MAPPING CEMETERIES WITH BALLOON AERIAL PHOTOGRAPHY

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ABSTRACT

Many times, aerial photos via platforms like airplanes and helicopters are chosen for ground reference. Compared to satellite-borne images, such aerial photos provide spatial details that allow investigators to closely examine features and their spatial distribution. Aerial mapping companies update their aerial photo archive once in several years, even once in decades in some areas. Requiring flight lines to fit special research needs normally is time consuming and expense prohibiting. This project demonstrates the use of balloon aerial photos for mapping small features over a small geographic extent, e.g., gravestones in cemeteries. The imaging system consists of a consumer digital camera, a camera mounting rig with picavet suspension, a balloon measured at 1.5 meter diameter filled with helium (sometimes a 2.8-square meter kite), and a tether. The altitude of balloon was controlled by the tether at about 50 meter above the ground; resulting in high spatial resolution images at about 1.5 centimeter cell size. Another advantage of the balloon aerial photography is the flexibility. As long as weather permits, the temporal resolution can range from years, months, weeks, to days, hours, or even minutes. The system was tested on three cemeteries exhibiting several qualities of the Upland South Folk Cemetery complex near Chattanooga, Tennessee. Gravestones were digitalized from these aerial photos. Locations and facing directions of gravestones are compared to ground measurements using DGPS.

INTRODUCTION

Aerial photo has long been an important tool to monitor the earth surfaces. With advances in modern technologies, satellite images become an increasingly important tool to monitor the earth surface at the regional or global scale (Jensen 2007). However, under many circumstances, aerial photos still have the advantages of greater spatial details and flexible revisiting cycles. Mapping and monitoring cemeteries is such an application that requires fine spatial and temporal resolution data.

Cemeteries are important physical objects that provide insight into the creation of a regional culture (Jordan 1982). Some cultures express unique styles that could be easily observed and used to identify cultural background. The Upland South Folk Cemetery is commonly seen in southeast part of US, and expresses some unique styles, such as vegetation, grave shelter, grave decoration, ground scraping, “Decoration Day”, etc. (Jeane 1989). Some of the style could be observed spatially, such as hill-top location, unsanctified ground, orientation (east-west) of graves, and unorganized distribution of graves. Decoration Day is the day for family members to gather together and clean the graveyard, remove vegetation, and replace grave markers (Ball 1975). The practice of Decoration Day will greatly influence the temporal resolution of the imagery used for mapping and monitoring cemeteries.

Aerial photos by airplanes or helicopters usually require contracts with private mapping or survey companies and a long planning stage. Aerial photos by balloon, on the other hand, can be operated by one or two persons at an affordable cost.
THE STUDY AREA AND THE IMAGING SYSTEM

Three cemeteries were chosen as study area because of their proximity to Chattanooga, Tennessee and their strong Upland South Folk Cemetery characteristics. They are the Aetna Cemetery on Aetna Mountain in Marion County, TN (approximately 50 meter X 130 meters in ground area), the Slygo Cemetery in northern Dade County, GA (approximately 60 X 40 meters in ground area), and the Sarah Chapel Cemetery also in northern Dade County, GA (approximately 100 meters X 100 meters in ground area). Figure 1 shows their locations and in relation to Chattanooga, TN and nearby airports. FAA (Federal Aviation Authority) has regulations on any balloon or kite activities within 8 kilometers around any airport.

The imaging system consists of a consumer digital camera, a camera mounting rig with picavet suspension, a balloon measured at 1.5 meter diameter filled with helium (sometimes a 2.8-square meter airfoil kite), and a tether. A consumer digital camera, Olympus Stylus 800, was used in this study. This camera has an 8.1-mega pixel charged-couple device (CCD) sensor to capture images of 3264 X 2448 pixels. An intervalometer was customized to release the camera shutter at a pre-defined interval. The camera mount was made out of aluminum. It is suspended about 15 meters down the tether line from the balloon or the kite. A Picavet suspension was used to increase the camera mount stability during the balloon or kite flight. This imaging system could be mounted on a balloon or a kite, depending on weather conditions. For clear skies and calm conditions, the balloon is preferred. For clear skies and windy conditions, the kite is preferred. Through this study, most of the aerial photos were taken from the balloon. Figure 2 shows the balloon and the camera.

BALLOON AERIAL PHOTOS

Using a 1-Gb memory card, the camera is capable of capturing about 250 pictures. Setting the intervalometer to 15 seconds, this imaging system could last about 1 hour before taking it down to reload another memory card. During the flight, the balloon or kite was controlled at an altitude of about 30 to 50 meters above the ground. Adjusting the altitude was necessary because of ground obstacles such as trees. With 15 meter down the

Figure 1. The study areas: the Aetna Cemetery, the Slygo Cemetery, and the Sarah Chapel Cemetery.

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tether, the imaging system is about 15 to 35 meters above the ground, resulting a covered ground area of about 50 X 30 meters. With the image size of 3264 X 2448 pixels, the resultant spatial resolution is about 1.5 centimeters.

**Image Quality**

Once the imaging system is up in the air, we don’t have direct controls over the imaging parameters, such as focus and exposure. Auto exposure and auto focus functions provided by the digital camera were utilized during the flights. Still, the image quality is greatly influenced by the stability of the whole imaging system, which in turn is greatly influenced by wind the tether movements. Several hundred pictures were taken for each cemetery, but only about two dozen were selected as best images and used in this study. Three criteria were used to select pictures: areal extent of the image, verticality of the image, and image clarity.

Each selected picture has to be geo-referenced. Because of their extreme high spatial resolution, it is very difficult to find a reliable ground reference source. To our knowledge, USGS High Resolution Imagery with 30 centimeters spatial resolution is the best freely available imagery for the study area, yet has sufficient spatial details to provide ground reference for geo-reference (USGS 2004). For the Aetna Cemetery and the Slygo Cemetery, aerial photos were mosaicked together to form a big raster image, and then the big raster image was geo-referenced to USGS High Resolution Imagery. For the Sarah Chapel Cemetery, because of its relatively larger areal extent, aerial photos were geo-referenced to USGS High Resolution Imagery individually, and then mosaicked together to form a big raster image.

In addition, some headstones were chosen for verification. For these chosen headstones, their coordinates were surveyed using Trimble GeoXT DGPS (Differential Global Positioning System). In the meantime, these chosen headstones were digitalized from aerial photos. Two sets of coordinates were compared with each other.

**Aerial Photos for Cemeteries**

Seven aerial photos were used for the Aetna Cemetery site to form the mosaicked raster image, as shown in Figure 3. 16 headstones were chosen from the Aetna Cemetery. The average coordinates from all of these digitalized headstones have a less than 4 meters locational shift from the coordinates surveyed from DGPS. Three aerial photos were used for the Slygo Cemetery site to form the mosaicked raster image, as shown in Figure 4. 22 headstones were chosen. The average coordinates have a less than 2 meters locational shift from surveyed DGPS coordinates. 15 aerial photos were used for the Sarah Chapel Cemetery site to form the mosaicked raster image, as shown in Figure 5. 112 headstones were chosen. The average coordinates have a less than 2 meters locational shift from surveyed DGPS coordinates.
Figure 3. Aerial photos of the Aetna Cemetery.

Figure 4. Aerial photos of the Slygo Cemetery.
Temporal Flexibility of Balloon Aerial Photos

As long as the weather and illumination permits, the imaging system can take aerial photos of a given area with a flexible schedule and therefore offers a satisfactory re-visit capacity. Figure 6 shows aerial photos of part of the Aetna Cemetery before and after an event (cemetery cleanup). Despite of different illumination conditions and tree shadows, the appearances of ground features are clearly different. On the left hand side is the before event photo, and right hand side after the event. More features could be identified from the after event photo, and they show up much clearer.

Figure 6. Aerial photos of part of Aetna Cemetery before and after the cemetery cleanup event. Left hand side photo is before the event. Right hand side photo is after the event.
Figure 7 shows another example of this flexibility in temporal resolution. This aerial photo was taken over a city park, in which a social gathering event occurred. Note the swing set with a family around it on the middle left part of the photo. On the bottom of the city park aerial photo, there are five small consecutive photos showing the movements of the swing set. It is clearly showing the children on the swing set swinging back and forth.

CONCLUSION

The aerial photos taken from the balloon have shown a potential for detailed and small area ground coverage. Because of its extreme spatial detail, it is difficult to find a reliable ground reference source. Though the spatial accuracy of these aerial photos is acceptable, there is much room for improvement. On the other hand, the flexible launch schedule and re-revisit capacity does make this system useful for many projects that lack necessary funding yet require frequent re-visit and detailed ground coverage.

Figure 7. Aerial photos show the movements of the swing set in a city park.
REFERENCES


