Raid Assessment using Motion Compensation and Doppler Beam Sharpening techniques

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Abstract:

Generally Conventional Raid Assessment technique gives limited improvement in Range and Doppler resolution due to range migration. Proposed Raid Assessment technique gives the improvement in cross range resolution as well as slant range and Doppler resolution of a bunch of targets using Motion Compensation algorithm and Doppler Beam Sharpening technique. The overall five targets are to be taken in Raid assessment for simulation purpose.

Key Words: Raid, DBS, PMC, RMC, FFT

I. INTRODUCTION

In this paper, the echo data of raid assessment are simulated for given radar cross sections of targets. The function of Motion Compensation algorithm is to compensate the effect of relative motion of Platform and target. Distance moved in a small interval is obtained by a correlation technique. Distance obtained is used to get range rate. Range rate is used to compensate the movement during pulse compression. The function of Doppler Beam Sharpening is to resolve targets in Azimuth (Doppler) domain. Doppler Beam Sharpening (DBS) is a technique to enhance the azimuth Resolution. It use different Doppler shift of different angle of the target motion. The Doppler Beam Sharpening performs the cross range resolution improvement by analyzing the Doppler difference inside the lobe. Since the lobe has an open angle (for example 3 degree beam width) the returns come from different angles and have different Doppler velocities with in beam.

In Figure1, aircraft is moving along the velocity V_a direction, θ_b is beam width and θ_a is angle from flight path.

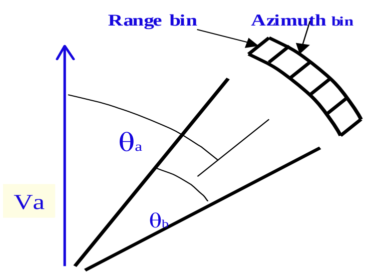

Figure 1

In normal mapping, the lobe is regarded as one whole and in DBS it is divided into sections according to the values of Doppler returns. These returns depend on aircraft velocity and relative angle to the target. The location of targets comes in different Doppler bins having same range bin after signal processing if targets are present at different azimuths within beam.

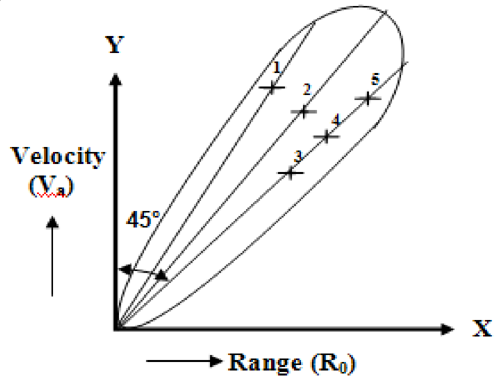

Figure 2: Geometry of Simulated Targets in Raid Assessment mode

The geometry of targets is shown in figure-2. The five targets are placed in beam. The one of the target is located at 44.9 deg, second at 45.0 deg and last three targets are at 45.1 deg within 3 deg beam width.

+ Symbol indicates the target. Y axis shows the Flight direction and platform velocity is taken in m/s. X axis shows the horizontal axis and range is taken in metre.

This paper consists of three main sections. Second section represent Block diagram of Signal Processing algorithm and algorithm details. Third section tells regarding simulation of algorithms and simulation results of Raid assessment mode in a system.

II. SIGNAL PROCESSING ALGORITHMS

Figure 3 represents the signal processing block diagram of Raid Assessment mode.

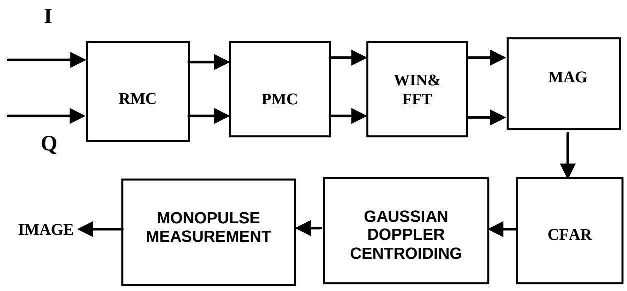

Figure 3: Block diagram of RAID Assesment SP Algorithm

The following Signal processing algorithms are like Motion Compensation (MC), Platform motion compensation(PMC), Constant False Alarm Rate(CFAR) and Gaussian Doppler Centroiding and Gaussian range Centroiding are used in Raid Assessment technique. In range migration correction processing, the N range-compressed profiles within the CPI are first accumulated in batches of m profiles to form N/m magnitude profiles. The number of pulses 'm' to be integrated in each batch is dependent upon the maximum range rate we are expecting. It is selected such that within 'm' pulses, the range profile doesn't move by more than one resolution cell in range. Then log of the accumulated magnitude profiles is taken to minimize the effect of amplitude fluctuation on correlation. After this all the N/m profiles are cross-correlated with the first one. But before correlation, the mean value of the profiles should be made zero; otherwise the correlation output will not be proper due to triangular buildup. The correlation offsets are stored in a buffer for all profiles and a straight line is fitted through these offset points by means of linear regression. The slope of the straight line when scaled up to m/s then gives the estimate of the range-rate.

After estimating the radar-target range-rate, the next step is to find out the phase terms that have to be compensated for in the original frequency-domain data. Range rate is used to compensate the movement during pulse compression in frequency domain by taking FFT of reference chirp. Phase for compensation is given in equation 1.

$$\theta(k) \;=\; 2 * pi * t_d * f * k \qquad (1)$$

Where t_d is time delay introduced due to relative velocity of target. k is pulse number and f is frequency value of corresponding frequency bin. Compensated chirp in frequency domain is given in equation 2.

$$Ref_{rmc}(f,k) = Ref(f,k) \, * \exp\left(-j * \theta(k)\right) \qquad (2)$$

Gaussian Centroiding techniques consider Gaussian shape response of FFT Output and Pulse Compression output so it searches for max value and two neighbouring point around max value of declared target so it takes only three bins for Centroiding and therefore it can resolve targets located at two bins apart. In case of weighted Centroiding technique, actual response of filter output is not considered , hence it does not gives so accurate value as well as during centroiding process continuous detected targets are taken to find one target. Due to this process weighted centroiding technique is not suitable for resolving targets in raid.

III. SIMULATION RESULT

Here we considered Doppler pulse radar transmits a pulse train at a fixed PRF. Radar flies along the Y direction with 500m/s velocity. The five targets (1 to 5) in the beam are shown in figure 1and fly with 500 m/sec parallel to boresight. Relative motion of platform and target is simulated. Range resolution is determined by transmitted bandwidth and Doppler resolution is determine by time on target (TOT).

For simulation of RAID echo data, radar parameters for RAID mode of operation are given in Table 1.
Echo data is simulated in video level using MATLAB.

Platform Velocity	500 m/s
PRF	10 KHz
Target Velocity	500 m/sec
Compressed Pulse Width	5µsec
Pulse Width	60msec
Time On Target(ToT)	60msec

Table 1: Parameter values for simulated data

Figure 4 shows the simulated RAID echo data of SP input. The figure 5 shows the output of pulse compression without range migration correction. The figure 6 shows the output after range migration correction. The Figure 7 shows the CFAR output. The Figure 8 shows the CFAR output after Gaussian Doppler Centroiding and Gaussian range Centroiding.

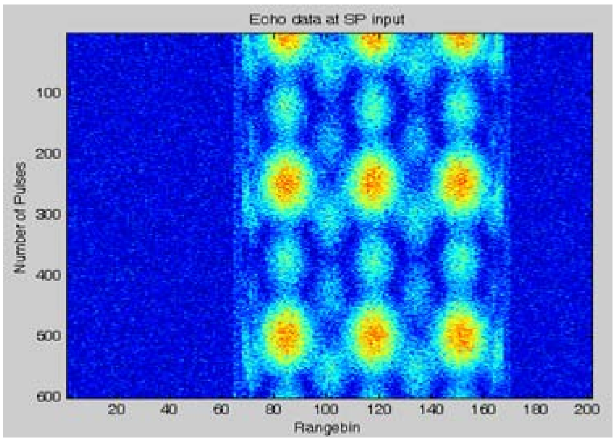

Figure 4: Raid echo data

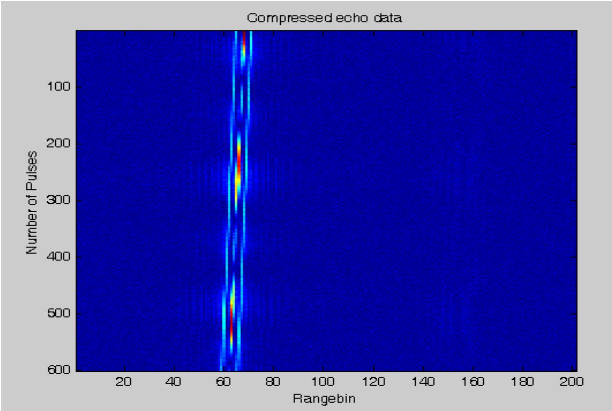

Figure 5: Output of range migrated compressed data

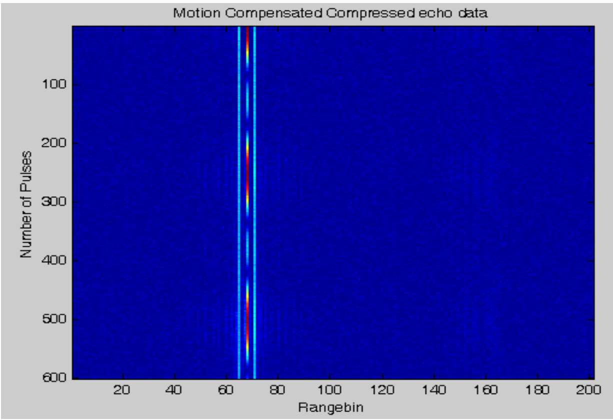

Figure 6: Output of Motion Compensated Compressed data

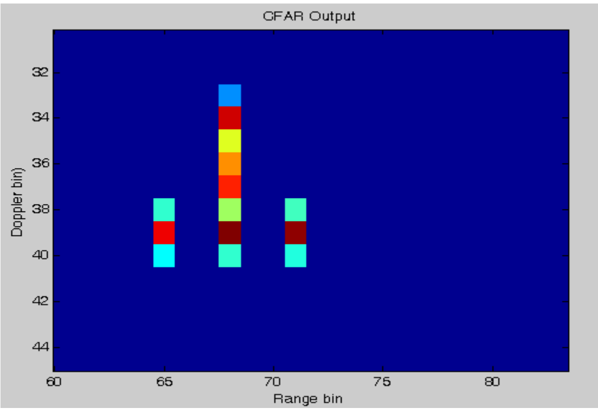

Figure 7: CFAR Output without Gaussian Centroiding

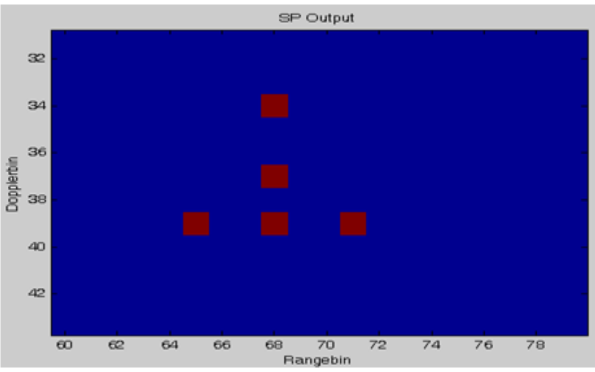

Figure 8: SP Output after Gaussian Centroiding

CONCLUSION

By using motion compensation, Doppler beam sharpening and monopulse measurement techniques, targets in raid are resolved in range, azimuth with better resolution compared to conventional Raid assessment techniques. Monopulse measurement technique gives the more accurate angle information of resolved targets in same range bin or different range bins.

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