Research of Track Fusion Technology Based on Artificial Intelligence

Hao NIE

The Aeronautic Electronic Engineering dept. of the First Aeronautic Institute of the Air Force,
XinYang, 464000, China

Keywords: Track fusion, Neural network, Expert system.

Abstract. With the development of air traffic, its safety is getting much more attention. Aimed at solving the problem of different sources in track fusion, this paper proposes track fusion technology based on neural network and expert system of artificial intelligence, which improves the precision of the track fusion and provides a good application prospect.

Introduction

Nowadays, Air traffic flow of China is increasing more than 10% a year, the increasing airport throughput, has caused the plane density, narrow spacing, the problem of air traffic safety is quite serious. Meanwhile in face of growing pressure of aviation safety, process control and radar control is inadequate.

ATC (Air Traffic Control) system has a variety of air traffic sources for information, such as primary radar, secondary radar, ADS, AFTN/SITA, aviation cable network, the flight plan etc. So on basis of the comprehensive information collection, processing and fusion of all kinds of sensor and data information can greatly enhance the ATC surveillance capability.

For data fusion method, there are the weighted average method, the method of voting rules, fuzzy theory and neural network theory, using the fusion method of expert system and so on, these methods have their own advantages and disadvantages, therefore, this paper provides an idea that based on neural network and expert system of artificial intelligence in data fusion technology, which can be used in the application of air traffic control automation.

To achieve the purpose of complementary advantages, we use neural network self-organizing, self-learning and adaptive ability to solve the difficulty of expert knowledge acquisition, good expert system is used to explain the function at the same time to make up the defects of neural network in the knowledge expression.

Principle of Track Information Fusion and the Key Problems

Because of the feature differences of the information sources, various types of tracking information provided by the data of different properties, some real-time, some non-real-time, some time, some time invariant, some precise, some fuzzy. Track information fusion technology can be according to certain optimization rules, to the multi-dimensional multi-level processing all kinds of information, integration of complementary information and eliminate redundant information, draw meaningful new information, so as to more accurately estimate target and environment characteristics.

Table 1. Different sources of track.

<table>
<thead>
<tr>
<th>Reference coordinate system</th>
<th>primary radar</th>
<th>secondary radar</th>
<th>ADS-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spherical coordinates</td>
<td>Spherical coordinates</td>
<td>WGS-84 coordinates</td>
<td></td>
</tr>
<tr>
<td>Data format</td>
<td>Slant distance, azimuth</td>
<td>Slant distance, azimuth, height</td>
<td>Longitude, latitude, height</td>
</tr>
<tr>
<td>Report period</td>
<td>3.8-6s</td>
<td>5-10s</td>
<td>variable</td>
</tr>
<tr>
<td>Identification ID</td>
<td>None</td>
<td>Dynamic allocation, Repeat possibility exists</td>
<td>Single number for each one</td>
</tr>
</tbody>
</table>
Generally speaking, the functions of information fusion system are as follows: the calibration, relation identification, estimation. Including calibration and correlation is to identify and estimate preparation, the actual fusion is carried out after the identification and estimation.

![Figure 1. Schematic diagram of track fusion.](image)

In practical applications, it is need to deal with three types of problem in track fusion, the first kind of detection problem is vehicle recognition, classification and hypothesis test, sometimes called detection fusion or statistics. The second kind for the estimation of the relevant aircraft problems is target tracking, location, filtering and prediction, etc., sometimes referred to as the estimation fusion problem. The third kind of track estimation problem is the establishment of a panoramic view, describing and estimating what is happening and what has happened, and assessing the degree and severity of events that may occur, to help decision makers to make decision.

Before track fusion, the need for data preprocessing, track filtering and correlation work is to implement and track fusion multiple sensor fusion target tracking, which is the most important steps. In this paper, the data fusion algorithm is proposed to track the relevant improvement ideas.

According to the system structure, function of system and resource allocation, information fusion system is generally divided into centralized structure, distributed structure and hybrid structure. A combination of high tracking precision and good real-time performance, according to the characteristics of the air traffic control, the distributed structure is popular with the majority of researchers and engineers. Based on the fusion algorithm and fusion strategy optimization, more and more evidence shows the advantages of distributed structure.

**Track Fusion Algorithm Based on Neural Network and Expert System**

Neural network has the advantages of self-learning and self-adaptive, self-organization and fault tolerance, and can be used for simulating the complex nonlinear mapping. This powerful ability makes it adapt to the multi-sensor data fusion technology in processing requirements very well. In a multi-sensor system, the uncertain information provided by the sensor fusion process is essentially a process of reasoning with uncertainty. However, the neural network also has obvious disadvantages. The reasoning process is a black box, for example, people can only see the input and output, intermediate reasoning steps cannot explain, and there is no good explanation mechanism. In addition, the neural network knowledge is stored in fixed link structure, which is not easy to modify for supplement.

Traditional expert system is based on knowledge processing system, the knowledge is transferred into a series of system that can be accepted and stored in the acceptable form. Using its reasoning process implementation for solution of the problem, expert system also has some problems: knowledge bottleneck, the study with low efficiency and low inference efficiency.

Therefore, the combination of neural network and expert system, can complement each other, each other takes the biggest advantage, which is studied in this paper with track data fusion algorithm based on neural network and expert system of artificial intelligence.
The Knowledge Representation

The Knowledge Acquisition

Knowledge acquisition is done automatically by the neural network. At first, knowledge of production rule in the base is converted into samples knowledge that neural network can learn. The second step, internal knowledge is obtained by learning samples in the neural network. Adopting BP algorithm, its purpose is to find the right threshold, so as to guarantee the network corresponding to each input vector and output vector produced by fully close to the desired output.

The Reasoning Mechanism

Within the neural network module, and knowledge reasoning mainly adopts "forward reasoning", steps as follows:

1. The original logic knowledge is put into the input converter.
2. Logical knowledge converted by the input converter is turned into data.
4. Data obtained by the BP is concentered into logical knowledge by the output converter.
5. Output new logical knowledge.

Inside the neural network module, knowledge representation and reasoning is closely integrated, parallel executed. Out of neural network module, it is application of traditional reasoning method. Under the control of the system management module, reasoning knowledge is sent into the traditional knowledge base.

The Explanation Mechanism

In order to realize the interpretation of the neural network expert system function, it is need to use of the individual data of neural network, such as input data, output data and output data hidden in layer neurons. The rule is formed by using the physical meaning of input layer neurons and output layer neurons.

Part of the Implementation of the Algorithm

Data from the target is processed in each sensor locally. After time alignment, the state assessment at time K of the target is obtained, which is $\hat{X}_i(k|k)$, and covariance matrix $P_i(k|k)$, $N=1,2,...,N$, N is the number of the sensors which can detected the target.

$$\hat{X}_i(k) = P(k) \sum_{i=1}^{N} P_i^{-1}(k|k) \hat{X}_i(k|k)$$

(1)
\[ P^{-1}(k) = \sum_{i=1}^{N} P_i^{-1}(k/k) \]  

(2)

In hypothesis, the random error \( \Delta x_i(i = 1, 2 \ldots n) \) of Targ X detected by n radars is irrelevant, and average value is 0, mean square error is \( \sigma^2 \), when the equation below is met, the \( \sigma^2 \) is the minimum.

\[ x = \sum_{i=0}^{n} k_i x_i \sum_{i=0}^{n} k_i = 1 \]  

(3)

\[ k_i = \frac{1}{\sigma_i^2} / \sum_{j=0}^{n} \left( \frac{1}{\sigma_j^2} \right) \quad \sigma^2 = 1 / \sum_{j=0}^{n} \left( \frac{1}{\sigma_j^2} \right) \]  

(4)

In the X-Y coordinate system of horizontal direction, mean square error of X, Y direction calculated by the elliptical contour curve is \( \sigma_x^2 \) and \( \sigma_y^2 \):

\[ \sigma_x^2 = \cos^2 \varphi \cdot \sigma_r^2 + r^2 \sin^2 \varphi \cdot \sigma_\theta^2 \]  

(5)

\[ \sigma_y^2 = \sin^2 \varphi \cdot \sigma_r^2 + r^2 \cos^2 \varphi \cdot \sigma_\theta^2 \]  

(6)

It is demonstrated through the analysis of actual data, in the condition that only the detected error of radar is considered in the weighted fusion, this method can get satisfied effect.

**Summary**

In the view of different source of much information in track data fusion, it proposes the information fusion technology based on a neural network and expert system of artificial network in this paper.

The algorithm aims at the perspective of improving precision of the track, building a model, less amount of calculation. On the premise of the real-time, data precision has been improved greatly.

**References**


