POSSIBILITY OF USING BUDGET UAVS TO DEM BUILDING

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At present, Unmanned Aerial Vehicles (UAVs) have become commonplace in the life of modern society. The way from expensive piece copies to ordinary "household appliances" and children's toys has been passed very quickly, which was facilitated by rapid technological progress and the huge market demand.

Current stage of UAV’s development is characterized by rapid expansion of the range of used equipment and its carriers. This raises a logical question – what equipment is necessary and sufficient to solve specific theoretical and practical problems? This issue is further complicated by the huge number of these tasks in a wide variety of industries.

The use of UAVs for environmental monitoring, as well as in agriculture and in the sciences serving it such as soil science, agricultural chemistry, crop production, etc. has a relatively short but rich history.

One of the promising scientific areas of UAV’s use is the construction of digital elevation models (DEM) based on photography materials.

The first step in planning of monitoring studies is the selection of equipment, which is often on a tight budget. The existing variety of UAV models and surveying equipment causes a natural difficulty for researchers when choosing, the criterion of which is to obtain sufficiently accurate data at minimal costs.

The studies were conducted at the Dokuchaevo landfill ground located in Kharkiv district, Kharkiv region, N49°53’55.69″, E36°27’39.74″.

A site area of 5.3 hectares was selected for UAVs testing, which is characterized by a rather complex topography – a combination of an elongated slope with a stabilized ravine. The absolute heights of the investigated territory are 132.7-156.5 m, the difference was 23.8 m.

During the geodetic survey, 14 reference points were fixed in the studied area. The points on the terrain were fixed with wooden pegs, and their centers were combined with labeled white plastic plates. This simplifies the identification of points among the vegetation and soil cover. For all points, using the Leica TCR 405 total station, geographic coordinates and altitude were determined. To increase accuracy, measurements were performed in duplicate. The scatter of values for the planned coordinates (X, Y) was +/- 2-5 mm, for high-altitude (Z) +/- 5-7 mm, which is an acceptable deviation, given the terrain.

In the studies, 6 different UAVs with 8 different cameras were used. For most UAVs, flights were carried out at three altitudes: 25, 50, 100 m/

The flights were conducted on 05.24.17 and 06.16.17 in similar weather and time conditions: cloud cover less than 3 points, wind speed – up to 3 m / s, from 11 to 15 hours. The shooting was carried out during hours of high sun exposure in order to minimize possible shadows and get the most natural color scheme in the pictures. Using the Pix4D Capture mobile software, auto-flight routes were constructed at the indicated heights with 80% photographs overlapping.

A total of 30 flights were conducted. The primary processing of the obtained images and DEM construction were carried out in specialized software. In this case, DEM was constructed in two ways: without reference to ground reference points (using the coordinates of the onboard GNSS UAV receivers) and with reference to them (the so-called Ground Control Points – GCP). In the latter case 6 reference points were used for snapping.

The average absolute errors, the average height errors, the root mean square errors (Root Mean Square Error), the planned (RMSE (XY)) and the root mean square errors (Root Mean Square Error) and the height (RMSE (H)) were calculated. The minimum and maximum values of absolute and altitude errors were determined. In further analysis the main indicators of the models quality were RMSE.

General patterns have been traced. So, with increasing height, the planned accuracy of the models decreases. At the same time, altitude accuracy, on the contrary, is the highest for maximum height (100 m). The latter fact is explained by the heterogeneity of the sample – at this altitude, only the Inspire-1 and Phantom 4 Pro UAVs were involved.

For a height of 25 m, the DJI Phantom 3 Advanced UAV showed the best model accuracy. In conditions without reference to ground points (option 1), the average RMSE (H) value over two repetitions was 0.538 m, RMSE (XY) – 0.93 m. Using ground control points to attach an image (option 2) significantly improved RMSE (H) – 0.198 m, but RMSE (XY) has significantly deteriorated – 2.061 m.

For a height of 50 m (option 1), DJI Phantom 3 Advanced was also the most accurate: RMSE (H) = 0.439 m, RMSE (XY) = 0.240 m. It is interesting that other models in this series (DJI Phantom 2 Vision + and DJI Phantom 4 Pro) showed significantly worse results.

In conditions of the image being linked to ground points, the "Lady Bug" UAV had the best RMSE (H) values – 0.165 m (with Firefly 6C camera) and 0.184 (with Canon Power Shot S100 camera). It also showed good RMSE (XY) values – 2.241 m (with a Firefly 6C camera) and 2.199 m (with a Canon Power Shot S100 camera). The second place took DJI Phantom 2 Vision +. The average RMSE (H) value for two repetitions was 0.365, RMSE (XY) – 2.224 m. Unfortunately, for technical reasons, it was not possible to obtain a model from the results of a survey conducted by DJI Phantom 3 Advanced.

We also note with regret that all of the above devices could not take part in a shooting at a height of 100 m. For option 1, DJI Inspire-1 with an X3 FC350 camera showed the best accuracy: RMSE (H) = 1.854 m, RMSE (XY) = 0.282 m. It should be noted that results deteriorated when using more powerful X5 FC550 camera on the same device.

In general, high variability and instability of the results should be noted. Thus, analysis of each UAV's results at different altitudes shows that in some cases there is a higher accuracy of the model with a higher altitude of the UAV. For example, for DJI Inspire-1 (X3 FC350 camera), the best planned accuracy of the model was obtained during shooting from a height of 100 m, which contradicts the logic. A similar situation was observed for Custom "Lady Bug" – the results of shooting at a height of 50 m were better than at a height of 25 m. Flights for Custom "Lady Bug" on both heights were performed in duplicate.

The results of evaluating the accuracy of DEMs obtained from survey data by budget UAV options showed that they can be used to create topographic and thematic large-scale maps even taking into account their discrepancies. In particular, the results of surveying with Phantom 3 Advanced at heights of 25 and 50 m correspond to a scale accuracy of 1: 5000 topographic maps. As for the construction of soil maps, we can safely recommend any of the UAVs used to build maps of scale 1: 5000.

The obtained results, considering the fact that the used drones belong to the middle price category, make it possible to talk about the prospects of their widespread use in agriculture.

At the same time, high variability of RMSE (H) and RMSE (XY) should be noted, which was not fully appreciated due to technical and organizational aspects. Unfortunately, it was not possible to quantitatively establish to what extend the accuracy indicators of models are improved when using reference to ground points. In view of the foregoing, the question of the possibility to use the indicated UAV models to construct more detailed topographic maps remains open

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