Using a small UAV for nautical ports inventory

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Abstract. Reliable knowledge of marinas is crucial for the water tourism. The tourist information base of sailing ports on inland waterways should be updated every year. In addition to the basic information about the marinas, aerial photographs of the port and its surrounding are now in demand. A small four-rotor Unmanned Aerial Vehicle (UAV) can be an ideal tool for such an inventory. Unlike airplanes or fixed-wings, small and cheap unmanned aircrafts do not require much open space to start an air mission. A properly configured Unmanned Aerial System (UAS) can bring camera equipment to the location where the pictures are to be taken. The drone can hover over an object allowing the operator to take the right shots. After the mission, a UAV can automatically return and make a safe landing. Photos taken with the drone provide potential users (sailors or fishermen) with basic information about the object's location: size, number of mooring spaces for boats, the difficulty of manoeuvring in the ports, as well as attractiveness of the adjacent area. The article presents an example of the application of DJI Phantom 4 Pro to the inventory of sailing ports on the route of the Great Masurian Lakes in Poland.

1. Introduction

Geoinformation for GIS (Geographic Information System) can be taken from digitized historical maps or plans or directly measured using instruments such as geodetic total station, GNSS (Global Navigation Satellite System) receivers, UAV (Unmanned Aerial Vehicle) with various sensors, satellite and aerial photos as well as terrestrial and airborne LiDAR (Light Detection and Ranging). Recent advances in surveying technology allow constructing a novel, automated measuring platform using modern sensors and processing algorithms [1]. Traditional geodetic survey techniques (total station and Real Time Kinematic RTK/GNSS surveys) are being frequently replaced with high resolution laser sensors and semi-automatic platforms: ALS (Aerial Light Detection and Ranging Systems), TLS (Terrestrial Light Detection and Ranging Systems), MLS (Mobile Light Detection and Ranging Systems) or PLS (Personal Laser Scanning [2].

Today one of the most popular measuring platforms, which is increasingly employed in many applications is UAV. Unmanned aerial system (UAS) can be cheap and easy to use advanced technology for gathering remote sensing data with high resolution [3]. Unmanned aerial vehicles, known as drones, offer significant advantages in geodata collection and are a low-cost alternative to the classical manned aerial photogrammetry or complementary solution to terrestrial acquisition [4].
Since the UAV technology is relatively new, we definitely haven’t discovered all its potential applications. UAVs increase the speed and reduce the costs of remote data collection. Using even a relatively small and cheap quadcopter, for example DJI Phantom, we can provide several minutes of effective working time/flight at working altitude up to 150 m above ground. This enables us to measure small engineering objects in limited terrain. The low cost UAV equipped with remote sensors or camera allows frequent flights at low altitudes in almost any area [5, 6].

The list of UAVs’ applications is now becoming longer. The drones can be used quickly without the need to have an extensive take-off and landing area. Flights can be performed at low altitude, which increases the resolution of photo and film material quality. They can be used in places that are difficult to access and dangerous for people. They are a good alternative to classic photogrammetric flights performed on small airplanes. Flights at low heights are supported by GNSS and INS systems, ensuring stability and flight safety. They also enable planning and implementation of autonomous missions. Nowadays, UAVs have applications in various fields of science: geodesy and spatial planning, inventory of inaccessible areas and objects, research and analysis of environmental quality, control of illegal dumps, monitoring in the mining industry, identification of construction arbitrariness, agriculture and many others.

The main products from the drones are ortho-photo mosaics presenting the image of the Earth's surface. All photos taken as part of the planned autonomous mission are combined and matched using specialized software. To increase the accuracy of the received mosaics, GCS (Ground Control Points) are used. Usually, they are marked in the area with special markers and their coordinates are determined by GNSS techniques with the accuracy of 1 cm. During drone missions, we obtain photos and films. Pictures can be vertical, tilted or oblique. Photographs are made in the visible spectrum using digital cameras integrated with the drone using a stabilizer (gimbal). In special cases, multispectral cameras can be used. They enable obtaining multi-channel images. By using drones in agriculture, we can obtain photos that can be used to assess the condition of crops, monitor diseases and pests.

The article presents an example of the application of DJI Phantom 4 Pro for the inventory of sailing ports on the route of the Great Masurian Lakes in Poland.

2. Methodology

Reliable knowledge of marinas is crucial for water tourism. The tourist information base of sailing ports on inland waterways should be updated every year. In addition to basic information about the marinas, aerial photographs of the port and its surrounding are now in demand. A small four-rotor UAV can be an ideal tool for such an inventory. Unlike airplanes or fixed-wings, small and cheap unmanned aircrafts do not require much open space to start an air mission. A properly configured UAS can bring camera equipment to the location where the pictures are to be taken. The drone can hover over an object allowing the operator to take the right shots. After the mission, a UAV can automatically return and make a safe landing. Photos taken with the drone provide potential users (sailors or fishermen) with basic information about the object's location: size, number of mooring spaces for boats, the difficulty of manoeuvring in the ports, as well as attractiveness of the adjacent area.

The presented work was implemented on the water route between Węgorzowo and Mikołajki (in the northern-eastern part of Poland). The article presents the results of 9 selected ports from 80 that have been inventoried. The locations of the ports are shown in Figure 1.
3. Experiments
DJI Phantom 4 PRO UAS (Figure 2) was used to take pictures during the inventory. The system consists of: Unmanned Aerial Vehicle (UAV), a 20MP camera, a radio control system (RC). The on-board camera uses 1-inch 20-megapixel CMOS sensor. Basic technical specification of the four-rotor UAV system is presented in Table 1.

Table 1. Basic technical specifications of used UAS

| Characteristics          | DJI P4 Pro UAS                  |
|--------------------------|---------------------------------|
| UAV type:                | Quadcopter                      |
| Control range:           | 7 km                            |
| Weight:                  | 1.288 kg                        |
| Positioning:             | GPS/GLONASS                     |
| Operating frequency:     | Article I. 2.4 GHz & 5.8 GHz    |
| Safety:                  | 5-direction obstacles sensing   |
| Camera:                  | 20MP, 4K/60fps video            |
| Camera stabilization:    | 3-Axis gimbal                   |
| Max. flight time:        | 30 min                          |
| Max flight speed:        | 70 km/h                         |
| Battery:                 | LiPo 3S 5870mAh                 |

The drone was operated manually. About 20 photos were taken on each object at different heights (10-100 m above water level). The UAV was manually launched from an open area near each port every time. Because of numerous high trees, hilly terrain and many other obstructions operating the UAV was neither easy nor comfortable. All photos were taken in good sunny weather. The only inconvenience was the strong wind.
Figure 2. DJI Phantom 4 PRO UAV before the mission

During the practical part of the experiment, photos of 80 ports on the route of the Great Mazurian Lakes were taken. Below are two photos for each of the nine selected ports (Figures 3-11).

Figure 3. Pictures of the first port
Figure 4. Pictures of the second port

Figure 5. Pictures of the third port

Figure 6. Pictures of the fourth port
Figure 7. Pictures of the fifth port

Figure 8. Pictures of the sixth port

Figure 9. Pictures of the seventh port
4. Results
After the mission of individual ports, all photos were analysed. The following port parameters have been developed on the basis of the photographs: location, number of parking spaces for boats, the difficulty of manoeuvring in the ports, as well as attractiveness of the adjacent area. Test results are presented in Table 2.

| Port | Location | Mooring spaces number | Petrol station yes-no | Difficulty of manoeuvring Min 1 Max 5 | Distance to the water route km | Attractiveness Min 1 Max 5 |
|------|----------|-----------------------|-----------------------|----------------------------------------|-------------------------------|--------------------------|
| 1    | 53.9635 21.8390 | 50 | no | 1 | 4.5 | 1 |
| 2    | 54.0111 21.7402 | 150 | no | 2 | 1.2 | 5 |
| 3    | 54.0326 21.7238 | 100 | no | 2 | 0.6 | 2 |
| 4    | 54.0312 21.7293 | 20 | no | 4 | 0.1 | 1 |
| 5    | 54.0281 21.7297 | 200 | no | 2 | 0.1 | 3 |
| 6    | 54.0313 21.7627 | 60 | yes | 2 | 0.1 | 5 |
| 7    | 54.0314 21.7586 | 100 | no | 3 | 0.3 | 3 |
| 8    | 54.0427 21.7413 | 45 | no | 2 | 0.1 | 4 |
| 9    | 53.9720 21.7582 | 50 | no | 2 | 0.4 | 1 |
5. Conclusions
The main goal of the experiment that was carried out on the Great Mazurian Lakes was the application of the DJI Phantom 4 Pro to the inventory of sailing ports. The presented work was implemented on the water route near Gżycko (in the northern-eastern part of Poland). The article presents the results of nine selected ports from 80 that have been inventoried. Photos taken with the drone provide potential users (sailors or fishermen) with basic information about the object's location: size, number of mooring spaces for boats, the difficulty of manoeuvring in the ports, as well as the information about petrol station. Additionally, the attractiveness of the adjacent area was analysed. A small four-rotor UAS can be an ideal tool for such an inventory. A properly operated UAV can bring camera equipment to the location where the pictures are to be taken. The drone can hover over an object allowing the operator to take the right shots. However, an operator should take the flight safety into consideration. Because of numerous high trees, hilly terrain, the possibility of strong wind and many other obstructions around lakes operating the UAV is neither easy nor comfortable. Final conclusions show that even low cost quadcopter can be an excellent tool for ports inventory on the water routes to provide valuable information for sailors.

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