ON GEOMETRIC PROCESSING OF MULTI-TEMPORAL IMAGE DATA COLLECTED BY LIGHT UAV SYSTEMS

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ABSTRACT:

Data collection under highly variable weather and illumination conditions around the year will be necessary in many applications of UAV imaging systems. This is a new feature in rigorous photogrammetric and remote sensing processing. We studied performance of two georeferencing and point cloud generation approaches using image data sets collected in four seasons (winter, spring, summer and autumn) and under different imaging conditions (sunny, cloudy, different solar elevations). We used light, quadrocopter UAVs equipped with consumer cameras. In general, matching of image blocks collected with high overlaps provided high quality point clouds. All of the before mentioned factors influenced the point cloud quality. In winter time, the point cloud generation failed on uniform snow surfaces in many situations, and during leaf-off season the point cloud generation was not successful over deciduous trees. The images collected under cloudy conditions provided better point clouds than the images collected in sunny weather in shadowed regions and of tree surfaces. On homogeneous surfaces (e.g. asphalt) the images collected under sunny conditions outperformed cloudy data. The tested factors did not influence the general block adjustment results. The radiometric sensor performance (especially signal-to-noise ratio) is a critical factor in all weather data collection and point cloud generation; at the moment, high quality, light weight imaging sensors are still largely missing; sensitivity to wind is another potential limitation. There lies a great potential in low flying, low cost UAVs especially in applications requiring rapid aerial imaging for frequent monitoring.

1. INTRODUCTION

Unmanned aerial vehicles (UAVs) offer interesting new possibilities for the remote sensing in wide range of application areas. Eisenbeiss (2009) and Evaraerts (2009) have recently published extensive reviews of UAV technology and examples of numerous potential UAV applications.

For commercial actors it is relevant to manage data collection under different conditions, which is significant difference in comparison to conventional airborne photogrammetric applications. Many UAV remote sensing applications require data collection in certain period of time and optimal conditions cannot be ensured. Examples of these applications include precision agriculture, water quality assessment, insect and disease detection in forests and disaster mapping. Multi-temporal data collection is also necessary to provide time series that are needed in multi-temporal reflectance models of earth surfaces used in environment and climate related applications.

We have been operating Microdrones (2011) md4-200 and md4-1000 quadrocopter UAVs with light weight consumer cameras since 2009. Our objective is to develop robust methods for local area remote sensing and photogrammetry that are operable under different conditions. Our approach in image processing is to carry out rigorous georeferencing and point cloud generation and then perform radiometric corrections. The subsequent applications will be based on analysis of point clouds and spectral information, optionally by fusing passive and active methods. (Honkavaara et al., 2009; Leberl et al., 2010; Hakala et al., 2010; Rosnell and Honkavaara, 2011)

In this study we emphasize georeferencing and point cloud generation. New matching strategies have been proven to provide dense and accurate point clouds from image blocks with large overlaps (DeVenecia et al., 2007; Leberl et al., 2010). Quality of image matching is dependent to a high extent on radiometric image quality, which is influenced by many factors. In the passive, low-altitude UAV imaging, the major radiation components reflected from the object and entering to the sensor include the direct sun illumination, skylight and illumination reflected from surrounding objects; the dominating radiation component is dependent on the atmospheric state and shadowing objects (Honkavaara et al., 2009). With consumer cameras the amount of light reaching the detector is controlled by exposure time and f-stop, and the signal amplifying is controlled by ISO setting. Sensor sensitivity and stability and especially the signal-to-noise ratio (SNR) are fundamental quality indicators. The image radiometry is also dependent on the object, and the status of object is expected to have influence (for example, leaf-on and leaf-off or snow and no-snow conditions). Furthermore, with low weight imaging systems the image motion and non-regular block structures due to wind will influence the point cloud quality.

Objective of this investigation is to consider aspects of georeferencing and producing point clouds from UAV image data sets that have been collected under different seasons (spring, summer, autumn and winter), under different conditions (sunny, under cloud cover, different solar elevations) and using different systems. We first describe the test arrangements in Section 2. In Section 3 we present the results of geometric processing and point cloud generation and the conclusions are given in Section 4.

2. TEST SET-UP

2.1 UAV imaging systems

Two UAV based imaging systems were used in the experiment. Microdrone md4-200 is an electronic quadrocopter UAV manufactured by Microdrones company (2011). It is capable of

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