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Radar Target Tracking Algorithm Based on Association Rules

Yanchen Xing*

Harbin Huade University, Harbin 150025, China

18794085@qq.com

**corresponding author*

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Abstract: The progress of radar technology has brought strong support to science, technology and military. At present, China's radar technology is making continuous progress. One of the most important is the radar tracking technology. The tracking of radar system is a complex process. The simulation of radar target tracking algorithm mainly uses Matlab as the software, and uses the function model established by MATLAB to analyze it and obtain an ideal data set. This paper intends to improve the ability of radar target tracking by using association rules and algorithm optimization. In this paper, through experimental simulation and comparison, under the same experimental conditions, different algorithms have different tracking effects. The experimental results show that the shortest calculation time of EKF is 0.02, but the estimation accuracy is not high. PF has better performance in complex strong nonlinear and non Gaussian environments.

1. Introduction

In our life, we often encounter many problems about multi-target tracking. How to accurately locate the moving target, how to effectively use the existing data information, how to use the minimum cost to calculate the target position and so on become the main direction of target tracking. The target tracking algorithm must be introduced into the tracking radar to provide more accurate target state information for the control system, so as to improve the tracking accuracy of the radar for highly mobile targets.

There are many theories about radar target tracking based on association rules. For example, some experts have made a detailed analysis of the target motion model and the filter, which is the basis of the target tracking technology. Some experts have also proposed a multi-target tracking data processing method suitable for high-frequency radar target tracking, and others have also proposed to track and filter the target as a point target. If the target is an extended target, the extended target cannot be tracked stably due to the complexity of data mapping and the divergence of tracking. Therefore, the radar target tracking algorithm proposed in this paper needs to use association rules to improve the ability of tracking and detection.

Firstly, this paper introduces the relevant theories of radar work, and on this basis, analyzes the joint movement relationship between the unsupervised component and the supervised component. Then an inversion formula is derived by using inversion method. This method can be well used for Kalman filtering, state transition matrix and other problems. Then, the multi-attribute spatial clustering based on decision tree algorithm is used to study the multi-attribute spatial clustering. Then the data association algorithm is analyzed concretely. Finally, the application of target tracking algorithm is described, and experiments are designed to obtain the relevant algorithm results.

2. Radar Target Tracking Algorithm Based on Association Rules

2.1. Working Principle of Radar

The radar antenna transmits electromagnetic signals and spatial signals. Through noise reduction and filtering, the basic position of the target is finally determined. The radar system includes various electromagnetic technologies and digital technologies. The basic composition of the air target detection radar can be simplified as shown in Figure 1:

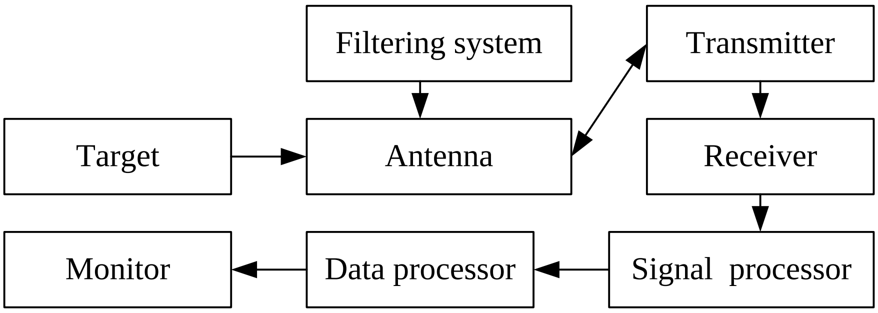

Figure 1. Basic composition of target detection radar

In radar system, radar horn radiation is transmitted in space. When electromagnetic waves hit the target in space, some electromagnetic waves return and spread in space after transmission. This process involves identifying targets. If the amplitude of the processed signal is large enough, the target can be identified. Target echo processing can detect the azimuth, range and other characteristics of the target. The processed signal is finally displayed on the display screen, allowing the operator to monitor the trajectory of the target.

The working range of radar determines the detection range of the farthest target, which is the main indicator of radar performance. Because the target surface can emit electromagnetic waves, the target will send echo signals to space. The most common coordinates include target position, height, and speed. The radar antenna will detect the signal. Target angle measurement includes target azimuth and target inclination. Target height measurement is based on distance and height measurement.

2.2. Data Association Algorithm

Association rules refer to the fact that when a marked object moves in space or is interfered by other external factors, these are considered to be related but do not affect its original relationship.

By adjusting its intermediate variables, you can change the attributes of the things you need to observe. Association rule is a joint allocation between sets of multiple observation samples in a multi-attribute data set environment to determine whether they have some relationship. Each individual has its own unique, independent and relevant history. These records include all possible "potential" tags defined. Association rule mining is to use statistical methods to find samples that are closely related to each other, analyze them, find some relationships, and express these relationships with certain mathematical formulas. These different types and distribution parameters are used as a new variable for correlation detection and tracking. Association rule mining is to study the movement track and movement law of the target, and predict its future development trend according to these data. First, we assume that all the detected objects are regarded as a complete space system when the distance is known. Secondly, the relevance of the current project set is determined according to the relationship between the known point and the past current location. Finally, a large number of representative feature sets are obtained through association rule mining.

Data mapping is the core of multi-target tracking technology. Due to measurement uncertainty, data mapping can determine possible paths. Set the tracking gate, and the candidate echo meets the formula (1)

$$\left[\mathrm{c}_i(l) - c(l|l-1)\right]^S R^{-1}(l)\left[\mathrm{c}_i(l) - c(l|l-1)\right] \le p \qquad (1)$$

Where in, $\hat{c}(l|l-1)$ is the center of the tracking gate.

The probabilistic data mapping algorithm weights each effective echo. Based on PDA algorithm, a general probabilistic data association algorithm is proposed. The results show that general echoes not only come from one target, but also belong to different targets. The state equation of objectives is:

$$A^s(l+1) = GA^s(l) + H(l)Q^s(l), s = 1,2,...,S \qquad (2)$$

After receiving the confirmation matrix between the effective measurement and the target or error alarm, the confirmation matrix must be divided to obtain all connection matrices representing connection events.

Multi hypothesis tracking combines the advantages of common probabilistic data association algorithm and neighborhood tracking algorithm. Track segmentation is a data mapping algorithm based on probability function detection. Through the reconstruction of fuzzy membership, fuzzy mathematics and neural network provide a new method for calculating association probability and realizing target tracking. Due to the uncertainty of the data mapping process, the traditional data mapping algorithm based on single scan may not get the correct results. The calculation of probability function is the core of multi scan data mapping algorithm.

2.3. Application of Target Tracking Algorithm

When the radar tracks the target, it can measure the angle, distance and radial velocity of the target through the antenna echo. The target state information given by radar is accompanied by random error components. In order to reduce the noise, filtering must be carried out to make the radar accuracy meet the requirements.

The software of the radar servo system ensures the high real-time performance of the tracking control system. The target tracking algorithm receives the target measurement data sent by the main console to the servo system through the serial interface, and obtains the target positioning amount required for filtering through the serial interface program, including target pitch, azimuth and inclination. Tracking radar requires high real-time performance, so the sampling time of radar servo period and filtering algorithm is relatively short. In order to improve the tracking accuracy of the turntable and increase the speed device, it is necessary to provide accurate target speed for the servo control system. Therefore, the filter is required to obtain not only accurate angle information, but also relatively stable and accurate target velocity information.

The purpose of radar target tracking is to improve the timeliness of the system in different environments (disturbance, movement, multi-source information). Therefore, this paper proposes a strategy that is most widely used in association rule based methods. The strategy uses the observation sequence to estimate the current position and time interval of the predicted object, and calculates a "node" with the highest accuracy. At the same time, this value is used as the final foothold of the tracking target to determine the tracking task in the next stage, so as to improve the system performance. There are two main methods of radar target tracking, which are based on feature set and unsupervised classifier. This paper uses a regression algorithm based on support vector machine. Support vector machine (SVM) uses a common statistical learning theory to describe a large number of data samples in the training process, and obtains a new value. This helps us build models to reduce training errors. The original input data is predicted when the parameters are estimated in the online spatial domain. This unsupervised method makes the calculation more efficient, fast and accurate.

3. Realization of Radar Target Tracking Algorithm

3.1. Experimental Simulation Platform

We use supervision rules to judge whether the target exists. Because each detection space has its own different estimation standard. Therefore, in order to better identify the ratio difference between the distances of each point on each data set to be inspected and their difference ratio with the current time, it is necessary to calculate these data sets and compare them with their average values to obtain the probability that the object may be changed or lost. Based on the Simulink platform of MATLAB, this paper completed the modeling, simulation and verification of the common association rule estimation problem in target tracking. By using SAS software, it is simple and convenient to build one, which is highly consistent with the current actual situation and meets the relevant conditions. The SAS program is used to design the corresponding sub modules to realize the single step test method, and different models are used according to different types of users to detect the change trend of system parameters and compare and analyze their tracking effects.

3.2. Target Tracking Module

In this paper, we give an inverse model of target tracking, that is, two independent and correlated subdomains (subdomains) contain multiple variables and frequency bands at the same time. In the target tracking method, we need to compare and analyze two sub models (sub models) with negative correlation. The first is to train spatial entities based on eigenvalues. Because each region has its own properties and characteristics, several independent components are selected as candidate location sets in a specific range to establish the association rule base. The second is to determine the interdependence between attribute values and candidate sets according to the subset obtained from the combination of attribute values and candidate sets. The maximum membership function in the matrix generates the sub model, and uses the least square method to fit to obtain the best matching point set.

This technique uses two different types of training sets for target classification. The first is to make a complete hypothesis experiment on the area where the testee is located to determine whether there is a correlation between the unit to be identified and the candidate individuals. The second is to start from the established function library to find the required marker points and candidate sample subsets and label each test set. Finally, the association rules contained in the data and the classifiers used in the training set are judged according to their eigenvalues.

3.3. Algorithm Verification

This paper verifies the association rule tracking algorithm based on supervised rules. First, the white noise technology is used to generate the position relationship between the two targets through calculation and analysis. Then we use the estimation to generate a new user model. The second step is to determine whether the method can effectively improve the recognition rate and false alarm rate. The third step is to select the appropriate type from the multidimensional data as the test set and train all samples to the performance parameter values of the association rule tracker in the current scene, so that the white noise technology has a better effect in practical applications.

4. Analysis of Experimental Results

4.1. EKF, UKF and PF Tracking Performance

The initial position of the target in the radar rectangular coordinate system is [5,5,5], the initial velocity is [50,50,50], and random Gaussian noise is added. Calculate the root mean square difference of speed under different frames. Through the simulation experiment results of Matlab, the tracking performance of UKF is higher than that of EKF. See Table 1 for details:

Table 1. The root mean square difference of speed in EKF, UKF, and PF

	EKF	UKF	PF
10	59	12	22
30	12	8	10
50	6	10	6
70	2	5	5

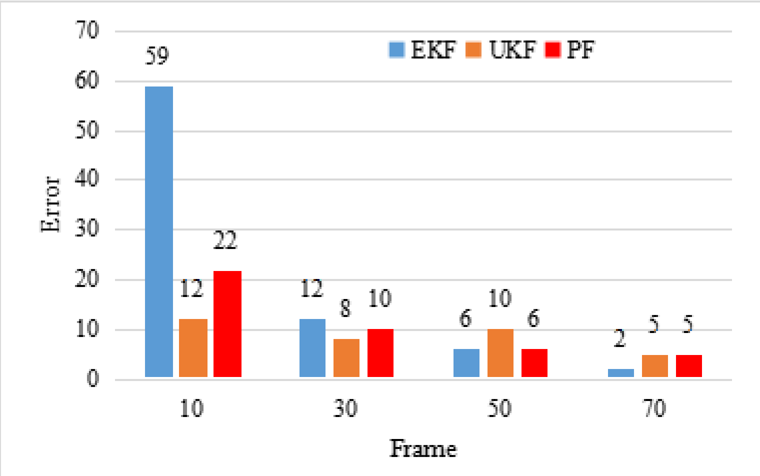

Figure 2. The root mean square difference of speed in EKF, UKF, and PF

As shown in Figure 2, we can see that the speed root mean square error of PF is faster than that of UKF, and the tracking accuracy of the two filters is basically the same. This paper only simulates PF under Gaussian random noise, and the selected posterior probability density function also follows Gaussian distribution, so the simulation environment is very gentle.

When the distance from the initial position of the target is 5km, the overall tracking effect of PF is very good, and the target can be accurately tracked at the initial stage. PF has no initial jump of EKF and UKF, and has good tracking stability. See Table 2 for details:

Table 2. The root mean square difference of location in EKF, UKF, and PF

	EKF	UKF	PF
10	300	220	158
30	150	125	128
50	120	92	102
70	110	98	98

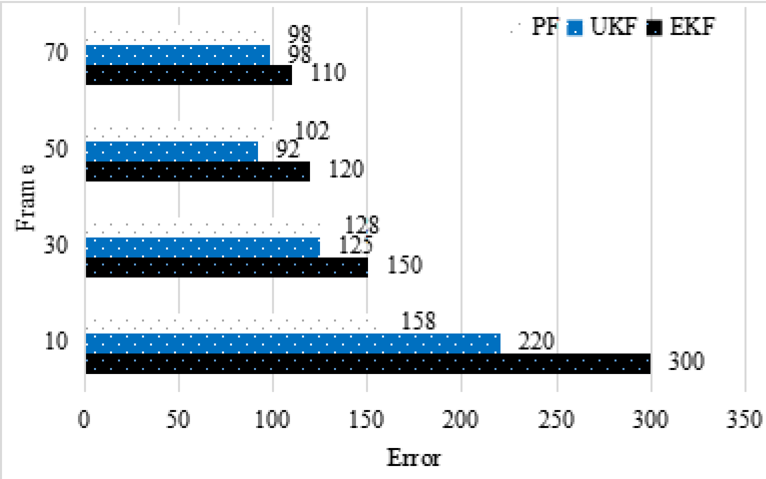

Figure 3. The root mean square difference of location in EKF, UKF, and PF

As shown in Figure 3, we can find that the UKF tracking performance is much higher than the extended Kalman filter accuracy under the same frame number. The final convergence value of the root mean square error of PF is less than UKF, which indicates that the tracking performance of PF is slightly better than UKF under the condition of Gaussian nonlinearity.

5. Conclusion

Radar target tracking is an important work. We need to study how to improve its accuracy to provide help for similar problems in the future. This paper adopts a method - Dependent Association Rule Model (SVM) and other related technologies to realize the research of radar tracking strategy and tracking performance. This model can be used to obtain the maximum likelihood value when the training data are concentrated on a certain number. When the number of samples used is small, the model can effectively reduce the false detection rate, and can obtain the most accurate approximate results in a large range. Although the model proposed in this paper can be applied in real life, there are many problems in real life that need further study.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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