Building a UAV from Scratch

DŠGS asked themselves how to build a UAV and they built one: the FlyEye, it exceeded all goals and expectations.

The DŠGS FlyEye is an unmanned aerial vehicle (UAV) built from scratch as a data-capturing tool and learning exercise by members of the Slovenian Students of Geodesy Association (DŠGS) at the University of Ljubljana. Having started as just an idea over a year ago, today the FlyEye has exceeded all goals and expectations. The process of learning to build and operate a UAV, and collecting and processing the data, has opened the authors' eyes to new possibilities in the world of UAVs and 3D representations. Hopefully, it will continue to inspire future generations of geodesy students.

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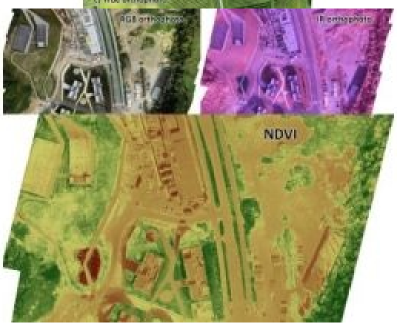

The rise of UAVs in recent years has increased their use in the field of geodesy. Since the University of Ljubljana’s Faculty of Civil and Geodetic Engineering did not own its own UAV for spatial data acquisition purposes, as students from DŠGS we decided to build one for the benefit of the geodetic educational community in Slovenia. Building a UAV was both a challenge and an opportunity for us to prove our ingenuity and expertise in a fun and engaging way. With help from our Faculty and private donors, to whom we are very grateful, we collected the necessary funds to purchase tools, components, a camera and other supplies needed for building a UAV.

Research

Since this was our first attempt at building a UAV, we initially spent a lot of time on internet research for component combinations that would most suit our technical requirements and financial capabilities. We decided to build a quadcopter as it is the most common and easy-to-build multi-rotor UAV that can be used in more instances than other UAV types, such as plane, fixed-wing or balloon. The advanced autopilot system Pixhawk with corresponding u-blox GPS+compass module, telemetry radios, open-source firmware (ArduCopter) and software (Mission Planner) for PC or tablet was selected for our project due to its completeness and simplicity (from calibrating and adjusting a UAV to planning and executing a flight). We powered our UAV using an aluminium and glass-fibre quadcopter frame with a diagonal length of 666mm in combination with 490kv brushless motors, 12-inch plastic propellers and a 4-cell lithium polymer battery with 5,000mAh capacity. The digital compact camera Canon IXUS 132 running on open-source CHDK (Canon Hack Development Kit) software was the least expensive option for us to collect aerial imagery of sufficient quality.

As the components began to arrive, we started piecing them together and soon the DŠGS FlyEye was born and flew in the sky for the first time. To tailor the UAV for data capture we had to make a few modifications on the camera mount to stabilise it and remove vibration effects from acquired photos. The DŠGS FlyEye (Figure 1) has been fully operational since April 2014, five months after the start of the project.

Operating the UAV

In addition to building the UAV, we also had to learn how to operate it. Piloting skills were first practised using a small quadcopter toy called Hubsan. This turned out to be quite difficult because none of us had previously operated radio-controlled (RC) aerial vehicles; just like when learning to drive a car, we had to get used to the RC transmitter controls and quadcopter responses.

Next we had to learn how to adjust and calibrate the UAV for flying, and plan an autonomous flight with Mission Planner. Fortunately, Mission Planner is very user friendly, particularly in terms of planning an autonomous flight path for surveying an area of interest (Figure 2). Depending on the required parameters (spatial resolution, overlap, sidelap) and characteristics of the area (size, diversity of terrain), the height and flight speed were set and automatic data capturing positions were programmed.

For our first planned flight, we had to set several ground control points (GCP) in order to produce georeferenced data. These were clearly visible targets in the area of interest that were positioned with a GNSS receiver (total station). The battery of the DŠGS FlyEye allowed us to fly it for a maximum of 15 minutes. Therefore, we prepared a flight path over the area of interest for about 10 minutes, giving enough time to safely take off, execute autonomous flight and land. During flight, the UAV had to be continuously watched to ensure that the autonomous flight was proceeding as planned.

The acquired photos and GCP positions were then post-processed for a variety of final products. Our options were to collect a point cloud, digital surface or terrain model (DSM/DTM) and orthophoto or true orthophoto. For post-processing we used Agisoft Photoscan, but we also had an opportunity to try some others (3Dsurvey, Pix4Dmapper, DroneMapper). All have their pros and cons, but the final results are of high quality in most cases. Other software solutions that we found useful for working with post-processing or presentation were ArcGIS, Global Mapper, FugroViewer, Geomagic, Sketchfab and ExtraZoom.

Results

Since the DŠGS FlyEye has been operational, we have managed to finish quite a few test projects and gained diversified results. For example we produced a point cloud, DSM and true orthophoto of a vineyard in Slovenian Styria obtained from aerial imagery captured by the DŠGS FlyEye (Figure 3). Other examples can be viewed on our website (www.dsgsflyeye.com).

Besides capturing images in nadir direction, UAVs also allow data capture at different angles. This motivated a project in which aerial photos of our Faculty building on Hajdrihova Street in Ljubljana were captured with the DŠGS FlyEye camera in nadir direction and from an angle of about 45 degrees. Some photos were also taken from the ground. The result of the data processed with Agisoft Photoscan was a 3D model reconstruction of a building (Figure 4).

We also tested using a digital camera Canon A490 modified to sense infrared (IR) light. The default RGB filter that blocks IR light was replaced with a filter that allows it to pass through. Out of the imagery gained with the normal camera and imagery gained with the IR-modified camera, we created two orthophotos (RGB and IR) of newly constructed housing estates and a material depot in Ljubljana. With the red and IR band orthophotos, we were able to calculate the normalised difference vegetation index (NDVI) in ArcMap (Figure 5).

Future plans

With our time as master’s students soon coming to an end, it is necessary to start considering the future of the DŠGS FlyEye. Our plan is to recruit young enthusiasts such as ourselves and hand over the DŠGS FlyEye to them. Hopefully it will be upgraded and successfully used by future DŠGS generations for many years to come. The DŠGS FlyEye already represents an important development in our careers; it has completely changed our perspective on the world and has considerably expanded the horizons of our expertise. We are eager to learn and work with the DŠGS FlyEye while we still can – and with passion and hard work, we believe there will still be a place for us in this beautiful world of UAVs and 3D representations.

Authors

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