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PUTTING THE DRONES TO WORK: LANDSCAPE SURVEY AND ANALYSIS WITH REMOTELY-CONTROLLED QUADCOPTERS

Robert Moore

In the first issue of *Landscape Issues* I wrote a short article on using a remotely-controlled model aircraft to take aerial photographs of sites for landscape architecture projects. Commercial colour photographs at that time were prohibitively expensive. Three decades later, Google Earth provides us with comprehensive digital image coverage of the globe, and it seems that obtaining baseline site data no longer presents the problems it was formerly.

Yet it is probably true to say that Google Earth (and all the other online map sources) are not the panacea often celebrated. Image resolution is not everywhere of high quality and image capture can be as much as ten years old, despite the declared aim of updating between one and three years (Google, 2015). Ironically, though, historic imagery is becoming a common feature of many Google scenes, thus enabling useful temporal comparison.

So what is the latest device that people are turning to to improve the situation? Checking through the literature, I have found that researchers have for a few years been investigating the use of remotely-controlled camera-equipped drones in a wide variety of applications; and if recent anecdotal evidence is to be believed, hobby-level drones have been topping last Christmas's gift lists (Stevenson, 2014). So with an 'entry-level' quadcopter in hand, I decided to test the potential of these model aircraft specifically for landscape architecture site survey, a particular area of the subject I have a keen interest in.

This short article reports on my findings and reviews some of the literature and web sites which discuss the technology in detail. I also visited a local model-flying club to evaluate practically more sophisticated quad- and hexacopters as they were put through their paces. I conclude the discussion with some pointers on their advantages and disadvantages, identifying the opportunities, reviewing the legal implications and making some recommendations.

The Hubsan x4 quadcopter (Fig. 1) is quite small, only measuring 16 by 16cm including the rotor shielding. Once charged up and with the video camera switched on, I made a couple of abortive attempts to achieve lift-off, but soon learnt the controls and managed to take the copter up to 50m above Pittville Park in Cheltenham. The December day was fine, with little wind, so hovering was not a problem. Battery-life is not long so it soon returned to earth with a bump. Surprisingly robust, it suffered no damage. My only worry was a springer spaniel that ran over to its landing site but thankfully it did not attack it! Uploading the video to my PC revealed a very acceptable film, from which Figs 2-4 are individual screen shots. As can be noted in the original source file, there is some bleeding of colours and parts of the images are blurred – vibration being the main cause – but I was sufficiently impressed with the results to investigate the technology further.

Drones, UAVs and quadcopters

According to Wikipedia, drones are unmanned aerial vehicles (UAVs) which can be remotely controlled and they can take the form of a traditional fixed-wing or a rotary-wing aircraft (that is, helicopter or multicopter:

Fig. 1 Hubson x4 quadcopter

Fig. 2 Pittville Park, Cheltenham (stills taken from the Hubson video)

Fig. 3 Pittville Park, Cheltenham

Fig. 4 Pittville Park, Cheltenham

with four rotors = quadcopter, six = hexacopter). Originally developed by the military and currently used by them in various operations (mainly surveillance and in theatres of war), their potential civilian use has now been realised, first as a enthusiast's 'toy' allowing amateur aeronautical experimentation at an affordable price, then as a practical means of obtaining 'difficult' film footage. For example, the aerial cinematography industry uses remotely-piloted copters to serve as camera platforms (Anderson, 2012). Non-military security work is possible such as inspecting power or pipelines in difficult terrain. Here also, forestry agencies use them to map tree health (with infra-red sensors) and forest fire incidences (Paneque-Galvez, et al, 2014).

Some farmers now use drones to monitor their crops, produce maps and compute optimal irrigation and fertiliser application (Walthall, 2011; Huang, 2013). And there is a plethora of scientific uses for drones, from studying algal blooms in lakes and oceans to measuring solar reflectivity of the Amazon basin. In conservation, habitats can be filmed and analysed: vegetation can be classified and endangered animal tracks and nests identified (BBC, 2014). In the immediate aftermath of Typhoon Haiyan in the Philippines, the damaged areas were mapped at high resolution by remotely-controlled drones (YouTube, 2013).

Coincidentally with these practices, improvements in the actual technology are advancing at an exponential rate: performance regularly doubles while size and price decrease (Anderson, op cit) which effectively puts drones and associated hardware and software in reach of a range of users from hobbyists to scientists even to landscape architects.

Specification

As stated earlier, the choice of UAV is between fixed-wing and multi-rotor craft. While there are clear benefits from using the former (longer flying times), for the specific use of obtaining site photographs for landscape architectural projects experienced pilots would recommend the greater control and hovering capabilities of the rotor types (Van Geme, 2014).

In terms of basic equipment, a quadcopter with a good gimbal capable of holding something like an 'action' GoPro camera will provide acceptable resolution photographs and videos. You then need to decide whether you want FPV (First Person View) capability which is simply video piloting, seeing what you are filming on a ground monitor. Given that the vehicle is unlikely to go out of view, the experienced pilot can generally obtain adequate photography by careful use of the controls. FPV can mean the addition of another on-board camera which increases the payload such that it might be better to consider a larger hexacopter (fig 5) but unfortunately with an understandable increase in price (Perry, D, 2015).

Many ready-to-fly UAVs are available to buy online or in local model shops, but some also come in kits which are relatively straight-forward to build. For these models described above, you are looking at prices in the range of £500-£1000. The kits can also come with a geographical positioning system (GPS) and a flight-controller (often with greater functionality for aerial photography) so with these and standard extras (laptop for setting up, 8-channel transmitter to relay messages to the copter, batteries and chargers etc) the price inevitably increases. But is it worth the investment?

Benefits

Since the UAVs are flown within sight of the pilot (see legal requirements below), the low-altitude view of an area of interest results in much higher resolution pictures. More exact analysis is possible: plant species can be identified, micro-relief is more pronounced (better with long shadows) and 3D visualisation of the whole site from selected viewpoints can be

Fig. 5 Quadcopter (right) and hexacopter at Gloucester Model Flying Club field

specified. Compared with satellite images and manned aircraft aerial photography, this acquisition of site data is substantially cheaper. Thanks to their automatic geo-referencing, vertical photographs can be mosaicked and draped over Google Earth images or imported into geographical information systems (GISs) and accurately-scaled maps produced.

For more complex output, drone cameras can be modified to take multi-spectral images, capturing data in the (near) infrared as well as the visible spectrum, which together with image processing software provide a means of classification of species types and the state of plant health (a consequence of disease, pollution, insufficient water) (Knoth, 2013), obviating the need to invest in commercial providers such as IKONOS and QuickBird satellite data. Elevation data in the form of point clouds can be captured then resolved into 3D models compatible with a range of computer software (Lucieer, 2014).

Drawbacks

As indicated with the small quadcopter I evaluated at the start of this article, picture quality depends largely on the type of camera and the degree of vibration it is subjected to. The GoPro action cameras are the ones most recommended in the literature for this application and the preferred

Fig. 6 Gloucester Model Flying Club flying field (© D. Perry)

UAVs are those with flight control systems using levelling gyroscopes or gimbals for hovering capability with reduced blurring, underlining the truism that you get what you pay for (thebestquadcopterreviews, 2015).

Performance in terms of flight duration is determined by battery size and the better the battery, the heavier it is and the bigger the copter needs to be to cope with the increased payload. For those in the lower price range (up to £1000) flying time is measured in minutes (eg 5-10) which clearly restricts the distance that can be covered (Perry, 2015). On-site replacement or recharging of the battery is possible of course so with careful planning survey operations can be successful.

Weather conditions, however, are a serious restriction with copters more than with fixed-wing UAVs. Wind speeds need to be low (less than 5mps), gusting also is problematical, rain should be avoided (damage to electronics) and fog is an obvious impediment. Basic knowledge of meteorology is essential, according to Peter Sachs (2015). Experienced UAV operators have assured me that a short training period is sufficient for newcomers to become competent pilots, but there is a danger that "inexperienced and unqualified operators could accidentally damage vital infrastructure" such as power transmission lines (Independent, 2015).

Noise generation is another drawback. While our environment is a rich composite of sounds, some pleasant, some unwanted, we should be very mindful of adding another high-pitch noise to the soundscape. The whirring drones have been likened to "God-forsaken things appearing in the sky like demented insects" (BBC, 2014) and can upset humans and animals alike.

Legal requirements

In the UK the Civil Aviation Authority (CAA) states that drones can be flown without a pilot's licence so long as they weigh less than 7kg, stay below 122m and within visual line of sight, and are flown away from populated areas and airports. It is perfectly acceptable to fly close to buildings, vehicles and people so long as permission has been obtained from the owner of the take-off point and those directly affected have been briefed about the use of the UAV. It would be irresponsible to fly over or near members of public who are not aware of the purpose of the flight.

Pilots must be able to take manual control when necessary to keep the UAV within 500m. Good visibility is essential and they should not be flown at night. Drones must not be operated over or within 150m of a congested area or organised open-air assembly of more than 1000 people. "In short, unless you're in the countryside, a big park or a massive garden (not royal), you're potentially flying into trouble" (Stevenson, 2014).

Insurance and ethical issues

Currently there are two categories of insurance to cover the use of UAVs: Sport & Recreation and Aerial work. The grey area in the middle into which non-commercial, scientific (academic) research falls may be covered in a new category being proposed: Data Development and Demonstration. The British Model Flying Association is offering insurance to cover this area. There is the safety issue: safety of the general public and damage to property. There is the privacy issue and there are broad ethical considerations including noise pollution and psychological distress.

Currently there is no international guidance as each country seems to be developing its own legal framework: the USA and South Africa are applying quite severe restrictions on drone use. The British guidelines (BMFA, 2015) are fairly comprehensive and demand a common sense interpretation. "The misuse of drone technology for surveillance without acceptable transparency and communally-agreed rules of engagement could provoke severe conflicts...of privacy violations and spying" (Paneque-Galvez, 2014). In summary, there is clearly a need for the UAV industry to develop protocols, guidelines and standards (Huang, 2013). The recently-published House of Lords report on the Civilian Use of Drones in the EU (2015) argues for the Commission to take a leading role in developing safety rules proportionate to the risks presented by the various types of UAV (they prefer to use RPAS, Remotely Piloted Aerial System). They go further and recommend the creation of an online database where UAV users would post information on the purpose, location and duration of their flights in order to advise all parties who may be affected. Baroness O'Carthain, chair of the Lords' Committee, is anxious that any rules do not stifle the new industry, to ensure Britain maintains a 'leading edge' in future applications (BBC, 2015).

Recommendations for use in landscape survey

The potential use of UAVs across a wide range of environmental disciplines is well acknowledged. Present research is investigating both refinement of data capture involving GPS and advanced sensors and the development of more efficient airframes allowing bigger payloads and greater flight endurance. For landscape architects, desirous of up-to-date imagery, what is currently available – the relatively simple use of drones described above – can offer acceptable photographic coverage of a site from different heights: low-level verticals for detailed vegetation mapping or higher-level total-site oblique visualisations (see Figs 7 and 8). So for basic site survey and analysis of the kind recommended for most student projects, it would seem that it is a technology worth investing in. At the time of writing, the landscape department in Cheltenham does not own a UAV but as shown in these last illustrations, winter-time is not the ideal season for vegetation identification. However we do intend to explore the possibilities in future projects and the results will be discussed in a future issue of this journal.

Fig. 7 Ground cover from low height (© D. Perry)

Fig. 8 High-level oblique (© D. Perry)

Biographical notes

Robert Moore teaches on the landscape architecture course in the University of Gloucestershire. His teaching responsibilities fall into two main areas: cartography, surveying and geographical information science on the one hand, and soil science, applied climatology and hydrology on the other. He has long researched the role of GIS and GPS technology in the education of landscape architecture students and is currently investigating the potential of intelligent data capture using quadcopters.

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