LIDAR FOR CITY MODELS – EXPERIMENT OF LAS VEGAS STRIP

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LiDAR (Light Detection and Ranging) has its unique capability of mapping terrain features both day and night and measuring areas in the shadows of trees and buildings. We h ave conducted an experiment using LIDAR to produce a DEM and orthophotographs for a city model covering an area of the Las Vegas Strip. The benefit of using the Strip of Las Vegas is that it represents the more realistic challenges of using LiDAR in a city with tall bu ildings, many of which have significant glass windows and other reflective surfaces. This experiment was developed with three components: LiDAR data collection, ground -truth establishment, and LiDAR data processing and product evaluation.

Terrain data were co llected using an ALTM 1225 LiDAR system, over an area of Las Vegas Boulevard measuring 2 x 6 square miles. The LiDAR system has a pulse rate of 26 KHz. The scan rate of the scanning mirror is 42 Hz. With an 8-degree field of view and an altitude of 5,300 f eet above ground level (AGL), 22 flight lin es, wit h 180-m flight line spacing, were made, covering the area. A 1 -m laser (GSD) was obtained with a fixed wavelength of 1.064 micrometers. An on -board 4k x 4k digital frame camera (DFC) took photographs whil e LIDAR collected terrain data. With a 90 -mm focal length of the camera, the photo scale was 1:18,000. The image GSD was about 15 cm.

For ground truth, DEM data and ortho -images were generated on a softplotter. Digital image data used on the softplotter were made by scanning 11 aerial photographs taken by an RC -30 camera, at an altitude of 6,000 feet AGL that produced a photograph scale of 1:12,000. Twenty -one ground control poi nts, observed by Global Positioning System (GPS) technology, were used for the block adjustment. Photo graphs were scanned at a pixel size of 25 micrometers.
Through rigorous post -processing, DEM data were produced from raw L iDAR data. Orthophotos were produced by rectifying digital image data from the 4k x 4k DFC, using LiDAR DEM da ta. All processing was made within 1 km x 1 km tiles. A total of 30 tiles, full or partial, cover the experimental area. Perspective views of casinos and hotels have also been produced. Building models are produced through sequential post processing: (1) layout of 2D building footprint, (2) filtering extract building point-cloud, (3) 3D display of building point-cloud, (4) 3D perspective view (extruded point -cloud model, (5) 1st iteration solid model, and (6) final model with the processing of inserting ob lique images of the building. Rigorous editing was involved for buildings in the city.

Post-processed LiDAR points, the DEM, and orthophotos were evaluated by comparison with ground truth established by digital photogrammetric methods and GPS technology. Evaluation of LiDAR data was performed by comparing LiDAR discrete measurements with GCP and comparing DEM and orthophotos generated from LiDAR with that processed from the traditional digital phot ogrammetric methods. A precision of better than 10 cm was obtained from the LiDAR measurements. The DEM data have a 1-meter ground spacing distance (GSD), while the resolution of the orthophotographs is 15 cm. As an example, GCP #20 is covered by LiDAR flight lines 9 and 10 and has an elevation of 595.75 m (at th e top), whereas the LiDAR data produce elevations of 595.67 m and 595.61 m from lines 9 and 10, respectively, (Table 1, Column 4). The elevation differences are only 3 and 9 cm for lines 9 and 10, respectively.

Table 1. Comparison of GPS and LiDAR Measure ments for GCP #20

	X (m)	Y (m)	Z (m)	
GPS Coordinates	665206.975	4002574.421	595.70	
LiDAR Line				**Delta Z (m)**
9	665206.869	4002574.160	595.67	-0.03
10	665206.424	4002574.161	595.61	-0.09

To evaluate DEM data generated from LiDAR, 21 GCP and 61 tie points were compared with elevations from LiDAR DEM data. Evaluation results are listed below with three different methods for reading out elevations from DEM data (Table 2): Evaluation #1:Search for 1 closest point (X, Y, Z m), read out Z; Evaluation #2:Withi n 2-m X and Y, search for the closest Z; and Evaluation #3:Search for 3 closest points (X, Y, Z m), interpolate Z.

Table 2. Three methods of reading out DEM data.

Evaluation	Range (m)	Mean (m)	RMSE (m)
#1	-0.570 ~ +0.300	-0.078	0.067
#2	-0.510 ~ +0.090	-0.086	0.013
#3	-0.640 ~ +0.700	-0.115	0.064

Evaluations #1 and #3 are very close and more meaningful indicating that LiDAR has a measurement precision of about 6.5 cm. Since there are no elevation data in the ortho -image data, only X and Y coordinates are compared with GCP and tie points. The precision of X and Y coordinates is 0.231 m and 0.527 m, respectively. The precision of X and Y are dependent upon flight heights, whereas elevation precis ion is independent of flight heig hts because those elevations are derived from time.
This paper describes the procedures, presents various products, and discusses evaluation results of the experiment.