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A Method for Orth–Rectification of Satellite Images Using Topographic Form–Line

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Various types of control information are used in precise–rectification of high–resolution optical satellite image products. Here, the accuracy of rectification results depends on the quality and quantity of control information, and its distribution in an image to be rectified. These can be mitigated and re–processing of rectified images using a digital elevation model (DEM) can be avoided if the topographic form–lines with topological tendency reflected are used as control information for precise–rectification of satellite images.

In this paper, we propose a method for precise–rectification of high–resolution optical satellite images at mountainous areas using the linear features such as topographic form–lines generated by a DEM, and roads, rivers and railways from geo–database as ground control information.

Satellite images with GCLs are rectified via, 1) abstracting Image Control Lines(ICLs) corresponding to Ground Control Lines(GCLs) such as topographic form–lines, roads and rivers in satellite images; 2) establishing mathematical relation between GCLs and image control lines extracted from satellite images, whereby transforming the images; 3) resampling DN(Digital Number) values of the images.

Extraction of ICLs from satellite images is time–consuming, so we do not try to extract them using a direct method. Instead, we use an indirect method. First, overlaying GCLs on a satellite image, local area (distorted area) where GCLs do not fit nicely with corresponding topographic form–lines, river system and roads in the satellite image are selected. Next, in this area, the poorly–fit ground control lines are selected one by one and displaced to be overlapped with the conjugate topographic form–lines, rivers and roads in the satellite image (ICLs).

In general, nodes are arbitrarily distributed. Hence, Polynomial Point Interpolation Method using polynomials as basic functions can be used. Here, one of the problems arising in the implementation of this method is the singularity of constitution matrix essential for calculation of expansion coefficient. Thus, the Point Interpolation Method (PIM) using radial basis function (or RPIM) is used.

Algorithm for precise rectification is as follows:

ⅰ) extract vector topographic form–lines data (waterlogging lines and watershed lines) from a Digital Elevation Model,

ⅱ) overlain GCLs on high–resolution satellite image,

ⅲ) select a rectangular area to be rectified (distorted area),

ⅳ) choose GCL available for rectification reference and obtain the image coordinates of nodes on the GCL.

ⅴ) move the GCL to be overlapped with corresponding ICL, obtaining image coordinates of nodes on ICL,

ⅵ) repeat ⅳ~ⅴ one by one for each desired GCL in the selected area until image coordinates of nodes on ICLs and GCLs enough for rectification are obtained,

ⅶ) interpolate the sub–image by using radial point interpolation method(RPIM) with all the ICLs and GCLs obtained in the selected area and its boundary coordinates to calculate the rectified image coordinates of all the pixels in the sub–image,

ⅷ) make sampling DN values of pixels by means of image coordinates, and rectify sub–image of selected area,

ⅸ) repeat ⅲ–ⅷ until the overall satellite images are rectified.

In order to verify the accuracy and effectiveness of the method proposed, we test the method for a scene of Level 17 image downloaded from Google Earth, which includes rivers and roads. According to the corresponding DEM, the area being mountainous and the distinct GCPs and GCLs being difficult to obtain, topographic form–lines as well as rivers and roads were utilized to perform rectification.

To evaluate quantitatively the result of rectification, we measured the positions of the check points with a RTK–GPS (Real–Time Kinetic Global Positioning System) receiver H32, which ensures the planimetric accuracy of 1cm order in the test areas and in the measured conjugate points of the rectified satellite images.

We expect our method to undoubtedly provide a new approach to reach higher rectification accuracy of optical satellite images.

In future, we will focus on the determination of reasonable flow accumulation value in extracting of topographic form–lines, improving the extraction accuracy and automatic ortho–rectification based on GCLs.