"Environmental Engineering" 10th International Conference
Vilnius Gediminas Technical University
Lithuania, 27–28 April 2017
http://enviro.vgtu.lt

eISSN 2029-7092 / eISBN 978-609-476-044-0

Article ID: enviro.2017.159
DOI: https://doi.org/10.3846/enviro.2017.159

Application of New Technology Data Acquisition Using Aerial (UAV) Digital Images for the Needs of Urban Revitalization

Anna Banaszek[1], Aleksander Zarnowski[2], Anna Cellmer[3], Sebastian Banaszek[4]

[1]*Department of Real Estate Resources, The Faculty of Geodesy, Geospatial and Civil Engineering, University of Warmia and Mazury, Olsztyn, Poland*
[2]*Department of Geoinformatics, The Faculty of Civil Engineering, Environmental Engineering and Geodesy, Koszalin University of Technology, Koszalin, Poland*
[3]*Department of Geoinformatics, The Faculty of Civil Engineering, Environmental Engineering and Geodesy, Koszalin University of Technology, Koszalin, Poland*
[4]*Operations Director, Dron House S. A, Warsaw, Poland*
E-mails: [1]anna.banaszek@uwm.edu.pl (corresponding author); [2]azarnowski@wilsig.tu.koszalin.pl; [3]anna.cellmer@tu.koszalin.pl; [4]sebastian.banaszek@dronhouse.pl

Abstract. The municipal authorities are responsible for carrying out relevant, objective analysis of areas for revitalization, identifying problems and barriers, diagnosis of the causes and determiningthe appropriate range of activities. From the point of view of urban regeneration one of the key issues is to obtain timely and reliable geospatial data. The article presents the possibility of using digital images obtained from the UAV platform to support the urban regeneration process. As part of the research work involving an inventory of urban space one made photogrametry flights with UAVs DJI Inspire One. Data processing software that was used is Pix4D and QGIS. The results allow the conclusion that the use of UAV in the process of obtaining imaging geoinformation and spatial data for planning and documentation of revitalisation work may be practical mode near-real-time. It replaces the previously used laborious and lengthy process to update data while ensuring their detail and accuracy.

Keywords: urban revitalisation, UAV, digital image.

Conference topic: Technologies of Geodesy and Cadastre.

Introduction

The task of revitalization activities should be to increase the opportunities for development of cities and improve the quality of life of their citizens through a comprehensive transformation of fragments of urban space while maintaining the material and spiritual heritage and the principles of sustainable development. Maintaining national and local coordinated professional revitalization activities requires dimensioning of the problem which, is the degradation of cities. In Poland, there is no central database of crisis areas, and at the regional level all kinds of inventories are mostly random and incomplete. In this situation, the creation of a national database that includes information about the area, forms of use and characteristics of different types of areas (among others; post-rail spaces, post-industrial, post-port, post-military) must be considered a prerequisite for effective spatial policy in general and the revitalization policy in particular.

New technologies for geospatial data help to create the overall image of the city, so the planner or designer can identify the part or structure "embedded in the whole" (Lynch 2011). The municipal authorities are responsible for carrying out relevant, objective analysis of areas for revitalization, identifying problems and barriers, diagnosis of the causes and determining the appropriate range of activities. From the point of view of urban regeneration one of the key issues is to obtain timely and reliable geospatial data.

Development of technologies for data acquisition using photogrammetric and remote sensing methods in contemporary spatial information systems use as the primary data source digital images of aerial and satellite. In recent years, the acquisition of geospatial data are increasingly used unmanned aerial vehicles (UAVs). The type and quality of the data obtained using them depends largely on installed on them sensor and the technical design and control of photogrammetric flights. Currently, even the simplest models of UAVs are equipped with good quality RGB sensors. The standard sensors of RGB are the use of dies with a resolution of at least 12 megapixels, which turn into the most photos with a resolution of 4000x3000 pixels. High-resolution images taken from the deck of unmanned aircraft can be used in the process of revitalization in order to: inventory of objects in degregated areas, to determine the technical condition of buildings and structures in the area of revitalization, monitoring changes in space subjected to revitalization. Products that can be generated based on digital images obtained from the deck of the UAV and the use of which may bring a new quality in the process

of revitalization are: digital terrain model or point cloud, orthophotomap, orthophotoplan or 3D models. Recent methods advances in the field of image processing, derived from the deck of UAV, mapping and 3D modeling based on them are contained in the works Remondino *et al.* (2011), Uysal, Toprak and Polat (Uysal *et al*. 2013), Sužiedelytė-Visockienė (Sužiedelytė-Visockienė *et al*. 2016a; Sužiedelytė-Visockienė *et al*. 2016b). Experiments with the use of unmanned aircraft to document cultural heritage are described in the works Püeschel, Sauerbier, Eisenbeiss (Pueschel *et al*. 2008; Sauerbier, Eisenbeiss 2010), Brumana (Brumana *et al.* 2012), Zarnowski (Zarnowski *et al*. 2015) and Sužiedelytė-Visockienė (Sužiedelytė-Visockienė *et al*. 2015). Research on the potential use of UAV 3D modeling of cultural heritage present the works Pierrot-Deseilligny, De Luca, Remondino (Pierrot-Deseilligny *et al.* 2011), Grün, Zhang, Eisenbeiss (2012). The combination of laser scanning technology and digital images acquired from the UAV platform in order to build high resolution three-dimensional models of the city described by Gruen (Gruen *et al.* 2013).

The aim of the study was to carry out the experimental work and the development of technical guidelines to obtain low-level geoinformation imaging using UAVs for the process of revitalization of urban areas. In the study a digital camera mounted on board the UAV was used to obtain geoinformation imaging for: inventory of areas and individual objects intended for revitalization (video, single digital images); photo interpretation (digital images, orthophoto, orthophoto); photogrammetric (orthophotomap, ortofotoplan, DEM); urban and architectural (orthophoto, 3D models of buildings and their facades). This article presents part of the results of research using UAVs DJI Inspire One with a FC350 camera and examples of studies data using software Pix 4Dmapper Pro and QGIS.

Research experiments description

The flights were carried out for areas designated for revitalization in the city of Olsztyn, Warmia and Mazury, Poland. The flight was made by UAV DJI Inspire 1 (Quadrocopter) with FC350 camera – Shutter Type Rolling Shutter, the matrix with a resolution of 12 megapixels, the focal length of 3.6 mm, the physical pixel size of 1.6 microns. For processing the data acquired from the UAV platform used software Pix4D and QGIS. The processing of the data in the software Pix4D is carried out in 3 stages:

1. Initialing Procesing where we have to choose options: General, Matching and Calibration. To process the images used in the following settings: Image Keypoints Scale – Full (General), Image Matching Pairs – Aerial Grid or Corridor (matching), targeted Number of Keypoints – Automatic, Colibration – standard, Rematch – Automatic (Calibration).

2. Point Cloud and Mesh, where we have to choose options for Point Cloud, Textured 3D Mesh, Advanced. To process the images used in the following settings: Point Cloud Densification: Image scale – 1/2 (Half image size), Multiscale – YES, Point Density Optimal, Minimum Number of Matches – 3 (point cloud), Generation – Generate 3D Mesh Textured – YES , Settings – Medium Resolution (Textured 3D Mesh), Point Cloud Densification – Matching Window Size 7x7 piksels, Textured 3D Mesh Settings: Density Sample Divider – 1, Maximum Number of Triangles per Leaf – 8 (Adwenced).

3. DSM, Orthomosaic and Index, where we have to choose options: DSM and Orthomosaic, Additional Outputs, Index Calculator. To process the images used in the following settings: Resolution – 1 x GSD (DSM and Orthomosaic). As a result of geographic reference image processing, the software will allow generation of point clouds, 3D models, orthophoto and Digital Surface Model.

For the purpose of checking the suitability of the use of UAV-acquired images to support the urban regeneration process conducted flights in seven locations, acquired a total of 1,401 images by processing which generated seven orthophotos, seven point clouds and 3D model of the historic building. In two cases, limited only to the execution of photographic documentation and video documentation to support the determination of the technical condition of monitored buildings.

Rezults

In the course of the research almost 10 hours of flights was carried out and over 30 hours devoted to the processing of data obtained. This way acquired a total of nearly 1 TB of current data. As a result of processing images obtained orthophotos, which can be measured 2D with an accuracy of up to 1 cm, orthophoto enables vectorization architectural details in 2D with an accuracy of less than 1 cm and point clouds allowing to perform both measurements of surface and cubic accuracy of less than 1 cm. Details of experiment are shown in Table 1.

Table 1. Results of experiments

Name of object	Type of object	Mode of flight	Time of flight [h]	Images	Products	Points [mln]	Accuracy [cm]	GSD [cm/pix]
Barrack Dragoons	surface	automatic	0,5	127	orthophotomap points cloud	25	6,0	4
Stadium	surface	automatic	0,5	179	orthophotomap points cloud	13	10,0	3
Planetarium	surface	automatic	3,0	289	orthophotomap points cloud	45	9,0	5
Warsaw street	surface	automatic	0,5	138	orthophotomap points cloud	21	2,0	3
Stable Barrack Dragoons	cubature	manual	1,0	100	orthophotomap points cloud	62	0,5	<1
Tenement house	cubature	manual	0,5	51	orthophotomap points cloud	33	1,0	1
The Historic Sawmill	cubature	manual	1,5	256	orthophotomap points cloud 3D model	13	2,0	<1
Tenement house	cubature	manual	1,0	126	photos	---	---	---
Tenement house after fire	cubature	manual	1,0	135	photos, video	---	---	---

In the study two modes of implementation of the flight were used, depending on the type of object. The automatic flight for surface objects and manual for cubature objects. The flights were created and carried out automatically based on the application Map Pilot, which allows performing a photogrammetric flight including basic parameters: the type of camera, longitudinal and transverse coverage, area of the flight. The easiest and which does not require carrier postprocessing data obtained from the UAV platform are the digital images and video files. They allow making optical inspection of the monitored area or object not giving, in principle, the possibility of making a reliable quantitative assessment. Such data are usually used at the initial stage of the revitalization plans for inventory of areas intended for revitalization.

Shown in a Fig. 1 the image was made from a height of 37 m as a diagonal image. It allows evaluation of the technical condition of the roof of one of the houses located in the area planned for revitalization. Processing of digital images allows evaluation of both qualitative and quantitative examined phenomenon in the analyzed area. The basic result of postprocessing photogrammetry is the orthophotomap. Currently, the standard of orthophoto generated from images acquired from the UAV platform ground resolution of 5 cm/pix, however, depending on the selected parameters of the flight and RGB sensor it is possible to obtain a resolution even at 1 cm/pix allowing to reproduce the space with very high accuracy. Orthophotomap may give rise to the development of, among others, cadastral map, situational-altitudemap, basic map, topographic maps, thematic maps, maps ranges of the studied phenomenon. Example orthophoto imaging space with an area of 0.8 km^2, established on the basis of 289 images almost vertical, made during a flight characterized by the following parameters: longitudinal and transverse coverage – 70%, altitude – 120 m AGL, GSD – 5 cm/pix, is shown in Fig. 2.

The possibility of vertical ascent, hovering and performing flights at low altitude means the UAV can carry out raids on the need for an inventory of buildings, particularly the generation of orthophotomaps (vertical ortho) facade with an accuracy greater than 1 cm/pix. An example of such orthophotomap contained in Fig. 3 shows the western elevation of destroyed building Stables on the premises Barracks Dragoons. The presented orthophotomap was made on the basis of 100 digital images obtained during the manual flight where the UAV Pilot tried to keep a 90% longitudinal and transverse coverage and distance of 5 to 10 m.

Fig. 1. Object – Tenement House (digital image)

Fig. 2. Object – Planetarium (orthophotomap)

Fig. 3. Object – Stable Dragoons Barracks (orthophotomap)

Orthophotomap allows you to make any 2D measurement with an accuracy of 1 cm, which makes for highly accuracy vectorizing of the content documenting the construction of the building. The technology which was used allows high resolution of the inventory eg. each single brick. The vectorized form of an orthophotomap exemplified object The Historic Sawmill (Fig. 4), where the orthophotomap was generated on the basis of 256 images received from the flight performed in manual mode at a distance of 5 to 15 m away.

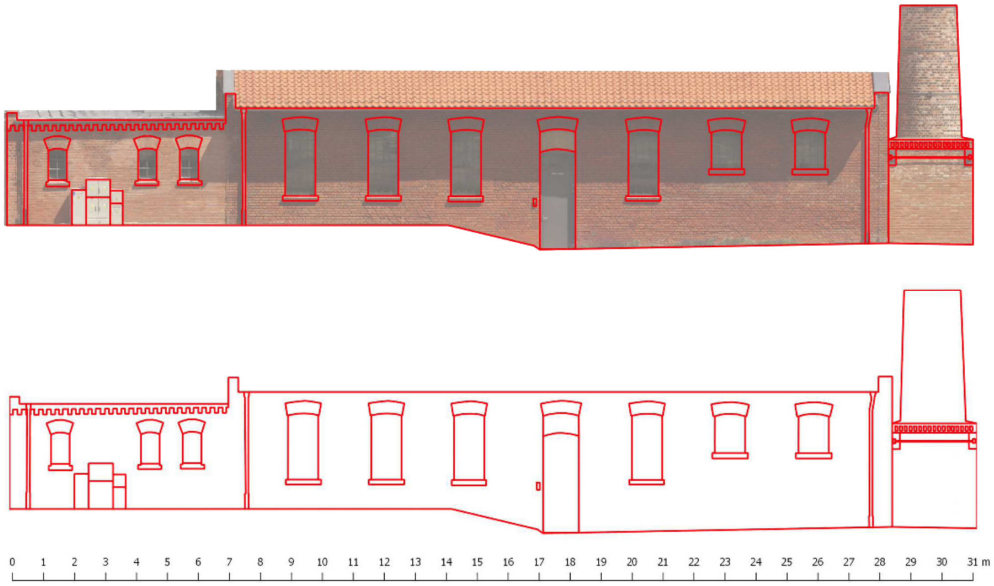

Fig. 4. Object – The Historic Sawmill (vectorization)

In the processing of images acquired by UAV besides orthophotomap can also generate a point cloud, which is a numerical representation of the site and its cover (natural and anthropogenic elements). A fragment of point cloud, consisting more than 21 million points, which is generated on the basis of 138 horizontal images, taken in the context of photogrammetric flight over the object – Warsaw street is shown in Fig. 5. The flight was created and realized basing on the following parameters: longitudinal and transverse coverage – 80%, altitude – 80 m AGL, GSD – 2 cm/pix.

Fig. 5. Object – Warsaw street (point cloud)

The generated point cloud allows 3D measurements of any element imaged urban system to be made, it can provide a basis for the execution of the technical documentation or the chosen analysis. Figure 6 shows a point cloud generated basing on images obtained during the execution of the manual flight that includes photos which are almost vertical and oblique, realized to recreate the geometry of the facade building in 3D space. In the processing of 51 images the cloud consisting of 33 million points can form the basis of measurements for facade elements with an accuracy of 1 cm.

Fig. 6. Object – Tenement House (point cloud)

The final product of image processing obtained from UAV platform as part of ongoing research is a 3D model. Shown in Fig. 7 three-dimensional model of the object The Historic Sawmill, built with almost 5 million triangles generated on the basis of 256 horizontal, diagonal and nearly vertical digital images, made during a manual mode UAV flight is characterized by the following parameters: longitudinal and transverse coverage – 90%, GSD – 1cm/pix.

Fig. 7. Object – The Historic Sawmill (3D model)

Conclusions

Unmanned aerial vehicles broaden the opportunities offered so far by manned aircraft and satellite systems, and has several strengths that should be noted. The results allow for the conclusion that the use of UAVs in the

process of acquiring data for the planning, implementation and documentation of the progress of ongoing work of revitalization is simply unbeatable. It replaces the previously used laborious and long-term technology updates about space and construction facilities while ensuring their greater detail and accuracy. Note, however, that the quality of data obtained mainly depends on the proper selection of UAV and a digital camera, the technical parameters of flight, weather conditions and lighting and the ability to plan and execute the flight. UAV flights in the Polish airspace for purposes other than sports and recreation can only be performed by a UAV pilot with the appropriate qualification certificate issued by the Civil Aviation Authority.

As a result of the study it should be stated that unmanned technology can be applied at various stages of the process of revitalization of urban areas. This for the preparation of documentation relating to:

- initial inventory, carried out in order to define urban areas for revitalization, and specific inventory of areas designated for revitalization,
- technical inventory of urban space and buildings,
- monitoring the progress of the work,
- control of as-built.

In addition, due to the range of information obtained digital images from the UAV platform and other secondary digital photogrammetric products UAV technology is economic. Once obtained data can be used repeatedly for different urban projects, not only for the needs of urban revitalization.

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