Drones in Archeology: professional and avocational

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Abstract

Drones are quickly becoming a new and important addition to the archeologist's tool kit. They are fairly well known in the university and professional world now. This paper will acquaint those who have not had the opportunity to experience this new technology to learn in layman's terms just how it is being used. I will look at the technology of these aerial vehicles and their sensors being used within the university and professional community. I will also look at the still impressive technology available through lower costs to the avocational archeologists.

Professional use of drones in archeology

Drone use in archeology naturally began in the university environment. Not only do the universities have the funds necessary to look into a new technology, but they also have the young and entrepreneurial spirit of their student population constantly looking for ways that higher technology can make the job of the archeologist easier and produce better results.

Drone use began with the larger of the small drones in order to carry the heavier payloads of high capability cameras and other sensors. In many cases the drones were handmade. But whether handmade or commercial/off-the-shelf, the larger drones with more rotors were the first to be used. The cost of these earlier and larger drones was considered part of the university budget in expanding the data collection and processing of important archeological projects.

Figure 1. Recording ruins in Peru (credit: Reuters/Mariana Bazo)

There are four common techniques used for drone archeology. The first and most obvious is the standard camera or video and the simple technique of documenting the progress of an excavation from an aerial perspective. The second is 3D mapping of archeological sites. The third is thermal imaging, which in some cases can see objects below the surface. The fourth, which is the most expensive and complicated, is LIDAR mapping of archeological sites.

Standard photo and video recording: Drones being used in archeological projects is quite common now. They are used to record progress of excavation projects, overviews of large archeological areas and archeological surveys and reconnaissance. In many cases the photos and videos are now being used in presentations of archeological research. You can find them on educational websites, youtube.com, vimeo.com and at formal presentations and symposiums.

Figure 2. Steven F. Austin Field School (Steven F. Austin University)

3D Mapping: The next step for taking pictures was when 3D mapping became available through new software breakthroughs. The software came before the use of drone imaging, but archeologists quickly realized that drones were perfect in taking the many images on a specified flight path in order to develop 3D images of archeological sites and features. It now has become so popular that it is considered a specialized field of study under the field of computational archeology.

In order to accomplish 3D mapping you need to have a camera that can take gigabytes of digital images in automated intervals and internal GPS data of the exact location (called geotagging) of the camera that is included in the metadata of each image. The many images taken of the feature are then moved to a computer with 3D processing software. Essentially the software sews together all the images using the GPS data to build a three dimensional model of the feature that can be studied or presented to an audience from any angle. Many of the cameras with this capability are of the heavier variety, requiring a more powerful drone. However, cameras with this capability are becoming more compact.

Kreimer and Waite (2014) reported on breaking new ground using compact camera capability for 3D modeling when University of Nebraska-Lincoln Art History Professor Michael Hoff approached the Drone Journalism Lab in UNL's College of Journalism and Mass Communications about the possibility of using drones to photograph a large archeological dig site in southern Turkey. They used a DJI Phantom 2 quadcopter with a wireless telemetry system that uses an iPad Air to report location and speed, as well as provide an input interface for the intervalometer, used to instruct the camera to take pictures at defined intervals – in this case every two seconds. The captured terrain images consistently had overlap of about fifty percent. Overlap is crucial for making three-dimensional models. They used a compact Canon Powershot SX260 HS that has 12.1 megapixel capability and a built-in GPS chip that records the locations of each photograph.

Figure 3. DJI drone with Canon Powershot SX260 (Kreimer and Waite 2014)

They then used Agisoft's PhotoScan to assemble three-dimensional models of the excavations. This final step is the most complicated. Using the Photoscan program you must first align the photos by searching for and matching up common points on the images, then building a "density cloud" whereby the software calculates object spatial characteristics based on edges and contrasts in the image. From the 2,800 (16.37 GB) aerial photographs they narrowed them down through visual analysis to 249 final images to use in the program. The final step is to have the software create a polygonal mesh surface over the terrain's density cloud's points and add texture, draping the three dimensional model with lifelike surface details from the processed images. From this simplified explanation the reader can see why it is the university students are usually the first to work through these complicated problem sets and learn the software programs for the final computer processing.

Figure 4. 3D model of the Turkey archaeological site – Roman bath. Created from the 249 aerial photos captured by the drone-camera rig. Example blue squares (and captions) indicate the location (and filename) of individual photos captured during the flight. (Kreimer and Waite 2014)

Thermal Imaging: The technical term for this is aerial thermography. The process of using thermal imaging also came into its own with drones for archeology in 2014. This was most acutely represented through a recent paper in the Journal of Archeological Science by Dr. John Kantner of the University of North Florida and Dr. Jesse Casana of the University of Arkansas. They had been using drones to carry out an archaeological survey of a remote area in northwestern New Mexico while studying the culture of the ancient Puebloans. By adding a thermal imaging camera on a drone they were able to detect archaeological features buried up to a half-meter below the surface of the ground.

They used a Cinestar 8 (8 rotor drone copter) to fly a precise path established by GPS, with the camera imaging the ground. Images were then collated using advanced photogrammetric methods, producing an accurate thermal map of the area.

Firgure 5. Cinestar 8 drone copter and thermal imaging camera (J. Casana et al, Journal of Archaeological Science, May 2014)

Over the course of five aerial surveys, each about 11 minutes long, the drone used this technology to detect the footprints of a large block of rooms facing an open courtyard, as well as sections of enclosing walls, and — most notably — two large, deep, circular features, one of which fits the dimensions of a ceremonial kiva. The thermal imaging reveals the stone ruins, which retain heat longer than surrounding soils, as well as cool areas showing cavities below the surface.

Again, Agisoft's PhotoScan was used to assemble a map of the survey area so it could be compared to a previous survey of the same area by traditional optical mapping.

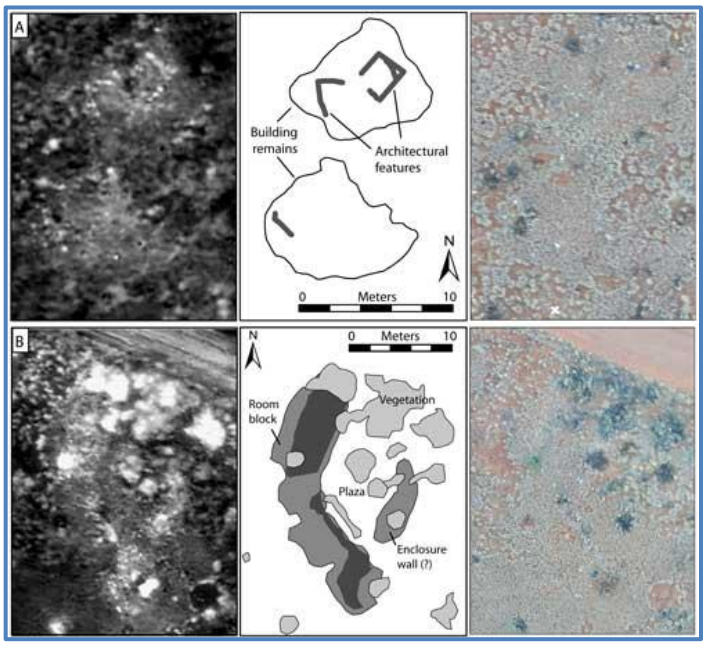

Figure 6. As detailed by the illustrations at center, the thermal images (left) reveal traces of ruins that aren't visible on the surface (right). (Kantner and Casana).

LIDAR – The future technology for drone archeology: Light Detection and Ranging is a laser-based remote sensing technology. LIDAR is not new; it has been used for decades all around the world. It is widely used for surveying and mapping natural resources and infrastructures. One of the great benefits is that it is non-invasive. However, LIDAR systems are typically heavy (40 to 200 lbs) and usually operate from a utility plane or helicopter. Due to high aircraft operation costs, this kind of sensor has not been attractive for small-area archeological surveying. But now several companies have designed miniaturized LIDAR systems that can be mounted on drones. The most well-known one at this point is Yellow Scan.

Figure 7. Yellow Scan LIDAR mounted on OnyxStar FOX-C8-HD (sUASnews.com)

LIDAR has been especially helpful in identifying lost cities in the jungles of South America. They can see through the canopy and accurately map in three dimensional format man-made structures beneath the vegetation. For example, researchers from the University of California San Diego's Qualcomm Institute coordinated with a team of archaeologists and drone experts to document the Mayan archaeological site of El Zotz in northern Guatemala. LIDAR gave Maya researchers the ability to effectively visualize the full extent of a Maya settlement and its surrounding landscape in an efficient and non-invasive manner. Even in sub-tropical environments where thick canopy obscures terrain and or archaeological features from view, LiDAR has proven to be an effective survey tool. (Paterniti 2014)

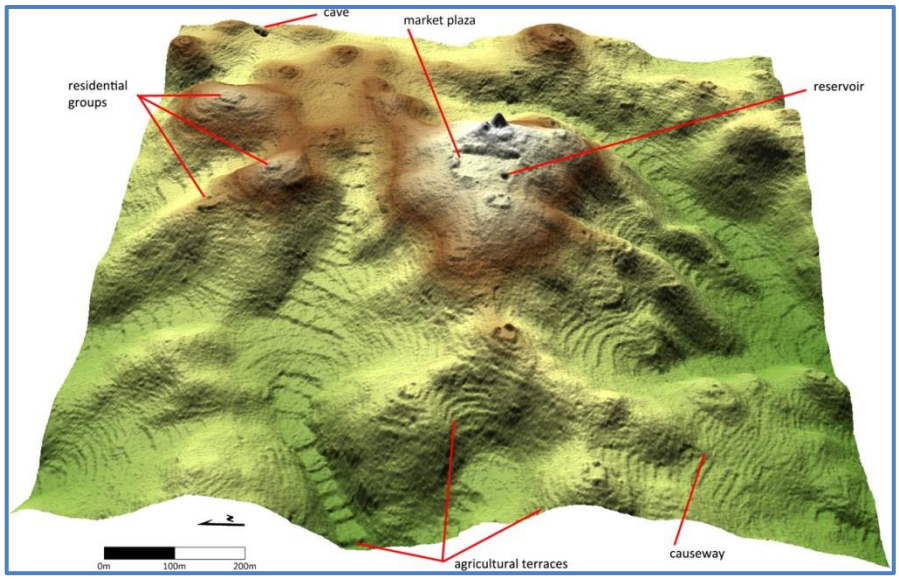

Figure 8. Example Results of LiDAR visualization model at Caracol. (Arlen F. Chase)

Avocational use of drones in archeology

Although the cost of the more sophisticated sensors and drones to carry them continue to come down, they are still somewhat out of reach for the avocational archeologist. In addition, although many of the 3D software packages are open source/free, they are extremely complicated and very time consuming to learn and process the hundreds of images from the sensors needed for proper mapping. In a professional or university environment the outcome is well worth the time and they are working with a high tech student population or professional employees to accomplish the tasks. What the avocational archeologist needs is an inexpensive, fairly intuitive out-of-the box drone to assist in the basics of the more tedious tasks of search, recording and documenting. This too became widely available in the 2014 timeframe.

DJI is the current leader in inexpensive, but well thought out drones that come with everything needed out-of-the box. They also supply free to their owners excellent applications to download and run on Android and Apple smart phones and tablets. The current inexpensive version is called the Phantom 2 Vision Plus quadcopter. It can be purchased from any number of outlets over the Internet or from brick and mortar stores. As of this writing a complete packages with extra battery, extra props, 32GB micro SDK memory card and misc. connection hardware is around $1000. In 2015 DJI also came out with the Phantom 3 which comes with geotagging capabiltity, a mile range and a flat camera lens instead of a wide angle, which the Phantom 2 Vision Plus comes with standard.

Figure 9. Phantom 2 Vision Plus and remote Control with smart phone (DJI Inc.)

Although DJI did not build its quadcopter with the archeologist in mind, their intuitive thinking that went into their applications can be used to great advantage for basic archeological projects and can be used effectively by the novice in drone/RC copter flying. It comes with GPS technology that makes flying extremely easy. For example, if you want to stop and hover you can just let go of the controls and it will hover in place on its own, waiting for the next command. It comes with a miniature, HD camera that can take 14.1 megapixel photos and 1080p high definition video. It can also be set to take pictures at specified intervals. According to some reports the newest firmware also now includes the ability for geotagging the photos, which would give it the 3D mapping capability. Reports are somewhat vague at this point, but with the popularity of this technology it will probably become an easy-to-use process in the very near future.

Figure 10. DJI Phantom Vision 2 Plus miniature camera (DJI Inc.)

With the main 'Vision' application on your phone or ipad you can control the camera functions and it also maintains all the flight display information needed to maintain situational awareness of the flight. Several safety functions will also help the novice. Two emergency functions are extremely helpful if you lose contact or sight and situational awareness of your aircraft. First it remembers exactly where it took off from. So, if you break the connection on purpose or fly it out beyond the WIFI limit it will automatically return to its original takeoff location (as long as it has enough battery life). Another function called "home lock" can be switched on in flight and by just holding back on the directional stick it will return to home no matter which way it is pointed or at what angle from home it is.

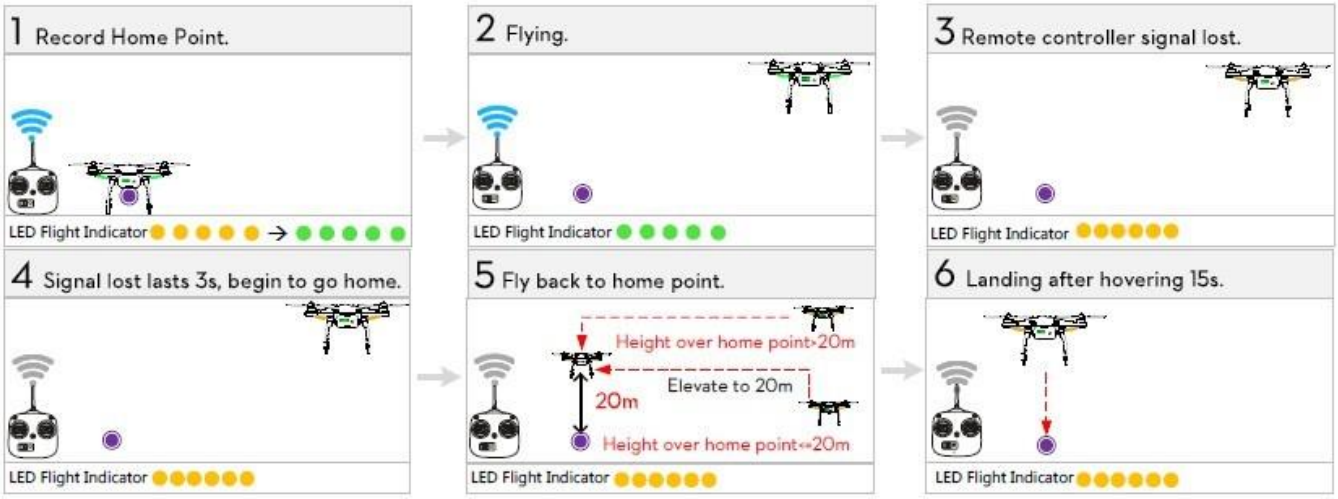

Figure 11. DJI fail safe procedures (DJI Inc.)

A second application called Ground Station is also available for programming in automated flight paths, using downloaded Google Maps and a point and click route planner right on the Google Maps screen. Once planning is complete you hit Go and the aircraft takes off, flies the planned route and returns home. If it ever gets to 30% battery life during the flight it automatically aborts the route and returns home on its own. While in flight on the pre-planned flight route you can have it video recording or taking pictures at specified intervals automatically.

Figure 12. Ground Station with Google Maps (DJI Inc.)

Figure 13. Ground Station route planning (DJI Inc.)

These kinds of tools can be of great advantage to the archeological tool kit.

1. The first, and most obvious benefit, is having video and aerial photos of a newly recorded archeological site when providing information for obtaining the trinomial identification for the site. The video and photos can be provided with the initial paperwork to be maintained in the state archeology library, in our case the Texas Archeological Research Laboratory (TARL).
2. The drone can be used to search large areas for archeological features – especially when used with other publicly available tools such as Google Earth - and reviewed on-site before initiating a foot reconnaissance.
3. The imaging can provide close-up overhead as well as very expansive overviews of archeological sites.
4. The video and photos can be used in subsequent papers and presentations.

5. Again, an important factor is its non-invasive technology. A good example of non-invasive archeological recordings, this one by someone not associated with archeology, but interested in drones and ancient petroglyphs in southern Utah, can be found on the Internet's youtube.com. The drone pilot for a small company called gotaerial.com decided to film some pictographs by drone that were unreachable under normal conditions due to their height up a sheer rock wall. He flew the quadcopter down from the top, facing back at the wall and filmed the petroglyphs for all to see.

Figure 14. Drone image of petroglyphs (gotaerial.com via youtube.com)

Conclusion

Drones are one of the best technologies to come along for archeology in a very long time. They are non-invasive and relieve the archeologist of extremely tedious manual tasks. The sensors they can carry are also much more accurate than any former methodologies of data collection and documentation, whether it is for imagery or actual depth and dimensional calculations. Some sensors can now see below the surface to determine where exactly an excavation should be performed and they can do it, in some cases, in minutes. Even at the extreme end of millions of bits of information to collect and process it may take only days compared to weeks or even months. Using drones we can now map entire archeological sites, no matter how large, and convert them into full 3D maps for further research, documenting progress or final excavation details. And in many cases it can be done in the field, without having to return to home base research facilities.

The avocational archeologists can now join their professional colleagues in assisting in high quality archeological studies with technology that could only be dreamed of even five years ago, but inexpensive enough to invest in with their own personal funds. Finding new sites can be found by aerial reconnaissance rather than "humping" randomly through the wilds of canyons, mesas and other wilderness areas. And sensitive features, such as pictographs and petroglyphs, located high up rock walls, can be recorded without risking damage to the features or risking injury to the recorders.

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