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Original article

Identifying the possibility of using unmanned aerial vehicles in the process of construction projects implementation

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INFORMATION

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ABSTRACT

Contemporary dynamic development in the field of modern technologies affects the development of unmanned aerial vehicles. The potential application area of this type of technology is constantly growing. The equipment is available to almost everyone and its use is becoming ever easier. The aim of the article is to present the possibility of using unmanned aerial vehicles in construction projects, for economic and time reasons, as well as to perform work in places that are inaccessible or too dangerous for humans. The article is the result of literature research, expert opinions and author's own analyses. The article draws attention to the fact that unmanned aerial vehicles may have a number of applications and unlimited possibilities. The use of modern technologies enables flights at different heights and within many kilometers. Due to the fact that they are equipped with various types of cameras, they constitute a useful observation tool in various projects. The authors of the article conduct research on the wide application of unmanned aerial vehicles in construction projects.

KEYWORDS

unmanned aerial vehicle, thermovision, modern technology

Introduction

Unmanned aerial vehicle have been used in the civil market in recent years in various sectors of the economy. They usually support aerial photography or filming. The equipment is available for almost everyone. In most cases, it is necessary to have ground staff who are responsible for the installation or operation of the vehicle and systems. It should be noted that unmanned aerial vehicles, in combination with appropriate sensors, are an excellent method of diagnosing and controlling the technical condition of objects. The combination of a thermal imaging camera and an unmanned aerial vehicle provides a useful tool for thermal imaging tests that can detect areas such as heat escapes from a building, thus preventing heat loss and significantly reducing building operating costs.

1. Unmanned aerial vehicles

Unmanned aerial vehicles (UAVs) is a generally accepted and used in engineering and science term. This term is also used by EUROCONTROL, the European Organisation for the Safety of Air Navigation, of which Poland has been a member since 2004 [1]. U.S. Department of Defense defines an unmanned aerial vehicle as "a powered aerial object that does not carry a human, uses aerodynamic forces to provide lifting power to the vehicle, can fly autonomously or be remotely piloted – which is very important, it can serve as a single use object or as a recovery object at the end of the flight. This structure is capable of carrying aerial warfare equipment and payloads" [2]. Other terms also found in foreign literature are:

- Drone – a name associated mainly with machines involved in military operations (e.g. in Afghanistan or Pakistan). These are unmanned aircrafts, programmed to fly in accordance with a certain course,
- RPA – (Remotely Piloted Aircraft) – the term used in documents of international organisations, including the International Civil Aviation Organisation (ICAO), also used in publications of the European Union [2].

Unmanned aerial vehicles fly by using two basic principles: the lifting force and reaction torque. In this type of devices, counter-rotating propellers are used, which stabilise the fuselage during spinning. An unmanned aerial vehicle may be remotely piloted beyond visual line of sight (by an operator), or fly autonomously (by itself using an autopilot or another on-board system) [3]. However, most of them are piloted in the line of sight. In both cases, ground staff is needed for the assembly, and systems and vehicle operation. The most important interface between the machine and the user is the radio system, the range of which is measured in kilometres. Many types of materials are used to construct modern unmanned aerial vehicles. The most popular are glass fiber, carbon fiber, as well as various types of plastic or metal. The materials listed above are characterised by a very good weight to strength ratio, but they are also very expensive.

In the reference literature different ways of classification and division of UAV can be found. However, the most popular is a division according to its intended use. The table below shows the classification of the UAV according to its intended use (Table 1).

Modern aerial vehicles (military, civilian) are the objects (systems) of very complex technical construction. They are usually built of many on board devices and subsystems, some of which make flying possible, while others provide the performance of specific functions within the combat mission. Their multifunctionality makes it possible, among other things, to perform reconnaissance flights [5].

UAV are of different configurations and sizes – typically quadruple and octocopter, with four or eight propellers respectively. The main propulsion systems include propellers and engines, which play a significant role here. The size of the propellers (blades) determines the lifting force, as well as the flight stability. The UAVs fuselage is stabilised by the counter-rotating propeller movement [6]. The selection of the right engines, which have to cope with the aerodynamic resistance, is an extremely important task. Thanks to them, UAVs can hover in the air for up to several dozen hours, uninterrupted.

UAVs can be equipped with various types of detectors, e.g. hazardous substances, automatic data analysis and transmission devices, as well as thermal imaging cameras. These devices

Table 1. Classification of UAV according to its intended use

Category	Intended use (main tasks)	Name and type of the system
Objectives and decoys	Visualisation of air targets for artillery and rocket launches	Voodoo, Banshee objectives (Meggitt Defense Systems)
Reconnaissance	Reconnaissance on a battlefield	RQ-1 Predator
Militant	Use in attack on specific targets	Schiebel S-100 Camcopter, MQ-9 Reaper (Predator B)
Logistics	For carrying loads and other protection of the battlefield	AirMule (Urban Aeronautics)
Research	Testing of new aerodynamic and electronic technologies and solutions	Altair UAV (General Atomics Aeronautical Systems)
Civilian and commercial	Carrying out commercial and civil tasks (border surveillance, monitoring of mass events)	Eagle Eye (Bell) – US Border Guard, Fulmar (Aerovision) – search for tuna schools

Source: [4, p. 15].

are mostly used for filming and photographing. Real-time video playback makes unmanned aerial vehicles an ideal tool for, among other things, monitoring of dangerous goods transport routes or supervision of mass events [6]. The combination of UAV with such devices as digital cameras, directional microphones, thermal imaging sensors and network transmitters creates a number of new possibilities. They can be used in both, site protection and investment control or logistics. They may be considered a tool that extends the range of offered services, but also significantly reduces operating costs [7]. The potential for the use of aerial vehicles is being increased by their constantly developing structures and resistance to atmospheric phenomena, greater range, as well as easier and more precise control. The dynamically developing market of telemetry and CCTV surveillance systems, which unmanned aerial vehicles can be equipped with, also contributes to the extended possibilities of using such devices [8].

2. Definition and application of thermal imaging tests

Thermal imaging, also called thermography, is a process of registering thermal radiation, emitted by physical bodies. The aim of thermal imaging testing is primarily to visualize in the infrared medium band (wavelengths from approx. 900 to 1400 nm) of heat emitted by physical objects. This process makes it possible to record the thermal radiation emitted by all physical bodies in the temperature range typical of everyday conditions. It should be stressed that objects do not need to be illuminated by an external light source. Such operation allows for a very accurate temperature measurement of objects in the places that interest us. Generally, thermal imaging testing is carried out in order to determine the level of emission and loss of thermal energy in, among others, industrial or residential buildings. This type of testing contributes to the determination of the object's thermal state. In addition, this method makes it possible to search for various inconsistencies and irregularities. Observation of heat emitted by objects in the field of vision is possible thanks to the use of a thermal imaging camera. It should be noted that all bodies whose temperature is higher than absolute zero are sources of radiation in the medium wavelength infrared, i.e. infrared

radiation with a wavelength of about 0.9 to 14 μm. Therefore, the functioning of a thermal imaging camera is based on a physical phenomenon concerning electromagnetic waves emitted by every body whose temperature is higher than absolute zero. Moreover, the intensity of infrared radiation is proportional to the body temperature [9].

The use of infrared has many advantages, especially when it is difficult to predict the temperature distribution. Infrared has the advantage of producing accurate images of a thermal field in a contactless manner.

Thanks to the use of modern thermal imaging cameras it is possible to make professional measurements characterized by high accuracy and precision. They can be used even in the most demanding scientific research, as they detect the slightest changes in a very wide temperature range. In addition, cameras provide the ability to capture and record images in real time. This makes it possible to perform accurate and broad analyses of phenomena characterized by high dynamics. The development of sensor technology has made thermal imaging cameras a cost-effective option today. A wide range of applications of thermographic tests enables diagnosis of technical anomalies of objects.

3. Copyright research

Thermal imaging is more and more often used in various areas of life, including heat engineering, construction, power industry and medicine. A professional high-resolution thermal imaging camera should be used in order to obtain reliable results. Thermal imaging testing is common in the construction sector. The most frequently performed thermal imaging services during the year are, for example, detection of water leaks from the central heating system, leak search and assessment of walls and ceilings dampness degree. Thermovision also makes it possible to search for leaks from underground heating networks of pipelines. However, such projects require appropriate conditions and experience of the camera operator.

Companies and private individuals owning buildings control the tightness of facades and roofs to minimise heat loss. Improper construction may lead to significant financial losses over time, especially in winter. A tool that enables easy measurement in individual places is a thermal imaging camera. With the use of this type of camera, it is possible to determine the temperature in a place that may be leaky, e.g. between a window and a frame. Thermal imaging may be considered one of the best ways to evaluate the quality of renovation work, such as thermal efficiency improvement of a building. Thanks to the combination of UAV and thermal imaging camera, this type of measurement can be performed even at considerable heights and in places not easily accessible to people. The advantage of this method is, first of all, accuracy, economy and a fast performance of measurements, thanks to which it is possible to rectify defects quickly [10]. For this type of measurements it is also recommended to use radiometric cameras, thanks to which one may read the temperature in the given point of the registered infrared image. The thermogram of the building made with the use of UAV is shown in Figures 1a and 1b.

A photograph taken with a thermal imaging camera shows characteristic temperature distributions that appear when cooler air penetrates through cracks in the structure and moves along the surface cooling it down.

Testing with the use of thermal imaging in an open field may be subject to errors resulting from the so-called environmental factors. Direct sunlight strongly affects the readouts from

a)

b)

Fig. 1. View: a, b) building thermogram made with the use of UAV
Source: Author's own study.

the thermal imaging camera. Both sunlight and shade can affect the distribution of surface temperatures of the building for hours after the sun has stopped shining. Therefore, differences in thermal conductivity can lead to major temperature differences. Rain, which lowers the surface temperature of the material, is an equally dangerous factor. The evaporation of rainwater cools the material, which leads to a disturbance in the temperature distribution [10].

When using a thermal imaging camera to detect insulation gaps or energy losses, it is best if the temperature difference between the inside of the building and the outside is at least +10°C. With a high-resolution camera of high temperature sensitivity, the temperature difference can be smaller. Therefore, building inspections are often carried out in winter.

Currently, the authors are also conducting research on the application of UAV in the following areas:

– drawing up three-dimensional, detailed maps of the areas to be developed, containing relevant data and information, which may be particularly important during the study phase and during the preparation of the conceptual project,
– drawing up three-dimensional, detailed maps of the areas to be developed, containing relevant data and information, which may be particularly important during the study phase and during the preparation of the conceptual project,
– ongoing monitoring of the construction site and works in progress,

– controlling and supervising the works performed by the contractor, as well as supporting persons responsible for supervision,
– control over the delivery of building materials and specialist equipment to the construction site,
– performing a simulation which will provide the client with information on the topography and on the best place for the foundation excavation,
– monitoring the location of construction equipment that changes its position on the site, as well as supervising employees, properly performing their assigned duties and complying with occupational health and safety rules [11]. The authors' preliminary research shows that the application of UAV in the above mentioned projects will improve the effectiveness of their implementation.

Conclusions

Initially, unmanned aerial vehicles were mainly used in the army. Over time, however, they became more and more important on the civil market, in many different fields. Due to the fact that they are equipped with various types of detectors, e.g. dangerous substances, automatic data analysis and transmission devices, as well as thermal imaging cameras, network transmitters, they offer a wide range of applications. Decreasing purchase costs and increasing availability result in growing popularity of UAV. Thanks to the autopilot function, the device is easy to operate for almost every user. Determining parameters such as flight speed and altitude, flight course, monitoring of objects or phenomena in hard to reach places does not constitute a major problem.

The possibility of using UAV together with thermal imaging cameras or HD cameras makes it a great tool for conducting various types of research. The conducted tests indicate that it is possible to identify areas of heat escape in the building and assess the temperature distribution. Moreover, the result is fast, accurate and non-invasive thanks to the use of an unmanned aerial vehicle combined with a thermal imaging camera. It allows, among other things, to locate defects in buildings, such as missing insulation, flaking mortar, dampness problems, as well as to assess the condition of heating, ventilation and air conditioning systems.

Such measurements are not only accurate, but also very cost-effective. Regular autonomous UAV flights may provide in a short period of time current and detailed data concerning the implemented construction projects.

In addition, photography and aerial filming is an ideal way to show the progress of construction works. When taking a UAV flight in the immediate vicinity of the works, it is possible to take photographs even in hard-to-reach places with a small financial outlay.

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Conflict of interests

The author declared no conflict of interests.

Author contributions

The author contributed to the interpretation of results and writing of the paper. The author read and approved the final manuscript.

Ethical statement

The research complies with all national and international ethical requirements.

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References

1. Maj-Marjańska J, Pietrzak P. *Prawne aspekty użytkowania bezzałogowych statków powietrznych*. Bezpieczeństwo narodowe. 2011;2(18):197-204.
2. Waniewska A, Skorupka D, Duchaczek A. *Unmanned aerial vehicles in polish and international law*. Wrocław: Wyższa Szkoła Oficerska Wojsk Lądowych imienia generała Tadeusza Kościuszki; 2016.
3. *Świat dronów*, [online]. (n.d.). Available at: www.swiatdronow.pl [Accessed: 7 March 2016].
4. Burdziakowski P. *Bezzałogowe statki powietrzne*, [online]. (n.d.). Available at: https://www.researchgate.net/publication/274067137_Bezzalogowe_statki_powietrzne [Accessed: 28 February 2016].
5. Becmer D, Romanek A. *Bezzałogowe platformy latające*. Wrocław: Wyższa Szkoła Oficerska Wojsk Lądowych imienia generała Tadeusza Kościuszki; 2011.
6. Audronis T. *Drony. Wprowadzenie*. Gliwice: Wydawnictwo HELION; 2015.
7. Cwojdziński L. *Zadania wykonywane przez systemy platform bezzałogowych i powody ich stosowania*, [online]. (n.d.). Available at: http://www.5zywiolow.pl/wp-content/uploads/2014/02/zasady-uzycia-uav-leszek-cwojdzinski.pdf [Accessed: 28 February 2016].
8. *Zastosowania dronów*, [online]. (n.d.). Available at: www.swiatdronow.pl/zastosowania-dronow [Accessed: 22 March 2016].
9. Adamczewski W. *Badania termowizyjne w elektroenergetyce*, [online]. (n.d.). Available at: www.termowizja.pl/artyk/Elektroinstalator_5.pdf [Accessed: 11 March 2016].
10. *Badania termowizyjne dla budownictwa*, [online]. (n.d.). Available at: www.kameratermowizyjna.com [Accessed: 11 March 2016].
11. Kowalski P, Bielecki K. *Zastosowanie termowizji z wykorzystaniem dronów w budownictwie*, [online]. (n.d.). Available at: http://www.inzynierbudownictwa.pl [Accessed: 7 March 2016].

Biographical note

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Identyfikacja możliwości wykorzystania bezzałogowych statków latających w procesie realizacji przedsięwzięć budowlanych

STRESZCZENIE Współczesny dynamiczny rozwój w dziedzinie nowoczesnych technologii wpływa na rozwój latających platform bezzałogowych. Obszar potencjalnego zastosowania tego typu technologii stale rośnie. Sprzęt dostępny jest niemalże dla każdego, a jego obsługa staje się coraz prostsza. Celem artykułu jest przedstawienie możliwości zastosowania, bezzałogowych statków powietrznych w przedsięwzięciach budowlanych

ze względów ekonomicznych, czasowych oraz wykonywania prac w miejscach niedostępnych lub zbyt niebezpiecznych dla człowieka. Artykuł jest wynikiem badań literatury, opinii ekspertów oraz analiz autorskich. W artykule zwrócono uwagę na fakt, iż bezzałogowe platformy mogą mieć wiele zastosowań, a także nieograniczone możliwości. Wykorzystanie nowoczesnych technologii umożliwia wykonanie lotu na różnych wysokościach i w promieniu wielu kilometrów. Dzięki wyposażeniu w kamery różnego typu stanowią one przydatne narzędzie obserwacyjne w różnego rodzaju przedsięwzięciach. Autorzy artykułu prowadzą badania nad szerokim zastosowaniem bezzałogowych platform latających w przedsięwzięciach budowlanych.

SŁOWA KLUCZOWE bezzałogowe statki powietrzne, termowizja, nowoczesna technologia

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