Air Target Attack Intention Recognition Analysis

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Abstract. Aimed at the problem of air target attack intention recognition, based on the analysis of the influencing factors of air target attack intention, the common methods of air target attack intention recognition were analyzed , the air target attack intention recognition method based on fuzzy similarity was proposed, the basic steps of air target attack intention recognition based on fuzzy similarity were proposed, and the establishment method of membership function was analyzed.

Keywords: air target; atack intent; distinguish; influencing factors; common methods; membership functionr.

1. Introduction

Air target attack intention recognition usually refers to the judgment and evaluation of the tactical purpose that the air target will achieve. At present, it mainly studies the target characteristics and analysis methods[1-7]. Based on the influencing factors of air target attack intention, this paper puts forward the identification and analysis method of air target attack intention.

2. Influencing factors of air target attack intention

The main influencing factors of air target attack intention include:

(1) Air target distance

The closer the air target is, the greater the threat degree of the target is.

(2) Air target altitude

When the target flying altitude is low, the greater the threat degree of the target.

(3) Target route shortcut

The target route shortcut can be calculated by the following formula

$$L_{mhj} = \sqrt{D_{mhj}^2 - H_{mhj}^2} \sin q_{mhj} \tag{1}$$

Where L_{mhj} is target route shortcut, D_{mhj} is target distance, H_{mhj} is target flight altitude, q_{mhj} is target airway angle.

If the target coordinate values are $X_{mhj}, Y_{mhj}, Z_{mhj}$ respectively, there are

$$D_{mhj} = \sqrt{X_{mhj}^2 + Y_{mhj}^2 + Z_{mhj}^2} \tag{2}$$

$$H_{mhj} = Y_{mhj} \tag{3}$$

$$q_{mhj} = arctg(Z_{mhj} / X_{mhj}) \tag{4}$$

(4) Target arrival time

After obtaining the target position information, the target trajectory can be predicted, and then the target flying time can be calculated.

3. Common methods of air target attack intention recognition

The following air target attack intention identification methods are adopted:

(1) Bayesian network

Bayesian network, also known as belief network, is a directed graphical description of probability relationship. It uses probability theory to deal with the uncertainty caused by describing the conditional correlation of different knowledge components. It is suitable for uncertain and probabilistic things. It provides a graphical visualization method of knowledge intuition, which is applied to the decision-making that conditionally depends on a variety of control factors. In Bayesian network, the data of cause hypothesis and result are represented by nodes, and the relationship between them is represented by directed arc. Draw their causal relationship between variables, and use them in the form of digital coding to describe the extent to which one variable may affect another variable. However, because Bayesian network needs to determine a large number of prior probabilities and conditional probabilities, which is often difficult.

(2) Evidence theory

Evidence theory is an uncertain reasoning method, which was first proposed by Dempster and further developed by sharer, so it is also called D-S theory. Because the theory has great flexibility, it has attracted people's attention. As an uncertain reasoning method, evidence theory has a strong theoretical basis. It can deal with both the uncertainty caused by randomness and the uncertainty caused by uncertainty. However, when the degree of evidence conflict is high, the conclusions obtained through its combination rules are often contrary to common sense. When there are many data, it has the disadvantages of potential exponential complexity and long reasoning chain.

(3) Hidden Markov model

Hidden Markov model is a stochastic process composed of two mechanisms. One mechanism is an internal finite state Markov chain, and the other is a set of random functions. Each function is associated with a state, and the Markov chain changes the state according to the transition probability matrix. The reason why it is called hidden Markov model is that the observer can see the output value of the random function associated with each state, but can not observe the state of Markov chain, which is relatively less real-time.

(4) Fuzzy Petri net

In order to enhance the ability of Petri net to represent and process fuzzy knowledge, people associate the classical Petri net model with fuzzy mathematics, and fuzzy Petri net came into being. As an important branch of Petri net, fuzzy Petri net is more in line with human thinking and cognitive mode. It has a wide range of significance in describing and analyzing the parallel and concurrent behavior of many physical systems and even social systems. Although fuzzy Petri net can solve fuzzy problems well, its disadvantages are also obvious. The most important thing is the state combination explosion problem faced in modeling. The network scale increases exponentially with the increase of system dimension, which greatly increases the difficulty of system analysis.

(5) Multi agent technology

Multi agent technology mainly studies a group of autonomous agents to complete complex control or task solving through intelligent behaviors such as interaction, cooperation, competition and negotiation in a distributed and open dynamic environment. Because it can better reflect human social intelligence and is more suitable for open and dynamic social environment, it is widely used in scientific computing, computer network and software system, flexible manufacturing system, e-commerce, enterprise management, power system, traffic control and other fields. The research of multi-agent technology involves two aspects: Theory and application. In theory, it mainly studies the architecture, coordination and learning mechanism of multi-agent system. In order to meet the requirements of real-time control, it is one of the difficulties in agent research to study the method of making each agent have the function of rapid learning and coordination in a short time in an open dynamic environment, and the technology in this field is still not mature, especially when the number of tracking agents is too large, it will consume a lot of computing resources and time.

4. Air target attack intention recognition method based on fuzzy similarity

4.1 Basic steps of air target attack intention recognition based on fuzzy similarity

Air targets have a variety of attack intentions, and each air target attack intention can be regarded as a pattern. Each pattern represents a set of features, which depend on the air target attack intention parameters. Each set of features describes a certain air target attack intention.

Let the air target attack intention parameter vector observed at a certain time be $K_{mh}=(K_{mh1},K_{mh2},\ldots,K_{mhm})^T$, the known air target attack intention space be $Y_{mh}=(Y_{mh1},Y_{mh2},Y_{mh3})^T=$ (strong, medium, weak)^T, and the known characteristic vector of the target corresponding to the jth air target attack intention Y_{mhj} be $K^*_{mhj}=(K^*_{mh1j},K^*_{mh2j},\ldots,K^*_{mhmj})^T$. $1\leqslant j\leqslant 3$。   Then the basic of fuzzy similarity recognition of air target attack intention is as follows:

(1) According to the following membership function, the target feature observation vector K is blurred to obtain the target fuzzy observation feature vector $\hat{K}_{mh}=\left(\hat{K}_{mh1},\hat{K}_{mh2},\ldots,\hat{K}_{mhm}\right)^T$.

(2) According to the following membership function, the target known feature vector K^*_{mhj} corresponding to the j-th air target attack intention is fuzzed to obtain the target known fuzzy feature vector $\hat{K}^*_{mhj}=\left(\hat{K}^*_{mh1j},\hat{K}^*_{mh2j},\ldots,\hat{K}^*_{mhmj}\right)^T$ corresponding to the j-th air target attack intention.

(3) By using the weight determination method such as analytic hierarchy process, the attribution weight vector of the attack intention Y_{mhj} of the j-th air target is determined and set as $\omega_{mhj}=(\omega_{mh1j},\omega_{mh2j},\ldots,\omega_{mhmj})^T$.

(4) The fuzzy similarity matrix $\hat{K}_{mh}$ between the component of the target fuzzy observation eigenvector and the target known fuzzy eigenvector $\hat{K}^*_{mhj}$ corresponding to the j-th air target attack intention is established to represent $\gamma_{mhij}\to[0,1]$. $1\leq i\leq m_{mh}$.

The commonly used construction methods of fuzzy similarity matrix include maximum and minimum method, Hamming distance method, Euclidean distance method, Chebyshev distance method, absolute reciprocal method, absolute value index method, exponential similarity coefficient method, LAN distance method, data product method, included angle cosine method, correlation coefficient method, arithmetic average minimum method, geometric average minimum method, etc. The maximum and minimum method is used here, γ_{mhij} can be expressed as

$$\gamma_{mhij}=\frac{\min\left(\hat{K}_{mhi},\hat{K}^*_{mhij}\right)}{\max\left(\hat{K}_{mhi},\hat{K}^*_{mhij}\right)} \tag{5}$$

(5) Solve the fuzzy similarity between the target fuzzy observation feature vector $\hat{K}_{mh}$ and the j-th air target attack intention Y_{mhj}, C_{mhj} can be expressed as

$$C_{mhj}=\sum_{i=1}^{m_{mh}}\omega_{mhij}\gamma_{mhij} \tag{6}$$

(6) According to the above method, the fuzzy similarity C_{mh1}, C_{mh2} and C_{mh3} of the target observation feature vector K_{mh} to each element in the air target attack intention space Y_{mh} can be obtained respectively. According to the maximum membership method, the air target attack intention is the intention category with the maximum fuzzy similarity.

4.2 Establishment of membership function

Fuzzy set is described by membership function, which plays a very important role in fuzzy set. At present, there is no mature and effective method for the establishment of membership function,

the construction of membership function has no reliable theory as the basis, and most system establishment methods still stay on the basis of experience and experiment. For the first mock exam, different people will create incomplete membership functions. Although the form is not the same, they can reflect the same fuzzy concept, and the effect is the same in solving and dealing with practical problems. The commonly used membership function construction methods are as follows: fuzzy statistics method, example method, expert experience method and binary comparison ranking method. For different input variables, the corresponding membership function should be adopted according to the specific characteristics of the input variables. The following analysis is divided into two cases.

4.2.1 When the input variable is a real value

For quantitative characteristic elements, the membership degree is determined by fuzzy distribution method.

(1) π_{mh} function

The mathematical expression of π_{mh} function with center L_{mhb} and width of $2 L_{mha}$ is as follows, $\pi_{mh}(x_{mh}, L_{mha}, L_{mhb}) \in R_{mh}$.

$$\pi_{mh}(x_{mh}, L_{mha}, L_{mhb}) = \begin{cases} 0 & x_{mh} \leq L_{mhb} - L_{mha} \\ 2(\dfrac{x_{mh} - L_{mhb} + L_{mha}}{L_{mha}})^2 & L_{mhb} - L_{mha} < x_{mh} \leq L_{mhb} - \dfrac{L_{mha}}{2} \\ 1 - 2(\dfrac{x_{mh} - L_{mhb}}{L_{mha}})^2 & L_{mhb} - \dfrac{L_{mha}}{2} < x_{mh} \leq L_{mhb} + \dfrac{L_{mha}}{2} \\ 2(\dfrac{x_{mh} - L_{mhb} - L_{mha}}{L_{mha}})^2 & L_{mhb} + \dfrac{L_{mha}}{2} < x_{mh} \leq L_{mhb} + L_{mha} \\ 0 & x_{mh} > L_{mhb} + L_{mha} \end{cases} \quad (7)$$

Therefore, π_{mh} function is an intermediate membership function.

(2) Inverse Z_{mh} function

The inverse Z_{mh} function can be described by the following model

$$u_{mh}(x_{mh}, L_{mh\alpha}, L_{mh\mu}) = \begin{cases} 0 & x_{mh} \leq L_{mh\alpha} \\ 2(\dfrac{x_{mh} - L_{mh\alpha}}{L_{mh\mu} - L_{mh\alpha}})^2 & L_{mh\alpha} < x_{mh} \leq L_{mh\beta} \\ 1 - 2(\dfrac{x_{mh} - L_{mh\mu}}{L_{mh\mu} - L_{mh\alpha}})^2 & L_{mh\beta} < x_{mh} \leq L_{mh\mu} \\ 1 & x_{mh} > L_{mh\mu} \end{cases} \quad (8)$$

Where $L_{mh\beta} = \dfrac{L_{mh\mu} + L_{mh\alpha}}{2}$.

Therefore, the inverse Z_{mh} function is a relatively large membership function.

(3) Z_{mh} function

The Z_{mh} function can be described by the following model

$$Z_{mh}(x_{mh}, L_{mh\alpha}, L_{mh\mu}) = 1 - u_{mh}(x_{mh}, L_{mh\alpha}, L_{mh\mu}) \quad (9)$$

Therefore, Z_{mh} function is a small membership function.

4.2.2 When the input variable cannot be quantified

When the input variables cannot be quantified and can only be expressed in qualitative language, fuzzy statistical method or expert experience method can be used to solve the membership degree.

5. Summary

By analyzing the influencing factors of air target attack intention, based on the analysis of common methods of air target attack intention recognition, an air target attack intention recognition method based on fuzzy similarity is proposed, and the air target attack intention is determined and recognized, which provides a method basis for air target attack intention recognition.

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