A Track-Before-Detect Algorithm based on KA-HT

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Track-before-Detect (TBD) methods have been applied in the fields of dim target detection in radar systems. The basic principle of TBD is actually the theory of multiple frame integration detection, that is, using the multiple scans data to detect the dim target by accumulation effect which make use of information about target motion trajectory to increase the target detection capability of a system. This paper presents a knowledge-aided Hough transform (KA-HT) method for TBD to detect dim target in low SNR environments, which make full use of the information in three-dimensional range-Doppler-frame space.

Hough transform is a feature detector which can detect the characteristic of a straight line or featured curve by mapping the line or curve into Hough parameter space. However, there are several shortcomings about standard HT. One is that different parameter space granularity will make effects on the system detection probability. Another is the big computation. A two dimensional searching of the polar distance ρ and polar angle θ is made during the process of standard HT. It takes a lot of time for meaningless value of ρ and θ, which won't happen in reality. To solve the above problems of standard HT, KA-HT algorithm is proposed in the paper. It substitutes point-slope HT for the standard HT to avoid the problem of determining the parameter space granularity and aided knowledge is used to reduce algorithm computation.

Direct processing to the data in three-dimensional range-Doppler-frame space is more complex than the one in the two-dimensional space. KA-HT employs a technique to divide the three-dimensional space into several two-dimensional spaces called 'Doppler division processing'. It comprises the steps of data separation and data recombination. First, the raw data of each coherent processing interval (CPI) is transformed into Doppler domain by FFT operations, and then Doppler domain data in each CPI is separated into multiple Doppler cells. And then, the data recombination is made by composing the same Doppler unit of multiple frame data into a 2D data space which is Doppler-range space. Through the Doppler division processing, the three-dimensional data processing is divided into several two-dimensional processing. The foundation of Doppler division technique is the regularity of target Doppler characteristic.

The procedures of TBD based on KA-HT in detail can be described as follows:

Step 1. Transforming the multiple CPI districts data into Doppler districts by FFT operation;

Step 2. Making the Doppler division processing;

Step 3. Composing the same Doppler unit of all received frame data into a 2D data space which is Doppler-range space;

Step 4. Making point-slope HT to each 2D Doppler-range space data with aided knowledge;

Step 5. Making a detection decision by a threshold detector to declare a target.

To illustrate the validity of the suggested algorithm numerical experiment is accomplished. Fig.1 shows the system detection probability curve comparison between the condition of six frame integration by TBD method based on KA-HT and single frame detection in the SNR from 0 db to 20 db. By employing TBD method based on KA-HT, the needed SNR is nearly 8db, while using single frame detection, the needed SNR is nearly 16db. That's to say, there is a SNR improvement about 7 to 8 db after six frame integration by TBD method based on KA-HT. In a certain SNR environment, there will be an optimum number of integration

frame. The curves of system detection probability by different integration frame data (1 to 7) are shown in Fig.2. It shows that different SNR leads different optimum number of accumulated frame. For example, in order to keep the system detection probability beyond 90%, the best number of accumulated frame is four in the SNR of 10 db, while five for 9db and six for 8db.

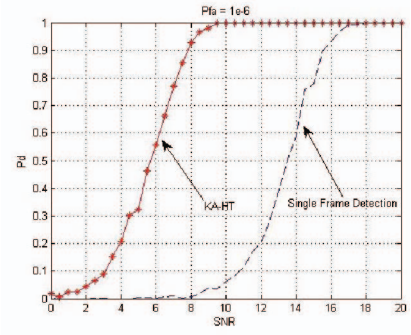

Fig.1 Plot of detection probability

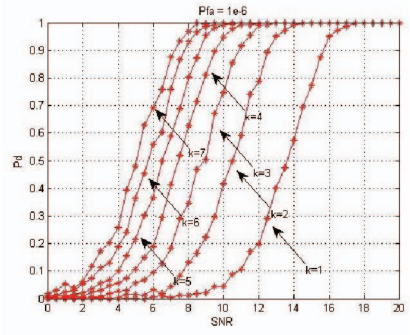

Fig. 2 Plot of detection probability in different integration frame number

The proposed algorithm can solve the problem of multi-frame integration processing in 3D range-Doppler-frame space. The simulation result proves the proposed method is available for dim target detection in 3D space.

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