A RESEARCH AND DEVELOPMENT OF NON-CONTROL DIGITAL CLOSE-RANGE PHOTOGRAMMETRY

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ABSTRACT:

The system-“non-control digital close-range photogrammetry system” researched in this paper is a new-style measuring system. It integrates with GPS, electronic theodolite, metric camera, Personal Digital Assistant (PDA) and other hard equipments. Matched data processing center, we can acquire information of targets such as position, texture, attribute more quickly. This system is an upgrade of the traditional ground photogrammetry operation mode, and will be expected to fill up the blank of the incorporate machine for domestic ground (close-range) photogrammetry.

1. INTRODUCTION

As is well known that the development of device plays a leading role in the field of photogrammetry, however the corresponding technologies and processing methods are relatively lagging behind.

The instrument connecting the camera and the electronic theodolite used in topographic surveying had arisen in 1970s, however these instruments were phased out entering into the digital photogrammetry era. In 1990s, Carl Gravel et al. developed a computer assisted photogrammetry system (CAPS), in which a digital camera was installed on the stent of the total station horizontal level, so that the camera was incapable to be vertical rotating along with the collimation axis. The photo total station(PTS) developed in 2005 by Zhang Zu-xun is a supplement digital close-range photogrammetry for China. A mechanical link part is used to fix a digital camera on the total station collimation axis and composing a rigid body with a total station telescope. The offset between the camera and the total station was measured by a particular calibration bar[1].

The disadvantage of these referred instruments is using the control/detail separate surveying method, which is not taking advantage of GPS to solve the positioning and controlling problem together.

Hence, this paper proposed a new-style non-control digital close-range photogrammetry system to solve the problem. This system can fill up the existing instruments’ deficiency and the gap of the incorporate machine for domestic ground (close-range) photogrammetry.

2. SYSTEM DESIGN CONCEPT

2.1 System Composition

The Non-control digital close-range photogrammetry system researched in this paper makes use of GPS positioning technology, close-range photogrammetry technology and computer vision technology synthetically. The system consists of the matric camera, Global Positioning System (GPS), the electronic theodolite, Personal Digital Assistant (PDA) , the tripod and other assistant tools. Its structure is shown in Figure 1:

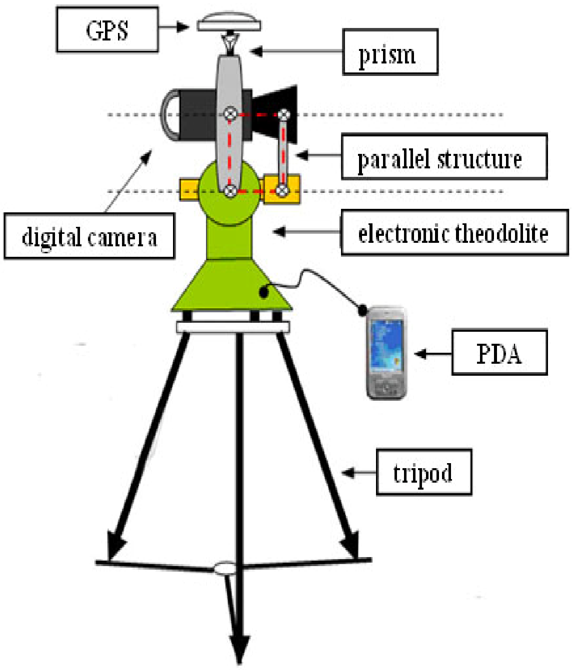

Figure 1. Non-control digital close-range photogrammetry system

2.2 Design Concept

The whole designing idea is: First of all, The position coordinates, camera pose, object images and object attribute information can be obtained by the DGPS technology, goniometrical function of electronic theodolite, camera and PDA respectively. Secondly, the observation data is processed as interior work to get calculate elements of exterior orientation,

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then object points coordinates can be get by the one-step direct calculation method with photogrammetry. Finally, we use object points coordinates to construct buildings, and then restore its real texture, thus 3-dimensional simulation modeling of buildings is completed.

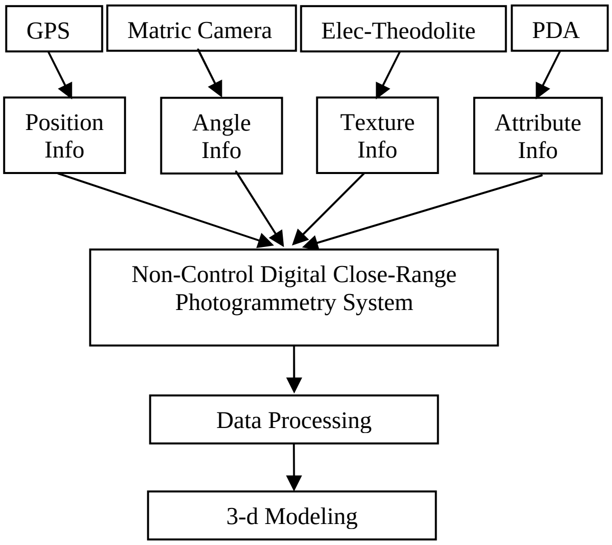

Figure 2. Non-control digital close-range photogrammetry system schematic diagram

2.3 Integration Key Technology

Considering that the camera itself does not have the goniometrical function, so how to determine the pose information when the camera is working becomes a key problem in integration system. For solving the problem, a parallelogram synchronization gearing structure fixed in the camera objective lens and theodolite telescope respectively, is designed as well as being tested. When one end has a movement, the corresponding end has a consistent motion along with it, its parallel structure is invariable。Therefore, the camera will be able to ensure synchronous rotation with the theodolite, and the angle measured by theodolite is equal to the angle which the camera rotates.

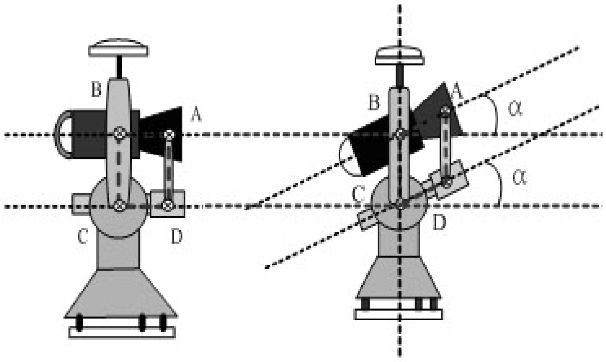

Figure 3. Parallelogram synchronization gearing structure schematic diagram

After the system integration, it should satisfy that:

1) Guaranteeing that it will not appear the displacement transfinite each other, and meanwhile the displacement offset tends to constant as possible.

2) Considering that it should have expansibility when integrated. Such as embedding a prism between the camera and GPS, easy to late data check.

3) Reciprocal connection devices should use light metal, easy to carry.

4) It is not complete rigid body after instruments integration, it can dismantle an independent individual, easy to acquire and process alone. Such as the camera may photography alone, may determine inner orientation elements alone; the electronic theodolite may do some examine and emendate alone and download data; GPS may work independently, may introduce or derive data.

5) GPS is located in the top of the whole system when integrating, so should fully consider the horizontal and vertical position of GPS antenna. Because when we process the signal data receiving by GPS, it is the phase center's coordinate of GPS antenna, but not the geometric center of GPS antenna. Thus, the system's integration should consider eccentricity correction of GPS antenna.

2.4 Work Flow

According to the principle of close-range photogrammetry, stereo images are the foundation of the analytical aerotriangulation, which we can acquire by using the matric camera to photography the same object in two different location of ground.

Non-control digital close-range photogrammetry system’s work flow mainly includes three parts: preparation work, field surveying acquisition and interior work.

But traditional close-range photogrammetry needs control/detail separate surveying, and finally uses common camera to acquire texture. The newly arisen laser scanner is so expensive that is difficult to form scale. The traditional technological process is shown in figure 4:

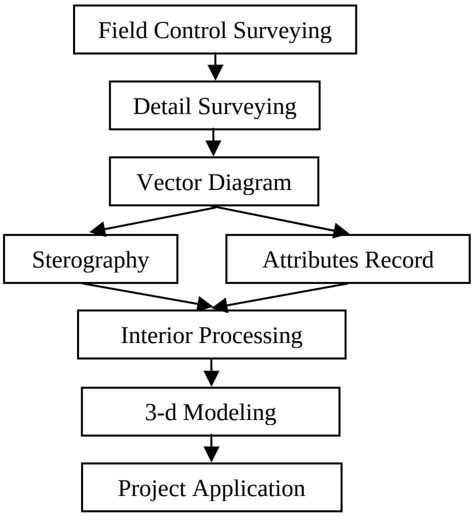

Figure 4. The traditional technological process

Compared with the traditional technological process, the new system also uses some new technologies. Such as graph 5, where the red pane part is not involved in traditional technological process.

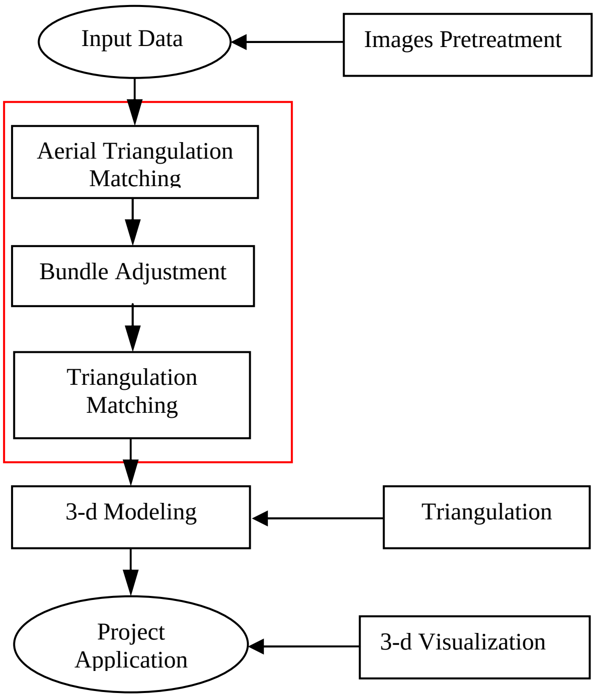

Figure 5. The comparison of the traditional technological process and new technological process

Compared with traditional work flow, this system has more advantage, mainly displays in:

1) Real-time positioning. Traditional method is through control/detail separate surveying point coordinates transfer, not only increases working time and funds, but also more important produces error accumulation by coordinates transfer. This system can position disposable positioning, reduces coordinates transfer and improves system's precision;

2) Diversity positioning. It may use a high precision network RTK operation mode, also may use differential positioning operation mode;

3) It can realize accurate matching of short baseline, multi-image, high automation. Traditional operation mode is subjected to the restriction of baseline length, that can not too short, so in some extent restrict the development of traditional photogrammetry in close-range photogrammetry;

4) Improving efficiency. Traditional close-range photogrammetry procedure is complex, it must consider the distance of the object being shot. This system uses matric camera, in some extent will weaken the effect;

5) Realizing non-touch surveying and mapping. We can not layout controls in the surface or around of objects, directly use images to carrying out photogrammetry, and realize real surveying and mapping.

3. EXPERIMENTAL ANALYSIS

In order to verify the measuring accuracy of integrated system, we established a special calibration field and laid 9 known control points. Using this system, we carried out a photogrammetry on the calibration fields. Some parameters are given as table 1:

integrated camera	Rollei d7
focal length	7mm
pixel	1,000,000
photographic distance	50 meters

Table 1. The camera parameters

The accuracy of measuring points are shown in Table 2,3,4, where X, Y, Z are known control points coordinates, X', Y', Z' are coordinates obtained by photogrammetry △**x,** △**y**, △**z** are the differentials between X, Y, Z and X', Y', Z'.

X	X'	△**x**
4418899.560199	4418899.5693	-0.009
4418899.582962	4418899.5790	0.004
4418899.581086	4418899.6473	-0.066
4418899.559981	4418899.5358	0.024
4418899.575842	4418899.5239	0.052
4418899.559886	4418899.5840	-0.024
4418899.588384	4418899.6484	-0.060
4418899.564724	4418899.4960	0.069
4418899.575567	4418899.5488	0.027

Table 2. The difference between X and X'

Y	Y'	△**y**
-436263.266573	-436263.3448	-0.078
-436260.712698	-436260.7689	-0.056
-436260.674658	-436260.6949	-0.020
-436263.240997	-436263.297	-0.056
-436260.690621	-436260.6759	0.015
-436263.240536	-436263.2535	-0.013
-436260.673415	-436260.6073	0.066
-436263.233272	-436263.1888	0.036
-436260.700426	-436260.6096	0.091

Table 3. The difference Y between and Y'

Z	Z’	△z
79.872362254	79.9424	-0.070
77.18244432	77.2688	-0.086
74.455180572	74.5137	-0.059
74.438227564	74.4564	-0.018
71.734683973	71.7519	-0.017
69.024122769	68.9579	0.066
66.350015471	66.3003	0.050
63.618518274	63.5326	0.086
60.933201491	60.8459	0.087

Table 4. The difference between Z and Z’

As shown in these tables, the biggest differential value and smallest are 6cm and4mm respectively in terms of x-axis direction, while in y-axis direction they are 9cm and 1cm correspondingly. However, the accuracy in z-axis is worse than those of in plane direction, all of them are less than 10cm yet. To explain this result, mainly have two aspects:

1) The error is coming from machine processing which leads to the electronic theodolite and camera asynchronous. Since this fact, there is a deviation between the real camera rotation degree and observed value .

2) The error is coming from eccentric magnitude correction which leads to the camera,electronic theodolite and GPS not coaxial, so effects positioning precision.

4. APPLICATION DEMONSTRATION

Taking a group of high building as a example,this paper studies non-control digital close-range photogrammetry system's operation characteristics.

First of all, according to photographic objects and surrounding environment, to determine photographic baseline, to make photographic program, then to do field surveying;

Secondly, to make data pretreatment, to solve GPS data, to check images overlap in order to remarking;

Then, making interior work data processing, and using one-step direct calculation to obtain object points coordinates;

Finally, making 3-dimensional modeling and roaming display by AutoCAD, Multigen Creator, Multigen Vega et., completing 3-dimensional modeling of the whole demonstration area, its effect is shown in figure 6.

Figure 6-1. Front

Figure 6-2. Left

Figure 6-3. Back

Figure 6-4. Right

5. CONCLUSION

The paper identifies a non-control digital close-range photogrammetry system’s design concept, and verifies its precision through practical example. The result indicates that the centimeter level accuracy of positioning may use 1:500 large scale plotting directly. The advantages of convenience and integrative gathering way can enhance the work efficiency of field work significantly and reduce the production period. Since the lower cost of equipment and production of the system proposed in this paper, they are easier to be mass production comparing to the expensive three-dimensional laser scanner system. Last but not the least, the application of the system can be achieving the visualization, digitization and information requirements in these fields, such as digital city construction, 3 dimensional simulation system, the protection of heritage architecture, precision industrial devices measuring, traffic accidents, engineering construction, etc. As a result, it will have a promising market future.

Main research results are as follows:

1) It is the first time to bring forward the new terrestrial photogrammetry — Non-control digital close-range photogrammetry system and last accomplish integration.

2) The field work model and data acquisition flow is provided. And the data disposal that suits the system is also provided.

3) The collinear equation model that suits this system is also brought forward. And with it we can easily work out the elements of exterior orientation.

4) This article carries through the analysis of data precision and brings forward the means of evaluation of precision.

5) It provides means and ways for some domains such as digital city construction and accident scene investment. With this system, it increases of efficiency and is more visual.

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