GNSS/IMU Data Supported Feature Matching for Aerial Oblique Images

YUNSHNEG ZHANG (zhangys@csu.edu.cn)
ZHENGRONG ZOU (zrzou@csu.edu.cn)
HONGBO PAN (Hongbo640@gmail.com)
CHAO TAO (kingtaochao@csu.edu.cn)
Geosciences and Info-Physics, Central South University, 932 South Road Lushan, Hunan, P.R.China

Abstract

Feature matching is an important and difficult task for aerial oblique image triangulation and bundle adjustment. Due to the serious varying view point among images from different directions and scale difference within an oblique image, typical tie point matching approach and software may face problems when dealing with aerial oblique images. This paper presents a novel feature matching method to overcome the mentioned possible problems. The core idea is to use derived EOPs (Exterior Orientation Parameters) to estimate connectivity between images to guide stereo matching and to pre-rectify image to alleviate the difference among oblique images. The procedures of the new method include three steps: 1) Generating connectivity graph using approximate EOPs and average height, 2) Image rectification based on approximate EOPs, 3) Feature matching and free-network generation.

1) Generating connectivity graph based on approximate EOPs and average height: For typical aerial oblique system, GNSS/IMU system is connected to the nadir camera. Thus, the EOPs of the nadir camera can be estimated based on the GNSS/IMU information if we ignore the bore-sight between IMU and nadir camera. After that, the calibrated translation/rotation parameters between nadir camera and oblique cameras are employed to estimate the EOPs of all the oblique cameras, and then approximate EOPs for each image can be obtained. Based on approximate EOPs, the boundary of each image is projected to a given average height plane, then the relationship between image is estimated based on analysing the intersection of the projected quadrilateral. The derived connectivity graph will be used to guide subsequent stereo matching.

2) Image rectification based on approximate EOPs: After deriving EOPs for each image from above step, all images are pre-rectified to an average horizontal plane. To rectify an image based on plane, homography transformation parameters have to be calculated via collinear equations combined with IOPs (Interior Orientation parameters), EOPs and the height of the used plane. After calculating homography transformation parameters, indirect method is employed to rectify the original images and the used parameters related to each image are stored.

3) Feature matching and free-network generation: After image rectification, standard SIFT feature detection is performed on all the rectified images. Then the coordinates of the detected feature are mapped to the original image space. During the image rectification processing, some pure black area is filled in the rectified image, which can lead to numerous features detected between the transitions from effective to invalid area. These features (near the boundary of the original image) have to be removed to avoid processing in subsequent matching. After feature detection, stereo matching based on the detected feature with descriptors is carried out on each available stereo pair selected from the connectivity graph, and then a free-network generation processing similar to structure-from-motion processing is *performed. The difference is that we used calibrated IOPs for each camera, thus, we don't refine each added images when carrying out the structure-from-motion processing. Until all the images are processed, the free-network generation is terminated. Finally, we perform a bundle adjustment employed all the images without tuning IOPs but refining the EOPs all the images and coordinates of all the reconstructed 3D points.*

A set of aerial oblique images with typical texture and scene is employed for quality and quantity evaluating of the proposed method. The data set includes 52 images. For evaluating the proposed method, six special indicators for aerial oblique image triangulation are used: RMS indicates the mean back-projection error; N_{3d} *indicates average number of reconstructed 3D points for each image;* N_{img} *indicates average image number related to a 3D point;* R_{cov} *indicates the average overlap of the feature matches on image;* N_{dir} *indicates average directions of each 3D points derived from;* R_{ndir} *indicates the ratio of the 3D points derived from more than one direction image. For evaluating different advance feature matching methods on aerial oblique image matching. SURF, MSER and ORB are also employed to perform the feature matching on original image. The comparison result is shown in Table I. From the result, we can find that SIFT and SURF algorithm is more suitable for tie point matching of aerial oblique images. After comparing, SIFT algorithm is selected to perform the proposed method and compared to the matching result without rectifying images. The result is shown in Table II. It can be found that the matching result is improved, which reveals that the rectification processing can alleviate the difference between images and to improve the robust of the matching processing.*

Table I. Comparison results of different feature detector

algorithm	SIFT	SURF	MSER	ORB
RMS	1.04	0.93	1.18	1.44
N_{3d}	3560	3046	647	4686
N_{img}	2.48	2.32	2.17	2.29
R_{cov}	93.2%	93.4%	87.6%	85.8%
N_{dir}	1.23	1.30	1.16	1.17
R_{ndir}	20.8%	27.9%	16.0%	16.2%

Table II. Comparison results of different matching method

algorithm	*RMS*	N_{3d}	N_{img}	R_{cov}	N_{dir}	R_{ndir}
Original	1.04	3560	2.48	93.2%	1.23	20.8%
Proposed	0.65	4143	2.85	92.1%	1.63	33.1%

KEYWORDS: aerial oblique images, feature matching, aerial triangulation, image rectification