Three-component decomposition for polarimetric SAR

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The decomposition of Polarimetric Synthetic Aperture Radar (PolSAR) data is a useful tool to analyze and understand the scattering mechanism of ground targets. Freeman decomposition [1], a very famous model-based incoherent decomposition, models the polarimetic coherency matrix as the contribution of three scattering mechanisms: surface scattering, double-bounce scattering, and volume scattering. When Freeman decomposition is applied to real PolSAR data, the power of surface scattering or double-bounce scattering sometimes become negative for some pixels. Since power is supposed to be non-negative, the emergence of negative power values indicates that the model of Freeman decomposition is not consistent with the actual scattering mechanism of these pixels. It is, therefore, necessary to improve the Freeman decomposition to eliminate these negative powers, so that the model can better conform to the actual scattering mechanism of ground targets.

An improved three-component decomposition for PolSAR data is proposed in this paper. The method is based on Freeman decomposition, but the reasons of the emergence of negative powers in Freeman decomposition have been thoroughly analyzed, and three corresponding improvements are included in the proposed method. Firstly, the deorientation [2] is applied to the coherency matrix of each pixel before it is decomposed into three scattering components. The purpose of the deorientation is to remove the fluctuant influence of randomly distributed target orientation angles on polarimetric scattering, and it can make two identical targets with different orientation angles yield the same coherency matrix, which will finally lead to the same decomposition results. Secondly, the coherency matrix whose polarimetric entropy[3] is equal to one is used as the new volume scattering model instead of the original one adopted in Freeman decomposition. This kind of coherency matrix corresponds to totally random scattering, so it is more appropriate to model the volume scattering than that used in Freeman decomposition. Thirdly, a power constraint is added to the proposed three-component decomposition. It restricts that the powers of the three scattering components should be non-negative and that the sum of the powers of the three scattering components is equal to *Span*, i.e., the total power received in all the polarimetric channels. The principle of this constraint is similar to that used to deal with pixels with negative powers in [4]. Based on this principle, two modification steps are added to the decomposition procedure for complete elimination of pixels with negative powers.

The E-SAR polarimetric data acquired over the Oberpfaffenhofen area in Germany are used for experiment. The results show that the proposed three-component decomposition works better than Freeman decomposition. In Freeman decomposition, some of the adjacent urban and forest areas exhibit similar volume scattering characteristics and the result is not consistent with the actual scattering mechanism; however, in the proposed method, these areas are distinctively separated. In addition, the number of pixels with negative power is significantly decreased by the employment of the new volume scattering model and the deorientation, and if the third improvement is also applied, pixels with negative power are totally eliminated. Therefore, the model of proposed three-component decomposition is better consistent with the actual scattering mechanism than that of Freeman decomposition.

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