Performance Evaluation According to Virtual Grid Size in the Rational Function Model Generation for KOMPSAT-5 SAR Imagery

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ABSTRACT: In utilizing satellite imagery, the Rational Function Model(RFM) simplifies the geometric relationship between image coordinates and ground targets. In this study, the RFM model for KOMPSAT-5 was generated and evaluated. The general least squares adjustment and Tikhonov regularization in the RFM generation process were applied to calculate the RFM coefficients. The virtual grid was generated using the physical sensor model for KOMPSAT-5 and used as control points to calculate the RFM coefficients. As a results, the virtual grid size did not show significant improvement from 7x7. In addition, the analysis result according to the number of the elevation layer was obtained sufficiently stable result even at 10x10x5.

1. INTRODUCTION

The geometric relationship between the image coordinate of Synthetic Aperture Radar (SAR) and the ground coordinate of a target can be defined by a physical sensor model. In SAR satellite image, the physical sensor model is generally defined as Range-Doppler model. However, in the case of physical sensors, it is difficult for the non-expert to use, and there may be a security problem. Therefore, recently, in the case of optical satellites, Rational Polynomial Coefficients (RPCs) are often provided.

The ground control points extraction process using the virtual grid can lead to uncertainties in the image coordinates and the ground coordinates, and the errors generated can affect the geometric correction results. Therefore, we attempted to analyze the uncertainty that may occur when performing an analysis using a virtual grid. Virtual grids of various sizes were created to perform the experiments of Rational Function Model (RFM) generation, and virtual grids of 100x100x100 were created to evaluate the performance of the proposed geometric process. The virtual grid of 100x100x100 size was applied to perform the evaluation process.

The RFM model is a kind of interpolation model, and the number and distribution of control points can affect the precision. Since the generated virtual points are equally distributed, the size of the virtual grid is an important factor in the stability of RFM generation. Although large virtual grids are more effective, problems may arise in the time and memory management required to create large virtual grids. Therefore, in this study, we analyzed by the size of the virtual grid to derive the proper size of the virtual grid.

2. METHODOLOGY

2.1 RFM Generation

If a physical sensor model is available to determine the RPC, it can be estimated by the terrain-independent scenario using it (Hu et al., 2004). Terrain-independent scenario is a method of estimating the RPC by creating a virtual grid when the physical sensor model is available. The RFM, which has been normalized, can achieve very high accuracy compared to the physical sensor model that has not been normalized. When the possible conditions are met, it is reported that an error occurs within 0.04 pixels compared with the physical sensor model (Grodecki and Dial, 2001). This is almost similar to the accuracy of existing physical sensor models, and terrain-independent scenarios have been widely used to completely and safely replace RFM with physical sensor models and to determine RPCs (Hu et al., 2004).

In order to perform the terrain-independent scenario, first, a virtual grid of mxn size including the entire image is created. The physical sensor model is applied to find the image grid points corresponding to the ground grid points. The x and y axes of the 3D grid are determined using the full range of the image, and the z axis is calculated using the elevation values of the terrain estimated from the Digital Elevation Model (DEM). These virtual grids consist of several layers (Tao and Hu, 2001). After the 3D virtual grid is generated, the RPC can be estimated by the least square method as input of ground virtual grid points and image grid points (Hu et al., 2004). The coefficients generated in this way have very high correlations with each other because they do not have a physical meaning unlike physical geometry models, and models composed of these coefficients may be incomplete (Zhang et al., 2011). To solve this problem, the normalization methodology is applied and Tikhonov normalization methodology is used.

2.2 Assessment Metric

In order to evaluate the accuracy of the generated RFM, 100x100x100 independent check points were generated. The Root mean square error (RMSE) and Maximum Absolute Error (MAE) generated when the image was generated using the generated RPC were calculated. If the graph of error generation according to the size of the virtual grid is graphed, it can be seen that the error is actually smaller as the size of the virtual grid increases, and The algorithm proposed by Zack et al. (1977) is applied. This algorithm is a way to find the valley point in the histogram.

3. RESULTS

The RFM generation performance according to the virtual grid size was analyzed. The data used for the experiments in this study were KOMPSAT-5 SAR imagery, and images taken on January 8, 14, and 15, 2016 in Enhanced High Resolution, High Resolution, and Ultra High Resolution modes were used.

The horizontal virtual grids were created at intervals of 1x1 from 5x5 to 30x30, with 20 elevation layers. Even when the horizontal virtual grid size was 5x5, the precision was analyzed to be more than 10^{-2} pixels, and it showed a tendency to decrease rapidly to 15x15. The elbow points methodology was applied to find the optimal virtual grid size, and 7x7 was analyzed as the most suitable virtual grid size. The vertical virtual grid size was set at one interval from 5 layers to 40 layers, and the horizontal grid size was set to 10x10. The results of the analysis did not show significant results according to the change in the number of layers.

4. CONCLUSIONS

The RFM can simply define the relationship between image coordinates and ground targets. In this study, we compared and analyzed the accuracy of the generated image according to the virtual grid size setting during the RFM generation process. The size of the virtual grid was analyzed horizontally and vertically, and the appropriate size of the virtual grid was derived based on the analysis results. Even when the size of the virtual size was 10x10x5, the accuracy of the generated RFM was analyzed to be 10^{-9} pixels.

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