A Novel Method for Limiting the Amplitude of SAR Images with the Principal Axis Detection

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Abstract—Amplitude limiting of SAR target is one important preprocessing procedure in SAR target recognition. Traditional amplitude limiting adopted simple threshold value and is usually sensitive to noise. In this paper, a novel method for limiting amplitude is proposed, which is based on the priori knowledge that normally the strong scatter points are nearby target’s principal axis. First, target’s principal axis and its center is detected with the strong scatter points, then the target area is estimated and the strong scatter points’ amplitude are limited by a simple smooth process. Experiments on SAR image show that the proposed method can limit the amplitude of the strong scatter points and enlarge that of the weak scattering points well.

Keywords—SAR; amplitude limiting; principal axis detection; strong scattering points

I. INTRODUCTION

Synthetic Aperture Radar (SAR) has the ability of obtaining high resolution images of targets under all day and all weather conditions from far range. It is know that SAR can be either stationary on the ground or mounted on moving platforms, and is usually used to image the moving objects, which range from man-made objects like aircrafts, ships and satellites to natural objects like moons and planets. With the development of automatic recognition techniques, in recent years, SAR has been applied widely for military or civil purposes and SAR target recognition attracts more and more attention.

The SAR image usually should be preprocessed before feature extraction and classification. One of the important preprocess procedure is the amplitude limiting. The reason for this step is s follows: The SAR target can be regarded as formed by several reflector. Take the plane target as an example, it may contain ten or more source of strong scatters, with quite different scattering intensity (the difference of the scattering intensity maybe as high as 40dB). As a result, images of SAR target might consist of a few highlight points, sometimes maybe only one point, and this make it is hard to recognize the target with image recognition method. To make the weak scatter source can contribute to target recognition, it is needed to limit the amplitude of the each of strong scatter source, so the strength of target in image is more uniform [1-5].

II. TRADITIONAL AMPLITUDE LIMITING METHOD

Traditional amplitude limiting method [3] merely used a threshold to realize limiting amplitude, as follows.

\[ g'(x, y) = \begin{cases} g(x, y) & g(x, y) < H \\ H & g(x, y) \geq H \end{cases} \]  \hspace{1cm} (1)

Here \( g(x, y) \) is the intensity of one point with the location of \( (x, y) \), \( g'(x, y) \) is the intensity after amplitude limiting, and \( H \) is the threshold value.

In the traditional method, it is difficult to obtain appropriate threshold value selection algorithm which can work well with different target images. Thus, the threshold value is not adaptive. Some results of the traditional method with different threshold are shown in Fig.1 and Fig.2.

![SAR image with different thresholds](image1.png)

Figure 1. SAR amplitude limiting with different threshold
It is can be seen from above results that traditional amplitude limiting method is insensitive to the threshold greatly. If the threshold value is small, more detail of the target can be reserved, while some noise also be preserved, on the other hand, is the threshold is big, noise can be inhibited effectively, but part of target is deleted and the target image is not integrated.

III. AMPLITUDE LIMITING WITH PRINCIPAL AXIS DETECTION

The traditional amplitude limiting method has to face to the difficulty of appropriate threshold selection, which can inhibit the noisy and preserve the details of the target. In this paper, a novel amplitude limiting method is introduced. The idea of the proposed method is as follows: Consider the fact that strong scatter points mainly locate nearby target’s principal axis, so if the principal axis of an SAR target can be detected, SAR target area and its center can be further determined along the axis. After these work, a relatively lower threshold value can be selected easily. With the threshold, the strong scatter points’ amplitude is limited and the weak scatter points’ amplitude is enlarged with a smooth process. Since the work is within the target area, little noise is preserved. The principal axis of one target is shown in Fig.3 [3]

There are five steps in the proposed method:

A. Determine strong scattering points and their locations
Suppose there are N points in an SAR image, then N*0.01 points whose intensity are maximum is selected as strong scattering points. Set \( f(x_i, y_i) \) is the intensity of the \( i \)th point locates in \((x_i, y_i)\), and \( i = 0, 1, \ldots N * 0.01 \).

In this way, almost all of the strong scatter points can be selected.

B. Calculate direction of target’s principal axis and its center.

Calculate the covariance matrix \( B \) of the matrix \( A \) which is formed by strong scattering points’ location, and the eigenvector corresponding to the maximum eigenvalue for matrix \( B \) denotes target’s principal axis direction. Then target’s center can be calculated by counting mean value of the location of \( N * 0.01 \) strong scattering.

The covariance matrix \( B \) of the matrix \( A \) is calculated as follows:

\[
B = \frac{1}{M \times N} \sum_{i=1}^{MN} (f(x_i, y_i) - \mu_b)(f(x_i, y_i) - \mu_b)^T
\]

\[
\mu_b = \frac{1}{M \times N} \sum_{i=1}^{MN} f(x_i, y_i)
\]

Here \( \mu_b \) is the target center. The principal axis direction can be obtained with the eigenvector corresponding to the maximum eigenvalue.

C. Calculate length of the principal axis and determine main area of targets

Search along the principal axis from target center to find strong scattering points, and then repeat the above way along the auxiliary axis. After this, target area can be measured. Based on this, calculate the main distribute area of target energy.
D. Limit amplitude for the strong scattering points and smooth weak scattering points

Based on the intensity value of target distributed area and select the mean intensity of this area as threshold for amplitude limiting, then limit amplitude of the strong scattering points whose intensity is bigger than the threshold, and replace the intensity of weak scattering points with the mean intensity.

E. Delete noise points beyond target area

Determine whether the points beyond target area are noise or not by the combination of their intensity and their distance to the principal axis.

IV. EXPERIMENTAL RESULTS

Experiments of results of the proposed method are shown in Fig.4 and Fig.5.

We can see from Fig.4 and Fig.5 that our approach not only effectively decreases noise but also can preserve target details and reach positive results.

It should be noticed that the proposed amplitude limiting method works well under different imaging angle and different rotation.

V. CONCLUSION

A novel principal axis based method for amplitude limiting is proposed in this paper, which shows the following advantages:

- Amplitude limiting works only within the determined target area, and this can decrease the risk of noise and lower the requirement to threshold.
- The threshold is estimated with points within target area, which makes the threshold more useful.
- The principal axis and the target area can be determined fast and easily with low computation. Experiments show that the proposed method is promising.

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REFERENCES


