CALIBRATION OF SPACEBORNE POLARIMETRIC SAR DATA USING A GENETIC ALGORITHM

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Abstract

Recently, some spaceborne polarimetric synthetic aperture radars, such as TerraSAR X (X-band), RADARSAR-2 (C-band) and PALSAR (L-band), are available to measure a scattering matrix of terrain, and polarimetric data analysis techniques are being developed for terrain classification, forest biomass and soil moisture estimations, etc. Thus, polarimetric calibration is necessary to obtain the accurate analyzed results from the polarimetric SAR data [1][2][3]. The polarimetric calibration is to estimate the channel imbalance and cross-talks on polarimetric radar system. In the case of spaceborne SAR, the ionosphere affects a radar signal and a polarization plane of radar wave is rotated. This effect is Faraday rotation and affects a measurement of the polarimetric SAR data. Then, polarimetric calibration of the spaceborne polarimetric SAR [3] becomes complicated procedure as compared with a polarimetric calibration of an airborne polarimetric SAR [2]. Thus, the polarimetric calibration parameters for spaceborne polarimetric SAR are channel imbalance, cross-talk and Faraday rotation angle. Freeman proposed the polarimetric calibration method of the spaceborne SAR to estimate channel imbalance and Faraday rotation angle under the condition that cross-talk is negligible and polarimetric data has the reflection symmetry property. These conditions mean that his method can not derive all calibration parameters of spaceborne SAR and restricts the polarimetric data.

This paper presents a polarimetric calibration method using a genetic algorithm. This method can estimate all polarimetric calibration parameters including Faraday rotation angle and does not need a polarimetric data satisfying reflection symmetry property. The genetic algorithm (GA) is based on the theory of evolution and can be used to find an approximated global optimal solution to a nonlinear optimization problem [4]. When GA is applied to a problem, the selection of fitness function is important to converge for obtaining exact answer rapidly. Since SAR system is a monostatic radar, we define the fitness function based on the reciprocity [5]. The reciprocity means that S_{hv} is equal to S_{vh} and has to be satisfied anywhere in SAR scene. Moreover, we add the information of trihedral corner reflector to the fitness function. Therefore, the proposed calibration method does not need the data satisfying the reflection symmetry and the assumption to neglect the cross-talks.

To show the effectiveness of the proposed calibration method, Advanced Land Observing Satellite (ALOS) / Phased Array type L-band SAR (PALSAR) data was used. PALSAR observed Nagasaki, Japan on December 23, 2007. In Nagasaki, there are very few areas where the reflection symmetry is satisfied. When PALSAR observed Nagasaki, one trihedral corner reflector was deployed in a playground of Nagasaki University. Initial GA parameters where chosen as $0.5 \leq |f| \leq 1.5$, $-180° \leq |Arg(f)| \leq 180°$, $0.0 \leq |\delta| \leq 0.3$, $-180° \leq |Arg(\delta)| \leq 180°$ and $-5° \leq \Omega \leq 5°$. The estimation results were compared with JAXA(Japan Aerospace Exploration Agency) polarimetric calibration parameters. When fitness function became small, f_1, f_2 and δ_{1-4} estimated by proposed method were close to JAXA values. Moreover, Faraday rotation angle estimated by proposed method was similar to that estimated by Freeman method. Therefore, it was confirmed that the polarimetric calibration method using genetic algorithm can estimate not only channel imbalance and cross-talk of SAR system but also Faraday rotation angle simultaneously.

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