Close Range Photogrammetric Model for Measuring the Size of Objects

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ABSTRACT: This study is on the development of photogrammetric method for measuring the size of object without control points and the system of adopting the method. The model is composed of interior orientation parameters, which are consist of specifications of CCD camera and lens distortion parameters, and exterior orientation parameters, which are calculated through relative orientation and scale adjustment. We evaluated the accuracy of the model to find that it is possible to measure the size of object using the model. The system is composed of GPS, CCD cameras and PC. We also evaluated the performance of the system.

1. INDRODUCTION

Maintaining good cityscape is one of the important tasks of government offices. There are many kinds of private facilities which spoil cityscape, and government office should control it's installing and shape. A sign-board is significant facility to be controlled for good cityscape. In case of Korea it is playing a main role in spoiling cityscape, and the government have started controlling its size, color, subject, and so on. To control the sign-board's installing and shape, the adequate system and method are needed. The system should have functions, gathering images, calculating the size, editing the properties of it, and so on. Sizing is most important function to be realized, because it is very difficult to size the sign-board installed on the high floors of buildings and it's numbers are too many.

To solve the problems we developed a photogrammetric method and system which can measure the size of sign-board of large quantity without any control points and build up database containing information about it, based on a 3D GPS coordinates. Through this paper, we introduce the composition and functions of the system, and the performance and accuracy are reviewed with field test and analyzing the result.

The method to measure the size of sign-board is mainly based on the close range photogrammetry, and it is consist of relative orientation method, the scale adjustment for calculated exterior orientation parameters and calculating 3D model coordinates for conjugate points of two stereo image pairs with co-linear equation. System configuration is much similar with land based mobile mapping system. It has a GPS receiver, multiple CCD cameras, and related software - one is for field data collection, and another is for sizing and database editing - and PC. The differences between the system and common mobile mapping system is that our system don't have inertial navigation system(INS) so its price is very low. None the less, there is no problem with its usage for measuring the size of object and matching survey result with maps using 3D GPS coordinates.

Mobile mapping systems represent a significant advance in integrated, multi-sensor digital mapping technology, providing an innovative path towards rapid and cost-effective collection of high-quality and up-to-date spatial information(Tao C.V. et al., 2001). Up to date systems provide the absolute positioning accuracy of sub-meter and a relative accuracy of under 0.3m within a 35m corridor(Tao, C.V. 1999; Tao, C.V. et al., 2001). Our system uses a relative positioning method of mobile mapping system for measuring the size of the object and supply convenient database editing environment related with GIS data to match a survey result with cadastral and building information.

In this paper, we introduce the main method, composition, accuracy of the system.

2. PHOTOGRAMMETRIC METHODS FOR SIZE MEASUREMENT

Some photogrammetric methods are adopted to develop the method for measuring the size of distant object. The method is consist of relative orientation process, scale correction for relative orientation results - calculating exterior orientation parameters(EOPs) based upon model coordinate system, and 3D model coordinate calculation of conjugate points by using EOPs and collinear equation.

2.1 RELATIVE ORIENTATION

To perform survey with stereo image pair, EOPs of both images should be determined formerly. EOPs can be determined through bundle adjustment based on collinearity condition or relative orientation process based on coplanarity condition. In this research, we adopted EOPs based upon model coordinate system to realize the system capable of calculating EOPs and measuring the size of objects without control points. We adopted relative orientation rather than bundle adjustment because relative orientation process is less heavy than bundle adjustment and the number of parameters is smaller than bundle adjustment. Through relative orientation, relative differences of attitude parameters can be calculated exactly, but that of positional parameters include scale problem. To measure size exactly the scale problem of positional parameters of EOPs should be resolved.

2.2 SCALE CORRECTION FOR EOPs

The scale problem of relative EOPs can be solved by adopting one known parameter, the distance between principle points of two cameras - the base distance. In two sets of six EOPs, three parameters defining the position of projection center of one camera should be corrected. Correction method is simple. We can make a vector connecting projection points of two CCD lens, and any point of both projection points can be defined as initial point. By adjusting the length of the vector to be same with the base distance, we can change the position of terminal point, another projection point. Through this process three positional parameters of one camera changed and other parameters are not changed. This is a scale correction process for EOPs and Figure 1 is describing this process.

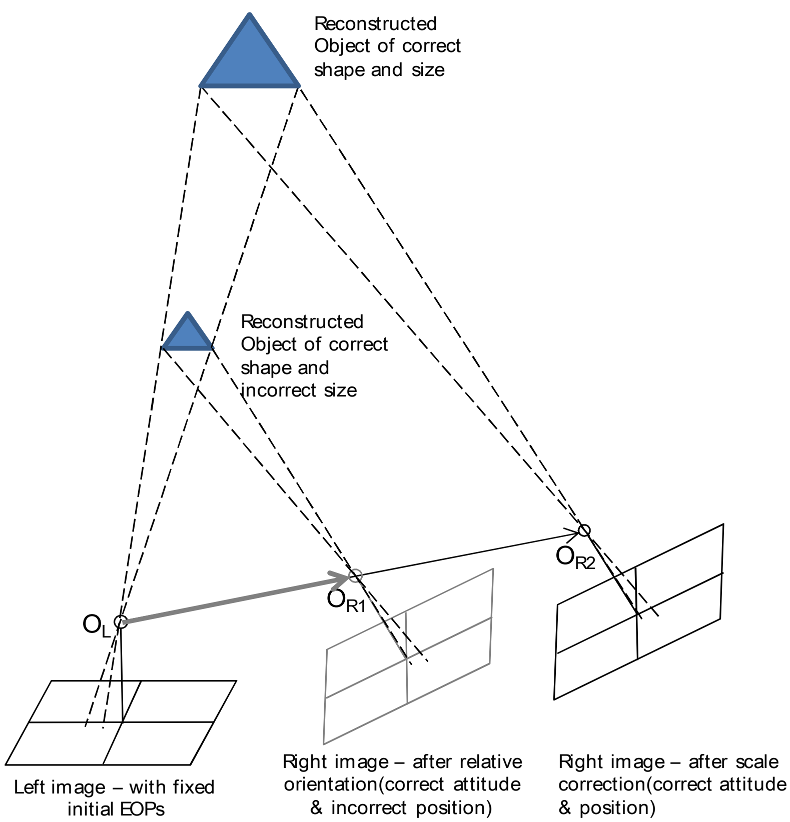

Figure 1. Exact reconstruction of object size through scale adjustment of EOPs calculated through relative orientation process

2.3 3D MODEL COORDINATES AND SIZE CALCULATION

If scale problem corrected EOPs are given, 3D model coordinates can be surveyed with stereo image pair. With two sets of image coordinates of conjugate point from stereo image pair and EOPs, we can set up four collinearity equations of which unknown quantities are three model coordinates of conjugate point. 3D model coordinates can be calculated by least square adjustment computation, because the numbers of equations are over the number of unknowns. Finally, with two or more 3D model coordinates, the length or area of facilities can be calculated.

3. SYSTEM COMPOSITIONS

The system is composed of two pairs of CCD cameras, one GPS, and one laptop computer. Upper camera pairs are for photographing sign-board on high floors and lower ones are for middle and lower floors. Each camera is connected to laptop and GPS receiver by 1394 cables. Four 1394 cables transmit images from CCD cameras to laptop and another cables transmit trigger signal for photographing from GPS to each camera. All images and position data are stored in laptop. Image data is timely synchronized with GPS position.

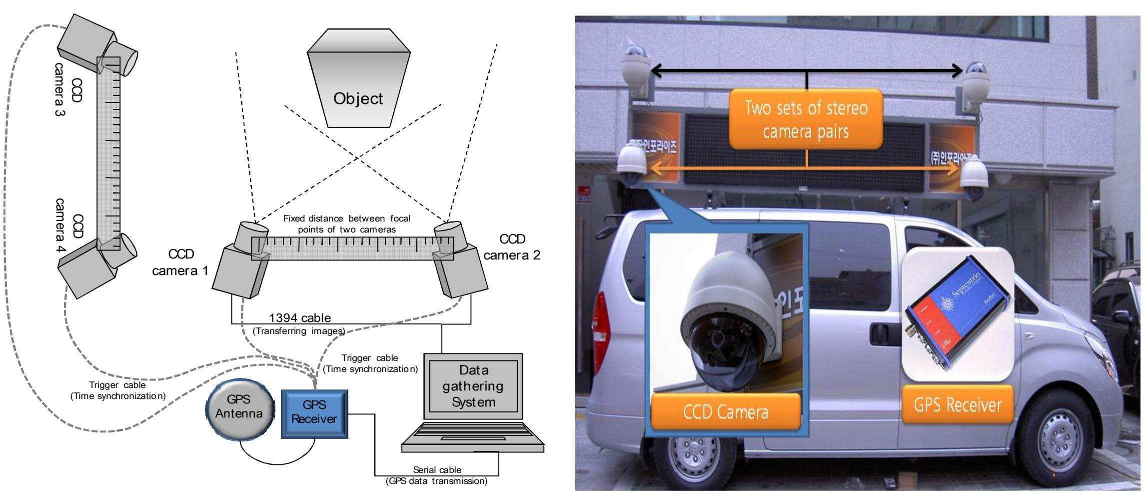

Figure 2. The compositions of the system (two pairs of CCD cameras, one GPS, one laptop computer)

The process of gathering images and size measurements for sign-boards is described in Figure 3.

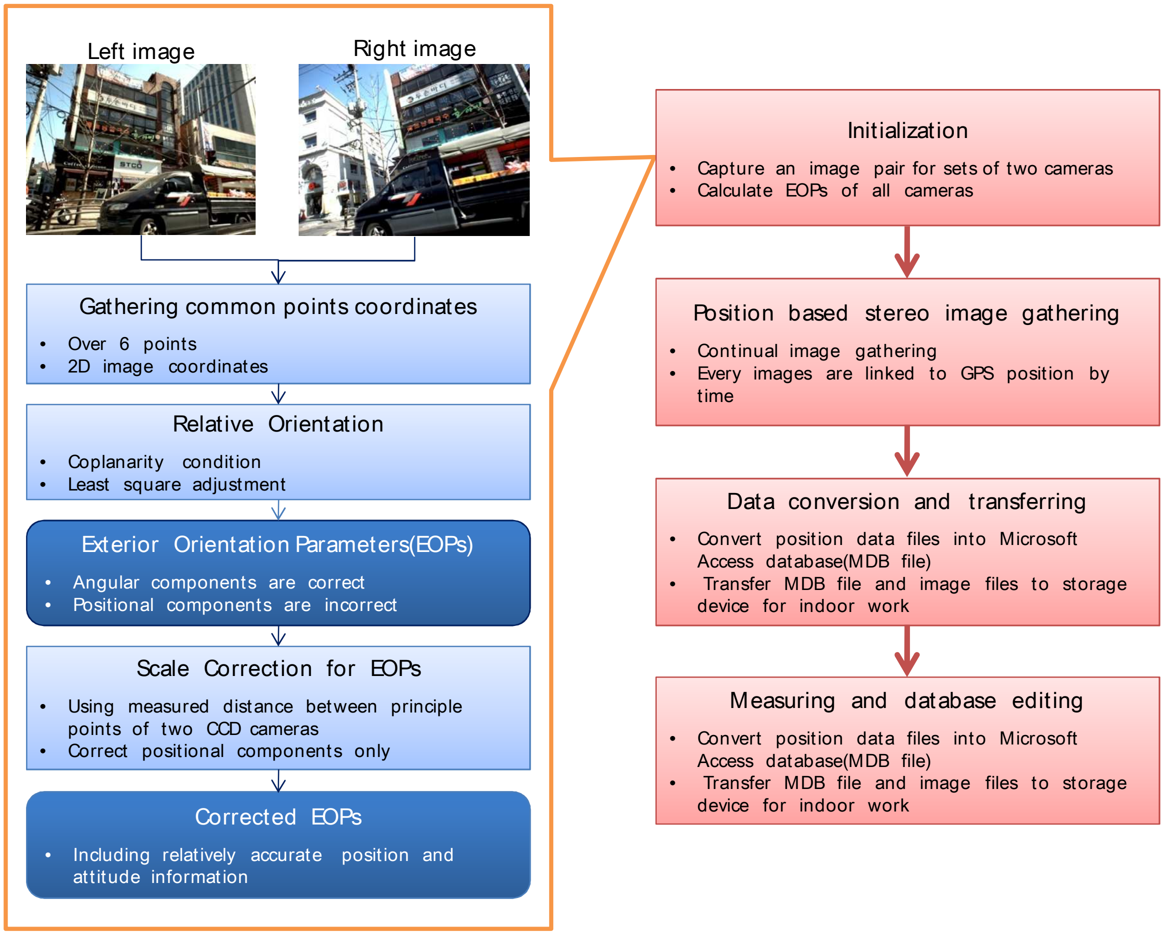

Figure 3. The process of gathering images and measuring size of sign-boards

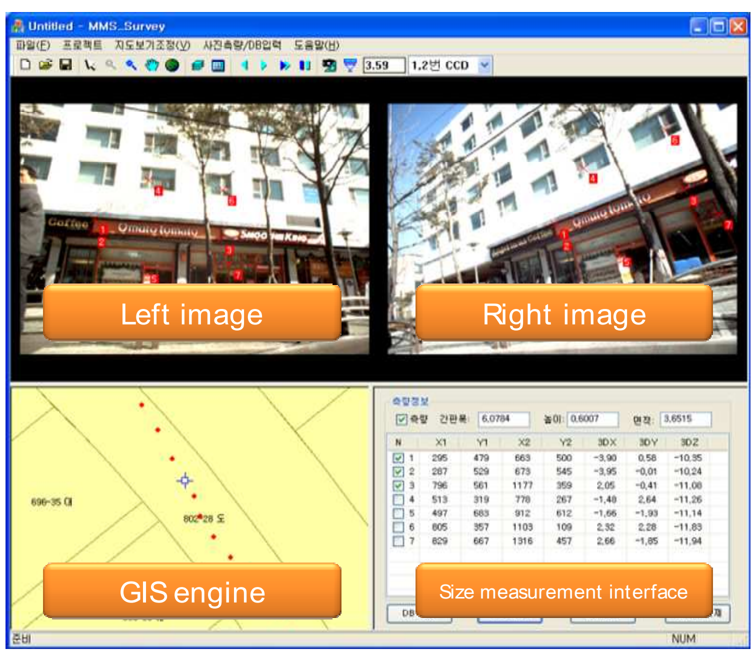

Figure 4. The interface of software for size measurement and DB editing

4. ACCURACY EVALUATION

To test the accuracy of developed close range photogrammetric model and the performance of the system we have done two kinds of test, laboratory test and field test. The results of laboratory test are described in Table 1. It is showing the size measurement errors varies with angular separation and distance between object and camera.

Table 1. Accuracy evaluation results of laboratory test

Check lines on 5m distance		Errors at each angular separation					
Line number	Length	15deg	20deg	25deg	30deg	35deg	40deg
①	50cm	0.5cm	0.7cm	0.4cm	0.4cm	0.5cm	0.4cm
②	60cm	0.2cm	1.0cm	0.2cm	0.4cm	0.7cm	0.5cm
③	35cm	0.2cm	0.6cm	0.2cm	0.2cm	0.3cm	0.2cm
Average		0.3cm	0.8cm	0.3cm	0.3cm	0.5cm	0.4cm
Check lines on 7m distance		Errors at each angular separation(absolute value)					
Line number	Length	15deg	20deg	25deg	30deg	35deg	40deg
①	50cm	1.4cm	0.9cm	1.8cm	1.6cm	1.6cm	1.2cm
②	60cm	1.5cm	1.0cm	1.8cm	1.7cm	1.6cm	1.3cm
③	35cm	1.3cm	1.0cm	1.0cm	1.2cm	0.7cm	0.8cm
Average		1.4cm	1.0cm	1.5cm	1.5cm	1.3cm	1.1cm

In case of field test the amount of size measurement errors were about 30cm at 50m corridor and the errors increased in proposition to the distance between object and camera.

5. CONCLUSION

As a result of the research we found that the model we developed for the size measurement of object – especially for sign-boards – is very accurate and the system of least components and low-price is adequate for field work.

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