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Study of Single Network Adjustment Using QOCA Software in Korea

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***Abstract*—**For this study, this researcher conducted a precision network adjustment with QOCA, the precision network adjustment software developed by Jet Propulsion Laboratory, to perform an integrated network adjustment on the Unified Control Points managed by the National Geographic Information Institute. Towards this end, 275 Unified Control Points observed in 2008 were selected before a network adjustment is performed on those 275 Unified Control Points. The RMSE on the discrepancies of coordinates as compared to the results of GLOBK was ±6.07mm along the N axis, ±2.68mm along the E axis and ±6.49mm along the U axis.

***Keywords*—**Network adjustment, QOCA, unified control point.

I. Introduction

WITH the advancement of GNSS survey technology, the need for an efficient control point system is growing, making it necessary to provide homogeneously accurate results on the horizontal and vertical control points. The National Geographic Information Institute installed/surveyed some 1,200 Unified Control Points—combination of triangular points and bench marks--with a 10km x 10km interval for three years from 2008 to 2010 [1]. To determine the coordinates of the Unified Control Points, the GPS interpretation software developed for scientific purpose was used. However, there may be some errors in terms of the survey date and interpretation of data processing since different software was used every year. To minimize such errors in this study, this researcher performed a precision network adjustment on the 275 control points installed and observed in 2008 by using QOCA software before comparing the results with the previous observation.

II. Research Methodology

A. Selection of GPS Survey Data

To perform a network adjustment on the observation results obtained every year from the previous researches by using different software such as GAMIT/GLOBK and BERNESE, 275 out of the 1,200 control points observed in 2008 were used. Since the previous studies employed GLOBK in performing the network adjustment after using GAMIT software to interpret the base line, there may be some survey errors due to differences in survey date and interpretation of the measurements. To compensate for such potential such discrepancies, the precision network adjustment was performed by using QOCA, the software designed to be compatible with GIPSY/OASIS II, GAMIT/GLOBK and BERNESE. Fig. 1 shows the distribution of Unified Control Points as of 2008.

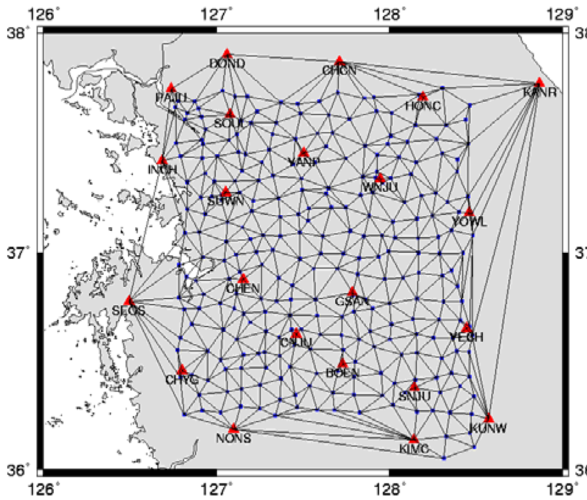

Fig. 1 Distribution of Unified Control Points as of 2008

B. Data Processing Software

In this study, QOCA, a non-commercial software developed by NASA's Jet Propulsion Laboratory. A short for Quasi-Observation Combination Analysis, the software is designed to calculate tectonic transformation data by interpreting the location of multiple observation points and their incremental movement at the same time. QOCA is also post-processing software which is capable of integrating and processing satellite survey data such as GPS, VLBI and SLR and ground survey data such as EDM, triangulation surveying and leveling. Furthermore, the software can potentially perform an integrated processing of SAR data, gravity data and tectonic movement data [2],[3].

One of the most desirable features of QOCA is that the software is compatible with the program format GIPSY/OASI II, GAMIT/GLOBK, FONDA and BERNESE, while it also

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supports SINEX format. In addition, it can calculate the locations, movement speeds and parameters of control points simultaneously, while it is also capable of analyzing/processing noisy time series data through robust analysis. Fig. 2 shows the data processing flow of QOCA.

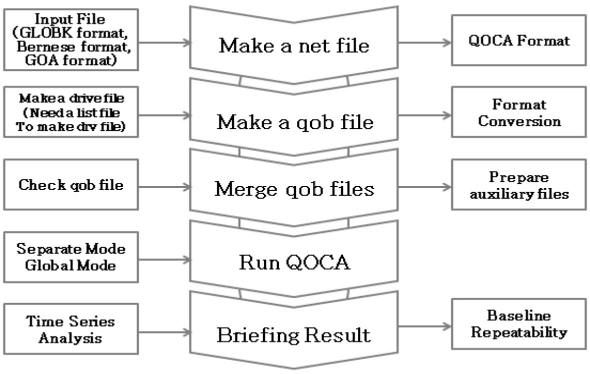

Fig. 2 Data processing flow of QOCA

III. Result of Data Processing

A. Data Processing

Fig. 1 shows the difference between the results of precision network adjustment performed with QOCA and those obtained from another precision network adjustment performed in 2008 with GLOBK.

TABLE I
RESULTS OF PRECISION NETWORK ADJUSTMENT PERFORMED WITH QOCA AND ACCURACY

SITE	1sigma			Difference		
	N(m)	E(m)	h(m)	dN(m)	dE(m)	dh(m)
0001	±0.001	±0.001	±0.005	0.006028	0.002296	-0.008944
0139	±0.002	±0.002	±0.01	0.002551	0.001004	-0.007423
0140	±0.002	±0.001	±0.008	0.003391	0.001520	-0.010281
0141	±0.001	±0.001	±0.006	0.004283	0.001490	-0.010748
0142	±0.002	±0.002	±0.01	0.005015	0.001226	-0.009641
0143	±0.002	±0.001	±0.01	0.004953	0.001783	-0.009638
0144	±0.002	±0.002	±0.012	0.005226	0.000633	-0.008204
0145	±0.001	±0.001	±0.006	0.002939	0.000844	-0.010550
0146	±0.001	±0.001	±0.007	0.005057	0.001825	-0.008596
0147	±0.002	±0.001	±0.009	0.005987	0.001300	-0.011960
0148	±0.002	±0.002	±0.01	0.005291	0.002521	-0.011217
0149	±0.002	±0.002	±0.009	0.004261	-0.000418	-0.010592
0150	±0.001	±0.001	±0.008	0.002759	0.000847	-0.009679
0151	±0.002	±0.001	±0.007	0.004838	-0.000260	-0.011318
0152	±0.001	±0.001	±0.006	0.004740	0.001471	-0.009253
0153	±0.001	±0.001	±0.006	0.003892	0.001862	-0.009581
0154	±0.002	±0.001	±0.008	0.004372	0.001333	-0.009546
0155	±0.001	±0.001	±0.004	0.005820	0.001872	-0.009108
0156	±0.002	±0.001	±0.008	0.005000	0.000158	-0.008176
0157	±0.001	±0.001	±0.004	0.004569	0.001358	-0.010470
⋮	⋮	⋮	⋮	⋮	⋮	⋮

The distribution of accuracy level of each constituent is as shown in Fig. 3.

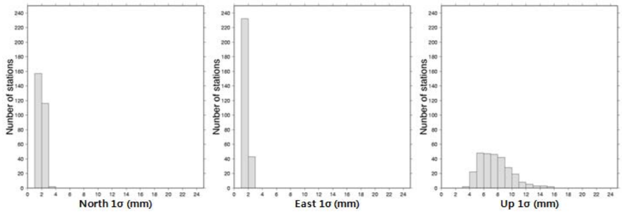

Fig. 3 Distribution of accuracy level of each constituent

The result of statistical analysis on the accuracy of each constituent is as shown in Table II.

TABLE II
STATISTICAL ANALYSIS ON THE ACCURACY

	N(mm)	E(mm)	U(mm)
MAX	3.00	2.00	5.00
Mean	1.44	1.16	7.18
SD	0.51	0.36	2.28

To give a brief overview on the accuracy of each constituent, it was 1.44mm on average (standard deviation: ±0.51mm) along the N axis with a maximum variance of 3.0mm, while it was 1.16mm (standard deviation: ±0.36mm) along the E axis with a maximum variance of 2.0mm. Along the U axis it was 7.18mm on average (standard deviation: ±2.28mm).

B. Comparison/Analysis of Calculated Results

The horizontal and vertical distribution of the differences between the previous data and the newly network-adjusted data is as shown in Fig. 4.

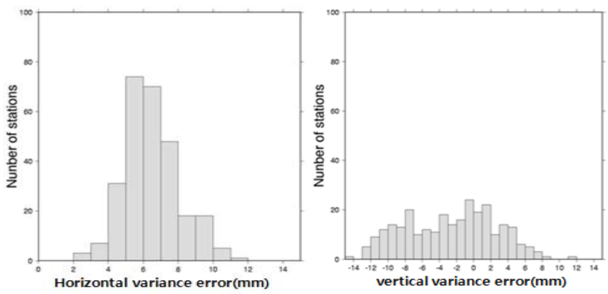

Fig. 4 Horizontal and vertical distribution of the differences (mm)

The result of the statistical analysis on the differences between the two different sets of data is as shown in Table III.

TABLE III
THE RESULT OF THE STATISTICAL ANALYSIS

	dN(mm)	dE(mm)	Horizontal	Vertical
MAX	10.61	5.9	11.65	16.9
Mean	5.82	0.75	6.44	-2.76
SD	1.7	2.57	1.57	5.87

According to the result shown in Table III, the error is 5.82mm on average (standard deviation: ±1.7mm) along the N axis with the maximum variance of 10.61 as compared to the coordinates determined by the previous result, while it was 0.75mm on average (standard deviation: ±2.57mm) along the E axis with the maximum variance of less than 5.9mm. Finally, the error was 6.44mm on average along the horizontal axis (standard deviation: ±1.57mm), while it was -2.76mm on average (standard deviation: ±5.87mm) along the vertical axis. Next, Fig. 5 and Fig. 6 each show the position vector along the horizontal and vertical axis on the 275 control points.

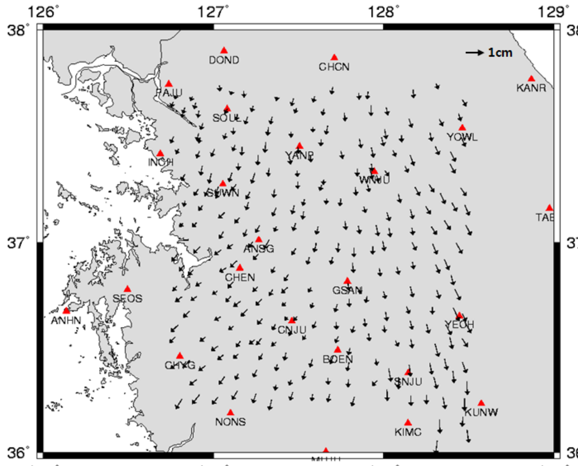

Fig. 5 Position vector of horizontal axis

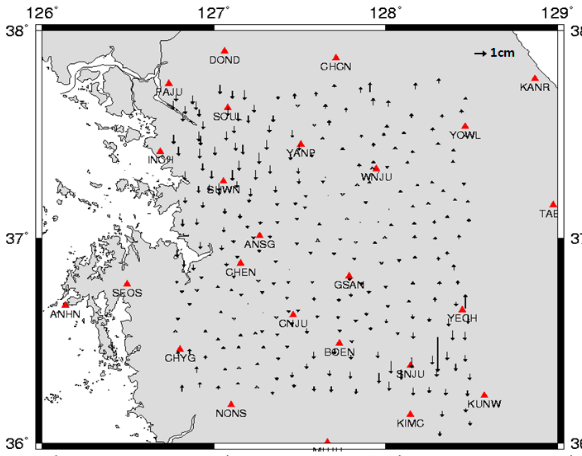

Fig. 6 Position vector of vertical axis

The accuracy of the calculated results was assessed by calculating RMSE (Root Mean Square Error) on the previous data and those calculated by QOCA. Table IV below shows the result of the accuracy assessment obtained through RMSE calculation.

TABLE IV
RESULT OF THE ACCURACY ASSESSMENT

	dN(mm)	dE(mm)	Horizontal (mm)	Vertical (mm)
RMSE	6.07	2.68	6.64	6.49

As with Table IV, the result of the accuracy assessment obtained through RMSE calculation was ±6.07mm along the N axis, ±2.68mm along the E axis, ±6.64mm along the horizontal axis and ±6.49mm along the vertical axis. The difference between the previous result and the newly network-adjusted result using QOCA shows an error of ±6.00mm each along the horizontal and vertical axis.

IV. Conclusion

In this study, the comparison of the accuracy of QOCA software was conducted, which is used to compensate for the survey errors due to survey date and different data analysis methodology when the integrated precision network adjustment is performed later. The RMSE data as compared to the results calculated with QOCA using the survey data on the 275 Unified Control Points measured in 2008 by GLOBK out of the total survey data for the past 3 years was very good: ±4.56mm along the X axis, ±5.57mm along the Y axis and ±11.97mm along the Z axis. However, there are limitations: the maximum number of network-adjustable site is capped at 750 control points, while an additional research is deemed necessary as a glitch occurred during the format conversion of the base line interpretation file which was processed with Bernese.

It is believed that additional studies on the diverse types of software are required to obtain unified and consolidated result on the Unified Control Points and other GPS data.

References

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