SOLUTIONS IN PROPERTY PROTECTION BASED ON PHANTOM 4PRO+ UAV, IN FAVOR OF LOWERING OF THE TERRORIST THREAT

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Abstract: Property protection represents an outstandingly important aspect these days. Terrorist attacks are occurring ever more frequently in the European Union and abroad, so the preservation of human lives is a question of key importance. It is impossible to have an efficient property protection without solutions based on computer science. By means of the appearance of UAVs, the human forces can monitor given buildings or building complexes more efficiently. These remotely controlled miniature airplanes are fitted with a camera enable the possibility of reconnoitering a large land surface in a short time period. However, it is important to note that the adequate choice of UAVs is an imperative, as these vehicles possess a number of specific characteristics, which may influence the defense. These features may be the length of flying time, the resolution of the onboard camera system, the obstacle sensor, or the resistance against various weather conditions. The deployment of the Phantom 4Pro+ UAV in property protection is formulated as a proposal, as it possesses a number of technical characteristics, which are enabling it for the execution of various tasks of defense and reconnaissance. This vehicle facilitates and simplifies the flight engagement by means of its intelligent flight characteristics, while the onboard infra-red sensor identifies the obstacles and corrects the flight in order to avoid them. The vehicle uses 7 various cameras during the flight, with an infra-red sensor system, along with a double satellite positioning system (GPS & GLONASS), respectively two ultrasound employing distance measuring units, facing downwards. These all are specific traits, which may greatly enhance the effectiveness of the property protection.

Keywords: keyword1; terrorism; property protection; UAVs

1 Preface

In the second part of the 20th century, the measure of urbanization has sped up. Utilizing the dynamically developing urbanization, the terrorists attack various complexes and properties more frequently.

The urban space and lifestyle subserve the terrorists. This is facilitated by the factors (besides the density of built-in areas and populousness) like the fact that in the large cities, political, administrative, economic, cultural, touristic and entertaining institutions and their serving infrastructure are densely present. All these factors are ”offering” a multitude of possible targets, for the terrorist organizations. From the aspect of statistical data and the experienced terrorist attacks:

- religious sanctuaries (places of worship, temples, mosques, and synagogues);
- various facilities (vehicles of public transport, railway and underground carriages, airplanes, railway- and public transport terminals, stations, tunnels),
- services (port offices, mail-order networks);
- offices of political organizations and parties;
- premises of multinational enterprises (banks, offices, branch offices);
- buildings of jurisdiction (courts and prosecutor’s offices);
- buildings of the government, the administration and of law enforcement,
- diplomatic organizations (embassies, residencies, consulates).

The choice of possible targets depends on more factors. From one side, the characteristics of the urban architecture are influential, the number, location, and accessibility of more vulnerable complexes, which are relatively easier to attack [1].

In order to lower the terrorist threat, the estates and premises should be defended by efficient methods. This can be greatly facilitated the reconnaissance based on UAVs, which elevates the operation of security services, as it is able to oversee the greater area of defense in the same timeframe. The characteristics of the Phantom Pro4+ UAV enable the vehicle to perform the tasks of property protection.

2 Terrorist threat

Acknowledging that no one definition of terrorism has gained universal acceptance, the U.S. Office of the Coordinator for Counterterrorism has endorsed the following definition, found in the United States Code (Title 22, Section 2656f[d]) and adopted by the Department of State, Department of Defense, and Central Intelligence Agency:

The term ‘terrorism’ means premeditated, politically motivated violence perpetrated against noncombatant targets by sub-national groups or clandestine agents, usually intended to influence an audience. The term ‘international terrorism’ means terrorism involving citizens or territory of more than one country. The term ‘terrorist’ group means any group practicing, or that has any significant subgroups that practice, international terrorism [2].

As a result of recent events, governments have shown growing interest in the protection of strategic infrastructures against sabotage and terrorist attacks in particular, are vulnerable because they cover large geographical areas and are difficult to protect [3]. The UAVs may lend an efficient aid in the reconnaissance of large land areas in a short time period. In favor of the prevention and a successful defense against terrorist attacks, property protection based on UAVs may be of outstanding importance.

The terrorist threat concerns mainly cities, amongst which the more significant threat looms over large cities. The experiences of terrorist attacks happened in the world until now unanimously prove this. The characteristics of urban space and way of life more likely subserve the operation of terrorist organizations. Due to their traits and possibilities, large cities count as a real ”paradise” and a series of easy targets from the aspect of these terrorist groups. The explanation of this phenomenon is not very complicated, as due to the processes of urbanization, the metropolises of our time concentrate systems of political, administrative, economic, touristic and entertaining institutions, and their serving infrastructures. Terrorists may choose infinite number of possible targets based on the density of the built-up areas, the buildings, other facilities, premises, and the high number of people living in cities. Large cities possess developed infrastructural, traffic and telecommunication networks, in order to accommodate and supply the population and to attend and secure the functional conditions of the infrastructural facilities and elements of institutions and their systems. These networks form a complex system, and they are vulnerable, so their defense against a terrorist attack is very expensive and presents a nearly impossible task. Besides the high concentration of population, the relatively high vulnerability of infrastructural facilities and networks increases the defenselessness and sensibility of large cities against the terrorist attacks. Upon a successful terrorist attack, depending on the characteristics of the facilities or systems harmed or destroyed, or on the modality of the destruction, the extemporal lack of services, paralysis of the communication network and/or considerable traffic jams may be expected. Based on the high populousness, the specificities of urban structure and the vulnerability of infrastructural systems, it is not an exaggeration to state that it is easy to execute terrorist attacks in large cities, with a relatively small effort, claiming even mass casualties [4].

3 Property protection

A property is an accurately confinable area, on which buildings of various function may be located. The level of endangerment is defined by the building's operation, the security level of the upkeep, the materials used in its construction, the technical devices present, the demand for information, also their value and marketability, the presence of (contamination with) crime, the business hours, the time of day, the dependability of the property defense system deployed, the objective and subjective rapidity of countermeasures and a reaction force, the character (criminality) of unwanted actions, and their influence in the area [5].

Property protection represents a field of safeguarding, which is accomplished by the combined deployment of up-to-date mechanical and electronic devices, besides manpower. Various objects, implements, material goods, and so the properties must be defended against all the outer and inner influences and factors, which by any way endanger their proper usage or the performing of their designated functions. Their status and value producing processes within them need to be supported by a continuous defense, upholding their safe environment [6].

Possible solutions in property protection:

- Manpower (by a security service);
- Mechanical solutions of defense (locks, doors, fences, portals);
- Electronic solutions of defense (UAVs, alerting and camera system, admission system).

As it can be seen, the defense based on the UAVs is categorized in the class of electronic defense solutions, and their operation demands an adequate training, presumably possessed by the security service.

4 UAVs

UAVs (unmanned aerial vehicles) are of a great interest in military and civilian applications, including mapping, patrolling, and search and rescue [7]. UAV quadrotors are designed to easily move in different environments while following specific tasks and providing a good performance as well as a great autonomy [8]. The possibilities offered by UAVs may be efficiently utilized in property protection. These miniature airplanes can scan the whole defended object, as they soar at high enough altitudes. They are capable of tracking humans, or rather of performing various tasks of reconnaissance. In these cases, UAVs are performing tasks of prevention and defense. The first priority of defense timeframe is the protection of human lives, only then the protection of material goods may follow [9]. UAVs may uncover potential threats and unauthorized intruders more easily.

The given property may well be supervised through continuous or periodical overwatch. If the solutions of property defense involving UAVs are utilized on a daily basis, the manpower in defense is tasked with yet another group of assignments:

- The upkeep of UAVs;
- Monitoring tasks (the analyzing of the UAVs' recordings);
- Adequate level of training in relation to the UAVs' operation;
- Continuous state of alertness (through 24 hours) - (keeping up battery charge, monitoring the state of charge);
- Providing an area for the UAVs, so it may be deployed at any time.

Three categories of UAVs may be distinguished:

- Fixed-wing UAVs;
- Rotary-wing UAVs;
- UAVs operated by upward propulsion.

The rotary wing, pilotless flying vehicles appeared in common knowledge about 11 years ago, hence their quantity is continuously growing. Determined by the tasks beforehand, these devices may appear in various sizes, ranging from extra light (16 grams) to heavy (22 kg). In case of a deployment involving UAVs, numerous characteristics must be taken into account:

- the size of the monitored area;
- the type of recording of field data,
- the weight of the camera and;
- the anticipated in-flight time.

These parameters basically determine what type of UAV will be needed during the operations. During the repetitive straight-lined or circular path flights, records are often made. In order to successful recording or photographing, intelligent methods, provided by the manufacturers may be implemented. During time sliced photographing, or by the use of more cameras at a time above a given area, the flight mode called "Waypoints" is useful. The subject is, that the UAV must fly between two grid-points, at a precisely determined altitude with a constant set airspeed.

UAVs have not only positive qualities. The flight time is a critical point. While the smaller UAVs are capable of 18 to 20 minutes of flight time, greater machines or ones equipped with heavier cameras can fly only for 6 to 12 minutes. Accordingly, the mapping of vast areas is not possible. Another important factor is the weather conditions. In high winds, above 20 to 40 km/h of wind speed,

depending from the UAVs' size, precise navigation is not possible anymore. In the case of smaller machines, the wind may prevent them from a safe return or landing [10].

4.1 Two-way communication with UAVs

The guidance of RC aerial vehicles and UAVs has undergone a huge transformation during the recent years. The remote controlling utilizing a single signal direction has been changed to two-way communication, where the pilot gets feedback information from the UAV. The two-way communication has enabled the operator to see and handle all the telemetry data of the UAV and all of the attached supplemental sensors in real time. By the frequency jumping communication (FSHH), utilizing the digital ISM-band at 2,4 GHz, not only the pilot is capable of giving navigational orders to the UAV, but the vehicle can send back telemetry data, and the sight picture of the on-board camera towards the user. Thus, the actual GPS coordinates, the charge level of the batteries, or data sent by other sensors may be followed. The duplex-digital signal transfer uses the ISM-band, thus the maximal distance between the UAV and the user is greatly influenced by the saturation of the frequency band, and it is further determined by other factors, like the geographic position, ratio of built-up areas or time of the day. By means of the digital signal transfer, the system is less prone to disturbance, in comparison with the vehicles of earlier generations (thus, their sabotage is harder to accomplish). A great problem is, however, the saturation of the ISM-band at 2,4 GHz, which is used by most of the vehicles [11].

5 Phantom 4Pro+ UAV

The Phantom 4Pro+ UAV has specific characteristics, which are perfectly enabling it to perform tasks of property protection.

Figure 1
Phantom 4Pro+ UAV

5.1 Navigation system

Three sets of double visual sensors form a navigation system of six-cameras, which is in constant operation; it calculates the air-speed and distance between the drone and the obstacle. Using this front, back and downward facing visual sensor grid, the Phantom 4 Pro is capable of a precise hovering in places without GPS signal, during indoor missions, or even when flying through a window, with a minimal input from the pilot. The Phantom 4 Pro is capable of flight in a complex environment, even with an air-speed of 50km/h, while dodging or evading the obstacles in its way. It automatically adjusts the obstacle sensing system to the air-speed, enabling the evasion at lower or higher speeds.

5.2 Obstacle sensor

The Phantom 4 Pro+ has been expanded with a high definition stereo-visual sensor at its back side, also a pair of these at its front, plus further infrared sensors can be found on the left and right side of the hull. This grid is sensing obstacles in five directions, and the vehicle is able to evade in four directions, thus it defends the integrity of the Phantom 4 Pro.

5.3 Flight Autonomy

Flight Autonomy is an automatization platform with a developed intelligence. It consists of a complex network of ten components, including two cameras (front and back, plus dual visual sensors at the bottom, and the main camera), an infrared

sensor system, double satellite positioning (using GPS & GLONASS), two ultrasound rangefinders facing downward, IMU and a compass, and a group of powerful, specialized processor cores. The Phantom 4 Pro acquires data in real time from the environment, and it gathers information considering the altitude, and the position of the obstacles in the vicinity, thus devising a 3D map, on which it places itself. The basic flight data is gathered by the IMU and the compasses, like the air-speed and the flight direction, while the secondary IMU and compass are responsible for the critical data and are designated to filter out possible mistakes, ensuring a more secure flight.

5.4 Active Track

Automatically recognizes (even moving) objects, follows and records them. The fast-moving objects are hard to track, but by means of an advanced image-identification technology, the system easily identifies objects and focuses on them while the tracking. This new algorithm is able to identify more images and objects, ranging from vehicles to animals, and it adjusts the in-flight dynamics accordingly.

5.4.1 The pilot may choose

- Trace – the object to be followed is pursued from the front or back while evading the obstacles automatically;
- Profile – flies beside the object, nearing it at various angles;
- Spotlight – the object is kept in the center, while the flight path may be anywhere [12].

5.4.2 The infrared tracking system

The UAV uses infrared sensors. Those are located on the left and right side of the hull, and tasked with the measuring of the distance between the vehicle and all types of obstacles, utilizing a 3D infrared scanner. These sensors possess a viewing angle of 70° horizontally, and 20° vertically, both in default or tripod mode, ensuring the wide viewing angle on the hull sides of the Phantom, up to 7 meters. The traditional ultrasound sensors were efficient only up to 3-5 meters, and they could be easily disturbed, due to the vibrations from the propeller or upon sensing an uneven surface. The infrared sensor system is capable of mapping a great surface, while measuring the distance, determining the nearest object, dodging the interference and providing a reliable defense.

The Obsidian remote control unit of the Phantom 4 Pro has been provided with a Lightbridge HD video signal transmitter, so it supports data transfers at 5.8GHz. A possibility is left for the choice of the 2.4 GHz and the 5.8 GHz bands, which enables the pilots to minimize the interference noise, or in case of an overload of a frequency, the latency may be eliminated by switching over to the other band. The Wi-Fi video signal transfer system usually uses the 2.4 GHz band, while the remote control functions at 5.8 GHz, avoiding the disturbance from the interference, stemming from the use of the same channel. The use of two dissimilar frequencies influences negatively the flight performance.

The Lightbridge HD video signal transmitting system, used in the Phantom 4 Pro remote control unit called Obsidian, utilizes TDM (Time Division Multiplexing) for the signal transmission, provided with sending and receiving the information on the very same frequency. The frequency of 2.4GHz is often disturbed because of the Wi-Fi signal, while the 5.8GHz band increases the efficiency of signal transfer. Upon being switched on, the Phantom 4 Pro measures the level of saturation of the local frequencies and chooses automatically the band least disturbed by the interference. Thus, it enables the maximal effectiveness of video signal transfer, which could even peak at 3.5km.

5.5 Intelligent flight

As the time passes, UAVs are increasingly easier to fly, although practice and experience are unavoidable for the mid-air photographing of acceptable quality. As the UAV uses seeing and depth-perception technology, the Phantom 4 Pro Obsidian is capable of complex movements, while the commands themselves are simple. Contrary to the intelligent flight based on satellite positioning, the Intelligent Vision provides precise camera view and control.

5.6 Draw

A flight path may be drawn on the display of the remote control unit, thus, the UAV will move to the desired direction, while it would keep the flight altitude. By these means, the pilot is able to concentrate on camera control. There are two modes of operation in the Draw function, which may be used in various cases, as the actual situation requires.

- **Standard:** The vehicle flies at a constant speed through the determined flight path, while the camera faces forward;
- **Free:** The UAV follows the determined path only when it receives a command for that, while the camera may be turned to whichever direction in this mode [13].

The vehicle's technical specifications are described in the table below:

Table 1
Technical specification of Phantom 4Pro+ drone

Weight (Battery & Propellers Included)	1388g
Diagonal Size (Propellers Excluded)	350mm
Max Ascent Speed	S-mode: 6 m/s; P-mode: 5 m/s
Max Descent Speed	S-mode: 4 m/s; P-mode: 3 m/s
Max speed	S-mode: 72 kp/h; P-mode: 58 kp/h;
Max Tilt Angle	42° (S-mode); 35° (A-mode); 25° (P-mode)
Max Angular Speed	250°/s (S-mode); 150°/s (A-mode)
Max Flight Time	6000m
Max Service Ceiling Above Sea Level	32° to 104° F (0° to 40° C)
Satellite Positioning Systems	GPS/Glonass

The UAV's battery determines the in-flight time. The more potent the battery is, the longer time the vehicle may spend in the air. The capacity of the vehicle's battery is described in the table below:

In order for the UAV to be deployed successfully in various tasks involving property protection, the camera system is greatly involved, since in flight, the user may rely only on the remote control and the camera system mounted on the vehicle itself.

Table 2
Battery specification of Phantom 4Pro+ drone

Capacity:	5870 mAh
Voltage:	15,2 V
Energy:	89,2Wh
Net weight:	468 gr
Max charging power:	100W

Conclusions

The property protection based on UAVs is considered a novelty these days. Numerous sources of endangerment may arise on a daily basis, which has to be mapped and reacted to timely, in order to avoid the undesired events.

The solution for property protection supported by the Phantom 4 Pro+ UAV greatly contributes to the successful defense of the building designated for protection. The vehicle can be easily controlled by means of its advanced navigational system. The obstacle sensors prevent the accidental collision with a potentially harmful object. The vehicle is able to map its surroundings efficiently, through the data gathered in real time. By the ActiveTrack solution, the UAV is capable of tracking even moving persons. Finally, the Draw function must be mentioned, which is essential in property defense, since a flight path may be drawn on the display of the remote control unit, which the vehicle is able to follow. Thus, the borderline of the defended perimeter may be set, in which area the UAV may perform reconnaissance flights.

References

[1] Horváth, Attila: Characteristics of the terrorist threat of European cities during the period before the Islamic State came. (Az európai nagyvárosok terrorfenyegetettségének jellemzői az Iszlám Állam megjelenése előtti időszakban) Hadtudomány: A magyar hadtudományi társaság folyóirata 28.E-szám (2018): 19-32.

[2] Stevens, Michael J.: What is terrorism and can psychology do anything to prevent it?. Behavioral sciences & the law 23.4 (2005): 507-526.

[3] Arroyo, José M., and Francisco D. Galiana: On the solution of the bilevel programming formulation of the terrorist threat problem. IEEE transactions on Power Systems 20.2 (2005): 789-797.

[4] Horváth, Attila.: Terror threat: targets, big cities traffic. (Terrorfenyegetettség: célpontok, nagyvárosok közlekedés), Nemzetvédelmi Egyetemi Közlemények 10.3 (2006): 136-152.

[5] Tamás, Berek, and Bodrácska Gyula.: Live guarding in the building industry of object protection. (Az élőerős őrzés az objektumvédelem építőipari ágazatában), Hadmérnök 5:*(*4) pp. 38-49.(2010) (2010).

[6] Kasza, Zoltán: Evaluation of external structures and architectural solutions that compromise the security of buildings as objects. (Épületek, mint objektumok vagyonbiztonságát veszélyeztető külső szerkezetek és építészeti megoldások értékelése), Bánki Reports 1.2 (2018): 12-19.

[7] Ryan, Allison, et al.: An overview of emerging results in cooperative UAV control. Decision and Control, 2004. CDC. 43rd IEEE.

[8] Benallegue, Abdelaziz, Abdellah Mokhtari, and Leonid Fridman: High-order sliding-mode observer for a quadrotor UAV. International Journal of Robust and Nonlinear Control: IFAC-Affiliated Journal 18.4-5 (2008): 427-440.

[9] Nagy, Sándor.: The relationship between natural and civilization hazards with the protection of the population, the role of drons in effective event management. (A természeti és civilizációs veszélyforrások kapcsolata a

lakosságvédelemmel, a drónok szerepe a hatékony eseménykezelésben), Repüléstudományi Közlemények (1997-től) 29.3. (2017): 85-94.

[10] Krisztina, Major, et al: Use of visual research data for remote control drons in education. (Távirányítású drónok kutatási célú vizuális adatainak alkalmazása az oktatásban), ResearchGate, 2016.

[11] Hell, Péter: Safe communication of Drón systems. (Drón-rendszerek biztonságos kommunikációja), Köztes-Európa 8.1-2 (2016): 169-175.

[12] Extreme Digital: DJI Phantom Pro4+ drone. https://goo.gl/5qLVNM (Download time: 2018-08-09), 2018.

[13] Myactioncam: DJI Phantom Pro4+ drone. https://goo.gl/7FDBdG (Download time: 2018-08-09), 2018

[14] DrónExpert: DJI Phantom Pro4+ drone. https://goo.gl/Mxwbpx (Download time: 2018-08-09), 2018.

[15] Hobbycity: DJI Phantom Pro4+ drone. https://goo.gl/k3achS (Download time: 2018-08-09), 2018.