Applying Ground lidar and aerial photogrammetry combination technology in assisting large scale urban planning map charting

Huang Kuang-Huei[1], He Jian-Bang[2], Liu Chih-Heng[3], Chen Wen-Chin[4], Hsh Ming-Yi[5], Lin Chi-Yuan[6]

[1] Chief of central area plan team, Urban and rural development branch, construction and planning agency, ministry of the interior.
9F, No. 290, Mincyuan Rd., 403, Taichung, Taiwan; Tel: +886-23028450;
E-mail: kuang@tcd.gov.tw

[2] Attaché of central area plan team, Urban and rural development branch, construction and planning agency, ministry of the interior.
9F, No. 290, Mincyuan Rd., 403 Taichung, Taiwan; Tel: +886-23028450;
E-mail: bang@tcd.gov.tw

[3] Manager, ASIA GIS&GPS CO., LTD;
3F-1, No.241, Da-Ye Rd., 408 Taichung, Taiwan; Tel: +886-963233921;
E-mail: iuhenry_gis@hotmail.com

[4] Manager, ASIA GIS&GPS CO., LTD;
3F-1, No.241, Da-Ye Rd., 408 Taichung, Taiwan; Tel: +886-4-23221422;
E-mail: asia8992@gmail.com

[5] General Manager, ASIA GIS&GPS CO., LTD;
3F-1, No.241, Da-Ye Rd., 408 Taichung, Taiwan; Tel: +886-4-23221422;
E-mail: mingyi.hsu6700@msa.hinet.net

[6] Engineer, ASIA GIS&GPS CO., LTD;
3F-1, No.241, Da-Ye Rd., 408 Taichung, Taiwan; Tel: +886-4-23221422;
E-mail: bar0102@msn.com

KEY WORDS: Ground Lidar, Aerial Photogrammetric, Digital Topographic, Urban Planning

ABSTRACT: Appropriate urban development planning is the basic interaction of humanity and environment. Urban planning map with accuracy, wide range and vision are the essential. Urban planning map on 1 to 1000 are base map of infrastructure. Fast and correct map production process is the serious work for above all. The traditional topographic survey although hold the high accuracy but lack of fast update. Aerial photogrammetry has wide range and fast but insufficient accuracy for the need of large scale urban planning map. For solve these problem, this case present aerial photogrammetric and ground light combination technique to enhance the overall accuracy and shorten the serious mapping process., Carries on the high accuracy scanning all of the artificial objects and lead into the mapping process to prompt the accuracy and speed, assist the topographic map extension draw into the urban planning map. After 4 teams by 5 weeks comprehensive field survey, the results approximately 1600 hectares in the Tainan Randa area surpasses 95% above the qualified rate to complete the approval by divides a check area every 200 meters to carry on the random sampling and the actual survey process., The surveying and mapping system measured achievement, Becomes the first successful case in using the ground light is auxiliary to measure the 1/1000 topographic maps the entire Taiwan.

1. INTRODUCTION

Because typhoon carries the rich rainfall, so the main natural disaster of Randa district is the wind-caused disaster and the flood around. Typhoon cause the disaster year after year like Nari(2001), Naitang(2005) etc.. The great fierce of flooded is over one meters around the access road around Randa area which is caused by Morakot(2009). Because the rainfall intensity surpasses the design standard of dike for flood prevention to cause many place to be flooded over one meter around WenHsien district and BauAn district. Not only influence livelihood of the people, the agriculture and the industry disaster damage are also greatly. As a result of the influence climatic change in the future, the threat of flood will increase steadily. Therefore the examines of urban planning district should strengthen the disaster

prevention plan for the whole disaster prevention of strategy by apply the ecology city idea for flood detention, flood prevention and strengthens the disaster prevention function.
In this study case, AGG Company replace the traditional survey by ground lidar survey for time saving, human resource saving and even more promote the accuracy. From historical research, the RMS of land slide DTM with 1meters resolution around TsengWen seservior is 1.791 Lin (2006). Ground lidar would supply DTM with more high accuracy and more high resolution. Lin (2007) proof that 3D ground Lidar accuracy is within 2cm by fix point applies in field survey. This accuracy tallies in the speck of standards document. The survey data and results of this research study still prove the same conclusion and results twice.

2. STUDY AREA

The study area is within in Randa district, Tainan. This project includes Randa(WenHsien) urban planning zone and Tainan access road district urban plan zone. The area about 817.96 hectares, 787hetares respectively and position is shown as figure 1.
There are extra 30meters over the boundary also including in this study area, the total area is 1692 hectares. The Sanye river basin and extra 30 meters between these two zones is also including in. the extra boundary of this study is shown as figure 2.

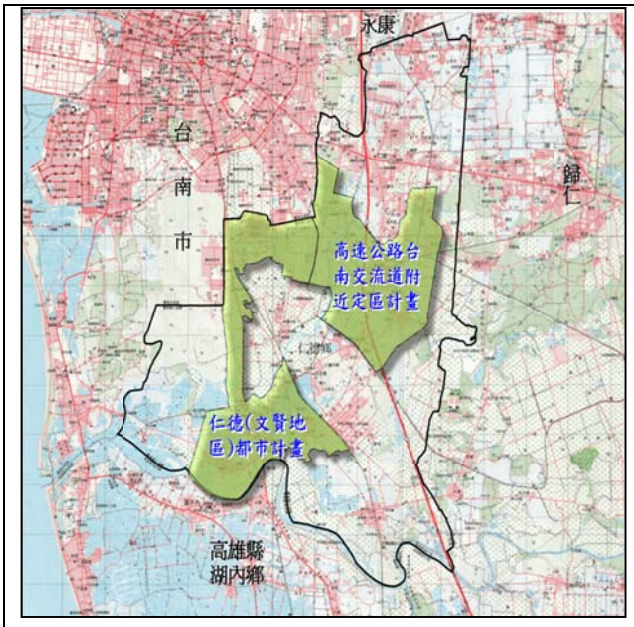

Figure 1 The boundary of study area

Figure 2 The extra boundary of study area

3. OPERATION AND PROCESSING

AGG Company use the ground lidar is design for the needs of terrain high speed scan. Device includes high speed laser scanning system, rapid and high accuracy signal processor, and high speed data link. Type of the instrument is RIEGL VZ400, space of VZ400 is shown as table 1.
Airborn lidar echo digitization and online waveform analysis technology were integrating successful into this instrument. The point cloud can also layer with the camera image with very high resolution and GPS positioning coordinate. Use RGB model can color the point cloud from panchromatic. It can complete all 360 degree surrounding scanning in 3 minutes. The accuracy of point cloud is 5mm. it can carry on the top of the car and operator from one stand to another. It makes the surveying operation easier and faster.

Table 1 Space and characteristic of RIEGL VZ400

VZ400	Space	Characteristic

	Long distance laser scanner range :maximum 600m speed :42000 points per second accuracy : 5mm high speed model range maximum350m speed:122000points per second accuracy : 5mm memory 32G	∗drum design, decrease the payload and noise of servomotor. ∗single plane operation, to increase the efficiency of surveying process. ∗operation from PDA or iPhone, or directly button on the screen. ∗scanning on the moving with surveying vehicle. ∗dexterous and light weight 9.6Kg, easy to move and operation. ∗combine with GPS, easy to transfer from relate to absolute coordinate. ∗combine with very high resolution digital camera, change the point cloud color type. ∗integrate airborne Lidar echo digitization and online waveform analysis.

figure 3 RIEGL VZ400 surveying vehicle

RiSCAN PRO is the software for process the point cloud of RIEGL VZ400. The same points at least four points were used to combine the point cloud from one stand to the other. The point cloud process algorithm is transforming the data into TIN by using the MSA (Multi Station Adjustment) module. After data transfer and then calculate, compare position and shape of thousands TIN data, modified the relationship between the point cloud. The error numbers of multi-station point clouds are smaller than cm. all the scan data combine together by using MSA and fix with the coordinate of control point, than enter the charting procedure.

There are three coordinate in RISCAN system. First is SOCS(Scanner's Own Coordinate System). Second is PRCS(Project Coordinate System) and third is GLCS(Global Coordinate System). Six variance include 3 displacement parameters and 3 rotation parameters are described the direction and orientation.

RiSCAN is using 4X4 Matrix presents the SOP (station position and rotation in PRC) of station and POP (relate coordinate transfer into the absolute coordinate parameters).

$$Matrix_{sop} = \begin{bmatrix} r_{11} & r_{12} & r_{13} & t_1 \\ r_{21} & r_{22} & r_{23} & t_2 \\ r_{31} & r_{32} & r_{33} & t_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

9 elements in the matrix represent the rotation (r11 to r33) and translation (t1 to t3); split the matrix into the rotation sub matrix (3X3) and translation matrix (3X1). Through define of rotation according the XYZ axis direction, the matrix may transform into roll, pitch and yaw 3 rotation angles.
Roll： Point cloud rotation of X axis quantity.
Pitch：Point cloud rotation of Y axis quantity.
Yaw：Point cloud rotation of Z axis quantity.
Formula of calculation of roll, pitch and Yaw is shown as follow:

$$\text{rotation matrix } R=\begin{pmatrix} R_{0,0} & R_{0,1} & R_{0,2} \\ R_{1,0} & R_{1,1} & R_{1,2} \\ R_{2,0} & R_{2,1} & R_{2,2} \end{pmatrix}$$

$$R = R_z(Y)R_y(P)R_x(R)$$

$$\text{rotation quantity of X axis } R_x(R) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(R) & -\sin(R) \\ 0 & \sin(R) & \cos(R) \end{bmatrix}$$

$$\text{rotation quantity of Y axis } R_y(P) = \begin{bmatrix} \cos(P) & 0 & \sin(P) \\ 0 & 1 & 0 \\ -\sin(P) & 0 & \cos(P) \end{bmatrix}$$

$$\text{rotation quantity of Z axis } R_z(Y) = \begin{bmatrix} \cos(Y) & -\sin(Y) & 0 \\ \sin(Y) & \cos(Y) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

There are two condition ：

1. if the x axis of scanner is not parallel to the z axis of PRCS($R_{2,0}$ not equal to 1)：

$$Y = a\tan 2(R_{0,0}, R_{1,0})$$
$$R = a\tan 2(R_{2,2}, R_{2,1})$$

1.1 if sin(Y)=0

$$P=\text{atan2}(R_{0,0}\cos(Y)^{-1}, -R_{2,0})$$

1.2 if sin(Y) ≠ 0

$$P=\text{atan2}(R_{1,0}\cos(Y)^{-1}, -R_{2,0})$$

2. if the x axis of scanner is parallel to the z axis of PRCS($R_{2,0}$ equal to 1)：

$$P=\text{sign}(R_{2,0})\frac{\pi}{2}$$
$$Y = a\tan 2(-R_{1,1}, R_{0,1})$$
$$R = 0$$

4. ACCURACY ASSESSMENT

We hold two field surveys for check accuracy and approval. The first field checks hold from March 14 to 17, 2011. The 726 check points was choice by random sampling from 200 hector, 736 points are pass and 26 points are fail, the ratio of pass is 96.6%. The second field checks hold from April 11 to March 6, 2011. The 2885 check points was choice by random sampling from 1692 hector, 2751 points are pass and 134 points are fail, the ratio of pass is 95.4%. Amount this, the 2680points as the check point for X, Y directions; 205 points are check point for Z direction. The statistic table of check point shows as table 2.

Table 2 the second field survey statistic table

	Total	accuracy	Pass Pt.	Fail Pt.	Pass ratio
X,Y check	2680	25cm	2551	129	95.2%
Z check	205	50cm	200	5	97.6%
Sum total	2885		2751	134	95.4%

Analysis the 2671 points of X, Y direction, the average error is 8.66 cm, the std. is 25.13, mean error is 26.58. There are 2562 points' error are smaller than std. the ratio is 95.9%. There are 70 points' error are one time to two times of std. error. The ratio is 2.6%. There are 36 points' error are over two times of std. error. The ratio is 1.5%.
The count tables of separate the errors by every 5cm shows on table 3.

Table 3 Table of analysis error by every 5cm

	deviation	Points	ratio	average	Std.
Accumulation	0 to 5	1439	53.9%	2.81	1.27
	0 to 10	2181	81.7%	4.27	2.42
	0 to 15	2407	90.1%	5	3.27
	0 to 20	2517	94.2%	5.55	4.11
	0 to 25	2551	95.5%	5.78	4.54
	0 to 100	2650	99.2%	7.07	8.49
	all	2671	100.0%	8.66	25.13
Count by every 5cm	0 to 5	1439	53.9%	2.81	1.27
	5 to 10	742	27.8%	7.11	1.39
	10 to 15	226	8.5%	12.05	1.41
	15 to 20	110	4.1%	17.56	1.58
	20 to 25	34	1.3%	22.67	1.11
	25 to 100	99	3.7%	35.8	15.73
	> 100	21	0.8%	209.88	178.68

We can figure that error smaller than 5cm is 53.9%, smaller than 10cm is 81.7%. From these results, we can say the error of digital terrain map is very small by using VZ400 scanning data. And the most important things are the members of check field survey are not the same groups with the member carries on the field survey.

5. THE ADVANTAGE OF VZ400

The superiority of RIEGL VZ400 scan data is describe the detail information and whole situation of the construction and shape of inside outside curve and so on…. Traditional survey need experimental person to pick up the character point of terrain to rebuilding the terrain model by inside work, the VZ400 no need this kind type work, the scan data can describe all the characteristic of terrain, and it is very easy to find the results by overlay with the digital map. The point cloud overlay with digital map shows as figure 5. It is no need the person who carrying on the survey process to

check the shape or present situation change of buildings. This is more convenient than traditional survey process during the whole process of field surveying and self- control or check for accuracy of the final results.
There is more advantage of using VZ400 is describe all the detail information like distribution, maintenance situation for all public utility. For example telephone pole, street light, and each flower height, windows and doors disposition. All this information can extract from the scan point cloud results.
The Sanye river basin are the major disaster by flooded, the dike facility, river shape to flow to, the elevation difference of river water and dike height, the basin nearby low-lying area (is flooded high risk area), all this information are describe very detail and complete by VZ400 points cloud results. The example of detail information shows as figure 6. This information is very useful for making plan to prevent the property and civil like by government.

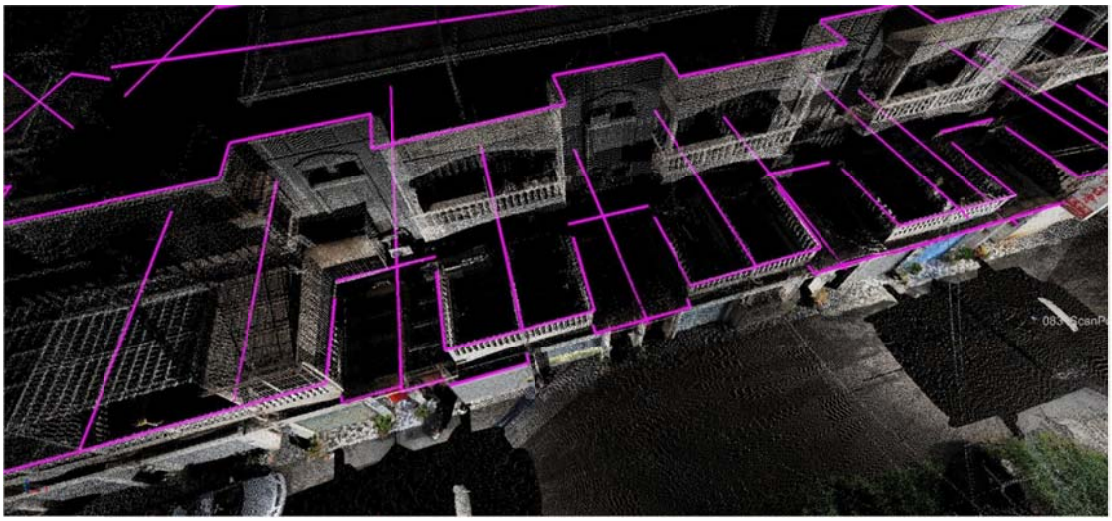

Fig. 2 Digital terrain overlay with the point cloud data

Fig. 3 the scanning data of Sanye river basin

Traditional terrain survey too much depends on the control points. Too much transparent points will cause the big error and this will not shows on the VZ400 lidar scan system. In good after-treatment condition, there is only need four control points in every 400X600 map sheet. The area is 1692 hectors; the total scan station is 8196. There were only 370 points used to transform the relative coordinate into the absolute coordinate system. The deviation between the coordinate by calculate from RiScan and absolute coordinate is almost around 1.5 cm in each scanning zone. This case start at July 27, 2010 and end at Jan. 21, 2011. There is 179 days to finish all the scanning procedure and after-treatment, that is, 9.45 hectors per day. The efficiency is better than the traditional survey method.

6. CONCLUSION AND DISCUSSION

The qualified ratios of two approvals are 96.6% and 95.4% separately by using VZ400. Especially the second approvals, 2885 points are check point by point, the deviation is smaller than 5 cm is over 50%, smaller than 10cm is over 80%, this is the prove of using the newest instrument with high technology, high speed and high accuracy. Using VZ400 to replace the process of traditional survey not only speed up the whole process, promote the accuracy but also record the detail information of terrain, characteristic point and cultural preservation information during the scanning. The colorful point cloud with abundant information is better than traditional survey in explaining strength. The entire examination of urban plan would enhance the strategy and practicable of eco-city at flood detention, flood prevention and function. This entire information is easy record by scanning during the work flow. This information is very useful for making plan to prevent the property and civil like by government.

7. REFERENCE

RIEGL Laser Measurement Systems GmbH, 2011, RiSCAN PRO Version 1.6.1 handbook.

Lin, Cho-chun, 2006, High Accuracy Digital Terrain with LiDAR on the Rapidly Investigation of Landslide Area, Master paper of National Cheng Kung University.

Lin, Wei-hsien, 2007, Application of 3D Laser Scanning on Land Parcel Survey, Master paper of National Cheng Kung University.