ISAR IMAGING OF MULTIPLE MOVING TARGETS BASE ON RANGE PROFILE SEPARATION

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Abstract: When multiple radar targets are close to each other, the returned signals from these targets are overlapped in time. Therefore, by applying conventional motion compensation algorithms designed for single target, the multiple targets cannot be resolved, and individual one cannot be clearly imaged. However, each individual target may have its own velocity different from others. For the ordinary Stretch method, the range profile in frequency and slow time are not in lines which can be separated with the chirp rate of the image. In this paper, a new method is proposed to separate the signals from different target on one range profile. By the CLEAN technique, the number of targets need not be appointed. We use original algorithms to compensate the motion of each target signals, and then the image of each target can be obtained. The results of computer simulation are given to show the efficiency of the proposed algorithm for multiple moving targets imaging.

1. INTRODUCTION

In the modern war, the targets are often dense multiple targets, such as multiple aircraft in formation flying, missile warhead and accompanying decoys in ballistic missile system. These targets are within the same antenna beam, close to each other, and moving with different velocities or in different directions. The conventional radar imaging algorithms, which work well for single moving targets, cannot compensate the phase error for each individual target. It usually compensates the phase error for one target but induces phase errors for others. Hence, multiple moving targets cannot be resolved, and each individual target cannot be clearly imaged. Radar imaging of multiple moving targets in the same antenna beam is an important issue [1, 2].

For the current techniques of multiple targets ISAR imaging, there are two thoughts such as multiple targets separated imaging and direct imaging. The key technology of multiple targets separated imaging is the separation of multiple targets return signal, after the separation we can get the ISAR image of each target with conventional motion compensation and image focusing. The range profile history is composed of several lines of a certain slope in [3, 4]. The target can be separated with different chirp rates in the ISAR image. Considering the radar is working as Stretch, the premise of method is that the measured reference range is right without error [3, 4]. For the radar measure error is unavoidable and the multiple targets detection in SAR imaging in [5], we propose a method of multi target ISAR range slope separating. We extract the range profile of single target, and then make range alignment with the extracted reference range profile. After phase adjustment, the image of each target can be obtained by applying Range-Doppler algorithm.

2 Model of multiple ISAR imaging

When the radar transmits LFM waveform, the transmitted signal is

$$s_T(t) = rect\left(\frac{t-nT}{T_p}\right)\exp\left\{j2\pi\left[f_0 t + \frac{k}{2}(t-nT)^2\right]\right\} \quad n = 0,1,\cdots,N-1 \qquad (1)$$

Where f_0 denotes the carrier frequency, T is the pulse repetition interval, k k is the chirp rate, N is the number of observed sweeps, T_p is pulsewidth, $rect(t-nT) = \begin{cases} 1 & |t-nT| \le \frac{T_p}{2} \\ 0 & else \end{cases}$.

The Stretch signal processing method is a high resolution method based on LFM signal, which let the easier, need less data size and operation complexity. The Stretch signal processing is shown as below, the radar transmits the LFM waveform, the reference signal is the transmitted signal with delay. In the method, the range processing, a narrowband signal is used to track the target real time, for the time delay of the local oscillation frequency. But the narrowband radar cannot get correct range without measure error, so the signals from the same scatterer are centered at different range bins in different echoes.

Suppose the reference range is R_{ref}. In each pulse (each cross-range), Δt and M are the sample interval and the number of samples respectively. After DFT, the range profile history is written in Fourier-Slow time

$$S_R(f_m,t_n)=P(f_m)\sum_{i=1}^{L}\sum_{j=1}^{q_i}A_{i,j}e^{-j(4\pi/c)(f_0+f_m)R_{i,j}(t_n)}$$

where $f_m=\frac{mB}{M},m=-\frac{M}{2},-\frac{M}{2}+1,\cdots\frac{M}{2}-1$

3 Multi target ISAR imaging method base on range profile separation

3.1 range profile extraction

The range profile extraction is the key technology of our algorithm. In Stretch, the range measure error is the same for each target, so we can separate the range profile of each target.

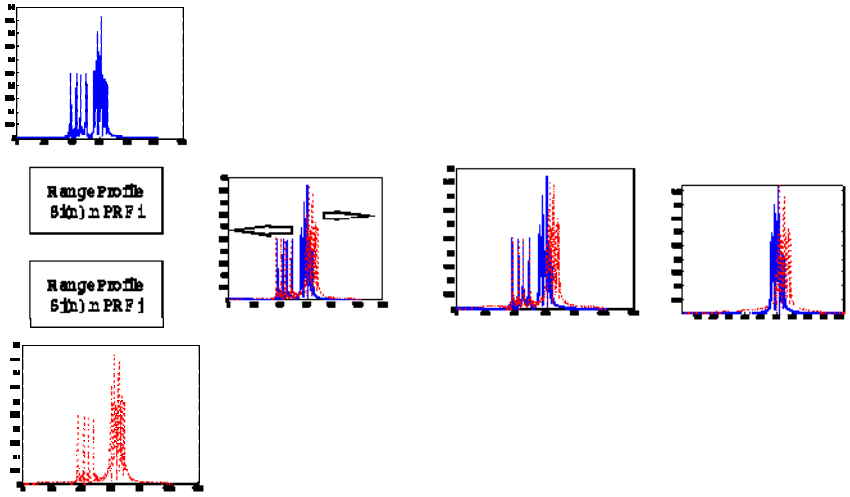
For target i, its range profile is

$$S_1(f_m)=P(f_m)\sum_{j=1}^{q_i}A_{i,j}e^{-j(4\pi/c)(f_0+f_m)R_{i,j}(t_1)}$$

$$S_2(f_m)=P(f_m)\sum_{j=1}^{q_i}A_{i,j}e^{-j(4\pi/c)(f_0+f_m)R_{i,j}(t_2)}=S_1(f_m)e^{-j(4\pi/c)(f_0+f_m)R\Delta}$$

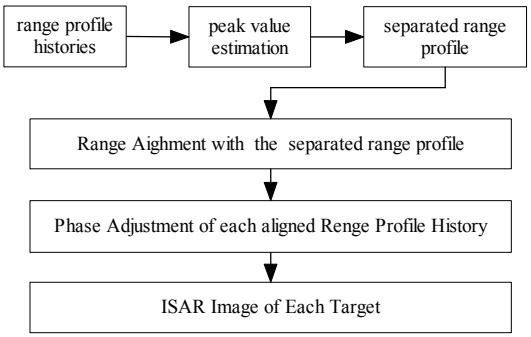
$$R\Delta 1=R_1+v_1t-R_{ref}$$

We find that the peak value change $R\Delta$ of the range profile can be used to separate the range profile. The processing steps of the proposed method are summarized as follows. For the sake of clarity a flow chart is depicted in Fig 1.



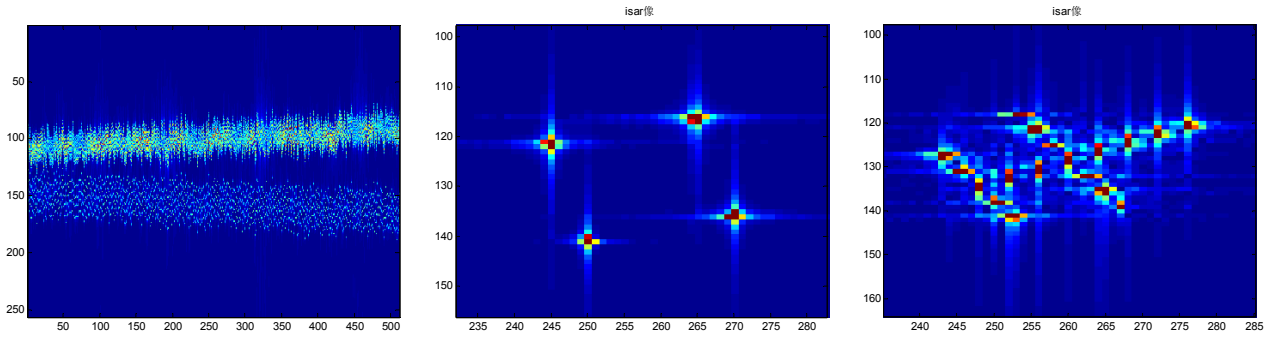
3.2 Flowchart of total method

Our proposed method flowchart is shown as



4 Simulation Results

The measure error cannot be neglected, we add the random noise to the range for simulation, then the range profile history of the two targets is shown as Fig 3. Using the proposed range profile extracted method, the range profile of targets are extracted as in Fig 4.and Fig 5.



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