The use of unmanned aerial vehicles (UAV) as a geospatial tool

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Abstract

With unmanned aerial vehicles (UAV) becoming increasing more prominent within South African industries, the correct use of these unmanned aerial vehicle systems not merely from an operations point of view but rather from a geospatial data point of view becomes vital to the success of the unmanned aerial vehicle industry.

This paper explores the use of unmanned aerial vehicle data – not as a stand-alone data source but rather coupled with existing data sources to provide data enriched products. One must not look at unmanned aerial vehicles as the beginning and end of all data, but more towards it being a tool one can use in order to achieve a certain goal.

Keywords

RPAS, UAV, UAS, drone, GIS, geospatial, tool, analytics, aerial, survey, environmental, agriculture, mining, precision, infrastructure, GI 2015.

Introduction

Geographic information systems (GIS) is a series of tools that has the ability to understand spatial awareness through the representation of spatial data. Spatial data is data with a known coordinate – these coordinates represents spatial data as this data can be represented somewhere in the 3D spatial environment. GIS works within this realm and lets you visualise, question, analyse and interpret data to understand relationships, patterns and trends.

Unmanned aerial vehicles offer geographic information systems further information that can be used to for decision support. Unmanned aerial vehicles are simply another geospatial tool within the geographic information systems toolbox, and each tool serves a certain function to achieve a certain goal. Unmanned aerial vehicles simply add to the ever expanding geographic information systems toolbox. The amount of data collection derived from unmanned aerial vehicles is proving to be a game changer with respect to speed of data delivery, cost of data capture and the products that can be created or derived from the captured data. Data, possibly for the first time, is now accessible to the industry at a more frequent and cost effective manner than ever before, but the age old question remains, what does one do with the data after capture and where can this data be used best to answer a question within the organisation or company.

The answer is geographic information systems.

UAV products and services

Unmanned aerial vehicles can produce a range of data products and services. These data products have been divided into two sections, namely: “basic products” and “enriched products”. The basic products are the products that most stand-alone unmanned aerial vehicle software packages can produce, while the enriched products are created through a variety of geographic information systems related software packages. At this present stage of unmanned aerial vehicle development, the main source of data extraction is photogrammetry – the use of photography in surveying and mapping to ascertain measurements between objects. Light Detection And Ranging (lidar) is the newest technology to enter the unmanned aerial vehicle industry, however still some time away from being an industry standard. When one looks at data, you must take into consideration the saying of “bad data in = bad data out”, and with unmanned aerial vehicles being the newest technology available, the resultant data still needs to go through strict checking and editing processes to ensure the end user gets the best possible data.

Basic products

A set of data outputs that all unmanned aerial vehicle software packages can achieve with limit processing knowledge required:

- **Orthomosaic image**: A single image over an area of interest. The unmanned aerial vehicle captures multiple images from the on-board camera. These images are run through the unmanned aerial vehicle software, georeferenced, stitched together and a single output image of your area of interest is produced.
• **Digital surface model:** It is important to remember here, that unmanned aerial vehicle mainly uses photography and therefore can only produce a digital surface model as the images cannot penetrate through dense vegetation. “Unlike lidar point cloud”, this surface model will include all objects and vegetation above the ground.

• **Derived digital terrain model:** Through a process called interpolation, the generated digital surface model above can be generated into a digital terrain model by removing all aspects of the digital surface model that are above ground. For instance, buildings and vegetation can be removed and the ground below those objects will be interpolated from known ground points to known ground points. In the case whereby no vegetation or buildings are present in the area of interest, the generated digital surface model is indeed the digital terrain model as no interpolation between ground points need to be analysed.

• **Contour generation:** As the unmanned aerial vehicle has a typical flying height of 120 m above ground level (AGL), this flying height combined with the camera focus length of 5 mm will result in a ground resolution of 3 – 4 cm pixels. Therefore contour generation of 3 – 4 cm can be produced. This is not typically the case; the amount of contour generation will not be needed for a wide variety of cases and further analysis. Generally speaking, 50 cm contour generation is the standard for technical projects.

• **Volume calculation:** Volume calculations is one of the main focuses for unmanned aerial vehicle aerial surveys, as these calculations are typically completed on coal stockpiles. These coal stockpiles do not have any vegetation present and therefore the calculation of the digital terrain model is completely accurate. After the digital terrain model generation, further analysis into volume calculation can now be done. As the end user knows the base level of the coal stockpile, and through photogrammetry the end user knows the height of the coal stockpile, through mathematical calculations, the volumes can be calculated accurately.

### Enriched products

These are the products that require additional processing through a variety of geographic information system related software packages. As this list will be as long as one has a geographic information system need, there is no need to run through an entire geographic information system analysis phase step-by-step. Below is a list of typically-used geographic information system functions derived from unmanned aerial vehicle collected aerial data.

• **Normalised difference vegetation index (NDVI) analysis:** Vegetation health analysis and monitoring.

• **Change detection:** One of the biggest problems that GIS faces is the regularity of data collection, with the use of unmanned aerial vehicle technology, this data can be collected at regular intervals.

• **Environmental monitoring:** Precision agriculture is on the rise with unmanned aerial vehicle technology, not only in the agriculture sector but also within the environmental sector. Monitoring of plant health, wetland health and growth are just some examples of using this technology to get to places and to have an aerial view that previously could not be generated. Time and money are saved.

• **Flood analysis:** Can be conducted through the created digital elevation model which was generated from the unmanned aerial vehicle captured data sets.

• **Slope analysis:** Can be conducted through the created digital elevation model which was generated from the unmanned aerial vehicle captured data sets.

• **Route analysis:** Can be conducted through the created digital elevation model, as well as the digital surface model which was generated from the unmanned aerial vehicle captured data sets. Up-to-date imagery combined with the various terrain models of the site all aid better decision-making.

• **Thermal analysis:** Thermal cameras for unmanned aerial vehicle technology is in the market and currently being used for security monitoring as well as underground coal stockpile fires.

• **Lidar collection:** Lidar systems have been implemented in unmanned aerial vehicle technology and is rapidly expanding this new frontier.

### UAV as a geospatial tool

Unmanned aerial vehicles are fast becoming the end user’s preferred choice of aerial data capture. This is mainly driven by the geographic information system sector. Geographic information system is present in also all of the major sectors within an organisation and the drive for problem specific data is an endless battle. Unmanned aerial vehicle technology as a further geographic information system tool can assist in this crucial aspect within geographic information system.
Where does UAV fit in?

Unmanned aerial vehicles fit in among all of the other geographic information system data collection tools, some of these tools are:

- Handheld GPS
- GeoTagged photographs
- Satellite imagery
- Aerial photography
- Lidar data

The unmanned aerial vehicle, simply put, is yet another geographic information system data collector tool. Having said all of this, the questions remain: why use unmanned aerial vehicle technology, and what are the benefits to geographic information systems?

Geographic information systems have always struggled with reliable and repeatable data sources. Having access to reliable and repeatable data for the end users projects could prove to be the deciding factor that can sway a project to completion or guide the end user to the correct decision. The unmanned aerial vehicle is that specific tool that has the ability to provide the end user with that reliable, repeatable data source for their area of interest, and having up to date aerial data that is repeatable is a geographic information system professional’s dream. The advantages of unmanned aerial vehicle data are seen below:

- **High ground resolution:** The image resolution achieved by unmanned aerial vehicle surveys is exceptionally high, and visual identification of certain vegetation types and structures can be identified from the aerial imagery. This in turn limits the amount of ground truthing that needs to be done in the field.
- **3D point data:** Through photogrammetry, common points within the various aerial imagery is converted into 3D point data. These points can be used to generate a digital elevation model as well as used to model buildings and vegetation, taking your data into the realms of 3D visualisation.
- **Near real-time data:** Data on demand has always been the Achilles’ heel of geographic information system professionals; having a tool that can acquire the data on a regular basis and when required is very appealing to all in the industry. This data can be acquired in real-time on a live heads-up display, or regular schedule of data capture set up for “data-on-demand”.
- **Cost effective:** Data costs can be high if not exorbitant. With unmanned aerial vehicle technology it decreases on the data capture cost by lowering the overheads of a regular fixed wing aerial survey through the following procedures:
  - No on-board pilot
  - No fuel
  - No parking costs
  - No flight travel costs
  - Limited maintenance cost

Timely, rich, localised and problem specific data is achievable from unmanned aerial vehicles.

**Forecasting**

Geographic information system is potentially the biggest unmanned aerial vehicle market in the world due to the fact that geographic information system has a very important role in most of the major contributing industries. The figure below illustrates the geographic information system overlap.
The four main industries are engineering, mining, environmental and infrastructure. Geographic information system plays a very important role in each of these industries, and therefore unmanned aerial vehicle technology and data capture becomes a vital source of information. Based on Fig. 1, unmanned aerial vehicle data is forecast to increase as the search for reliable and repeatable data sources is solved.

**Big data**

Big data is a term used for storing and processing large amounts of data. Unmanned aerial vehicle data capture could fast become a main contributor to big data – the notion of repeatable data capture over end-users’ areas of interest will fast become a reality. This data needs to be stored and processed in a geographic information system software package.

**Data analysis**

Unmanned aerial vehicle systems will be able to provide the end user with readily available data upon request. This data needs to be enriched in order to provide answers for spatial questions. Geographic information system data analysis is the perfect key to expand on the basic products that the unmanned aerial vehicle produces.

**Geographic information systems**

Geographic information systems become the vehicle to house the captured data into a geodatabase on which the above data analysis can begin. Big data only becomes valuable if the data being stored and processed is done correctly. The various open source and propriety geographic information system software packages available have the necessary tools and capability to be the house.

Geographic information systems should not simply be seen as software packages that can provide decision support, but should be seen as the stop shop software to provide your entire organisation with solutions, integrate various sources of captured data and house all data in a centralised database for further analysis.

**Conclusion**

The geographic information systems environment is an ever changing world; new technologies and software are continually being developed or improved to provide more options for analytics and decision support. Through all of the changes and developments, one aspect remains entrenched into all geographic information systems personnel and that is access to quality data that you can trust and rely on.

The introduction of unmanned aerial vehicles as a source of data capture has taken the geographic information systems industry by storm – providing this industry with the much needed reliable, repeatable data capture that does not come at exorbitant costs. For possibly the first time, access to data has become easier than ever before to obtain. It is through unmanned aerial vehicles that the geographic information systems industry has the ability to explode further into providing decision support for their related industries.

Geographic information system relies upon access to content, and unmanned aerial vehicles are the game-changer bringing that content to geographic information systems.

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