APPLICATION AND ANALYSES OF AIRBORNE LIDAR TECHNOLOGY IN TOPOGRAPHIC SURVEY OF TIDAL FLAT AND COASTAL ZONE

ZhaoLijian[a, b,*], LaiZulong[a] , LiYingcheng[b] , XueYanli[b] , LiaoMing[b, *], WuZhuolei[b], LiuPei[b] , liuXiaolong[b]

[a] Faculty of Engineering, China University of Geosciences, Wuhan 430074, China;
[b] Chinese Academy of Surveying and Mapping, Beitaiping Road 16, Haidian District, Beijing, 100039 China, - jianfei1123@sina.com;

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ABSTRACT:

LIDAR(Light Detection and Ranging) is a new technology of acquiring three-dimensional (3D) coordinates with high precise and density, which gathers laser measure distance, computer, GPS(Global Positioning System) and INS(Inertial Navigation System) in the integral whole. The topographic survey in intertidal zone is the basis work of protecting, exploitation and management of the TFACZ, and also is very important in the survey engineering of our country. This paper briefly introduces LIDAR Technology; Then on the basis of the analyses of the character and demand of TFACZ(Tidal Flat And Coastal Zone), the analytic result indicates that LIDAR technology is the most effective means of solving problems of geographical data acquisition in TFACZ; discusses lots of Application of LIDAR Technology in Topographic Survey of TFACZ; Lastly check the accuracy of the LIDAR data using Trimble GPS RTK system.

1. INTRODUCTION

TFACZ is the combination of sea and land; The scientific, effective, sequential and sustaining development on fertile and vast TFACZ must bring us huge dual-benefit of society and economy. However because there are complicated environment and difficult conditions and area of tidal flat is changed in intertidal zone very much, it is so hard to use traditional terrestrial surveys and photogrammetry to acquire accurate and real-time geographic data that lots of old and inaccurate data are used in factual tasks all along. Now these datum can't satisfy coasting economy of rapid development, and can't more match systemic and integrated coasting-GIS(Geographic Information System) which has already been built.

The aerial investigation technology based on LIDAR can acquire high precision and density elevation data of terrain surface quickly and exactly; with support of high-precision GPS and INS it can build high-precision DTM (Digital Terrain Model) without lots of ground control points. LIDAR holds the advantages on tidal correction and extraction and classification of coastal information; it is the most potential and important means of investigation on coastal zone and island in future.

2. LIDAR TECHNOLOGY

LIDAR gathers laser measure distance, computer, IMU(Inertial Measurement Unit), DGPS(Differential GPS) in the integral whole. The Technology brings about great breakthrough of real-time acquisition of 3D space information and is new means of acquiring high space-time resolution geospace information. LIDAR doesn't only quickly acquire the elevation data but also brings about a series of techno-breakthrough in Remote Sensing mapping and other fields. It possesses extensive development foreground in terrain surveying and mapping, environmental monitoring, 3D urban modeling, ocean science, geoscience and planet science etc. LIDAR possesses technology characteristics of higher automatization, 、less weather influence shorter data production period and higher precision than other remote sensing technology and is the most advanced aerial remote sensing system which acquires the real-time 3D spatial information and image of terrain surface.(E.P.Baltsavias, 1999; Brian, 2004; Wolfgang, 2006)

2.1 LIDAR Positioning Principle

The procedure for a LIDAR survey is to fly an aircraft (or helicopter) over an area and to operate laser scans from side to side. The receiver picks up the laser pulses reflection value of the target and records the time it takes from emission to when it is received back at the receiver. If this time is divided by two and multiplied by the speed of light, then that is the distance from the aircraft to the ground. The inertial system keeps track of the rotations of the aircraft in the three axes (along the line of flight around the wings and crab) and the GPS keeps track of the actual location of the aircraft in space. The direct result of a LIDAR survey is actually a set of points which consist of easting northing elevation (Li-Shukai, 2000; ZHANG-Xiaohong, 2004,). Figure 1 is procedure for a LIDAR survey.

LIDAR is an equipment through location, distance, angle and other observation data to access the 3-D surface target coordinates directly, it is a technology breakthroughs after Global Positioning System (GPS) in surveying and mapping field. (LIAO- Liqiong, 2004).

Airborne LIDAR systems include(LI-Shukai,1998):

(1) Dynamic Differential GPS receiver;
(2) Inertial measurement unit (IMU);
(3) Laser scanners;
(4) Laser rangefinders;
(5) Imaging device (usually digital aerial instrument);
(6) Central Control Unit Management System.

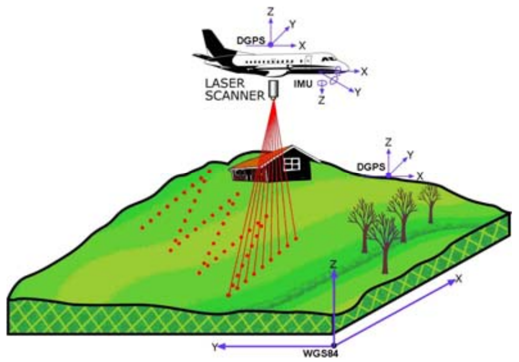

Figure 1. Airborne-LIDAR system principle

2.2 Advantage of LIDAR Technology

LIDAR technology has many obvious advantages, (LI Shu-kai, 1998). It has an active laser pulse sensor, and not influenced by the shadow angle of the sun, reduce their influence on data acquisition. Compared with photogrammetry technology, it avoids information loss (from 3D to 2D), has high elevation accuracy; Using multi-beam echo acquisition to get high density data. A significant reduction in ground control survey, air flight routes can automatically adjust, increase the level of automation, it can produce digital elevation model (DEM), digital surface model (DSM) and digital orthophoto map (DOM) of mass productions quickly.

2.3 Processing flow of LIDAR data

The original data obtained by Airborne LIDAR can be melt with all kinds of digital images after it has been processed by software, which can output all kinds of products of survey and remote sensing. The whole flow of data processing from data collection to production output can be divided into five main sections (LIU-Jingnan, 2005): Data collection, Data pretreatment, filter and classification of point cloud, fusion and application of LIDAR and other remote sensing data, ground-object extraction and modeling based on LIDAR data. Figure 2 shows detail flow of LIDAR data processing.

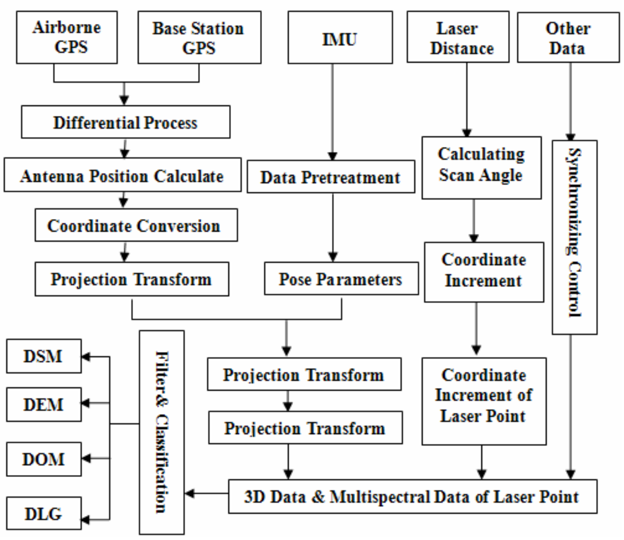

Figure 2. Flow of airborne LIDAR data processing

3. APPLICATION OF LIDAR IN TOPOGRAPHIC SURVEY OF TFACZ

LIDAR is the newest achievements of remote sensing technology; In TFACZ it is chiefly applied to the data acquisition which includes acquiring topocentric plane coordinate and elevation, differentiating the classification of Ground Objects and outputting 4D product (DEM, DOM, DRG & DLG) and so on. Compared with traditional remote sensing and aerial photogrammetry, LIDAR has it's original merit in the characteristic which suits TFACZ.

3.1 Characteristics of TFACZ

The most parts of TFACZ are Plain Coastal Zone covered with mud and widder, and are centralized with distribution; and the topography, landforms and natural vegetation of it are special, so the mapping method is different from ground surveys.

The tidal flat belongs to typical open system; it has the natural characteristic of space dynamic transfer; and it is sensitive to external interference. Therefore making clear the formation mechanism and evolvement characteristic of coastal tidal flat, developing space monitoring technology, putting fix-quantify dynamic monitoring of coastal tidal flat into effect, and mastering change law of tidal flat are the premise which application research is developed in coastal tidal flat. At the same time space characteristics of vegetative cover don't only change with tidal flat itself but also change with season and year; this requires that sensor which is used in data acquisition should be applied to dynamically monitor and be cheap.

Tidal flat is one of the uppermost landform types of silt coast and is the special zone which connects sea and land. Therefore it is difficult to access for person and the effective control point can be difficult to be fixed up it, which requires that data acquisition should not need a lot of ground control point and field intervention.

As described above, we find that airborne LIDAR technology being applied in topographic survey of TFACZ possesses the practical meaning; Using airborne LIDAR System to carry on high-precision mapping of coastal tidal flat can resolve problem which traditional aerial survey must require fix-quantity control points in work region where it factually is difficult to access or arrive and fills in the blanks of our country's high-precision mapping technology and means in TFACZ.

3.2 LIDAR Applications in TFACZ

Generate Digital Elevation Model (DEM) quickly. LIDAR offers advantages over traditional methods for representing a terrain surface. The advantages refer to accuracy, resolution, and cost. One of the most attractive characteristics of LIDAR is its very high vertical accuracy which enables it to represent the Earth surface with high accuracy. The raw data from LIDAR system are three dimension cloud points with intensity values. Laser returns are recorded from no matter what target the laser happens to strike. The desired target for the generation of digital elevation model is the bare-earth. However, the LIDAR raw data include everything on the ground such as buildings, telephone poles, power lines, and even birds. The post-processing of LIDAR data involves the removal of undesirable points by using filter algorithms. The final cloud points for DEM generation are those points which strike to the bare-earth ground. Bare earth mass points and break lines can be used to create a representation of the ground surface called a Triangulated Irregular Network (TIN). Therefore it is the most effective method carrying on DEM's data acquisition quickly.

Obtain the foundation geographical information of surveying and mapping in TFACZ. Except DEM, "4D" products of basic surveying and mapping include DOM, DLG and DRG. As for two kinds of products DOM and DLG, their production can't also be short of the support of high-precision 3D information. After POS's data are processed, data correction and inlay of CCD image are carried on through it and point cloud of LIDAR; finally DOM and DLG data can be produced.

Build 3D terrain model of coastal zone and island quickly. Digital Coast (DC) requires that building high-precision, true three-dimension, measurable, third-dimension and coastal 3D terrain model should be regarded as virtual platform which is applied to manage coast. However there are heavy workload, low efficiency and no good effects and width and depth that digital coast serves are influenced, when traditional technique is applied in coastal 3D modeling. Coordinates of high-density and high-precision 3D points can quickly be acquired by airborne LIDAR, and big-area 3D coastal model can conveniently be built when point cloud data is used to build model and texture mapping. Furthermore quick dynamic update can be put into effect and true guarantee can be provided for endurance and history of basic data source which is used to build digital coast. See figure 3.

Figure 3. 3D terrain model of coastal zone and island

4. ELEVATION ACCURACY CHECKING

As a new technology, users pay more interested on the stability and accuracy. We examine LIDAR data (3,000 meters flight height, 1m laser point interval) in using Trimble RTK (one base station and two mobile station) system, to ensure the accuracy and the reliability of static control points, when the base station is ok, we check the static control points using RTK mobile station, and also check the two mobile measurement, the results shown in Table 1.

GPS control check			RTK mobile check		
Dx	Dy	Dz	Dx	Dy	Dz
3	-9	7	6	3	13

Table 1. RTK reliability check (mm)

From Table 1, we can see that the base is reliable; the mobile station can be used.

We get many points in the flat areas, road centerline, which is relatively small regional up and down, no mutations, we can think that the elevation change is linear; we get the elevation laser points by linear interpolation method, hope that through this ways to reduce the impact of plane error, the results also reflect the accuracy of products generated by the laser point cloud data, 49 points were taken as analytical sample, the error distribution range is shown in Table 2.

Zone(m)	Num
<-1	0
-1～-0.5	2
-0.5～0	5
0～0.5	28
0.5～1	3
1～1.5	3
1.5～2	6
2.0～2.5	2

Table 2. Error distribution range

From table 2, We found the following law: 42 "+" Errors, only 7 "-" errors, there is a systematic error; secondly, from the location, most of the great errors locate in hillside.

12 check points located in flat places, the mean square error is ± 0.403m, the largest margin is 1.174m, the largest error in the remain 11 check points is 0.339m, the mean square error of the 11 remain check points is ± 0.227m; 22 points on the road and other relatively flat areas, the mean square error is ±0.821m, three points are big than 1.5 m, the biggest error of the remaining 19 is 0.71m, excluding these three larger check points, the mean square error of the check points is ± 0.370m; 15 distribution in topography changes regional, the mean square error is ± 1 .327 m, the absolute margin of seven check point are bigger than 1m, five are bigger than 1.5m. According the GBIT13990-92 <<1:5000, 1:10000 topographic map aerial photographic surveying industry standard>>, the accuracy can meet the demand of 1:5000 mountain topography mapping. Because laser point cloud data is so huge, we remove away some point when checking the accuracy, so, the actual precision of the products may be better to the above accuracy. When reducing the relative flight height and increase high-density of laser point, we can get greater scale topographic maps use this way.

5. CONCLUSION

Airborne LIDAR technology is now a proven method for acquiring accurate digital terrain model data and associated imagery under a wide range of conditions. As an active sensor it can be used when other remote sensing tools will not work, especially in the coastal zone where its flexibility and non-invasiveness are extremely relevant features. We believe that access to a technology that enables the acquisition and fusion of baseline cartographic data and digital photos in much shorter time periods when compared to conventional methods can speed up the initiation of projects related to TFACZ, and we believe the LIDAR technique will be a very promising technique in topographic survey of TFACZ.

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