Automatic Georeferencing Framework for Timeseries Formosat-2 Satellite Imagery using Open Source Software

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EXTENDED ABSTRACT:

Georeferencing is to assign mapping coordinate system and to produce a geo-rectified image for satellite image. It is an important preprocessing for multi-temporal images analysis as well as multi-source data fusion. Orthorectification and co-registration are two different methods in geometric correction. The orthorectification establishes mapping function between 2D image space and 3D object space while the co-registration adopts a global or a local image-to-image transformation. This two methods can be integrated sequentially for precise mapping. Due to the development of geospatial big data analysis, the growing satellite image archive requires automatic and precise georeferencing framework to handle time-series satellite images.

This study aims to develop an automatic georeferencing framework using open geospatial data and open source software for Formosat-2 satellite image archive. The input Formosat-2 satellite images are level 1A panchromatic and multispectral images while the output data are registrated pan-sharpening images. The sensor model of Formosat-2 in used is rational function model (RFM) for orthorectification. The georeferencing framework utilizes an orthoimage as a reference image. The open geospatial data for correction of terrain relief are 30m Shuttle Radar Topography Mission (SRTM) elevation data and EGM96 Geoid data. In order to perform automatic georeferencing, a predefined orthoimage is selected as a reference image to find corresponding points between reference orthoimage and Formosat-2 satellite image.

The geospatial open source software in used includes OpenCV (http://opencv.org/), Orfeo ToolBox (https://www.orfeo-toolbox.org/) (Christophe et al., 2008), and Arosics (https://pypi.python.org/pypi/arosics) (Scheffler et al., 2017). The main idea is to refine the satellite image using different approaches in different stages. The proposed framework includes four major stages: preprocessing, coarse-registration, fine-registration and color fusion.

The preprocessing stage uses OpenCV Library to construct an image pyramid-matching scheme in refinement of rational polynomial coefficients (RPCs). This stage effectively refines the metadata of input Formosat-2 image (i.e. RPCs) from pyramid images. A Speeded-up-robust-features (SURF) matching (Bay et al., 2008) is applied to extract registration points between orthoimage and Formosat-2 image. The height of registration points can be obtained from digital elevation model (DEM). Then, the extracted registration points is applied to improve the positioning accuracy of RPCs (Teo, 2011). The second stage is coarse-registration by refined RPCs and reference orthoimage. Several tools from Orfeo Toolbox are composed to build up an iterative refinement scheme in automatic coarse-registration. The automatic coarse-registration divides input image into different blocks and each block preforms SURF matching to find registration points. So, the registration points are equally distributed to cover the whole scene. The RFM is refined by additional parameters with outlier detection. This stage resamples the Formosat-2 level 1A image into initial geocoded image based on RFM, registration points and DEM. This coarse-registration might include geometrical discrepancy between initial geocoded image and reference orthoimage. Therefore, fine-registration is needed. The third stage is an image-to-image registration using local transformation. The Arosics is selected to do the fine-registration between initial geocoded image and reference orthoimage. As the initial geocoded image is similar to reference orthoimage, the phase-

shift image matching method is applied in fine-registration. The fine-registration also divides input image into different blocks and perform image matching iteratively. Finally, a high pass filter (HPF) color fusion method (Gangkofner et al., 2008) is applied to generate pan-sharping image from panchromatic and multispectral images.

The challenges of the proposed automatic scheme are cloud and terrain effects. Therefore, this study select a mountain area in different cloud conditions. The experiment utilized a set of Formosat-2 level 1A satellite images (28 panchromatic images and 28 multispectral image) with different cloud coverages (e.g. 0% to 40%) in year 2014. The reference orthoimage was also a 2m Formosat-2 image in year 2014. The proposed georeferencing framework automatically rectified satellite images and fused the panchromatic and corresponding multispectral images into timeseries pan-sharping images. This study selected 14 cloud free panchromatic images in accuracy analysis. The geometric accuracies before registration were ranged from -169.29m to 267.28m. After co-registration, the geometric accuracies improved to -4.17m to 3.13m. In summary, the geolocation accuracy of proposed scheme was improved from hundred meters to 5 meters level accuracy. One of the limitation for the proposed scheme is image quality (e.g. the percentage of homogeneous area). The future study will focus on excluding homogeneous area to improve the quality of georeferencing image.

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