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OPTIONS UAV APPLICATIONS IN THE CONSTRUCTION INDUSTRY USING PHOTOGRAMMETRY

Abstract:

This paper aims to introduce the possibilities of unmanned aerial vehicles (UAVs) in construction. UAVs were the domain of predominantly armies, which sought to develop and use them for military purposes to eliminate human losses, thanks to the possibility of piloting from vast distances. In the last few years, however, the use of UAVs has greatly increased, both among professionals and the public, and is increasingly interfering in the field of civil aviation. An unmanned system is an unmanned aircraft, controlled remotely or capable of flying independently thanks to reprogrammed flight plans and various autonomous systems. After prices have dropped and availability has increased, the range of affordable unmanned systems that are offered to people has increased rapidly, which means that almost anyone can afford an unmanned system today. It is therefore not surprising that although unmanned systems are often used in the military for reconnaissance and offensive flights, they are also used for many civilian tasks, such as firefighting, police surveillance or field reconnaissance, and finally, UAVs find many use cases in civil engineering and construction, which will be presented in this paper.

Keywords:

Drone, UAV, innovation, remotely piloted aircraft, 3D model, photogrammetry

JEL Classification: O32

1 Introduction

The subject of this paper is the possibilities of using unmanned aerial vehicles (UAVs) and similar devices in construction. In recent years, remotely operated unmanned aerial vehicles (UAVs) or drones have found use in construction, as in many other fields. They have great potential for improving the performance of the construction team and positively affect the overall efficiency and profitability of the project. We can take a images or video of the complete construction site with a drone, and with the help of specialized software it is possible to create a 3D image with which construction companies can continue to work for effective planning and also help to detect problem areas early. Drones can also be used to diagnose various building problems or for preventive site inspections.

During 2006, the market for unmanned systems boomed with the launch of a larger scale of independent sales. Since it was possible for unmanned systems to be able to receive GPS signals, control boards and motors have been miniaturized, battery capacity has increased, and so-called multi-rotor systems have begun to emerge. In the last ten years, several dozen companies have been established around the world, whose production has focused on unmanned systems. Many companies operating in the related industry have decided to adapt their portfolio to unmanned systems and have started manufacturing various products such as various sensors, batteries, suspension systems, cameras, software, electronics, and rescue elements.

Unmanned systems offer a great market opportunity for equipment manufacturers, investors, and service providers. The addressable market value of unmanned systems is more than $ 127 billion. The civil infrastructure is expected to dominate the addressable unmanned systems market, with a market value of $ 45 billion. According to a report issued by the Association for Unmanned Vehicle Systems, more than 100,000 new unmanned vehicle jobs are expected by 2025. The global market value of unmanned vehicle payloads is expected to reach $ 3 billion by 2027. This market is dominated by North America, followed by Asia Pacific and Europe. Business Intelligence expects unmanned system sales to reach $ 12 trillion in 2021, an annual increase of 7.6% from $ 8.5 trillion in 2016.

All these statistics show the economic importance of unmanned systems and their applications in the near future for equipment manufacturers, investors and various service providers. Unmanned systems provide a unique opportunity for their manufacturers to take advantage of new technological trends to overcome the current problems of unmanned system applications. To expand drone services worldwide, a complete legal framework and institutions are needed to regulate the commercial use of drones.

1.1 Drone autonomy and its systems

Unmanned systems were originally considered to be a solution for performing dangerous and besmirched activities. The first generation of these systems was designed with relatively limited capabilities, which affected their flexibility and, in a certain operational situation, their efficiency. The physical distance between the human operator responsible for carrying out an activity and the unmanned system that performs that activity presents some potential shortcomings in the system. The communication line that provides control of the unmanned system has some latency that may prevent the operator from providing effective feedback, and the bandwidth of the data transmission may limit the extent to which the data and information collected may be available to the operator for analysis. The communication line is also prone to intentional or unintentional interference, which may limit its availability during critical phases of the mission. In addition, a significant number of incidents related to unmanned system accidents are caused by operator errors. In order to overcome these potential shortcomings, the development of unmanned system autonomy has been identified as a possible way among possible solutions.

Unmanned system autonomy is defined as the unmanned system's own ability to achieve the objectives of its mission. Therefore, more complex tasks mean a higher level of autonomy. NATO divisions are used for unmanned systems in the military. NATO has defined four levels for classifying unmanned system autonomy:

Level 1	Remotely controlled system - The response and behavior of the system depends on the control of the operator.
Level 2	Automatic system - Response and behavior depend on pre-programmed built-in functionality.
Level 3	Autonomous non-learning system - The behavior depends on a fixed built-in functionality or on a fixed set of rules that dictate the behavior of the system.
Level 4	Autonomous learning system with the ability to modify rules Defining Behavior - Behavior depends on a set of rules that can be modified to continually improve targeted responses and behavior within an overarching set of inviolable rules / behaviors.

Figure 1 - 4 levels for classification of unmanned system autonomy according to NATO [10]

2 Drones and construction

Drones are increasingly being used in the construction industry to provide fast, inexpensive, and high-quality work without the need for human workers, in addition to the worker who controls the drone, unless it is fully autonomous. The time it would take to measure, and photograph a given plot of land without the use of a drone is many times higher than using a drone. The time saved can then be used to work with data provided by drones. Another advantage is wireless data transmission, where drones can transmit current data in real time to the server and the data can be accessed by anyone around the world with minimal delay. Another advantage is the accessibility of drones when they reach even hard-to-reach places or places that are dangerous for a human worker.

Another use can be technical inspection of buildings. For many companies that manage larger or smaller technical infrastructure, technical control of this infrastructure is essential. Examples are energy companies that manage thousands of kilometers of power lines or radio companies that need to control tall transmitters on the fly. Offshore wind farms are also inspected. Unmanned systems can fly close to the ground, close to the controlled equipment, and thanks to the ability to pre-define the path to be flown, it is possible to record the control at the touch of a button. In addition, if the unmanned system is equipped with a high-resolution camera, the technician on the ground will recognize even the smallest details. The whole control using an unmanned system is simpler, faster and, finally, cheaper. Specific knowledge of the problem before the exit of the technician enables a more efficient supply of spare parts, or the necessary technics necessary for revision. The downtime required for patch is thus minimized.

3 Results and discussion

The subject of this paper is the evaluation of the created 3D model using the drone scanning method. Before the raid, it is necessary to get acquainted with the environment and choose a suitable raid method. The construction of a point field in the binding systems S-JTSK and Bpv belongs to the preparatory work, as well as the creation of a flight plan and the drone raid itself for data acquisition. The preparatory work includes the construction of a point field in the binding reference systems S-JTSK and Bpv to explain, the creation of a flight plan and a raid with an unmanned vehicle for obtaining measurement data. The point cloud obtained from the data evaluation must always be cleared of excess and incorrectly evaluated points.

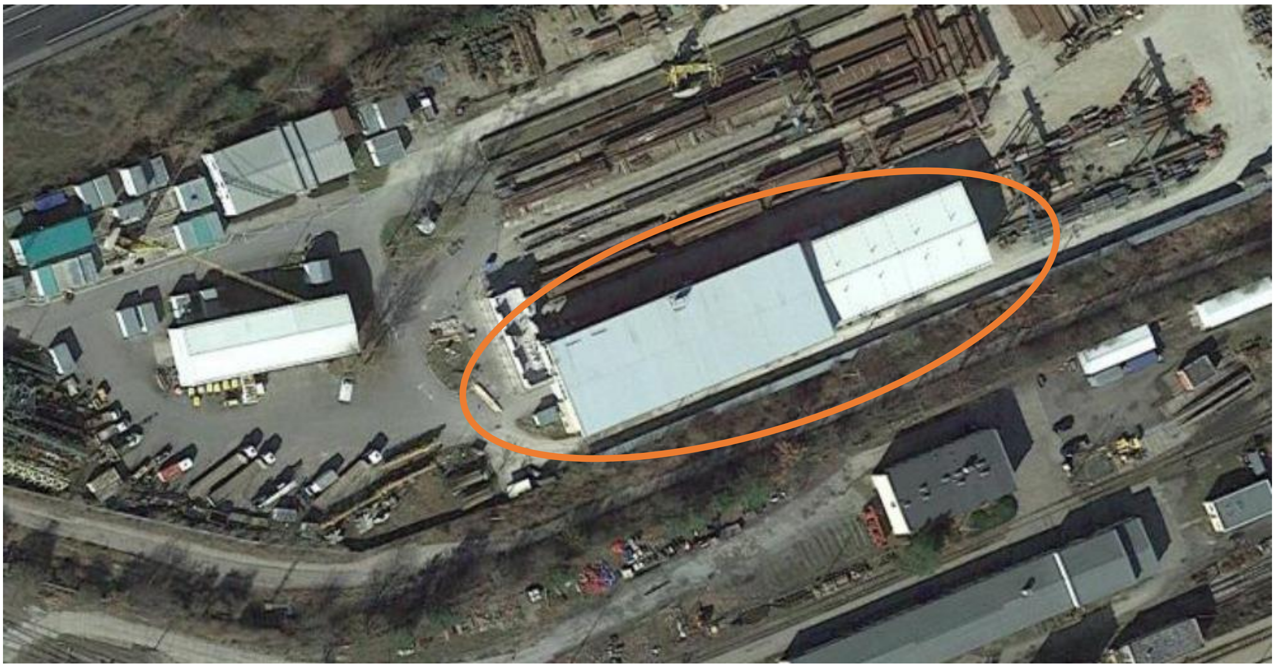
The Mavic 2 Pro quadcopter was used for the air raid, which is equipped with powerful engines, GPS and GLONASS positioning systems, a 4K Ultra HD camera mounted on a 3-axis stabilized suspension with integrated Lightbridge image transmission system, positioning system, anti-collision sensors and many other functions (Figure 2).

	Mavic 2 Pro	**Mavic 2 Zoom**	**Mavic Air**	**Mavic Pro**
				
Megapixels	20 MP ✓	12 MP	12 MP	12 MP
Sensor size	1“ ✓	1/2.3”	1/2.3”	1/2.3”
Max Frame Rate 1080P resolution	120 FPS ✓	120 FPS	120 FPS	96 FPS
Max Frame Rate 4k resolution	30FPS ✓	30FPS	30FPS	30FPS
Max Video Bitrate	100 Mbps ✓	100 Mbps	100 Mbps	60 Mbps
f/Number	f/2.8 – f/1.1 ✓	f/2.8 – f/3.8	f/2.8	f/2.2
Equivalent Focal Length	24mm	24-48mm 2x optical zoom ✓	24mm	26mm
Horizontal FOV	70°	40°-70° ✓	70°	66°

Camera Features	Variable Aperture, 10 Bit Color, 1" Sensor ✓	2x Optical Zoom ✓		

Figure 2 - Comparison of drone camera specifications for selection Mavic 2 Pro

The subject of this research is the creation of a 3D module using the drone scanning method. A production hall was chosen to create the model. The location cannot be mentioned due to a signed confidentiality agreement, where the owner of the building does not wish to mention sensitive information.

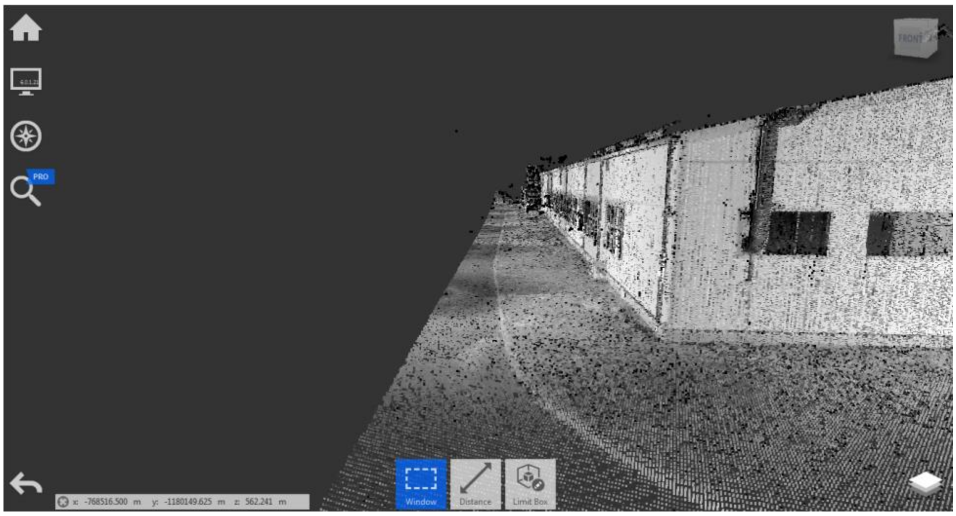


Figures 3 - Ground production hall from bird's eye view

Before the air raid, it is necessary to think about a flight plan. We need to know the altitude, scale of the image and the constant of the camera. Immediately before flight, we must map the photographed area and weather conditions and possible power lines in the raid location. Weather conditions must be taken into account, as an unmanned aerial vehicle (UAV) can only be flown up to a wind speed of 5 m / s. Due to the location of the production hall, which is not located in the development and lies on the plane, it is a crucial condition for the start of the flight.

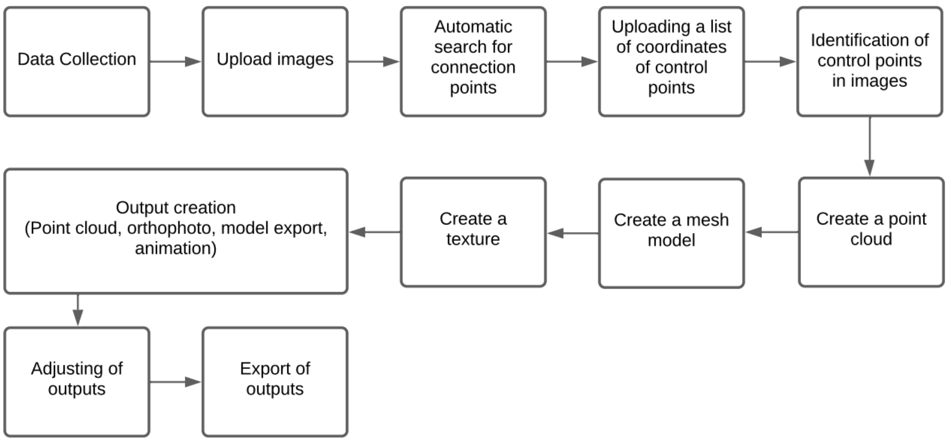
3.1 Creating a 3D model of a building using laser scanning

The process of creating a 3D model begins by scanning the external environment of the hall. The modeling was created on the basis of a point cloud to show the possibility of using an unmanned aerial vehicle (UAV) in construction. This is a total of 48mil points cloud. The input adjustment of a point cloud is the removal of object reflections or completely unnecessary points. The model have to be cleaned before the next steps.



Figures 4 - View of a cleaned model

The accuracy of the model was verified with a digital rangefinder by measuring all the perimeter cladding of the hall and the distances of the individual points. The 3D model differed within one centimeter from the measurement with a digital rangefinder in most of the verified places. A total of 20 measured sections were inspected, where 12 of them had an error of up to 1 cm. The other 7 sections had an error in the range of 1 - 2 cm and one point had an error of 5 cm. It can be stated that the scanned model is correct for further modeling and procedure. This is mainly due to very small differences in measurements and it can also be stated that there is a probability of inaccuracy of measurements with a digital rangefinder. This is therefore a sufficient model for further use. The model was created in the Revit environment (version 2019.3), which included the Scan to BIM extension. Using this extension, all the necessary elements of the model were modeled. The whole photogrammetric creation of a 3D model is mapped by the following scheme.



Figures 5 - Scheme of photogrammetric model creation

4 Conclusion

The use of UAVs and similar devices was presented by surveying the exterior of the production hall using laser scanning with a drone. The output of the raid was a cloud of points, from which a 3D model of the production hall was subsequently created. The subsequent model can be used, for example, when compiling a budget for the reconstruction or valuation of a focused object.

Drones are used in construction to inspect inaccessible and dangerous areas. However, they have the greatest use of drones in construction projects for photogrammetry. Photogrammetry is used to create maps and survey the earth. Previously, flights were performed with a conventional aircraft, only until the development of the UAV gave photogrammetry accuracy and possibilities for further use. The drone can be used to check the condition of the bridge structure, thermal imaging diagnostics of the perimeter cladding or flat roof, construction site monitoring in large construction projects, to create a 3D model in the absence of project documentation, to evaluate real estate but also to fight large fires or wash windows (mainly on skyscrapers).

Drones are also used in industry, where they can help with energy inspections, such as inspection of product and heat pipelines, high voltage inspections and inspections of photovoltaic panels. In agriculture, drones help with NDVI imaging, where the drone correlates the normalized ratio of the reflectivity of surfaces in the red visible and near infrared part of the spectrum. It is thus possible to find out when the plant suffers from "water stress". In agriculture, drones also help with afforestation after large-scale fires. The drone also helps to detect drainage pipes in the fields, and it is possible to prevent a situation where the drainage pipes become clogged and "water wheels" form in the fields, the pipes can also destroy agricultural machinery. In the mining and processing industry, drones are mainly used for the inspection of built or existing facilities, structures, and areas, where drones help mainly with the creation of 3D models, maps, documentation of the actual state and calculations of cubature. Drones can also be used for human and animal safety. Using thermal cameras, drones can identify a person in a forest, for example, or a man buried in an avalanche, which is important for fire brigades and rescue services. Police officers can use a drone to search for suspects or missing persons.

Regardless of the industry, it can be stated that drones make work more efficient because they save time and costs. Finally, by using a drone, we eliminate the safety risks associated with the human factor. Drones have a huge benefit for every technical field, but also for the other fields mentioned above. Drones in combination with supported technology and related software have huge potential in construction. With the help of a drone, accurate data can be obtained quickly and easily for all construction participants. As already mentioned, construction is the least digitized field and is still in its infancy with the use of drones and similar devices.

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