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Stitching of hyper-spectral UAV images based on feature bands selection

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Abstract: This study employed the feature band pre-selection and composite process to overcome the mosaic difficulties of large number of bands and huge data volume of the hyperspectral UAV images before the mosaic process being done. The application and comparison were done by using the UHD 185 hyperspectral camera, and the result showed that the band pre-selection and composite method used in this study can go up as high as being 390 percent faster than the single band mosaic (for the Normalized Differential Vegetation Index application), and about 46 times faster than full band mosaic. Besides, compared to the full band mosaic method, the method used in the study can reduce the maximum memory usage amount and final mosaic file size significantly.

Keywords: UAV, mosaic, hyperspectral, images.

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1. INTRODUCTION

With high spatial-temporal resolutions, low cost and risk, Unmanned Aerial Vehicle (UAV) remote sensing is an important complement for satellite remote sensing (Kelcey et al, 2012). Unlike the high-resolution satellite remote sensing which usually provides large area and usable geographical position, the UAV remote sensing, especially the multi-rotor electric UAV, often provides a small observed range and less accurate geographical position information for each image. As a result, for most of the UAV remote sensing applications, the first step is to obtain the mosaic image by using many individual images.

Currently, the image mosaic technology can be used well for images capture from different types of camera, such as true-color camera with red, green and blue three channels, multispectral camera with several discrete bands, and some of the hyperspectral camera with hundreds of channels. The obvious difference between the hyperspectral camera and true-color or multispectral camera is the former owns narrower band width over a continuous spectral range (Harsanyi et al, 1994). For the UAV image mosaic, the character of the huge number bands leads to large data volume which requires higher performance computer and more processing time. On the other hand, most of the applications only need several bands in the total bands of the hyperspectral images, e.g. the Normalized Difference Vegetation Index (NDVI) only needs near-infrared band and red band. This means most of the bands in the processing procedure were useless. As a result, before the hyperspectral images are processed, the feature bands used in the application should be selected. In this paper the band pre-selection and composite are presented, and how this method will speed up the processing procedure and reduce the requirement of the system resources are discussed.

2. METHOD

The general steps to convert UAV images into mosaic images can be described below, as shown in Figure 1. The first step is to obtain sparse cloud by using the Structure from Motion (SfM) (Sturm et al, 1996). In this step, the key-points of each image should be recognized firstly, the key-points detected algorithm, such as Scale-invariant feature transform (SIFT) (Lowe et al, 1999; Lowe et al, 2004), and Speeded Up Robust Features (SURF) (Bay et al, 2008) can be used to process the key-points well. Then the Random Sample Consensus (RANSC) (Fischler et al, 1981) algorithm is performed to match key-points from different images. Next, those matched key-points were used to obtain the camera positions and the camera's motion. In this stage, there are several methods to get the structure from motion, such as incremental SfM by which camera poses are obtained and added one by one to the collection (Wu 2013), the global SfM, by which the poses of all cameras are obtained at the same time (Cui et al, 2015). In this study, the software used to obtained the sparse depth image by using the VisualSfM which can be access from http://ccwu.me/vsfm/.

The second step is to create dense clouds and mesh, and then the mesh and texturing are processed respectively, and finally the orthorectification is performed by using digital differential inverse method to finish the mosaic. The software

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used for dense point cloud reconstruction is PMVS/CMVS (Furukawa et al, 2008).

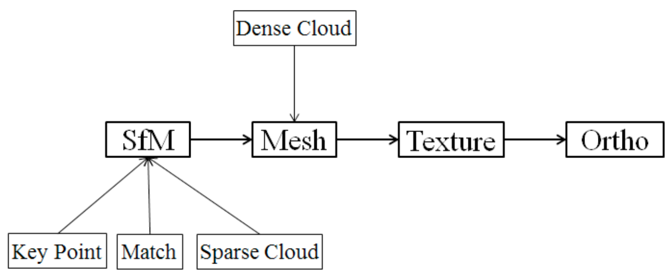

Fig. 1. The steps of creating a mosaic orthographical photo.

In general, for a really images stitching application, due to the SFM stage (key point detection, match and sparse cloud production) and Mesh stage only need the single band gray-scale image as an input file, so the first step is to convert the color image to the gray-scale image. Then, at the texture step, the true-color image will be loaded to generate a textured mesh, and the orthographical photo will be produced.

For hyperspectral images mosaic, the current process logics are as follows: processing all bands at once (only repeat the last two steps for each band), or processing one band once at a time and then repeating it for many times (all the 4 steps in Figure 1) to finish the procedure. In general, both of these two methods are time and resources consuming. Besides, the second logic may cause inconsistent result for each band, and the feature detection and matching algorithms may generate slight difference between two adjacent bands.

In practice, most bands information is useless for a specific application and should be removed from the original data to accelerate images mosaic processing. Therefore, the first step is to conduct feature band pre-selection, and combine those feature bands into a single image, as shown in Figure 2.

Fig. 2. The steps of creating a mosaic orthographical photo in this study.

Then the mosaic process begins normally as shown in Figure 1.

3. APPLICATION AND COMPARISON

The hyperspectral used in the application is Cubert UHD 185 provided by the Cubert GmbH technology company which owns 125 bands from 450-950 nm with 4 nm sampling interval and additional 14 bands with reduced Signal Noise Ratio (SNR). The UAV used in the application is DJI spreading wings s1000 and DJI A2 fly controller. The hyperspectral images were obtained in 15 Jan, 2016, at Xiaotangshan national precision agriculture research demonstration base, Beijing, China, with wheat growing here. The flight altitude and speed of the UAV are 30 meters and 1.5 m/s respectively, the total images number is 132, and imaged area is about 10000 m^2.

The original format of the hyperspectral data is cub, and then the cub format was converted to the Tag Image File Format (TIFF) format, and 6 bands (band 1, band 3, band 25, band 50, band 66, and band 102 with wavelength of 450-950nm, 460 nm, 550 nm, 650 nm, 715 nm and 860 nm, respectively) were selected from the TIFF format files to reflect growth status of the vegetation, and to composite a new multi-band file. The sensitive bands were selected based on the expert knowledge of remote sensing, e.g. the reflectance of wavelength of 860 nm for the vegetation is smaller than other background surfaces due to the high absorption of the water in the vegetation, and the reflectance of wavelength of 650 nm for the vegetation is larger than other background surfaces for the vegetation. As a result, the Normalized Difference Vegetation Index was used to evaluate the growth of vegetation. The full band files and the new multi-band files were used as input file to obtain mosaic files by using our own images stitching software. The test computer owns 4 TB hard disk, 32 GB memory and 32 cores of CPU. Figure 3 show the results of the stitching images.

Figure 3(a) is the true-colour stitching image in the same location and time by using Panasonic GH 4 camera, Figure 3(b) is the full band hyper-images mosaic result, Figure 3(c) and 3(d) is the NDVI and Enhanced Vegetation Index (EVI) images calculated from mosaic band through the band pre-selection method. As can be seen from the figure, the band pre-selection method can also produce preferable mosaic images.