AUTONOMOUS HYPERSPECTRAL UAS PHOTOGRAMMETRY FOR ENVIRONMENTAL MONITORING APPLICATIONS

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ABSTRACT:

The unmanned airborne system (UAS) based remote sensing using lightweight multi- and hyperspectral imaging sensors offer new possibilities for the environmental monitoring applications. Based on the accurate measurements of the way in which the object reflect and emit energy, wide range of affecting variables can be monitored. Condition for reliable applications is reliable and accurate input data.

Our objective is to develop an autonomous hyperspectral UAS imaging system and data processing chain that does not require any ground reference targets. Prerequisites for this kind of a system are an appropriate sensor setup, stable and well-calibrated instruments and rigorous data processing. In this presentation, we will describe a spectrometric UAS imaging system based on a new kind of a spectral camera and additional measurement instruments. We will also present a rigorous data processing chain developed for the system. Finally, we will consider the use of this system in several case studies, including precision agriculture, forest monitoring and water quality monitoring.

The system is equipped with a new kind of a light-weight spectral camera that collects area format spectral data cubes. It is based on a Fabry-Perot interferometer (FPI). By changing the air-gap in the FPI during the exposure, the sensor produces tens of successive images at different wavelength bands in very short time. As each spectral band is collected with a small time delay when using different air gap values, each band has a slightly different position and orientation. Size of single spectral data cube is 1024 by 648 pixels and the field-of-view at format corner is +/-31 º; the camera weighs less than 700 g. When images are collected continuously with stereoscopic and multiview setups in a block block structure, 3D surface information based on stereoscopy and spectral, bidirectional reflectance signatures can be produced; this is expected to be very powerful measurement technology in many environmental monitoring applications. Area format imaging principle is convenient in comparison to pushbroom imaging that is the conventional technique used in hyperspectral sensors. In order to enable autonomous atmospheric correction, incident irradiance is measured using irradiance sensors. For the georeferencing purposes, the UAS is equipped with RTK GPS positioning sensors and light weight IMU.

Important requirement in the data processing is to provide data characterizing the physical reflectance characteristics of the object. In typical UAS projects, the area of interest is covered by hundreds or thousands of spatially overlapping images collected under variable illumination conditions. The data processing combines rigorous photogrammetric and spectral data processing. Prerequisite for the data processing is the accurate radiometric and spectral sensor calibration in laboratory. After data collection, the laboratory calibration is applied to the images. Geometric processing includes the image orientation based on direct sensor orientation, self-calibrating bundle block adjustment and dense digital surface model and point cloud generation. Then radiometric post-processing takes place to provide reflectance image mosaics and point clouds; the processing includes elimination of impacts of varying atmospheric conditions and other instabilities, elimination of radiometric differences due to effects of view/illumination geometry, and the reflectance transformation.

In summer 2014 the system will be used in various environmental monitoring applications including precision agriculture, forest monitoring and water quality monitoring. The potential of the proposed system in will be evaluated in these applications.

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