Acquisition, orthorectification, and classification of hyperspatial UAV imagery

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Introduction

Unmanned aerial vehicles (UAVs) have great potential for rangeland management applications, such as monitoring vegetation change, developing grazing strategies, determining rangeland health, and assessing remediation treatment effectiveness (Rango et al., 2006). UAVs have several advantages: they can be deployed quickly and repeatedly; they are less costly and safer than piloted aircraft; they are flexible in terms of flying height and timing of missions; and they can obtain imagery at sub-decimeter resolution. This hyperspatial imagery, imagery with a resolution finer than the object of interest, allows for observation of individual plants, patches, gaps, and patterns over the landscape not previously possible. At the Jornada Experimental Range (JER) in New Mexico, ongoing research is aimed at determining the utility of UAVs for rangeland mapping and monitoring. Our efforts are focused on developing a complete and efficient workflow for UAV missions, consisting of flight planning, image acquisition, image rectification and mosaicking, and subsequent image classification.

The BAT 3 UAV

The BAT 3 UAV is an aircraft manufactured by MLB company. It has a 1.8 m wingspan, weighs 10 kg, and is capable of flying up to 6 hours at a maximum altitude of 3000 m. The BAT system consists of the fully autonomous GPS-guided UAV, a catapult launcher, ground station with mission planning and flight software, and telemetry system (Fig. 1). The UAV currently carries two sensors: a color video camera with optical zoom capable in-flight, and live video downlink to the ground station, and a Canon SD 900 10 megapixel digital camera. The onboard computer records a timestamp and position (X,Y,Z) and attitude (roll, pitch, heading) information for each image.

Fig. 1. BAT 3 UAV with video camera mounted in nose and digital camera in left wing (left), screenshot of mission planning software (middle top), ground station with laptop, video deck and telemetry antenna (middle bottom), and BAT on catapult launcher ready for takeoff (right).

Image Acquisition

Over a 3-day period in October 2006, we acquired 5145 images in 13 hours flight time, limiting the flying time between 9:30 am and 2:30 pm to reduce the effect of shadows. The UAV flew at an altitude of 150 m above ground, acquiring images with a footprint of 152 m x 114 m and an average pixel resolution of 5 cm. The limitation for image acquisition is at this point not the BAT's endurance, but rather the capacity of the camera's memory card for storing imagery. Our longest mission lasted 1.5 hours.

Image Processing Challenges

There are a number of challenges associated with orthorectification of the UAV imagery:

➢ Image distortion associated with inexpensive consumer grade digital camera

➢ Difficulty of detecting ground control points gathered from coarser resolution imagery (QuickBird, Digital Orthoquads)

➢ Limited accuracy of the exterior information (X,Y,Z, roll, pitch, heading)

Currently, we are pursuing 2 different approaches for obtaining georectified image mosaics. The first is a traditional photogrammetric approach using interior and exterior orientation parameters. The second approach is an image-matching approach followed by georectification.

Photogrammetric Approach

This approach involves a camera calibration to eliminate distortion, and subsequent orthorectification and mosaicking using the Leica Photogrammetric Suite (LPS) software. It is more time-consuming than the second approach, but yields ortho imagery and mosaics with high accuracy (RMS error of 1/3 pixel in aerotriangulation). Major challenges are finding control and tie points and dealing with the high error of the exterior information.

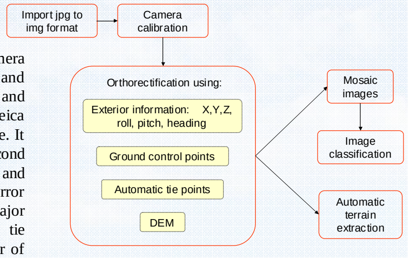
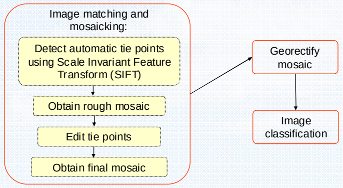


Image-matching Approach

In this approach, image matching and mosaicking are performed with the software Autopano Pro, which uses the SIFT algorithm (Lowe, 2004). The speed and reliability of this algorithm allows for creation of mosaics with little intervention. However, the mosaic has to be georectified in a separate step, terrain extraction is not possible at this point, and the mosaic has a lower planimetric accuracy.



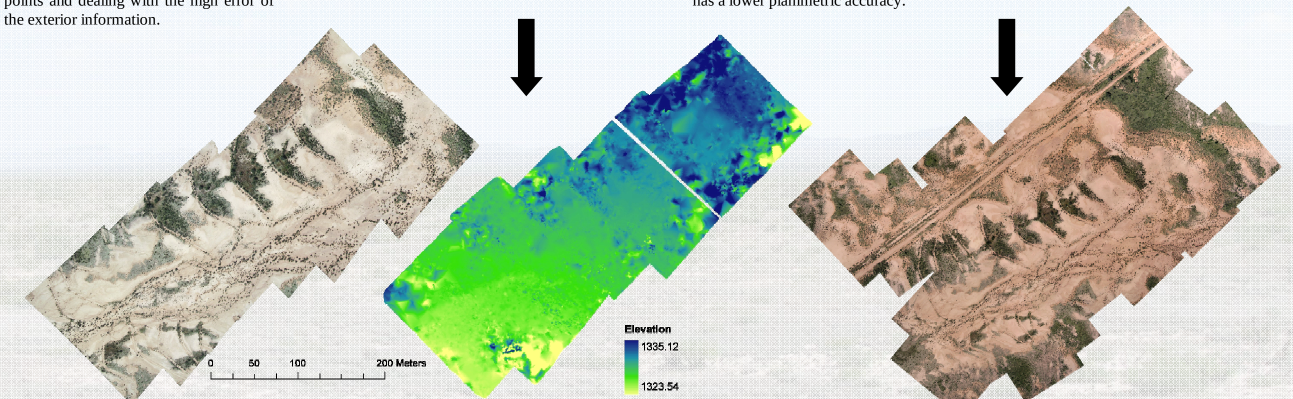
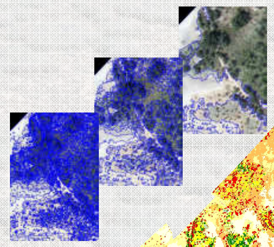
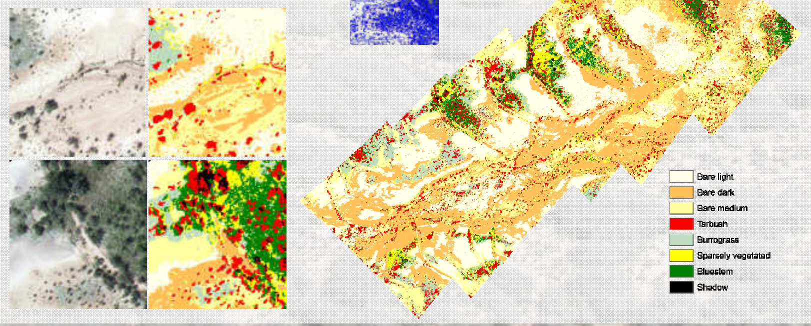


Fig. 2. Orthorectified mosaic of 7 images acquired with the UAV from photogrammetric approach (left), image-derived DEM (middle), and georectified mosaic of 34 images from image matching approach.

Image Classification

Image classification was performed using Definiens Professional 5.0, an object-based image analysis program very suitable for very high resolution imagery (Laliberte et al., 2004). The workflow consists of a multiresolution segmentation of the imagery into homogeneous image objects (top right), and subsequent classification of the image objects using either a rule-based or nearest neighbor approach (bottom).





Summary

Our experiences with acquiring, processing, and classifying hyperspatial UAV imagery demonstrate that this approach is feasible and effective for rangeland mapping and monitoring. Major findings:

➢ Acquisition and image classification are quite easily accomplished

➢ The most time-consuming steps are image rectification and mosaicking

➢ Both the photogrammetric and the image-matching approaches show promise, but more research and algorithm improvements are needed to provide a smoother, faster workflow from raw to classified imagery.

References

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