RESEARCH ON ANALYZE ACCURACY OF LIDAR DATA IN SURVEYING PROJECTS

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ABSTRACT:

There are over 10 sets of LiDAR system into China until end of 2007, but they did not in full of working. One reason is big capacity of the market need a long period time. Another is author of this article concerned that is accuracy of LiDAR data when it does surveying projects. In this article, the author make the analyze accuracy of LiDAR data base study site in Nanjing, China. All of them are from point of view productions of surveying and mapping. Last, the author make conclusion: LiDAR data acquiring is important and accuracy of LiDAR data is good, especially accuracy of DEM/DSM productions is very well.

1. INTRODUCTION

1.1 LiDAR technology developing is faster than before in China

Nowadays, LiDAR (Light Detecting And Ranging) is more and more frequent used in all kinds of fields, such as forest measurement, transportation and power transmission fields. A lot of enterprises want introduce LiDAR systems and software into China from abroad, which are close related surveying and mapping field. Until end of 2007 year, there are over 10 sets of LiDAR systems coming into China and extending surveying and mapping market. They are nearly including all kinds of type of LiDAR systems by commercial vendors: Optech, Leica, LitterMapper, Riegl, and TopoSys. The first commercial LiDAR system came into China in 2004. It is a quite big problem how to put them in full working, because big capacity of the market need a long period time.

1.2 The feature of LiDAR data

Airborne LiDAR data is including point clouds and images. Point clouds have horizontal and vertical positional information and intensity. Images are acquire if laser scanner with a digital camera. We can make DEM/DSM (Digital elevation Model or Digital Surface Model), DOM (Digital Orthoimages Mapping), DLG (Digital Line Mapping) and three-Dimensional Models (3DM) with LiDAR system. In survey and mapping field, LiDAR data have several benefits: first, it can get precise elevation of ground, trees and buildings, which can only be obtained by conventional aerial photography method before. Moreover, LiDAR method has more accurate than it. Second, points and images of LiDAR systems can be used to build three- dimensional models without current topographical map. This broke up current circle procedure of making three-dimensional models.

1.3 Accuracy of LiDAR data

In China, because the LiDAR system and main interrelated technique came from foreign country recent year, users do not really grip how much the deviations to practical value will be occurred if use LiDAR system doing projects, as well as how to control them. Morsdorf et al. [2004] and Lukas Wotruba[2005] put 4 cardboard covered tables at corner of study site to compute the planimetric offsets, height offset and height variations of the raw laser data. They make a perfect test on characters of raw laser data, but few people give a good comparison of four-D (DEM, DOM, DLG, and DM) production from two kinds of data source and methods: photogrammetry and LiDAR. This article will describe accuracy of LiDAR data from point of view production of it.

2. STUDY AREA

LiDAR data were collected over the study area in March, 2006 with an ALTM3100 Optech system mounted on a fixed wings airplane platform by Nanjing Institute of Surveying Mapping & Geotechnical Investigation, Co. Ltd. There are one small hill and several roads with many buildings standing on two of sides. The site is near downtown of Nanjing, Jiangsu province of China. Following picture (figure 1) will show the details of the study area.

Figure 1 Study area in Nanjing of China

According to the figure 1, the color picture in the middle is represent as study area, and the lines with small arrowheads are

flight lines. The spots surveyed by GPS are showed with the numbers with red color and little points. The area is about 10 square kilometers. The flight and footprints information are:

- flight height above ground: 800 meters;
- flight speed: 160 kilometers per hour;
- flight direction: from west to east and from east to west;
- the number of flight lines: 12;
- Pulse Repetition Frequency (PRF): 100KHz;
- Scan angle: 20 degree;
- The overlap of two conjoint swath: 44%;
- The mean distance of footprints: 0.51 meters;
- Distance from GPS base station to study area: 130 kilometers.

3. WHAT DID WE DO AND DISCUSSION

3.1 Accuracy of elevation of LiDAR data

We processed the LiDAR data with TerraSolid Software: TerraScan, TerraPhoto, and TerraModeler. The DEM and DSM data can be done with TerraScan and TerraModeler, and DOM need TerraScan and TerraPhoto. We also made three-dimensional models with TerraScan, TerraPhoto. Making DLG is more complicated, that need other soft and skills besides TerraSolid Software.

The precision of DEM is the most important to LiDAR system. We acquired points' XYZ with GPS in the site before the flight, then import to TerraScan soft. It can be got following result:

F:\宁南开发区LIDAR数据成果\JIANCE.txt

Number	Easting	Northing	Known Z	Laser Z	Dz
ld1	130404.695	141396.610	13.481	13.580	+0.099
ld2	130583.982	141141.073	21.471	21.560	+0.089
ld3	129479.590	140676.407	25.338	25.330	-0.008
ld4	130206.297	140877.628	26.185	26.240	+0.055
ld6	130091.842	140493.284	20.818	20.900	+0.082
ld8	130742.662	140383.073	16.641	16.620	-0.021
ld10	129907.651	140065.637	18.509	18.390	-0.119
ld12	129363.992	141286.615	32.422	32.490	+0.068
ld13	129174.019	141103.580	32.138	32.130	-0.008
ld16	128673.826	140009.613	32.409	32.560	+0.151
ld18	128668.458	141326.461	41.379	41.480	+0.101
ld19	127558.540	141322.459	27.658	27.670	+0.012
ld22	127685.330	139354.422	36.031	36.090	+0.059
ld23	127586.736	138688.504	24.400	24.410	+0.010
ld25	130870.793	139836.037	12.122	12.180	+0.058
ld26	129426.492	139102.398	23.945	23.910	-0.035
ld28	127487.616	140337.378	56.046	55.890	-0.156
ld29	127879.356	140594.842	55.038	55.140	+0.102
ld31	128237.660	139726.818	41.783	41.400	-0.383

Average dz	+0.008
Minimum dz	-0.383
Maximum dz	+0.151
Average magnitude	0.085
Root mean square	0.119
Std deviation	0.122

Figure 2 Deviations of ground footprints to GPS points

There are 19 points we have got coordinate. We found that average dz is 0.008 meter, root mean square is 0.119 meter, and standard deviation is 0.122 meter. The accuracy of elevation is every good.

3.2 Accuracy of DLG by LiDAR data

After processing point clouds of LiDAR data, we according images obtained by camera of ALTM3100 system, drew one sq. kilometer topographical map at 1:1000 scale in 4 sheets. The maps from LiDAR system were contrasted with the map at 1:500 scales from field surveying. Following figure 3 showed there are small offset between two kinds of maps, except for some edges of small road line in front of houses.

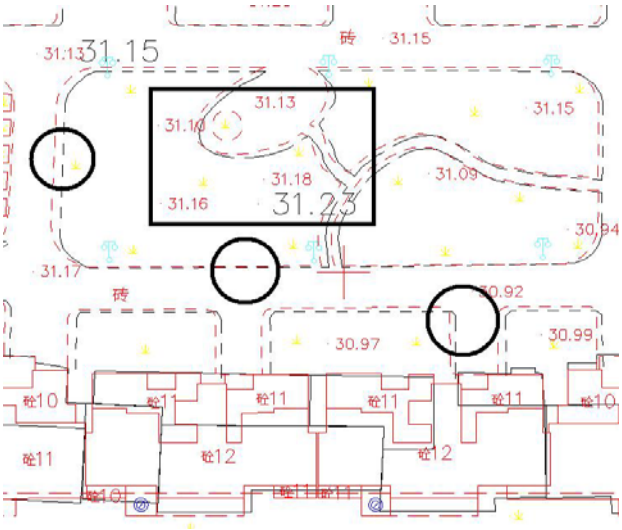

Figure 3 Differences between 1:500 and 1:1000 DLG

The elements in 1:1000 scale DLG was draw in black, which were made in TerraSolid software with LiDAR point clouds and images. In comparison, 1:500 scale was done in field survey with Total Stations drawing in red color. From black circles in figure 3 we can see 1:1000 scale map is deviate to east. But, the distance is less than 0.8 meters, and it is systemic. In black rectangle of figure 3, elevation values are almost same that proved elevation accuracy very good.

3.3 Accuracy of DOM and three-dimensional models by LiDAR

DOM can be done with the images of digital camera, such as ADS40, DMC and UCX. It also can be done with the images of camera installed along laser scanner in LiDAR system. We have done 10 sq. km DOM in Nanjing and check its accuracy with two types of methods, which are based GPS and DLG survey. The following figure shows how to add 1:500 scale DLG onto DOM.

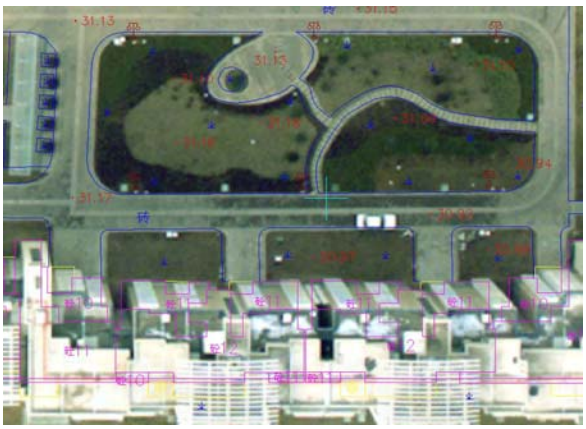

Figure 4 contrast of DLG and DOM

The figure 4 showed DLG and DOM were matched well. There is small deviation on two type of map. If we consider DLG have high accuracy, the DOM have a systemic error according showing of figure 4, which is 0.8 meter with west to east direction.

LiDAR technology is one kind of high technology integration system, which can explore objects and measure distance by the way of laser scanning. With this system we can obtain urban data surface model easily. How to build 3D models of digital city is a big issue to discuss by professional people. Working with point clouds of LiDAR data and images is good method, which only need point clouds. So, we build over 1000 buildings and some bridges with LiDAR data in Nanjing. Following figure 5 showed footprints and three-dimensional models.

Figure 5 LiDAR footprints display on three-dimensional models

We can make three-dimensional models according points and images. The cloud points can make more perfect description on proof of building than others. We also analyze accuracy of them. We found that the error of elevation is smaller than 0.5 meters and it can describe surface of top of buildings.

3.4 More research work we did

Another part of research work is field survey with GPS and Total Stations. We want to know how much deviation of LiDAR points in DEM. We selected 4 lines with 0.6KM、1.0KM、0.7KM and 1.1KM long, and they are on the asphalt of the road surface. The footprints are all on break line, so we can distinguish them between others. On the other hand, we got the coordination of these points with GPS, and then contrasted with them. We also survey 45 transects of the road with GPS, and made other contrast to find how much differences they had.

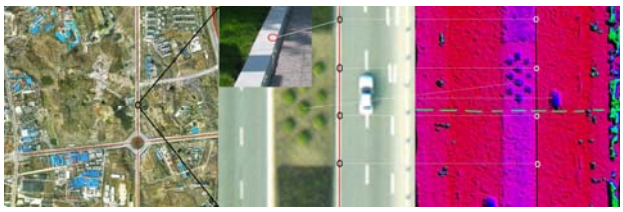

Figure 6 break lines survey in two ways

This figure 6 is divided into three parts: left, middle, and right. The left show the all concerned site and the middle is the details in black circle in the left. The right is same site as the middle but in shadowed feature of LiDAR data. They have same points that were connected by light lines and showing with small black or white circles. From our research it can be found that we can obtain break lines with LiDAR data, but it is dependent on the density of footprints. In other words, if the mean distance of two LiDAR points is bigger than one meter, acquiring ordinary break lines will be more difficult. From comparison between 45 transects of the road with GPS and obtained with LiDAR data, we conclude that there is no much different in them, and we can do transects of the road with LiDAR systems instead of field survey.

4. CONCLUSIONS

From our research work, we have got followed conclusion on accuracy of LiDAR data:

1, It is important that LiDAR data acquiring. Stabilization of flight is also important. It is the most important factor to affect accuracy of post processing.

2, Accuracy of DEM is very good, mean error is smaller than 0.15 meters in elevation value. It can be used in design projects of transportation and all kinds of survey projects.

3, Accuracy of DOM is good, mean error is smaller than 1 meter planar value. It can be used in almost survey projects and 3 dimensional model building projects.

4, Accuracy of DLG is OK, mean error of plane smaller than 1 meter. It can be used in drawing under 1:2000 scales topographic.

5, it is one of the best ways to found 3D models of digital city with data of LiDAR system.

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