Construction Of Georeferenced Mosaics Using Small Format Aerial Images

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Abstract

We propose to use small format aerial images (SFAI), considered as not controlled, and stereo-photogrammetry techniques for constructing georeferenced mosaics. The images are obtained using a digital camera coupled to a small, radio controlled helicopter. Techniques for removing distortions are applied and the relative orientation of the models are computed using perspective geometry. Ground truth points are used for absolute orientation, and a definition of scale and a coordinate system relate image measures to the ground.

1. Introduction

A mosaic is a composition of adjacent images aiming to provide a larger view of a desired scene. A georeferenced mosaic is obtained by relating the final composition to some coordinate system, after removing distortions and other errors caused by the acquisition process, so that measures in the mosaic reflect measures in the scene by some affine mapping (in general only a scale). Transformations are applied to reconstruct the positions and relative orientation of the images in relation to each other and in relation to ground truth points. The definition and adoption of a scale and the reference system are the main characteristics of a georeferenced mosaic. We acquire images using a common digital camera connected to a small radio controlled helicopter. This makes the acquiring process cheaper if compared to the other processes based on satellite or aerial cameras in airplanes. However, as SFAI has almost no control, it becomes indispensable to readjust and/or to create methodologies when using this kind of image.

2. Construction of georeferenced mosaics with SFAI's

Basically, we first apply techniques for camera calibration and correction of radial and radiometric distortions. Then, we proceed the reconstruction from stereo-photogrammetry itself and the generation of the georeferenced mosaic.

2.1. Stereo-Photogrammetry

The acquisition system guarantees longitudinal recovering of about 70% as well as lateral of about 30%, between the images. In this way, in each point of the mosaic, at least two images contribute to its value. We note that each image is acquired from a different positioning of the helicopter. The main problem of stereo reconstruction is to discover which points in each image correspond to the projections of a same point of the scene. This problem is known as *matching* [2] or simply correspondence, and it is the more expensive stage. After determining the correspondences for all pixels of the images, this information can be used in the construction of the mosaic. The depth for each pixel can be determined in relation to a reference fixed in the image center by a simple triangulation. This depth can help to differentiate the characteristics or attributes of data pixel since it appears in more than one image. We notices that, in the worse case, an average between the attributes can help to minimize problems of errors in the images. The correspondence between the images can be determined by using area or attribute techniques [2]. In general, this involves the application of operators such as normalized cross correlation (NCC) or sum of squared differences (SSD) [3]. The SSD is faster than correlation, but it is not immune to variations of illumination and brightness in the images, problems that do not affect the NCC.

2.2. Relative Orientation

As an observed simplification, some stereo-photogrammetry principles are used in the phase of relative orientation of the models produced for each pair of consecutive images. This phase's goal is to determine, approximately, the spatial positioning of the helicopter at the moments of taking each image, approximately given by the on-board GPS. This problem is currently well-defined in the photogrammetry literature and its formalization can be found in books, texts and articles [4]. Due to the simplification, only 6 pairs of points known in each model (between each pair of images) are necessary for obtaining a good precision in the determination of the transformation coefficients. The coefficients are then used to reconstruct the spatial positioning and orientation of the helicopter in each frame.

2.3. Absolute Orientation

For georeferencing the mosaic (determination of scale and referencing it to a known coordinate system), we determine terrain coordinates of the control points previously chosen in the study area by using a GPS. By using aerial-triangulation techniques [4], these known coordinates are extended to the points determined in the relative orientation phase. Note that, in the case of having an irregular terrain model, these coordinates could be extended to all the other points of all the images, generating, thus, coordinates referenced to a system for all points in the mosaic [1]. We notice that each pair of adjacent models has a common image, from which errors can be minimized and estimated, in order to compute point coordinates. The technique for aerial-triangulation adopted in this work uses least squared differences (LSD) to minimize errors in the process of determination of coordinates for the corresponding points of each model. Finally, we perform a block adjustment for determining the georeferenced coordinates of all the points. The result is the determination of coefficients for the transformations necessary to be applied in each image for the generation of the final mosaic.

3. Implementations and Partial Results

The software is divided in sequential modules, as shown in Figure 1. We perform some partial experiments in order to test the system. Figure 2 shows results for the Tsai calibration method that we implemented [3], and for radiometric and radial distortion corrections. The same Figure also shows results after applying affine and projective transformations, with coefficients given by relative and absolute orientation. A mosaic composed of 10 images with illumination correction is also shown.

4. Conclusion

We deal in this work with the development of a system that generates georeferenced mosaics by means of using stereo-photogrammetry techniques, from small format aerial images acquired by a common digital camera connected to a small radio controlled helicopter. The main con-

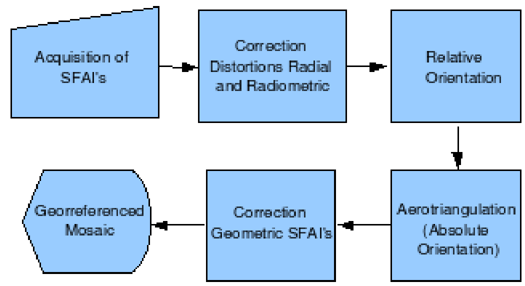

Figure 1. Structure of the system

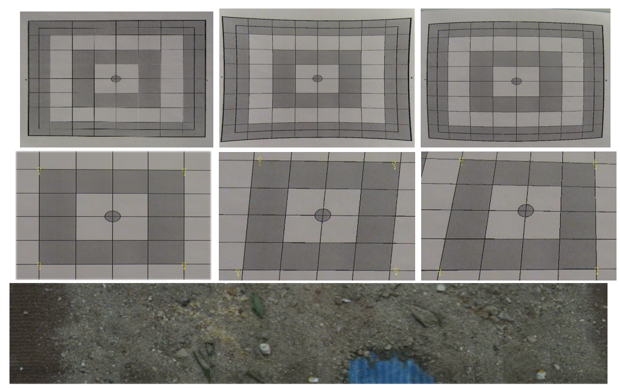

Figure 2. Camera calibration, Distortion Radiometric and Radial(Pincushion,Barrel), Image initial with Points, Affine, Projective and Mosaic Transformations

tribution of the present work is that this type of image has not been widely explored in the generation of georeferenced mosaics, in despite of using well controlled images with large format and, possibly, general techniques adopted in cartography projects. That is shown to be very expensive, so the present work presents a less expensive solution. We thank the financing of the CNPQ and RNP.

References

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