The Application of UAS and Scanners in Transportation Planning

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Background

In the realignment project of San Timoteo Canyon road, surrounding land conditions, also known as topographic data, are required for the design process. The data that is pertinent to the design aspect is the positioning of objects in the environment, which in the cartesian coordinate system can be described using the x, y, and z-axis. The x and y-axis describing how spaced apart objects are and the z-axis describes how elevated the object is. The focus of this study is geared towards the z-axis rather than the x and y-axis due to the random nature of the generated point clouds. In order to gather the data for design, two methods were utilized in the capturing of points; Unmanned Aircraft System (UAS) and Terrestrial Land Scanner (TLS).

Data Collection

UAS

For the purpose of our project, we used the Inspire 2 UAS coupled with the Zenmuse X5S camera (see Figure 1). In the case of the UAS, aerial targets were placed and surveyed on the ground. For areas with penetrable ground, two plastic bags sized 2 x 2 ft were placed in a cross pattern and secured using five 60d nails and a plate (see Figure 3). Careful considerations were made so that the orientation of the targets were facing north. For areas with non-penetrable ground, stencils were made using a cardboard cutout of a cross shape and spray paint (see Figure 4). Once the targets were set up, the UAS, which was preprogrammed to follow a tractor pattern over the area, was deployed (see Figure 2).

Figure 1. Inspire 2 UAS

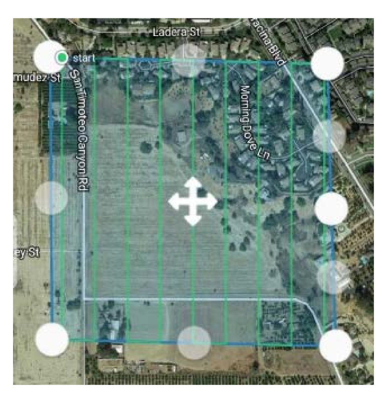

Figure 2. UAS flightpath set-up using DroneDeploy

Figure 3. Aerial target for penetrable ground

Figure 4. Aerial target for non-penetrable ground

Scanner

The TLS was mounted on a tripod and set in three different locations in the field dubbed points 50, 51, and 52. The locations of the points were obtained through the use of a GPS unit. Once the data was gathered, the three points were assigned an arbitrary or local coordinate system, which were later tied in with the coordinates of monuments in the surrounding area and the aerial target setups. A coarse scan was taken on all three points with an additional fine scan on point 52. The coarse scans took approximate 5 minutes each and the fine scan took approximate 10-15 minutes.

Figure 5. SX10 Scanner

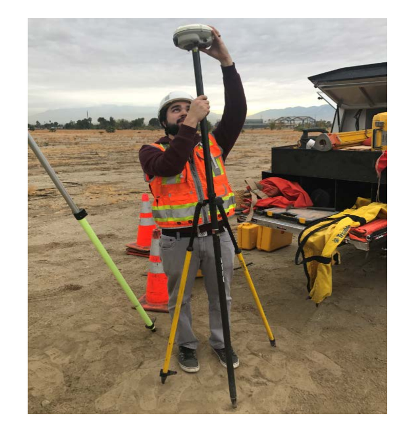

Figure 6. Setup of the GPS unit

Figure 7. USGS Surveying monument

Figure 8. Location of field points 50-52

Data Processing

Once the field data is collected, the data must be processed. The final product will be in the form of an orthomosaic (3D model created using pictures) for the UAS and point clouds for both the UAS and TLS. The raw data from the drone came in the form of 200 photos. These photos will be inputted into ContextCapture to generate the orthomosaic which will then be used in the point cloud extraction process. In the case of the scanner, the data is already in a point cloud format and only requires a few minor adjustments. Both sets of data need to be tied in to certain control points so that the coordinates are accurate relative to the correct geographic coordinate system and to each other.

Point Cloud Generation

The UAS photos were inputted into ContextCapture which generated a 3D model. 16 control points and 8 check points were used to for georeferencing purposes. The model is then imported into Bentley Descartes, which produced a scalable digital terrain model. From this model, contours, point cloud data and a triangle mesh model were extracted. Descartes ground extraction tool was used so that the point cloud only consists of ground points. The point cloud needed to be cleaned because there were residual points that created irregularities in the contour map. This was common in areas with high densities of houses and little overlap cover from the aerial photos. Once cleaned, the point cloud was exported in LAS format.

The TLS data was directly imputed into Trimble Business Center. The data had to be adjusted so that at coordinate system matched well with the record of survey. In order to do this, a minimum of three points is needed. Because all the shots were taken with a GPS receiver, the coordinate values were automatically assigned to each of their respective stations. Once assigned, the data was instantly rotated and translated to its real world position and a LAS file was generated. After that both LAS files were inputted into Cloudcompare for point cloud distance comparison.

CloudCompare Analysis

In order to analyze the difference between the UAV point cloud and the TLS point cloud, both point clouds must be similar in data point quantity and location for the results to be accurate. Because of this, it was necessary to decimate the TLS point cloud so it has around the same number of points as the UAV point cloud. Using the subsample function, Cloudcompare arbitrarily deleted points until all points remained a certain distance away from one another. In this project, a distance of 2.5 ft was chosen.

In terms of location, five adjacent plots along the roadway were chosen as the area of study. The corner of the roadway was picked because roads are generally leveled and remain continuous unlike the surrounding area. These conditions ensure that little variance will occur within the dataset. A total of five different 30 square feet plots were chosen. An arbitrary coordinate located in the center of each grid was chosen as a reference point so that the point cloud may be cropped around that area. Once each plot was made, CloudCompare compares the distance between the two sets of point clouds and computes factors such as the max and min distance between the plot datasets, the mean, and the standard deviation.

Figure 9. 3D surface model created from UAS photos using ContextCapture

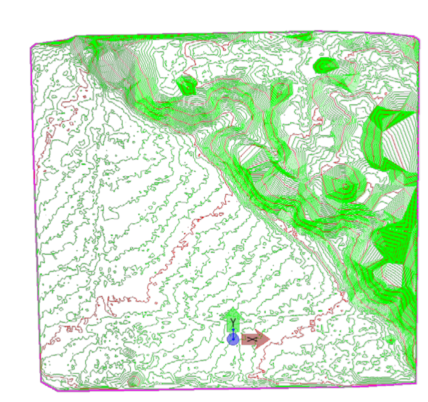

Figure 10. Elevation contour map created using Trimble Business Center

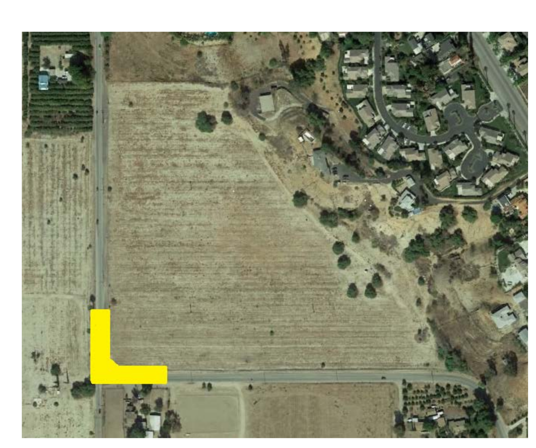

Figure 11. Area of study is highlighted in yellow

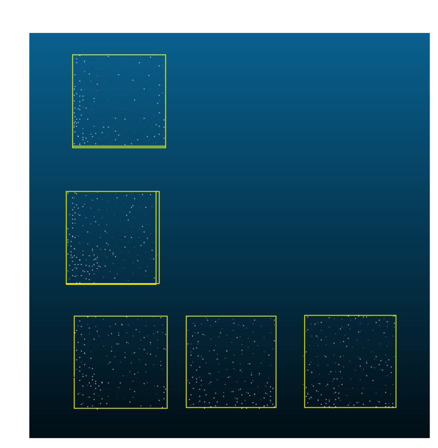

Figure 12. Five 30 sq.ft. plot grids cropped from both sets of point clouds

Plot Number	No. Points			Mean Z	STD Z	RMSE Z	Min	Max
	TLS	UAV	Total					
1	102	99	201	0.31	0.24	0.39	0.24	2.95
2	110	105	215	0.37	0.37	0.53	0.00	2.94
3	102	98	200	0.36	0.19	0.40	0.24	4.11
4	103	95	198	0.26	0.21	0.34	0.23	2.36
5	100	103	203	0.04	0.34	0.35	0.00	2.63

Table 1. Point cloud data generated using CloudCompare.

Conclusion

Looking at the data compiled from the experiment, the standard deviation between the two different point clouds in terms of the z coordinate ranges from 0.2 to 0.37. The values of the standard deviation are close to zero which indicates that in terms of height, TLS and UAS have very similar results to the mean. This is important because the mean dictates how close the points in the point clouds are to each other. A small mean indicates that the points are relatively close to each other in distance. Our mean falls within the range of 0.04 to 0.62ft which falls within industry standards when it comes to road construction. By achieving both a small standard deviation and mean, the experiment proves that in reality, surveys done with a drone and a scanner both achieve similar results. Because scanners are already used in industry and meet the status quo, then it follows that drones are a viable alternative and can also be used for transportation planning purposes.