESSMENT

If you are using Word, use either the Microsoft Equation Editor or the MathType add-on (http://www.mathtype.com) for equations in your paper (Insert | Object | Create New | Microsoft Equation or MathType Equation). “Float over text” should not be selected.

The environment of Robot Football Game is dynamic and continuous, so the factors influencing the situation are so many. This paper chooses three most important factors, a is the factor of distance that compare the distance between our team and opposite team to the football. $b$ is the Ball control rate of one team, $c$ is the distance from the ball to opposite team.

$a1$ is near, $a2$ is far, $b1$ is the ball in the control of our team, $b2$ is the ball in control of the opposite team, $c1$ is near, $c2$ is far. $d$ is the game situation of one team, $d1$ is superiority, $d2$ is inferiority.

Step 1: certain the Bias network topology structure. We can get Bias network module and the condition probability from the plentiful experience in the games. We can see from Fig. 2.

1. **Step2:**

   $G = (d \mid (a \mid b), c)$,

   $G = [(a \mid b), (c \mid \Omega); (d \mid \Omega)]$.

   Then

   $A(G) = \{ab, a, b, c \times \Omega \times \Omega \times \Omega \times \Omega \}

   = \{w_{12}, \cdots, w_{12}\}$
This paper studies Conditional Event Algebra Theory, combined with a good knowledge of the Bayesian network expression framework to draw a new assessment methods used in robot soccer simulation platform for smart referee. Experiments prove that the smart the referee has better intelligence, adaptability. However, deficiencies are still existed, such as computational complexity; accuracy is not high, needed after further efforts and improvements.

V. CONCLUSION

This paper studies Conditional Event Algebra Theory,