USING OF UAV FOR PHOTOGRAMMETRY AND THERMAL IMAGING

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Abstract: The UAV method of acquisition combines benefits of close range and aerial photogrammetry. As a result, higher resolution and mapping precision can be obtained over larger and possibly less accessible areas (e.g. mountains). The paper deals with the use of unmanned aerial vehicles in photogrammetry tasks. The Mikrokopter system is introduced in this paper as used for mapping in specific task. The problems of planning and data acquisition are illustrated by creating of orthophoto. Theoretical preparation of data acquisition deals with mission planning and operation. The paper is also focused on camera setting and evaluation of sensing methods. Two methods of calibration are presented: laboratory and field calibration. The outputs are compared and used in further processing. The own scripts written in Matlab are created for the photogrammetry mission planning. The data obtained are processed by several sets of software especially developed for close range aerial photogrammetry. The outputs are orthophoto images and digital elevation models. The precision and image quality of the results are compared with the geographic information systems. The final part deals with using UAV for thermal monitoring of dumps; our UAV was equipped with a thermal camera and small computer for data collection.

INTRODUCTION

Unmanned Aerial Vehicles (UAV´s) are gaining importance in mapping and monitoring tasks of our environment. At the Czech Technical University in Prague a case project for using UAV in photogrammetry and monitoring has been launched in 2011. The project´s aim is to develop and verify simple and low-cost technology for monitoring of small areas such as archeological digs, historical objects, dumps, and small orthophoto projects. In the past, UAV technology was exclusively employed by the military, but nowadays it is spreading into the civilian sector because it can acquire information conveniently over places not attainable by other means. Its development opens new possibilities in various scientific fields, such as photogrammetry and environmental monitoring. Nowadays UAV are equipped with sophisticated micro-instruments such as IMU, gyroscopes, GPS receiver, wireless image insight, wireless control, automatic stabilization, flight planner, etc.

Figure 1 : Hexa-copter with sophisticated electronic parts (left), final photo plan of the north part of the Litomyšl castle consisting of images taken from hexa-copter equipped with compact camera Canon S100 and from hand held camera Canon 5D

Figure 2: Hexa-copter reconnaissance flight

Figure 3 : Images from reconnaissance flight taken from hexa-copter over Litomyšl castle in the Czech Republic; no scaffolding or pull platform was needed

Figure 4 : Piloting of UAV

METHODS AND RESULTS

We tests our UAV for three types of projects: 1) using of UAV for historical object documentation – for inaccessible parts (north façade of the Litomyšl castle) 2) using of UAV for digital terrain model and orthophoto producing 3) using of UAV for dump monitoring with thermal camera.

The Mikrokopter system uses electric power from batteries and is constructed as a quadro-, hexa- or octo-copter with an adequate number of engines and propellers. The faculty UAV is hexa-copter with maximum load of 1,5kg. With the new powerful battery the flight can take up to 10 minutes. As the altitude availability is several hundred meters, the system by signal loss automatically returns to the starting position using GPS/IMU. Scientific equipment often contains remotely controllable digital camera; we use compact camera Canon S100 with 12MPix, which weights 200grams only. It is possible to obtain video or single images. Image geometrical resolution is given by the respective camera used and the height of flight; if the GPS/IMU is installed, approximate exterior orientation elements of all images are known. If there is sufficient overlap of images, bundle adjustment software can calculate precise elements of exterior orientation or calibration of the camera. Thus creating orthophoto and digital terrain models using today's computer technology can be very easy. The ordinary geometric resolution is now within the order of cm´s. The project used and tested Pix4D, Aerogis, Icaros. Dronemapper software.

Figure 5 : Orthophoto taken from UAV Mikrokopter; software Aerogis, pixel size 3cm, 103 images (6 ha). RMS of about 4cm (this value was computed from GPS measured checkpoints, which are not used in computing/adjustment). Approximate time of preparation and processing: 8 hours.

RESULTS

First, the digital camera must be calibrated i.e. by laboratory calibration or by flight. For laboratory calibration Photomodeler software has been used for laboratory calibration. In-flight calibration can be carried out by using adjustment with control and tie points on images. The calibration results are shown in Table 1.

Camera	Laboratory	On field in-field	Pix4D (16GCP)
Camera constant c	5.4057mm	5.4404mm	5.3847mm
Sensor	7.4501x5.5880mm	7.4501x5.5880mm	7.4422x5.5816mm
Principal point	3.6834, 2.7310mm	3.6834, 2.6923mm	0.0006, 0.0726mm
Radial distortion	K1:1.770e-003, K2: -1.624e-005, K3:0	K1:1.361e-003, K2: -3.159e-006, K3:0	K1:-5.04e-007, K2: 1.04e-007, K3:0
Tangential distortion	P1: 3.514e-004, P2: -5.603e-004	P1: 3.358e-004, P2: -8.055e-004	P1: -1.23e-004, P2: 1.22e-005

Table 1: Internal orientation

Figure 6 : Detailed view of thermal camera and small surveillance camera, max load capacity 1,5 kg.

The accuracy of automatically created orthophoto from UAV depends on the quality and number of control points, image overlapping, camera quality and flight height (we used compact camera with 12Mpix at a flight level of about 100m). The important result of our project was accuracy comparison of the measured object points in images with a different number of GCPs (ground control points). Positional accuracy was impaired only by using four control points. Along with the orthophoto , the standard output is also a digital terrain model. Object point position accuracy (for orthophoto with ten control points) is comparable in Pix4D and Aerogis software. The standard error in both cases is about 0.035 m, if we take into account the pixel size of orthophoto, which at Pix4D is 2.7 cm and at Aerogis 3 cm (the error is 1.4 pixels and 1.17 pixels respectively). The height difference, of course, is larger. The value of Pix4D is 0.019 m, at Aerogis it is 0.083 m. Pix4D has better accuracy in creating a digital model, but it has no effect in the position accuracy; graphically the orthophoto from Aerogis is better than by Pix4D software. Orthophoto from the Icaros software is graphically very good, but manual processors intervention is evident. The main difference compared with the remaining software is the resulting pixel size (about 10cm !)

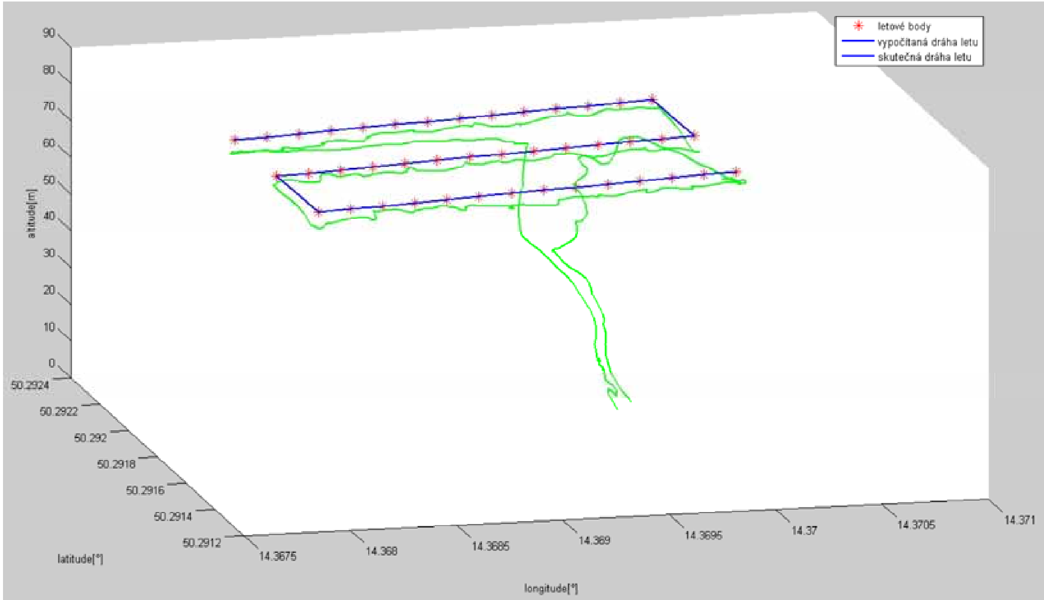

Figure 7: Planned and real trajectory

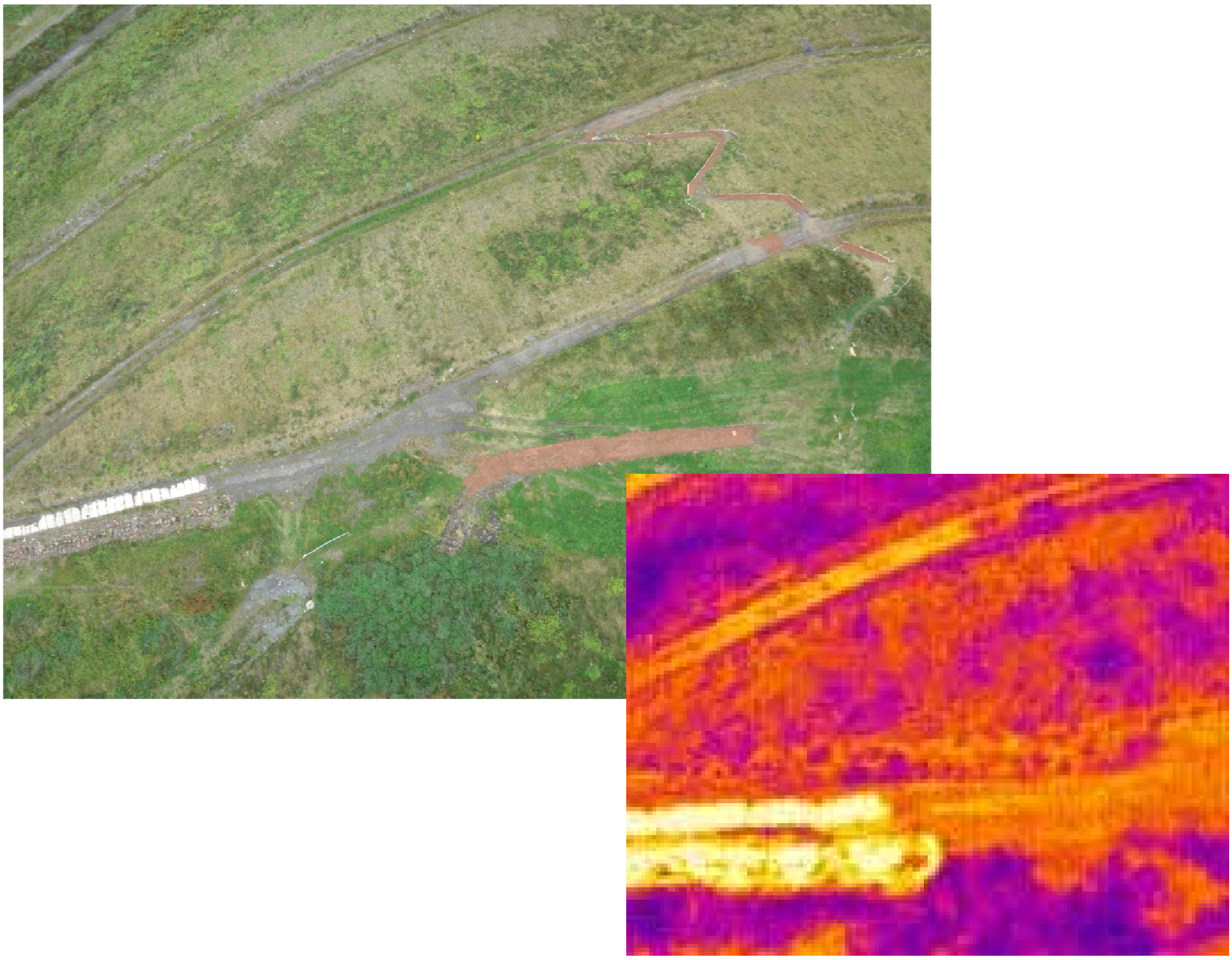

Figure 8: Image taken by digital camera and thermal camera (dump)

CONCLUSIONS & RECOMMENDATIONS

If the images with a large overlap are of sufficient, besides orthophotos we can also create a very precise 3D terrain model. The software which was used has been created by the German company ArcTron Aspect3D. It is graphical frontend software based on Bundler.

Some software, such as Aerogis, uses Bundler to create a digital terrain model for subsequent image orthorectification. On the basis of in- flight taken images Bundler can reconstruct 3D position of the camera at the time of every shot (using tie points found by image correlation). Besides elements of exterior orientation the software can solve the parameters of internal orientation. The parameters assume the PMVS / CMVS (Patch-based Multi-view Stereo Software / Clustering Views for Multi-view Stereo) algorithm that enable to obtain 3D coordinates of individual points on the object.

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