Automatic Generation Of Geographical Information System (GIS) Dataset From Total Station

Mohd Amry Johan Mohd Ali, Jasmee Jaafar, Azman Ali M. Habib Rahman, and Warishah Abdul Wahab

Abstract—A study towards optimizing engineering survey datasets towards Geographical Information System (GIS) data format is carried out. In this study, one hundred and thirty one (131) questionnaires were gathered from the licensed land surveyors in Malaysia who are the major contributors in carrying out engineering surveying work. It is found that, the data captured during field survey are in various formats and is not capable for direct usage in GIS environment. If the datasets are to be used in a GIS environment, further processing which involves expertise and manual editing need to be carried out as to comply with the GIS standard MS 1759:2004 data format. In this study, the automated system acquires engineering survey datasets from raw data generated by a variety of survey instrument and produce it to GIS ready format. The developed system is assessed qualitatively and quantitatively based on seven hundred and eighty eight (788) surveyed points. It is found that, in the qualitative approach; a good match is obtained in the plotted dataset. As for the quantitative approach, the accuracy achieved is less than 0.015 meters based on plotting points using AutoCAD and ArcGIS software. The results will be portrayed and tabulated accordingly.

Index Terms—Engineering survey, land survey, geographical information system, GIS, licensed land surveyor.

I. INTRODUCTION

In 2013, there are four hundred and thirty six (436) licensed land surveyors company established in Peninsular Malaysia [1]. All licensed land surveyors carried out their survey work using total station as a basic instrument for gathering site information. A diversity of surveying software is currently being used by the licensed land surveyors, to process their gathered datasets. Fig. 1 shows the data processing software used by various licensed land surveyors based on the questionnaire.

Referring to Fig. 1, it is shown that 83.5% of the respondents are using the product from Foresight Software Pty. Ltd. [2] known as CDS or Topographic Route and Processing Software (TRPS). Foresight Software Pty. Ltd. enters the Malaysia market and established a local distributor and a software called TRPS [2].

Fig. 1. Data processing method by licensed land surveyor.

Where else, another 14% equipped with Computer Aided Design (CAD) as a processing method in their practice, 2 % utilized other software and 0.5% using in house customized software.

II. CURRENT TECHNIQUE

The majority of the licensed land surveyors in Malaysia is using CDS as their processing tools (Fig. 1). CDS is an integrated Windows based program designed for Surveyors, Engineers and related professionals [3].

Fig. 2. Land survey work flow in producing GIS data format.

The current techniques of processing engineering survey data involve experts and it takes a long process which includes editing the dataset manually in order to comply with the GIS data standard. The process is time consuming, labor intensive and costly. Fig. 2 shows the general work flow in preparing the GIS final product.

Referring to Fig. 2, it is shown that various steps need to be carried out before the final GIS data format could be delivered. The process starts with data collection in the field using a total station. Upon completion the ground survey, the data is downloaded from the total station (survey instrument) using a downloader module dedicated to the total station (survey instrument) in used. The downloaded data will then be processed using CDS and exported to Drawing Exchange Format (DXF) or American Standard Code Information Interchange (ASCII).

In order to produce the GIS enable data format, a long process is needed [4], these include converting the dataset in

readable GIS format, verifying and editing the attributes and finalizing process which involves overall checking.

III. GIS DATASET

Nowadays, Geographic Information System (GIS) is widely used in a diversity of applications [5]. It should be noted that, the main aim of engineering survey work is to produce an engineering plan. Hence, the data captured in the field by various land surveyors comprise of a variety data formats which relates to the software and instruments in used. The datasets are not for direct GIS usage. Based on the study, it is found that, licensed land surveyors in Malaysia are keen to have the surveyed engineering dataset in GIS ready format as it is highly demanded.

Fig. 3 shows the percentage of the licensed land surveyor demanding further study to be carried out to utilize the engineering surveyed dataset gathered towards GIS applications. Based on Fig. 3, it is shown that 75.38% strongly agree, 19.23% respond with no comment and only 3.85 % does not agree, where else 1.54% had not responded towards utilizing the gathered engineering survey dataset for GIS applications.

Fig. 3. Respondent by licensed land surveyors towards utilizing the engineering survey dataset for GIS usage.

IV. AUTOMATION TOWARDS GIS READY FORMAT

Fig. 4. Workflow of myGEIS system.

The automation module developed in this study is known as Malaysian Geographic and Engineering Information

System (myGEIS). With the capabilities design to automate many processes towards generating GIS Standard dataset according to the MS 1759:2004 the Geographic Information or Geomatics – Features and Attribute Code. myGEIS retrieve, process and convert land survey raw data consisting of surveyed information automatically. Fig. 4, shows the workflow of myGEIS system.

Referring to the Fig. 4, the workflow consists of four (4) stages, namely the Current Practice Stage, myGEIS: Register and Retrieve, myGEIS: Management and myGEIS: Production. On completing the current practice stage (field work), which eventually involves the normal ground survey data acquisition stage, the automation system is ready to be used.

Fig. 5 shows the main menu of the myGEIS system.

Fig. 5. myGEIS Main Menu.

The system is also equipped with the management module which includes automatic survey correction, adjustment, and enables the user to perform editing and deleting of unwanted data. The Production Stage will then compile a report which includes the capability of exporting the dataset to MS 1759:2004 GIS formats. In this study, the developed system is assessed quantitatively based on seven hundred and eighty eight (788) surveyed points. It was found that, the accuracy (RMSE) achieved is less than 0.015 meters and portray a good match between the plotted dataset as shown in Fig. 6. The test is based on the plots derived using AutoCAD [6] system and the generated GIS data plotted using ArcGIS [7] software.

Fig. 6. (a) Data from Conventional Method and (b) Data Derived from myGEIS.

Referring to Fig. 6 (a), the data plotted is done by AutoCAD software derived from the conventional method while Fig. 6 (b) is generated using myGEIS system dataset plotted using the ArcGIS software. Both methods seem to give the same plot, but an additional benefit goes to the data generated by myGEIS where the attribute table will be

automatically generated. This is of high advantage where it complies with the GIS standard MS 1759:2004 (Fig. 7).

FID	Shape	Point	Easting (E)	Northing (N)	Reduced Lev	code	HPT	ZGP	NAM
616	Point ZM	1663	27396.561	5671.203	50.864	GL	3	0	GROUND LEVEL
617	Point ZM	1664	27393.855	5676.309	50.711	GL	3	0	GROUND LEVEL
618	Point ZM	1665	27399.013	5667.231	50.247	GL	3	0	GROUND LEVEL
619	Point ZM	1666	27393.292	5677.933	50.102	GL	3	0	GROUND LEVEL
620	Point ZM	1667	27402.33	5662.496	49.715	GL	3	0	GROUND LEVEL
621	Point ZM	1671	27370.938	5663.227	50.748	JO	3	0	METALLED ROAD
622	Point ZM	1672	27389.62	5665.845	50.781	JO	3	0	METALLED ROAD
623	Point ZM	1673	27371.415	5662.096	50.555	GL	3	0	GROUND LEVEL
624	Point ZM	1674	27368.737	5668.198	50.469	GL	3	0	GROUND LEVEL
625	Point ZM	1675	27372.441	5659.763	50.142	GL	3	0	GROUND LEVEL
626	Point ZM	1676	27368.008	5669.325	49.785	GL	3	0	GROUND LEVEL
627	Point ZM	1677	27374.943	5653.748	49.743	GL	3	0	GROUND LEVEL
628	Point ZM	1678	27347.391	5657.465	50.799	JO	3	0	METALLED ROAD
629	Point ZM	1679	27347.8	5655.031	50.867	JO	3	0	METALLED ROAD
630	Point ZM	1680	27347.116	5659.015	50.618	GL	3	0	GROUND LEVEL
631	Point ZM	1681	27348.569	5653.885	50.597	GL	3	0	GROUND LEVEL
632	Point ZM	1682	27347.355	5661.203	49.928	GL	3	0	GROUND LEVEL
633	Point ZM	1683	27349.435	5651.52	50.113	GL	3	0	GROUND LEVEL
634	Point ZM	1684	27353.057	5644.445	49.798	GL	3	0	GROUND LEVEL
635	Point ZM	1685	27328.029	5649.792	50.82	JO	3	0	METALLED ROAD
636	Point ZM	1686	27329.535	5647.76	50.894	JO	3	0	METALLED ROAD
637	Point ZM	1687	27327.295	5651.563	50.595	GL	3	0	GROUND LEVEL
638	Point ZM	1689	27325.707	5646.247	50.668	GL	3	0	GROUND LEVEL
639	Point ZM	1689	27356.418	5653.473	49.982	GL	3	0	GROUND LEVEL
640	Point ZM	1690	27330.316	5644.234	50.193	GL	3	0	GROUND LEVEL
641	Point ZM	1691	27332.169	5637.943	49.866	GL	3	0	GROUND LEVEL
642	Point ZM	1692	27325.742	5646.108	50.808	JO	3	0	METALLED ROAD
643	Point ZM	1693	27324.307	5648.261	50.794	JO	3	0	METALLED ROAD

Fig. 7. GIS standard MS 1759:2004 attributes data.

Apart from the attribute table generated using the automated system developed, the time taken to generate the GIS ready data format is much faster compared to the conventional approach. In this study, seven hundred and eighty eight (788) point data is used for the evaluation process. Table I shows the recorded time to process the survey data using both semi-automatic (Conventional) and myGEIS method.

Referring to Table I, semi-automatic (conventional) method takes two thousand three hundred and fifty seven (2357) seconds to complete the process in preparing the GIS MS 1759:2004 ready data format. As for the myGEIS system, three hundred and fifty seven (357) seconds are needed to complete the whole process. It is shown that, the time taken is much shorter compared to the conventional method. It should be noted that, if the number of points to be processed increases, the time taken to process using the conventional method will eventually increase. Furthermore, as shown in Table I, the developed system does not require performing step 2, 3 and 4 towards the creation of GIS ready data format compared to the conventional method and this will save time and avoid human error.

Thirty (30) points were chosen randomly to distinguish if there is any differences in coordinate and reduced level value result of the processing and transforming to GIS data format. Table II shows the selected GIS data derived from myGEIS system. The data are retrieved from total station (instrument) and process automatically to GIS standard data.

TABLE I: TIME RECORDED TO PROCESS DATASET

No	Step	Semi-automatic (Second)	myGEIS (Second)
1	Data Download	226	224
2	Data Cleaning	120	-
3	Create Comma delimited text	191	-
4	Export Shapefile	177	-
5	Editing and Create GIS MS 1759:2004	1621	129
6	Finalize GIS MS 1759:2004 Data	22	4
	Total time	2357	357

TABLE II: SELECTED DATA FROM MYGEIS SYSTEM

No.	Point Number	Easting (X)	Northing (Y)	Reduced Level
1	112	987.22	973.756	99.441
2	116	1007.4	976.886	99.741
3	123	989.367	1006.457	100.021
4	306	987.844	930.297	98.206
5	307	992.797	949.309	98.436
6	315	938.694	944.794	97.686
7	334	966.526	947.04	98.306
8	337	1016.905	954.202	99.436
9	403	930.62	972.172	98.054
10	417	963.903	969.137	98.164
11	423	944.886	986.993	100.284
12	502	907.811	1025.202	96.186
13	503	921.757	1020.536	96.156
14	513	949.38	1010.785	96.166
15	516	886.711	1021.995	98.786
16	526	909.647	1000.513	100.306
17	7	911.395	1054.244	96.392
18	602	888.257	975.763	98.362
19	606	893.368	1046.868	98.912
20	702	946.532	1096.075	100.715
21	707	969.351	1051.311	96.915
22	710	983.574	1023.282	99.485
23	718	957.323	1037.111	96.225
24	727	949.537	1062.89	96.165
25	730	934.537	1069.558	96.245
26	731	927.384	1052.738	96.165
27	736	919.749	1094.578	101.555
28	747	907.05	1076.218	101.335
29	753	868.785	1022.928	100.525
30	1	1000	1036.653	100.344

TABLE III: SELECTED DATA FROM CONVENTIONAL METHOD

No.	Point Number	Easting (X)	Northing (Y)	Reduced Level (RL)
1	112	987.219	973.757	99.441
2	116	1007.399	976.885	99.741
3	123	989.367	1006.458	100.021
4	306	987.847	930.296	98.205
5	307	992.797	949.308	98.435
6	315	938.694	944.784	97.685
7	334	966.527	947.036	98.305
8	337	1016.904	954.205	99.435
9	403	930.619	972.168	98.054
10	417	963.903	969.137	98.164
11	423	944.884	986.991	100.284
12	502	907.805	1025.2	96.181
13	503	921.752	1020.536	96.151
14	513	949.376	1010.787	96.161
15	516	886.705	1021.991	98.781
16	526	909.644	1000.511	100.301
17	7	911.387	1054.239	96.373
18	602	888.253	975.762	98.358
19	606	893.362	1046.867	98.908
20	702	946.525	1096.073	100.699
21	707	969.345	1051.31	96.899
22	710	983.57	1023.281	99.469
23	718	957.318	1037.109	96.209
24	727	949.531	1062.888	96.149
25	730	934.53	1069.556	96.229
26	731	927.383	1052.736	96.149
27	736	919.741	1094.575	101.539
28	747	907.043	1076.215	101.319
29	753	868.781	1022.923	100.509
30	1	999.992	1036.648	100.339

Table III shows the coordinate and reduced level from conventional method.

TABLE IV: DIFFERENCE OF COORDINATES AND REDUCED LEVEL

No.	Point Number	ΔX	ΔY	ΔRL
1	112	0.001	-0.001	0.000
2	116	0.001	0.001	0.000
3	123	0.000	-0.001	0.000
4	306	-0.003	0.001	0.001
5	307	0.000	0.001	0.001
6	315	0.000	0.010	0.001
7	334	-0.001	0.004	0.001
8	337	0.001	-0.003	0.001
9	403	0.001	0.004	0.000
10	417	0.000	0.000	0.000
11	423	0.002	0.002	0.000
12	502	0.006	0.002	0.005
13	503	0.005	0.000	0.005
14	513	0.004	-0.002	0.005
15	516	0.006	0.004	0.005
16	526	0.003	0.002	0.005
17	7	0.008	0.005	0.019
18	602	0.004	0.001	0.004
19	606	0.006	0.001	0.004
20	702	0.007	0.002	0.016
21	707	0.006	0.001	0.016
22	710	0.004	0.001	0.016
23	718	0.005	0.002	0.016
24	727	0.006	0.002	0.016
25	730	0.007	0.002	0.016
26	731	0.001	0.002	0.016
27	736	0.008	0.003	0.016
28	747	0.007	0.003	0.016
29	753	0.004	0.005	0.016
30	1	0.008	0.005	0.005
	RMSE	0.006		0.010

Assessment is measured using the Root Mean Square Error (RMSE) between data processed using myGEIS and derived value from conventional method. The RMSE calculation for X and Y (coordinate) value is based on (1) [8].

$$RMSE_{(x,y)} = \sqrt{\sum_{i=1}^n \left(\frac{(X_i - X_i^*)^2 + (Y_i - Y_i^*)^2}{n} \right)} \quad (1)$$

where

n : is the number of points;

X_i and Y_i : is the coordinate produced by myGEIS system;

X_i^* and Y_i^* : is the coordinate of derived points from conventional method; and

i : 1, 2, 3, ... n

Meanwhile RMSE calculation for Reduced Level (height) value is based on (2) [8].

$$RMSE_Z = \sqrt{\sum_{i=1}^n \frac{(Z_i - Z_i^*)^2}{n}} \quad (2)$$

where

n : is the number of points;

Z_i : is the height of point generated using myGEIS;

Z_i^* : is the height of point derived values from conventional method; and

i : 1, 2, 3, ... n

Table IV shows the difference of coordinate and reduced level for the same point between the two datasets. The results of RMSE analysis done from the thirty (30) random point data in the study area. The RMSE is 0.006 Meter and 0.010 Meter is acceptable for the engineering survey job.

V. CONCLUSION

The Engineering survey work is highly demanded in land development activities of the nation. Licensed land surveyors are among the people responsible in gathering the ground survey data towards the preparation of topographic and other related engineering surveyed plan. It is also known that, high demand in GIS users emerged to support a diversity of applications. In this study, it is shown that the engineering survey data could be easily converted to GIS ready format using the developed automated system known as myGEIS to support GIS users. The main advantage of the automated system include, fast and accurate data conversion and eventually save cost.

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Mohd Amry Johan Mohd Ali was born in Kota Bharu, Malaysia on 29 July 1982. He received a bachelor of science in surveying and geomatics from UiTM Shah Alam, Malaysia in 2008. Now he is finishing a Master of Science degree in the built environment at the same university.

He is a land surveyor in a licensed land surveyor firm in Shah Alam, Malaysia and undergoing articleship.

Mr. Mohd Amry Johan Mohd Ali is a senior member of the Royal Institution Surveyor Malaysia (RISM) since 2010.