Benchmarking the geometric performance of an unmanned aerial vehicle (UAV)

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Aims

The school of Civil Engineering and Geosciences have purchased an 'Unmanned Aerial Vehicle' (UAV) equipped with cameras which it aims to use to create aerial imagery for the purpose of taking metric measurements of ground features.

The aim of the research was to assess the performance capabilities of a small, relatively inexpensive off-the-shelf UAV system to create aerial imagery, investigating aspects of calibration and accuracy in the context of real-world applications.

Objectives

1) The Calibration of on-board camera sensors, establishing critical geometric properties;
2) Benchmarking system accuracy by comparing UAV outputs (digital terrain models and ortho-images) to validation data collected through GNSS and terrestrial laser scanning;
3) Developing an optimal workflow for image/ Digital Terrain Model (DTM) acquisition, enabling roll-out of the system to other groups across CESER and CEG.

Fig.1: A Quest 300 UAV (Source: http://questuav.co.uk/)

Hardware: Quest 300 UAV

A battery-powered, fixed-wing aircraft which can lift up to 2 kg in sensor weight. The system is equipped with an on-board autopilot consisting of a GNSS and IMU (Inertial measurement unit) system. It is also equipped with two Panasonic Lumix DMC LX5 digital cameras – one which records in the visible spectrum, and the other in the Infrared.

Test Site

- The University uses a test site in Low Hauxley in Northumberland. This site was ideally suited for purpose due to the open setting, space for system launching, and a variety of features such as trees and buildings which would provide important 3D geometry.

Calibration

-The purpose of camera calibration is to model the intrinsic parameters of the camera system so corrections can be made for distortions. Some of these parameters are focal length, format size, principal point, and lens distortion.

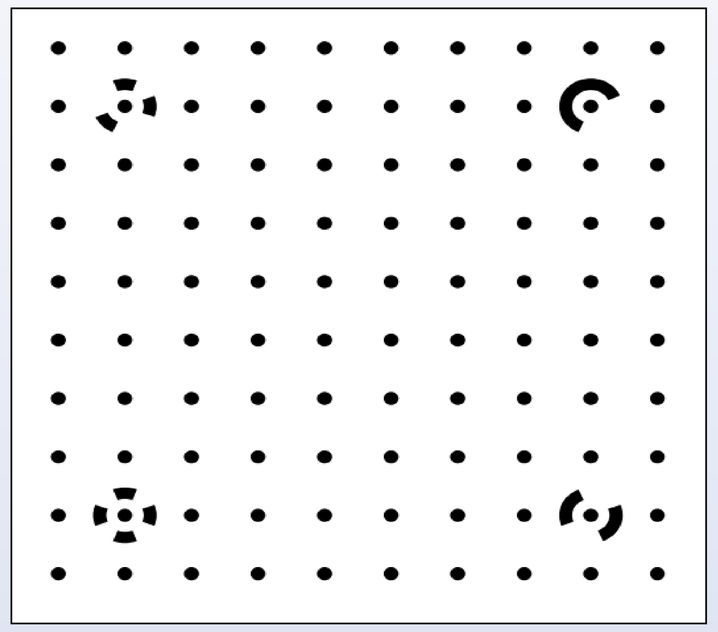

Fig.2 PhotoModeler Checker-board Grid.

-Lab based calibration uses a set of 12 images of a grid checker board grid (Fig.3). placed on the floor, taken at varying angles and from all 4 sides. 'PhotoModeler' software calculates distortions from images and provides a report with updated values for the modeled parameters

Fig.3: Field based calibration with photogrammetric targets on ground.

- GNSS referenced photogrammetric targets were used to provide absolute orientation for the model within the OSGB36 National Grid coordinate system. (Fig.4).

Fig.5: Flight Planning in 'SkyCircuitsPlan' software.

3D Models were produced from the captured imagery in a software package called 'Agisoft PhotoScan'. This software is new to the department and therefore required a period of experimentation in order to produce a workflow guide for its use to help provide the best quality of output in the most efficient manner. Reasonable 3D output was achieved using the software, as seen in Fig.6.

Fig.6: A 3D model generated In PhotoScan of the Low Hauxley test site.

Conclusions

The research has revealed many of the strengths and weaknesses of both the hardware and software components of the system and raised many strong issues which need to be addressed, as well as many potential specific research areas for future exploration. These will include aspects such as:
-Further assessment of system accuracy.
- Practical use in environments such as cultural heritage and water resource monitoring.
- Exploration into potential of 3D model output

The research has provided a strong foundation of knowledge for the future use of the system and will be very valuable when the UAV is utilized on a regular basis.

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