Using Digital Photogrammetry to Create Large-Scale Topographic Maps and Plans in Uzbekistan

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Abstract
The rapid development of digital photogrammetry in recent years has led to the revision of the outdated and introduction of innovative technologies in the creation of basic photogrammetric products, such as aerial photogrammetric triangulation, digital orthophoto, digital topographic maps, and plans, digital elevation models. Digital methods for creating topographic maps and plans today, being the most highly productive and operational methods, primarily ensure the automation of work, the quality, reliability of the products created, and the objectivity of information. The paper discusses the process of creating a topographic plan of 1: 2000 scale using digital photogrammetric methods for the newly built district in Tashkent – "Yangi Khayot" whose area is 7000 hectares. For this purpose, aerial photography was carried out by an UAV Geoscan 201 at a scale of 1: 1000 with a digital camera Sony DSC-RX1 with a forward overlap of aerial photographs of 70% and a lateral overlap of 50%. The height of the photographing flight was 400 meters.

1. Introduction

Digital technologies, which have become one of the indicators of modernity, penetrate more deeply into various spheres of human activity. They could not help but touch on aerial photography. The rapid development of digital aerial photogrammetry in recent years has been influenced by:

- widespread use of digital photogrammetric stations (DPS) and digital large-format photogrammetric cameras (ADS40, DMC, UltraCam), which completely replaced the use of analog cameras and images in photogrammetry.
- development of laser ranging systems (LIDAR) and radar systems, as well as the introduction of a new laser-ranging method of imaging to obtain an accurate DEM and surface.
- rapid development of computer and digital technologies, special software.
- reducing the cost of photogrammetric equipment as a result of increased competition among the companies that produce them.
- expanding the number of users of cartographic and GIS products and etc (Helpke, 1995 and Sefercik, 2007).

Digital aerial cameras have taken a strong position in the product list of many manufacturers. The use of such cameras is not only convenient but also economically justified (Reulke, 2000). It should be noted that shooting with digital cameras is often carried out with a large (more than 60%) overlap. This allows you to generate better quality orthophoto plans.

Since 2000, digital aerial imaging systems have been increasingly used in practical photogrammetry (Dlesk et al., 2020). If in the previous 100 years they mainly dealt with aerial cameras, now they have been firmly replaced by aerial photogrammetric systems, which make it possible to carry out the main complex of photogrammetric work in an almost automated mode - from taking a single image to creating an orthophoto (Helpke, 1995).

At the same time, it became possible to use unmanned aerial vehicles (UAVs) as a carrier of digital cameras, which are currently the most productive method for collecting spatial information, the basis for creating topographic plans and maps, creating three-dimensional models of elevation and terrain (Koeva et al., 2018). The aim of this research work is to create a topographic plan for the object “Yangi Hayot” on a scale of 1:2000 using modern photogrammetric technologies and equipment. On the way to achieving this goal, the following tasks will be considered in the work: the concept of UAV of an aircraft type; technology of aerial photography process using the UAV Geoscan 201; features of photogrammetric processing of aerial survey data obtained from the Geoscan 201 UAV.

2. Materials and Methods

In Uzbekistan, since 2016, when topographic and geodetic enterprises purchased unmanned aerial vehicles such as Geoscan 201, digital methods for creating topographic maps and plans have been actively used for surveying both areal and narrow extended objects (Kovalyov et al., 2016). In the State Unitary Enterprise "U'zGASHKLITI" who are engaged in research work and engineering surveys in construction, geoinformatics, and urban planning cadastre, in order to create topographic plans for large territories like our research object “Yangi Khayot” on a scale of 1: 2000, UAV Geoscan 201 is widely used.

The UAV Geoscan 201 belongs to the aircraft type, the launch of which is performed using a catapult, and the landing is performed using a parachute (Figure 1). Geoscan 201 is equipped with an automatic control system (autopilot), an inertial navigation system, a GPS/GLONASS signal receiver, a payload controller, a digital communication channel for transmitting command and telemetry information, a digital communication channel for transmitting video/ thermal imaging information from the UAV to the ground control station (GCS) in real-time (Smirnov, 2016). The main characteristics of the Geoscan 201 are shown in Table 1 (Geoscan, 2019).

Figure 1: Launch (left) and landing (right) of the UAV Geoscan 201

Table 1: UAV and camera specifications (Geoscan201)

Model	Geoscan 201
Camera	Sony DSC-RX1
Sensor width × height, mm	113,3 x 65,4
Image width × height, pixels	6000 × 4000 (max)
Pixel size, µm	6
Focal length, mm	35
Photo area for one flight, km^2	7-22
Flight speed, km/h	64 - 130
Maximum flight route length, km	210
Minimum safe flight altitude, m	100
Maximum flight altitude, m	4000
Maximum flight time, h	3
Geolocation	On-board GNSS

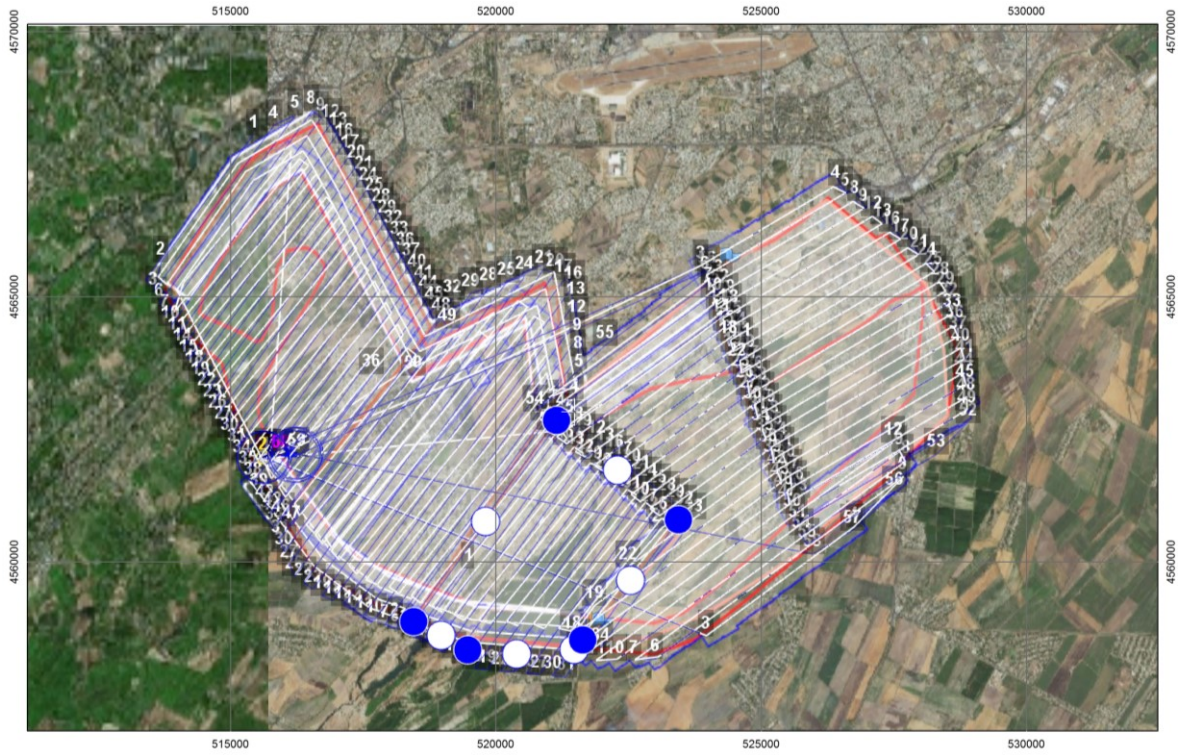

Figure 2: Flight route scheme

In total, 127 flight routes were performed for the entire object (Figure 2), the processing of which was carried out in the Agisoft Metashape software package, which provides automatic photogrammetric processing of digital images, the creation of georeferenced 3D models, orthophoto plans, and digital terrain models (DTM). It is one of the commonly used and productive software for photogrammetric image processing (Lehoczky and Abdurakhmonov, 2021).

To carry out field work on this object, the method of creating a geodetic control using GPS stations was used. Methods and programs for adjustment georeferencing of image centers to the State Geodetic Network were carried out in Magnetools software. Control points were not marked because it was possible to use the points of solid contours. Processing of digital aerial photography materials can also be performed at the digital photogrammetric station Photomod, which is currently widely used at topographic and geodetic enterprises in Uzbekistan. The Photomod software product provides a complete technological process that allows you to create a high-quality geodetic base without installing additional programs for block aerial triangulation or work with vectors.

3. Results and Discussions

Aerial photography for the purpose of creating a topographic plan at a scale of 1:2000 of the newly built district in the Tashkent city “Yangi Khayot” was carried out at a scale of 1:1000 with a forward overlap of aerial photographs of 70% and a lateral overlap of 50%. The height of the photographing flight was 400 meters, taking into account the accuracy of the camera (24 mP, see Table 1).

For the field flight survey, the territory was divided into 5 sections (Figure 3), taking into account the flight time and battery capacity of the UAV, the technical characteristics of which are shown in Table 2. For the of field flight survey , the territory was divided into 5 sections (based on the flight time and the possibility of the power source) (Figure 3) with the technical characteristics are shown in Table 2. Orthophoto referencing was done using horizontal control points, which were determined using RTK method of GNSS measurements. Within the object of study were determined totally 280 horizontal control points. The referencing of control points was carried out from the initial points of the State Geodetic Network, using GNSS receivers in RTK mode, radially, with the field calibration method.

Table 2: Specification of each surveying section

Spefications	Sections				
	1	2	3	4	5
Flight route length, km	138,8	127,1	121,7	112,9	79,7
Survey area, km^2	15,34	16,36	18,62	16,90	11,71
Flight time, m	130	121	112	101	73
Number of routes, p	28	26	24	25	24

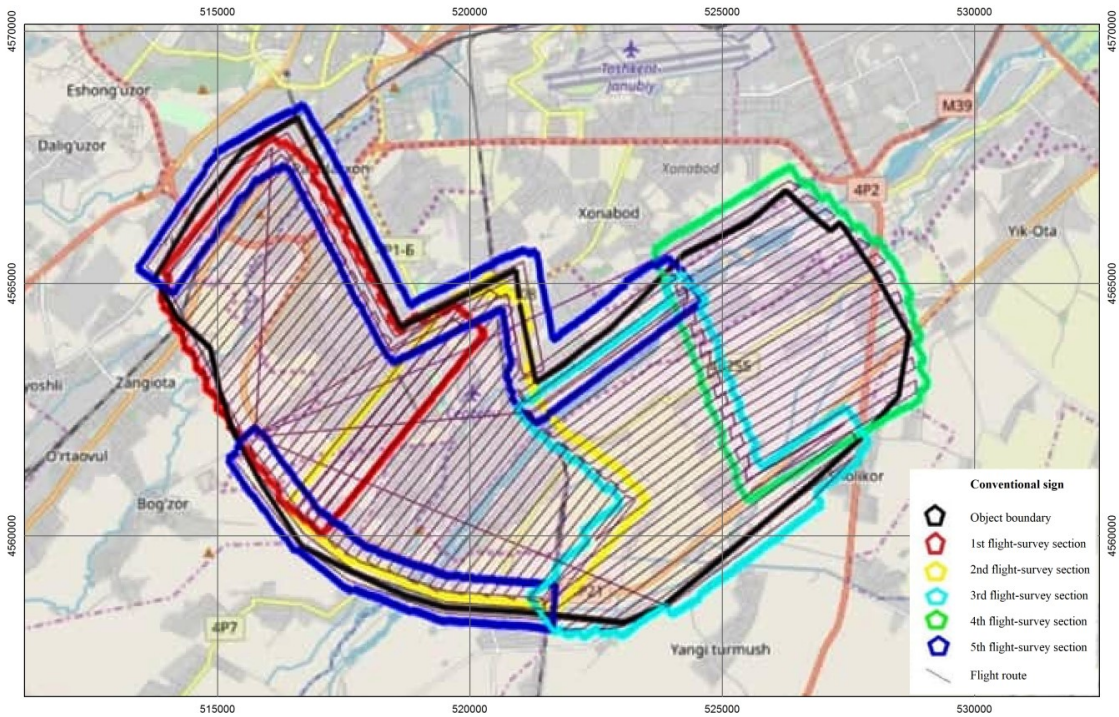

Figure 3: The boundary of the object and its sections

All measurements at the study object were carried out at the request of the current instructions (SHNQ 1.02.17-09, 2009). Figure 4 shows a fragment of the orthophoto plan of the "Yangi Khayot" object, which was obtained using the Agisoft Metashape software package. The grids shown in the figures are the SK-42 coordinate system, which was created in the Soviet Union in 1942.

The last and complex step in creating of topographic map of the study area is the interpretation or analysis of orthorectified images. Interpretation was carried out strictly in accordance with current instructions (SHNQ 1.02.20-09, 2010). In the process of interpreting images, terrain objects were identified manually and marked with appropriate symbols. Terrain objects, the reliability and correspondence of which are beyond doubt, were interpreted from the images using the special software AutoCAD 2014 of the AutoDesk company. At the same time terrain objects that could not be identified by images were identified directly in the field.

As a result of interpretations of aerial imagery topographic plan of the study area in a scale 1:2000 was created. The fragmet of the created topographic plan of the "Yangi Khayot" district is shown below in Figure 5. As a result of the interpretation of aerial imagery, a topographic plan of the study area was created on a scale of 1: 2000. A fragment of the created topographic plan of the "Yangi Hayot" district is shown in Figure 5.

Figure 4: Fragment of the orthophoto plan

Figure 5: Fragment of the topographic plan on a scale of 1: 2000

4. Conclusion

The use of digital photogrammetric methods described in this article to create a topographic plan for the newly built district in the Tashkent city "Yangi Khayot" made it possible to complete the work with high quality and high productivity in a timely manner. Digital methods of photogrammetric topographic surveys today are the most relevant and progressive methods, because it is primarily the automation of production processes, the quality, reliability of the products created, and the objectivity of the information received.

The use of remote sensing methods of the earth's surface especially use unmanned aerial systems enables to cover large areas to obtain all the necessary information about all objects located on them. The presence of modern hardware and software systems allows for high-precision measurements on the basis of the data obtained.

References

Dlesk, A., Uueni, A., Vach, K. and Pärtna, J., 2020, From Analogue to Digital Photogrammetry: Documentation of Padise Abbey in Two Different Time Stages. *Appl. Sci.,* Vol. 10(23), 1-16, https://doi.org/10.3390/app10238330.

Geoscan, 2019, Product Catalog, Available at: https://www.asi.ru/upload/upload_docs/sml/semenov/geoscan.pdf.

Helpke, C., 1995, State-of-the-Art of Digital Photogrammetilc Workstations for Topographic Applications. *Photogrammetric Engineering & Remote Sensing*, Vol. 1, 49-56, Available at: https://www.asprs.org/wp-content/uploads/pers-/1995journal/jan/1995_jan_49-56.pdf.

Lehoczky, M. and Abdurakhmonov, Z., 2021, Present Software of Photogrammetric Processing of Digital Images. *E3S Web of Conferences* , Vol. 227(146), 1-19, https://doi.org/10.1051/e-3sconf/202122704001.

Koeva, M., Muneza, M., Gevaert, C., Gerke, M. and Nex, F., 2018, Using UAVs for Map Creation and Updating. A Case Study in Rwanda. *Survey Review*, Vol. 50(361), 312-325. https://doi.org/-10.1080/00396265.2016.1268756.

Kovalyov, N. V., Shukina, O. G. and Muxitdinov, D. K., 2016, Photogrammetry and Remote Sensing, Tashkent, "TASI" PRESS, 159.

Reulke, R., 2000, Recent Progress in Digital Photogrammetric Stereo Cameras and Data Evaluation. *10th International Workshop on Theoretical Foundations of Computer Vision Dagstuhl Castle*, Vol. 2032, 67-80, https://doi.org/10.1007/3-540-45134-X.

Sefercik, U. G., 2007, Comparison of DEM Accuracies Generated by Various Methods. *3rd International Conference on Recent Advances in Space Technologies,* DOI: 10.1109/RAST.2-007.4284016.

Smirnov, A. V., 2016, Obzor bespilotnykh letatel'nykh apparatov (Unmanned aerial vehicles review). «Racurs», Moscow, Russia, Available at: https://racurs.ru/press-center/articles/bespilotnye-letatelnye-apparaty/-UAV-review/.

[SHNQ 1.02.17-09]: State Design Research Institute for Engineering Surveys in Construction, Geoinformatics and Urban Planning Cadastre, 2009, Reference geodetic network (Creation of reference geodetic networks for engineering and geodetic surveys for construction), Set of rules, SHNQ 1.02.17-09, Tashkent, 80.

[SHNQ 1.02.20-09]: State Design Research Institute for Engineering Surveys in Construction, Geoinformatics and Urban Planning Cadastre, 2010, Updating topographic maps of scale 1: 10000 and topographic plans of scales 1: 5000, 1: 2000, 1: 1000 and 1: 500, 1.02.20-09, Set of rules, SHNQ 1.02.20-09, Tashkent, 32.