COLLABORATION OF REAL TIME GIS AND SPATIAL DATA FOR LARGE SCALE MAP

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Key Words: REAL TIME GIS, GIS, GPS, RTK-GPS, VRS-GPS, Remote Sensing, Large Scale Map

ABSTRACT:

Much local government has been using large scale digital maps with Geographic Information System (GIS). However, the updating method of a map is not established yet. The purpose of this study is the real-time renewal of the digital map for local government by collaboration of REAR TIME GIS and spatial data. In this study, spatial data means Remote Sensing imageries and Real-time Kinematic Global Positioning System (RTK-GPS). REAL TIME GIS is the system for real-time updating at the field site by using RTK-GPS, GIS and cellular phone. First, change of the city is easily found that the Remote Sensing imageries are able to overlay with digital map by using GIS. Next, position of changed area was measured by RTK-GPS. But, RTK-GPS data did not correspond with digital maps because of different geodetic system. It is necessary to transform digital maps of an old geodetic system to new ones. In order to transform map coordinate, the parameters were calculated using Affine Transformation. In this paper, these parameters were named "High-Accuracy Regional Parameter (HARP)". Actual experiment was performed at two places in the narrow area at Kanazawa district in Japan. It was verified how far there are differences between BaseMap (BM) and RTK-GPS measuring data. As a result, the difference was 5~10cm at longitude and 30 cm at latitude. The differences at longitude are allowed in large scale digital map. It is suggested that the process of REAL TIME GIS and HARP should be introduced to the work of local government.

1. INTRODUCTION

Much local government has been utilizing the Base Map (BM) by GIS in order to support urban planning and management of facilities. GIS will be able to work efficiently and to reduce mapping costs. Furthermore, by sharing the data with their position in local government, it is possible to improve the service to a citizen. However, the maintenance and renewal of a map database need much labor and time. The updating method of a map is not established yet, and there are very few successful examples. The purpose of this study is establishment to update of the large scale map for local government using Remote Sensing, GPS and GIS.

In this paper, Remote Sensing means high-resolution satellite imageries (HRSI). By overlapping HRSI and digital map with GIS, it is possible to find the changed houses at urban area in detail. The changed area is surveyed by using RTK-GPS. RTK-GPS is able to survey absolute position with high accuracy. Simultaneous update of digital map is possible using cellular phone and RTK-GPS. On the study, system was defined as the REAL TIME GIS, i.e., collaboration of Remote Sensing, GPS and GIS is most important point.

Japan adopted new general standard for a map geometry since April 1, 2002. Ellipsoid of new geodetic system of Japan is almost equal WGS-84 of GPS. However, most of the digital map of local government is still Tokyo Datum of old geodetic system. In order to correspond with two kinds of data which have different geodetic system, it is necessary to transform coordinates.

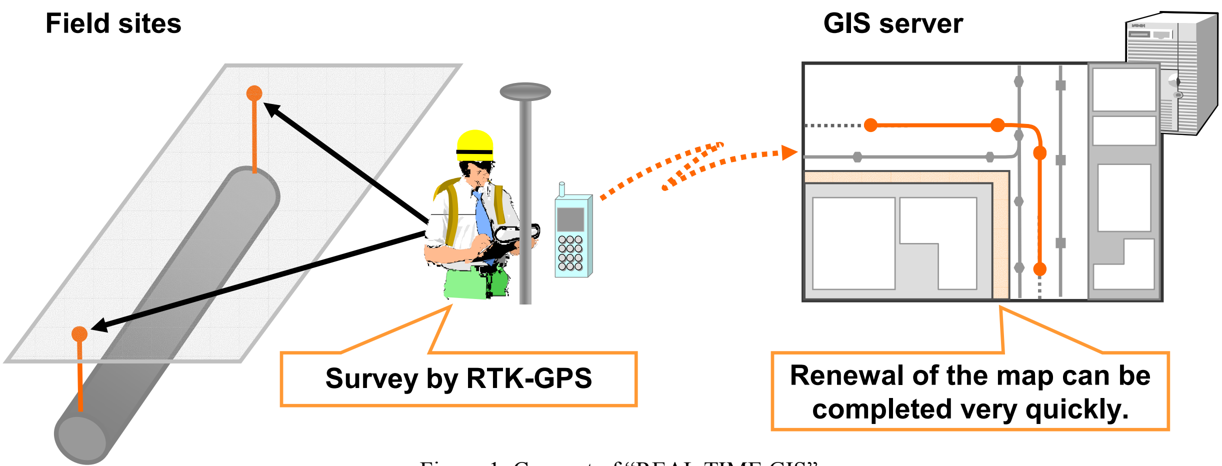
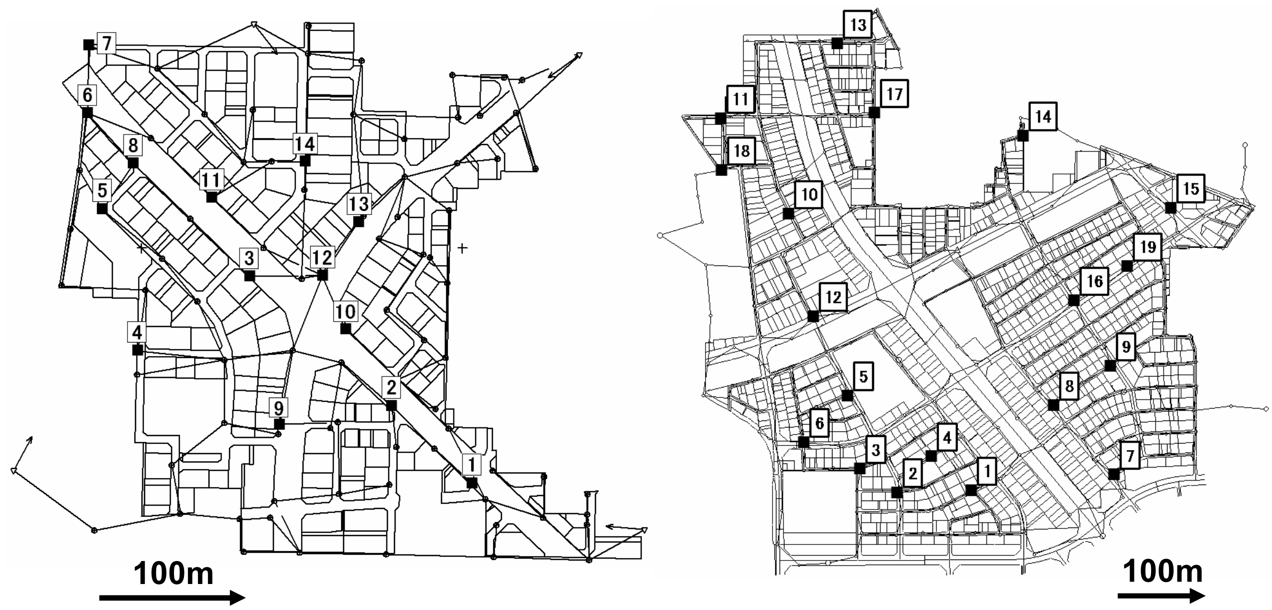
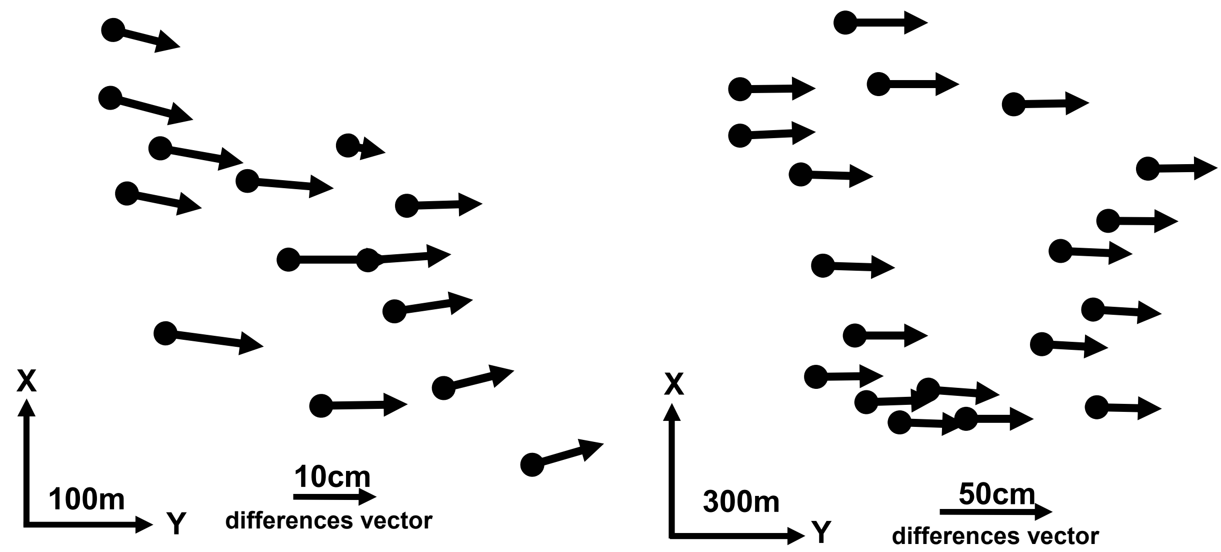


Figure 1. Concept of "REAL TIME GIS"



(a) Test field A (b) Test field B

Figure 2. Test field



(a) Differences of vector at Field A (b) Differences of vector at Field B

Figure 3. Differences of vector

2. CONCEPT AND SYSTEM OF REAL TIME GIS

“REAL TIME GIS” is the system for real time mapping and updating the Map at the field site using RTK-GPS and GIS. It can be connected with cellular phone through which the stored data can be transmitted to the host computer with GIS database. Figure 1 shows the concept of “REAL TIME GIS”. Position of gas pipe was measured by RTK-GPS as shown in the left side of figure. Measured position data are sent to mobile phone by wireless system. GIS data will be transferred to GIS server through mobile phone as shown in the right side of figure. Then the existing GIS data are immediately updated. “REAL TIME GIS” was defined by us.

However, GPS data did not correspond to standard of Japanese geodetic system because BESSEL ellipsoid and Tokyo Datum had been adopted general standard geometry until 31 March, 2003. If we directly use GPS data to digital map, geodetic system has to cause the coordinates transformation between old system and new system.

3. CONTROL POINT FOR CONVERSION

To convert the base map, the control point was made by using relative positioning GPS. In the research, control point means the point which shows both exact coordinates of Tokyo Datum and JGD2000. The verification area has the accurate data of Tokyo Datum (based on BESSEL ellipsoid and rectangular plane coordinate system), and it was generated for town planning recently. Experiment areas are “Area A” and “Area B” (After this, it is marked A and B). A and B has 14 control points and 19 control points respectively. Rectangular size of A and B is about 400m and 1000m respectively. To obtain coordinates of JGD2000, static measuring of GPS was performed over 2 hours at test field (Figure 4). Tested field of GPS measuring is shown in Figure 2.

Figure 4. GPS measuring at the field point

4. VERIFICATION OF THE TRANSFORMATION

4.1 Verification of "TKY2JGD" for Japanese standard conversion

First, coordinates of Tokyo Datum of old geodetic system was transformed to new one by using TKY2JGD. Differences of calculation results and GPS measuring data were verified. The results are shown in Figure3. The difference on the average at A and B was about 11.3cm and 31.9cm respectively. In addition, A was included rotation elements. Although these two areas are located within 3000m, the difference of vector B was twice the size of A. The results proved that it is necessary to verify the method of coordinate transformation in narrow area.

4.2 Verification of High-Accuracy Regional Parameter using Affine Transformation in narrow area

On the verification, Affine Transformation which is the most general and simple method in various geometric conversions was used. Affine Transformation makes the three parameters. Elements were rotation, scale and parallel. These parameters transform the geodetic system (x, y) of old geodetic system to (x', y') of new one. The conversion formula is as follows.

$$x' = x_0 + k_x x - \theta_y y$$
$$y' = y_0 + \theta_x x + k_y y \qquad (1)$$

Where (x, y) = coordinates of Tokyo Datum
(x', y') = coordinates of JGD2000
(x_0, y_0) = parallel transformation
k = scale
k_x = scale of X axis
k_y = scale of Y axis
θ = rotation
θ_x = rotation of X axis
θ_y = rotation of Y axis

In this paper, the parameters obtained by Affine Transformation were called "High-Accuracy Regional Parameter (HARP)". HARP was calculated by the coordinates of Tokyo Datum which was offered from the group of town planning work and GPS measuring data.

To compare of accuracy, 13 points were chosen in B district. This limited area was named Area B' (Figure 5: After this, it is marked B'). In addition, calculated parameter by the coordinates of A, B and B' was named parameter A, parameter B and parameter B' respectively. Each parameter was calculated by two methods as follows.

- Number and place of control points were selected 4 points at the "**corner**" of unit.
- Number and place of control points were selected 4 points at the "**center**" of unit.

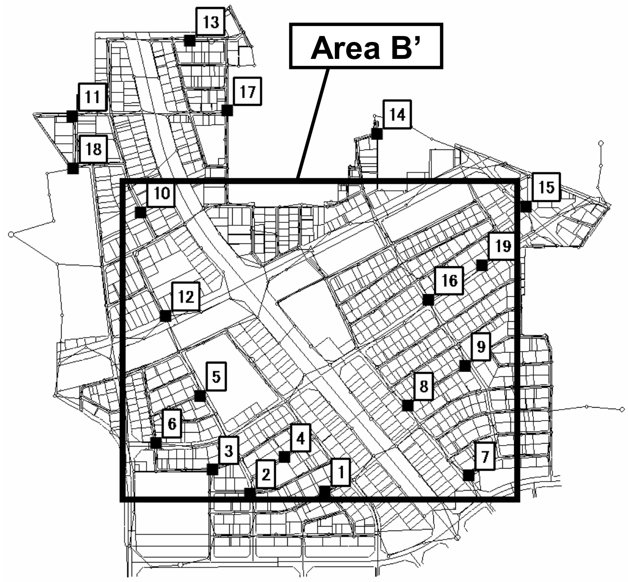


Figure 5. Limited Area B' in Area B

Number and place of control points	STD(m)	
	σx	σy
4 points at the corner of unit	0.0056	0.0199
4 points at the center of unit	0.0100	0.0222

Table 1. Standard deviations of A

Number and place of control points	STD(m)	
	σx	σy
4 points at the corner of unit	0.0084	0.0053
4 points at the center of unit	0.0145	0.0075

Table 2. Standard deviations of B'

Standard deviations of each area are shown in Table1, Table 2 and Table 3. As a result of verification, standard deviation obtained less than 3cm in X and Y at any case. In addition, the control points for the conversion have to place at the corner of unit.

Number and place of control points	STD(m)	
	σx	σy
4 points at the corner of unit	0.0120	0.0091
4 points at the center of unit	0.0252	0.0081

Table 3. Standard deviations of B adopted B’

4.3 Verification of HARP adoption for different area

In this paragraph, the parameter A was exchanged for the parameter B, and then standard deviations were compared. Table 4 shows that result of adopting the parameter to a different area. It became clear that there was a considerable difference in both areas A and B on standard deviation. The results proved that it is necessary to adopt the parameter in the area where HARP was calculated.

Parameter	STD(m)	
	σx	σy
Area A (parameter B)	98.048	97.033
Area B (parameter A)	299.979	290.680

Table 4. Standard deviations calculated by different parameter

5. OVERLAY OF GPS DATA AND TRANSFORMED BASE MAP INTO JGD2000 SYSTEM

5.1 Actual Experiment of RTK-GPS using Original Reference Station

Actual experiment was performed in the narrow area at Kanazawa district in Japan by using RTK-GPS. Reference station was located on the control point nearby field site. Communication from reference station to rover station for the RTK-GPS depended on radio broadcasts.

Base Map of local government was transformed from Tokyo Datum to JGD2000 by using the parameter A which located 4 points at the corner of unit. Measurement of RTK-GPS carried out on the road line of Base Map (BM). Differences of BM and RTK-GPS data were verified.

Figure 7 shows that GPS measuring data was overlaid with BM. Black circle symbol shows the RTK-GPS data. The difference of both data appears 5~10cm to 30cm at longitude and latitude respectively.

5.2 Actual Experiment of RTK-GPS using Virtual Reference Station (VRS)

Second actual experiment was performed at the same area. Virtual Reference Station (VRS) does not need to set the reference station. Virtual reference station was made virtually around the measuring point. Distance of virtual point to actual point is about 3m to 5m. Revision information of rover station was sent to mobile phone by using wireless system. This system is possible to measure by only one person with light baggage (Figure 6). The result of actual experiment is shown in Figure 7. A black triangular symbol shows the RTK-GPS data measured by VRS. It was measured around parked cars along the road side as shown in the left side of the Figure 7. As a result, two kinds of measurement results were almost the same. The accuracy will improve more and more by using the adjustment of offset. If signal of the mobile phone is weak, it is suggested that original reference station has to locate nearby the field site.

Figure 6. VRS-GPS measuring on the road line

6. CONCLUSION

If the local government introduces HRSI as a background of base map, government and general user can easily recognize the present conditions. We recommend that local government introduce the system of “REAL TIME GIS” and Remote Sensing imageries for their work. The simplification of mapping process, cost reduction of mapping and updating, and understanding of accurate urban conditions are connected with the improvement of the service to the citizens. As a result, collaboration of Remote Sensing, GPS and GIS is useful tool for local government to renew large scale map.

For example, we will show the future view to make barrier-free map for physically handicapped persons. A barrier-free map means the map which displayed the road whose physically handicapped person is able to pass. Displayed road needs the most recent conditions. REAL TIME GIS by using RTK-GPS is powerful tool to update road conditions. Government will

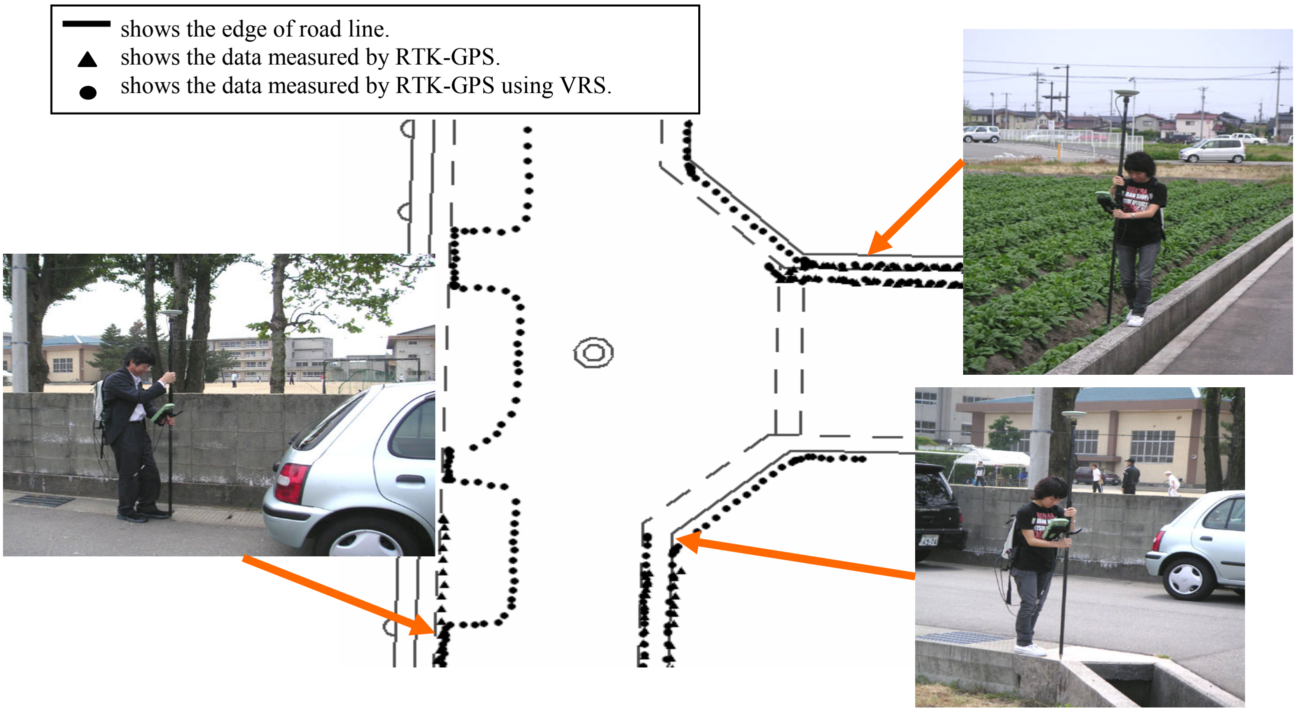


Figure 7. Overlay of GPS measuring data and BaseMap in area A

provide comfortable living of social environment for handicapped person.

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ACKNOWLEDGEMENTS

The authors wish to thank to Takehisa KUROSE and Mitsukuni MURAI of Kanazawa Water and Energy Center, Kiyotaka MASAKI of the group of town planning in Yokaichi-demachi, Hitoshi TOMITA of Hitachi, Ltd. and Yoshimitsu SOUDA of CENTRAL Aero. Survey.