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Automated Sensor Orientation Establishment for Mid-Resolution Satellite Images

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Abstract: Precise sensor orientation establishment is an important process to improve geometric accuracy of satellite images. It must be performed before using a satellite image. It requires ground control points (GCPs) in which image coordinates and ground coordinates accurately correspond. It can be performed automatically by matching images against GCP chips, a small image segment whose ground coordinates at its center are known precisely. Mid-resolution satellite images are suitable for monitoring large areas due to their wide swath width, and are utilized for extensive disaster analysis and agricultural monitoring. Therefore, it is also important to establish a precision sensor orientation for mid-resolution satellite images. Previous GCP chip matching studies were mainly conducted on high-resolution satellite images with GCP chips generated from high-resolution satellite or aerial images. However, there is a large difference in spatial resolution between satellite and GCP chip images. Previous studies maybe not directly applicable to mid-resolution satellite images. In this paper, we aim to reuse GCP chips prepared for high-resolution images for precision sensor modeling of mid-resolution satellite images. There are two major problems: First, GCP chip matching performance could be poor because of the resolution difference between a satellite image and GCP chips. Second, the matching process takes more time because more GCP chips are used due to wider coverage of mid-resolution satellite images. This study proposes a solution to these problems by performing satellite image upsampling and adjusting the number of GCP chips.

The proposed method, firstly, establishes the initial sensor model using the original Rational Polynomial Coefficients (RPCs) provided with the original image. RPC refers to a coefficient for constructing a sensor model using Rational Function Model (RFM). Using this sensor model, it searches for GCP chips in the entire satellite image boundary. In this progress, it selects the number of chips to be used for matching. Next, it upsamples at various ratios an original mid-resolution satellite image. We used bilinear interpolation as an upsampling method. In this process, RPCs provided with the original image were also converted according to the spatial resolution of the upsampled satellite images. Then, it resamples each GCP chip to the imaging geometry of the satellite image and downsamples it to the resolution of the upsampled satellite image. Finally, it constructs each image patch into a four-step pyramid image and matches the chips against the images using image matching algorithm. Based on the result of matching, it establishes precision sensor models. In this study, a RapidEye image with a resolution of 5m was used as a mid-resolution satellite image. GCP chips were prepared from high-resolution aerial orthographic images with a resolution of 0.25m.

The research area was selected as Cheonan, South Korea. About 1,300 GCP chips were included in the area covered by the test image. In this study, model accuracy and check accuracy were used as performance evaluation indicators. Model accuracy is the accuracy measured for the GCP used for calibrating the initial sensor model. Check accuracy is the accuracy measured for manually extracted reference points which are not included in the model points. All accuracy analyses were performed at the original resolution of 5 m. Figure 1-(a) and (c) show that model accuracy was improved with higher upsampling ratios and smaller GSDs. This indicates that estimation process for RPC updates has been applied successfully. Based on the check accuracy (Figure 1-(b) and (d)), the performance was better when upsampling was applied. In addition, they show that the accuracy was maintained even when the number of chips is adjusted to 80 to 40.

Results showed that matching with upsampled images outperformed that with the original image. In addition, when the number of chips was reduced, the geometric correction accuracy was maintained up to 60% of reduction. Through the method used in this study, position errors of 3m or 0.6 pixel of the original image, could be achieved. We confirmed the possibility of establishing an improved precision sensor model of mid-resolution satellite using high-resolution GCP chips.

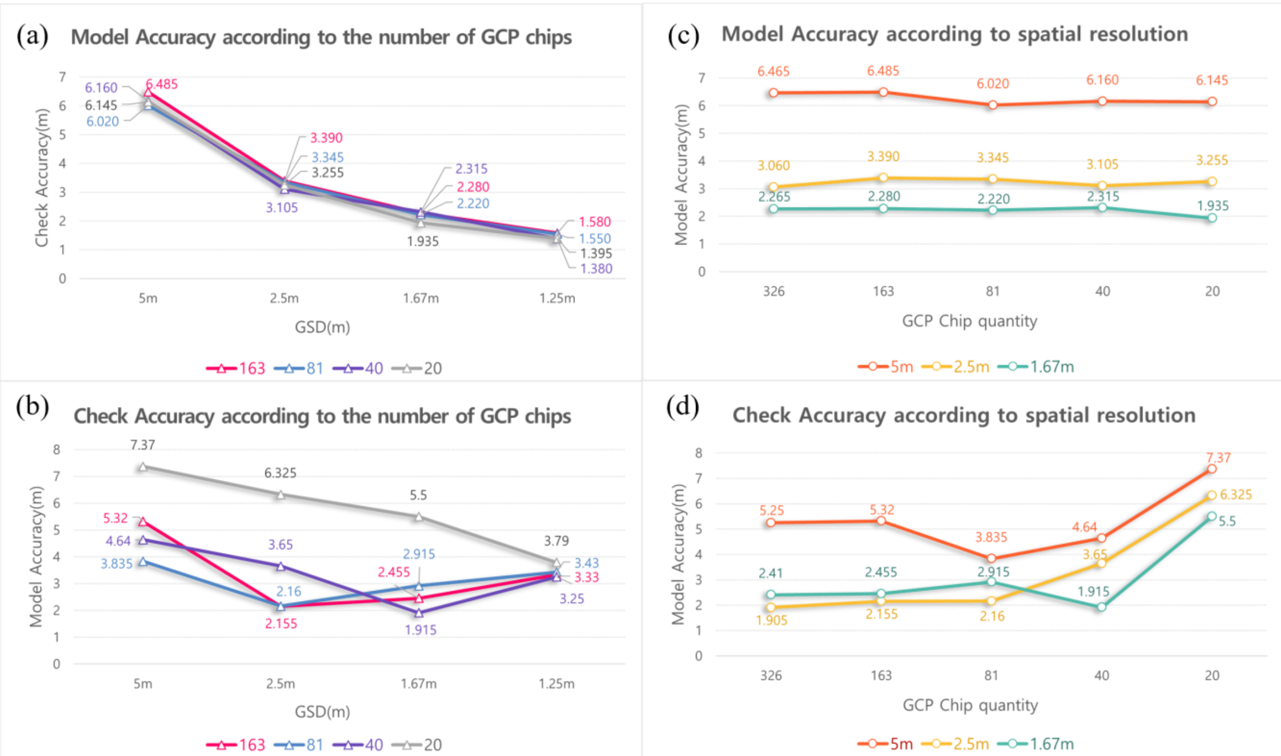

Figure 1. Changes in model accuracy(a) and check accuracy(b) according to the number of GCP chips at spatial resolution. And Changes in model accuracy(c) and check accuracy(d) according to spatial resolution at number of GCP Chips.

Keywords: Mid-resolution satellite, Sensor orientation, Geometric correction, GCP matching, RFM

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