RBM mode with enhanced and constant cross range resolution along range

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Abstract:

With pulse compression used for achieving better detection range as well as fine range resolution, the most challenging constraint in mapping radar is azimuth resolution. In a real beam mapping, azimuth resolution is determined by the antenna beam-width. Since in real beam mapping cross range resolution is dependent on range and it decreases with range. This paper proposes a technique to maintain a constant cross range resolution along range as well as enhanced cross range resolution.

Key Words: RBM, SAR,SUM, DIFF

I. INTRODUCTION

Since in a real beam mapping, azimuth resolution is determined by the antenna beam-width. While beam-width control is adequate for target detection, large antennas result for the narrow beams required to determine detailed characteristics such as the number, size or separation of targets. The need for large antenna led to the development of synthetic aperture radar for airborne platforms. But SAR also have limitations. SARs are unable to map at nose aspect, are expensive, and are hardware dependent, most importantly, they are comparatively slow in mapping due to the huge amount of signal processing required. These limitations have led to renewed efforts to improve the angular resolution of real beam systems.

This paper is having three sections. Second section explains the beam sharpening technique to improve the azimuth resolution of real beam map. third section represent the proposed method for constant azimuth resolution. Fourth section represents the simulation results.

II. BEAM SHARPENING TECHNIQUES

Beam sharpening reflects two areas of effort: actual beam sharpening algorithms, and image enhancement techniques which are applied after initial beam sharpening. These techniques enhance angular designation accuracy in all aspect scenarios. Further, real-time post-processing is possible to accomplish this without extending the radar frame time. Even while implementing these additional processors, real beam systems can map a 60 degree swath in just 1-2 seconds.

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1 Combination of Sum and Difference Channels

This method is useful for resolving point targets. The bore-sight null in the difference (D) channel pattern forms a sharp peak when combined with the sum (S) channel pattern. A weighting factor (K) controls the beam sharpening ratios. A value of (K) equal to 0 .75 is common. The output (S_c) is given by

$$S_c = abs(S) - K*abs(D) \quad (1)$$

Figure 1 and Figure 2 shows the above stated concept

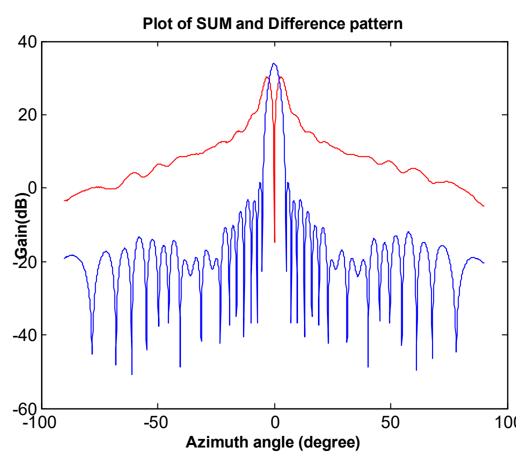

Figure 1: Plot of sum and difference pattern

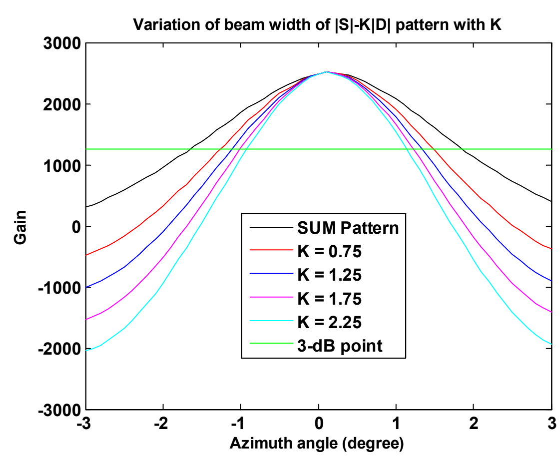

Figure 2: Variation of beam width of ISI-KIDI pattern with K

It is clear from Figure 2 that abs(S) - K*abs(D) pattern beam width decreases with increasing the value of K. Hence K controls the beam sharpening ratio. Since azimuth resolution depends on beam width, hence K controls the azimuth resolution. Higher the value of K, sharper the azimuth resolution.

III. PROPOSED METHOD FOR CONSTANT AZIMUTH RESOLUTION

In RBM mode cross range resolution is given as

$$Cr = \theta * R \qquad (2)$$

Where R is range of target and θ is array beam width. It is clear from equation 2 that cross range resolution depends on R. Proposed method uses sum and azimuth difference pattern to maintain constant cross range resolution. It is clear from equation 2, when value of range increases, cross range resolution becomes poorer. To maintain constant cross range resolution along range, beam width should decrease with range in same proportion. From above stated beam sharpening technique, It is clear that beam width could be sharpened using equation 3.

$$Sc = abs(S) - K * abs(D) \qquad (3)$$

In above equation, as we have seen in Figure 2, higher the value of K, lower would be value of beam width. Also from above equation, value of K can be obtained for required beam width as follows

$$K = \frac{(abs(S(\frac{\Delta\theta}{2}) - \max(abs(S))}{abs(D(\frac{\Delta\theta}{2}))} \qquad (4)$$

Where Δθ is required beam width.

To maintain constant cross range resolution, value of required beam width is calculated for given range. Based on required beam width, value of K is calculated and used during signal processing.

IV. SIMULATION AND RESULT

Four targets at 1 Km apart and 140 m width each simulated as input data to Signal processor. Simulated data passed through existing RBM , Beam sharpening RBM and proposed RBM signal processors.
For simulation of RBM echo data, radar parameters for RBM mode of operation are given in Table 1.

Parameter name	Value
Transmitted Peak Power	4 KW
Transmitted Pulse Width	100e-6 sec
Transmitted Carrier frequency	X-band
Target's Range	4, 5, 6, 7 Km
Number of Targets	4
Each Targets width	140 m
Start Slant Range	30000 m
Pulse Repetition freq	Low PRF
Number of Pulses	10
Each Target's RCS	4 m^2
Simulated Channels	Sum Channel and Azimuth difference channel as shown in Figure 1
Values of K for Targets	2.5, 4.6, 6.4, 9.2

Table 1

Figure 3 show the RBM output.

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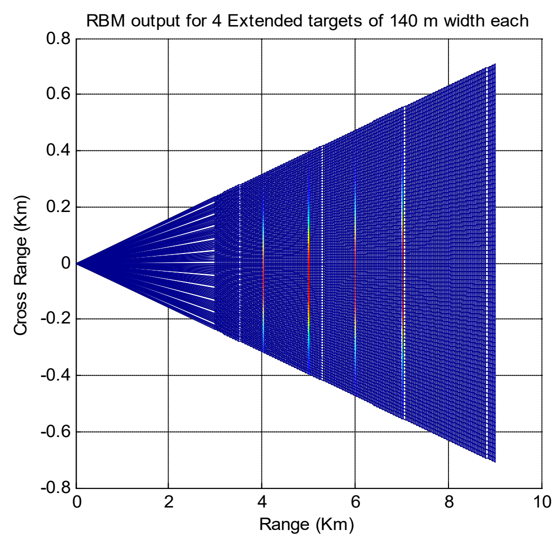

Figure 3:RBM Output

It is clear from Figure 3 that, cross range resolution decreases with range.

Figure 4 show the Beam sharpening RBM output.

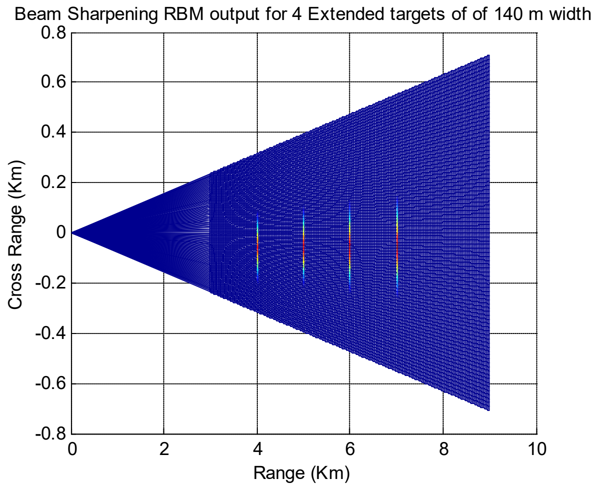

Figure 4: Beam Sharpening RBM Output

It is clear from Figure 4 that, cross range resolution decreases with range. But cross range resolution is for better than RBM.

Figure 5 shows the output of proposed method.

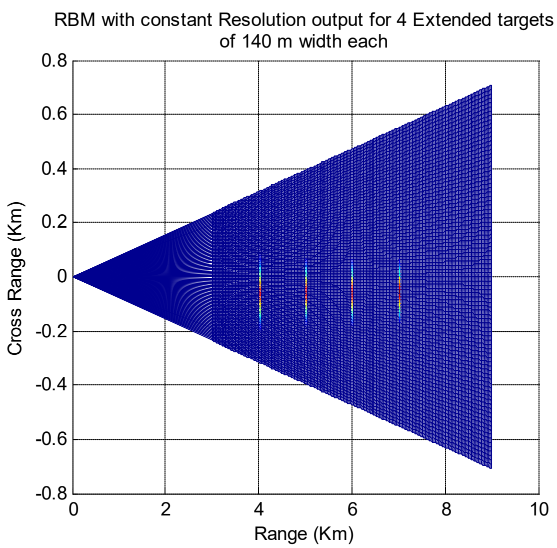

Figure 5: Proposed RBM with constant resolution

It is clear from Figure 5 that, cross range resolution is constant with range as well as cross range resolution is for better than RBM.

CONCLUSION

Purposed RBM with constant resolution provides better resolution as well as resolution does not change with range as happens in RBM and Beam Sharpening RBM. Proposed method provides constant resolution using only few mathematical operations and one extra azimuth difference channel is needed to perform proposed RBM with constant resolution. It is clear from above simulation and results that proposed method for RBM can be used at any aspect, particularly at nose aspect where SAR are unable to map and expensive for fine resolution as well as resolution would be maintained constant along range at cost of very few mathematical operations and one extra azimuth difference channel.

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Vinod Kumar Jaysaval: Presently working as a Scientist in LRDE, DRDO, Bangalore. He received his B.Tech degree in Electronics Engineering in 2000 from Bundelkhand University, Jhansi, U.P. and M.E. degree in signal processing from Indian Institute of Science, Bangalore. His current areas of interests mainly focus on the field of radar signal and image processing.