PSLR ESTIMATION CONSIDERING CLUTTER BACKGROUND FROM SAR IMAGE DATA

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1. INTRODUCTION

Synthetic aperture radar (SAR) image performance can be quantified by the impulse response function (IRF) resulting from a reference point scatterer on the ground test site. Due to the noisy and clutter environment on the ground, the IRF is directly affected by the overlapping sidelobes of distributed scatterers nearby the reference point scatterer. This background contribution is normally neglected under the condition of moderate image quality requirement. However, the clutter background can no longer be neglected in the accurate image quality evaluation. As one of important measure, the peak-to-sidelobe ratio (PSLR) is particularly sensitive to the level of a clutter background, and thus the realistic estimation of the PSLR is required for high PSLR performance requirement. Accurate SAR calibration methods have been reported using reference point targets [1]-[3], but these papers mainly focus on the estimation of backscatter coefficient in a SAR image scene without consideration of clutter influence on PSLR. Recently, a stochastic model considering clutter background was theoretically proposed for the estimation of PSLR performance [4], but this method does not consider the realistic influence of the various clutter backgrounds which should be extracted from an actual SAR image.

In this paper, an improved PSLR estimation scheme for advanced SAR image quality requirement is proposed by taking into account the clutter background collected from an actual SAR image. This scheme starts with the modeling and generation of an ideal impulse response function from the required system parameters, corresponding to the desired SAR image quality. In order to give realistic effects on the impulse response of the desired point scatterer, a large number of clutter patches are extracted from the desired clutter area of the actual SAR image, and the generated ideal impulse response is combined with the extracted clutter data. Using the modified clutter-containing impulse response, PSLR variation due to clutter background is finally evaluated with respect to the signal-to-clutter ratio (SCR). The proposed method can be used to estimate PSLR performance in realistic environment as well as to determine the radar cross section (RCS) level of actual reference point scatterer to minimize the clutter effect on PSLR performance.

2. PSLR ESTIMATION SCHEME CONSIDERING CLUTTER BACKGROUND

A scheme of PSLR estimation is shown in Fig. 1. In order to investigate the actual influence of clutter background on the ideal impulse response, first of all, the baseband received signal of a hypothetical point scatterer is generated by considering the actual SAR system parameters such as altitude, platform velocity, antenna weighting pattern in azimuth, operational frequency, FM rate, and so on. The RADARSAT-1 system parameters are applied in this paper [5]. And then, the clutter-free IRF of the isolated point scatterer is generated by two-dimensional matched filtering in range and azimuth direction.

In order to examine the realistic effect of clutter background, the clutter data to be applied on the generated IRF are extracted from an actual SAR image. Since the extracted data from the actual SAR image contain not only the surface reflectivity on the ground but also the receiver noise induced from actual SAR subsystems, the extracted data can be regarded as an appropriate signal model of the clutter background surrounding the point scatterer. In practice, a reference point scatterer, such as corner reflector or active transponder, is typically positioned on uniform and homogeneous area, so that the clutter data is extracted from farm land. Since the SAR image is composed of digital number (DN) data, the extracted clutter data needs to be converted to RCS level before applying the clutter background to the ideal IRF.

To provide the realistic effect of clutter background on the generated ideal IRF, the clutter patches extracted from the SAR image are then combined with the ideal IRF for PSLR quality estimation. An FFT interpolation method is applied for the detailed quantification, which utilizes a large zoomed data patch in time domain [6]. After the interpolation processing for each impulse response and clutter patch data, the expanded impulse response is overlaid and superimposed with the expanded clutter patch. Finally, this combined data can be dealt with a clutter-containing impulse response as in the actual clutter environment.

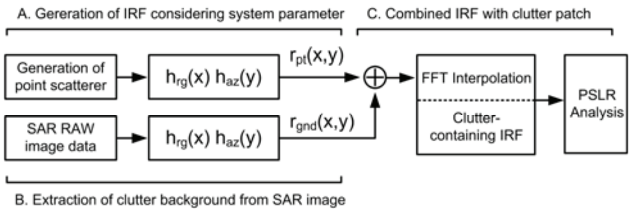
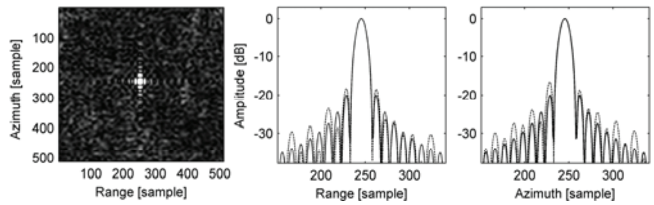


Fig. 1. A scheme of PSLR estimation considering clutter background



(a) (b) (c)

Fig. 2. (a) Clutter-containing 2D IRF (b) range IRF (c) azimuth IRF

3. SIMULATION AND DISCUSSION

A simulation using a realistic clutter-containing impulse response has been conducted for the PSLR performance estimation by taking into account the clutter background surrounding the reference-point scatterer. The simulation model was used as shown in Fig. 1. The raw signal of a point scatterer was generated using the geometry and system parameters of the RADARSAT-1, and the clutter patches were extracted from the actual SAR image as explained above in Sec. 3. The clutter-containing impulse response of the point scatterer is shown in Fig. 2 (a). In order to see the influence of the noisy and clutter background on the ideal IRF, the original and clutter-containing IRF profiles are compared in Fig. 4 (b) and (c). It is seen from the results in Fig. 4 (b) and (c) that the magnitude change of the clutter background can affect the shape of the IRF, and especially the sidelobe level of the clutter-containing IRF is considerably increased by the clutter background. This means that the PSLR performance of the combined IRF is degraded by the level of the clutter background surrounding the point scatterer. It is also noted that the clutter-containing impulse response width (IRW) is not much affected due to the clutter background compared to the original IRF.

For the detailed investigation on the influence of the clutter background, the various clutter-containing PSLR is need to be compared with respect to the SCR. For the fixed area of clutter background, the magnitude of original IRF is controlled by a scaling gain and the resulted PSLR variation due to the clutter background is investigated with respect to SCR. In addition, the original PSLR of -20 dB, -25 dB, and -30 dB is applied to investigate the effect of the advanced PSLR performance requirement. For the desired PSLR performance requirement the effect of clutter background can be estimated from the simulation results.

4. CONCLUSION

The clutter background surrounding a point scatterer may cause the sidelobe level of IRF to be increased, resulting in the degradation of the PSLR performance in the SAR image quality. In this paper, a realistic PSLR estimation scheme using the clutter-containing IRF is proposed by taking into account the clutter background. For the purpose of providing the realistic clutter background effect on the generated ideal point scatterer, the clutter patches extracted from the selected clutter area of actual SAR image are superimposed with the ideal IRF. The simulation result shows that the average PSLR varies from 0.4 dB to 2.0 dB over the various clutter backgrounds surrounding a reference point scatterer, which well represents the realistic clutter background compared to the ideal PSLR. The estimated PSLR of the proposed method is well consistent with the realistic variation of the clutter background. The proposed method can be used to estimate PSLR performance in realistic environment as well as to determine the RCS level of actual reference point scatterer to minimize the clutter effect on PSLR performance.

5. KEY REFERENCES

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