REMOTE SENSING OF VEGETATION FROM UAV PLATFORMS USING LIGHTWEIGHT MULTISPECTRAL AND THERMAL IMAGING SENSORS

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Introduction

The recent interest of unmanned aerial vehicles (UAV) for vegetation monitoring has been motivated by the benefits of these platforms as compared to full size airborne operations, namely the combination of high spatial resolution and quick turnaround times together with lower operation costs and complexity. These features are of special interest in agriculture where short revisit times are required for management applications and high spatial resolution is mandatory in heterogeneous covers like woody crops. Most of these applications have been possible due to the miniaturization of commercial multispectral and thermal cameras which however require radiometric and geometric calibrations together with atmospheric correction and photogrammetric techniques in order to provide images similar to the available from traditional airborne sensors. The radiometric quality of the images is critical in order to enable the application of quantitative remote sensing methodologies for a successful estimation of biophysical parameters from remote sensing imagery.

This paper describes the aerial platforms and sensors developed for multispectral and thermal image collection but also focuses on the calibration, postprocessing techniques and further validation of remote sensing products obtained using the combination of the images coupled to radiative transfer models.

System description

Two different types of sensors can be installed on the aerial platforms. The multispectral camera (MCA-6, Tetrascan Inc., USA) consists of 6 individual 1.3 Mpixel sensors and optics with interchangeable optical filters. The filters are selected depending on the vegetation indices (VI) that are required. Figure 3 shows the band centers and width of some of the narrow band filters used in this study.

The thermal camera installed is a Thermovision A40M (FLIR, USA) equipped with a 40° field-of-view lens. The image sensor is a Focal Plane Array (FPA) based on uncooled microbolometers with a resolution of 320x240 pixels and spectral response in the range 7.5-13 μm.

Image Products

The INS/GPS data from the autopilot at the exact time of image acquisition is used as an initial approximation for the aeronetralignment (AT). In order to provide a good synchronization of the autopilot data (UTC time) and the image acquisition, a second GPS was used as time source. The image trigger was captured together to the UTC time from the auxiliary GPS receiver using a dedicated microcontroller. The pulse per second (PPS) signal from the GPS was used to ensure time accuracies better than 10ms.

Automatic tie points are extracted using the SIFT algorithm which has shown very robust results as compared with automatic tie point extraction with other photogrammetric software. The images are loaded together with the auxiliary data into the Leica Photogrammetric Suite, where uniformly-distributed ground control points (GCP) were measured throughout the block (figure 7).

Different image products can be generated from the multispectral imagery calculating different vegetation indices and using predicting equations obtained from simulations of radiative transfer models that take into account the vegetation properties, canopy architecture or solar and camera geometries (figure 8).

Conclusions

This work demonstrated that it is possible to generate quantitative remote sensing products by means of a UAV equipped with commercial off-the-shelf (COTS) thermal and multispectral imaging sensors. Laboratory and field calibrations methods provided 8-band 10 cm FWHM multispectral imagery with RMSE of 1.7% in ground reflectance and less than 0.3% spatial resolution. For the thermal camera, atmospheric correction methods based on MODTRAN-radiative transfer model showed the successful estimation of surface temperature images of 46 cm spatial resolution, yielding RMSE < 1 K.

Photogrammetric techniques were required to register the frame-based images to map coordinates. Each camera geometry is characterized with its intrinsic parameters. These techniques along with position and attitude data gathered from the autopilot enabled the generation of large mosaics semi-automatically with minimum use of ground control points.

Appropriate bandset configurations enabled the multispectral camera to calculate several traditional narrowband vegetation indices (NDVI, TCARI/OSAVI, and PRI), which were linked to biophysical parameters using quantitative methods based on physical approaches such as PROSPECT, SAIL, and FLIGHT models.

The high spatial, spectral and temporal resolution provided at high turnaround times, make this platform particularly suitable for a number of applications, including precision farming or irrigation scheduling, where time-critical management is required.