Development of Optimized Geomatic System for Digital Close Range Photogrammetry

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ABSTRACT

In this research an integrated Geomatic system are developed. This system called (Camera Total Station System) "CTSS" which installs a digital camera on Total Station with a control system to compose an integration Geomatic system together with digital photogrammetric software. The whole process includes two stages: field survey and photogrammetric processing.Asteropair is exposed by a (Cannon EOS500D) digital camera with a resolution of 15 mega pixels.

Four computational tests have been made by using software Leica Photogrammetric Suite (9.2) to compute 3Dcoordinates of the object points besides the adjusted exterior orientation parameters .The results show high accuracy computed dimensions compared with the actual one. The results are very promising (±0.1mm).

Keywords: Digital close rangePhotogrammerty,Camera Total Station System(CTSS),Control System.

استحداث نظام جيوماتيك (مساحي) بأعلى اتقان ممكن في المسح التصويري الرقمي ذو المدى القريب

الخلاصه

في هذا البحث تم استحداث نظام جيوماتيك (مساحي) الذي تم فيه نصب كاميرا رقمية على جهاز المحطة المتكامل (Total Station) مع نظام سيطرة (Control System) حتى يشكل نظام متكامل مع برنامج التصوير الرقمي. تتضمن العملية مرحلتين: المسح الحقلي مع عمليات التصوير. تم التقاط زوج مجسم من الصور بواسطة كاميرا رقمية نوع (Cannon Eos500D) بقدرة تميز (15 mp). اجريت اربعة اختبارات فحص حسابية لحساب الاحداثيات الثلاثية الابعاد للنقاط بالاضافة الى عناصر التوجيه الخارجي المصححة.اظهرت النتائج دقة عالية للابعاد المحسوبه مقارنة مع الحقيقية. وكانت النتائج واعدة جداً (± 0.1 ملم).

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INTRODUCTION

Photogrammetry is a measurement technique, where the coordinates of the points in 3D of an object are calculated by the measurements made in two photographic images (or more) taken from different positions. Digital close-range Photogrammetry is a measurement technology which is used to acquire 3D spatial information about an object that is captured on the images. By this means, this technology derives measurements from digital images, rather than measuring the object straight [2]. One of the important current developments in digital close range photogrammetric systems is the full automation of the measuring process. The systems range from low accuracy (or low end) to high accuracy (or high end). Photogrammetry provides several kinds of digital products such as maps, digital elevation models and orthoimages. Due to this capability, digital close-range Photogrammetry is appropriate for a variety of applications, ranging from industry to archaeology, monitoring issues [3].

Camera Total Station System(CTSS) Components

The system consists of following parts:-

1. Digital camera type(Cannon EOS500D).
2. Total Station (LeicaTCR 405).
3. Labtop computer.

Figure (1) Digital Camera Total station Laptop

EXPERIMENTAL WORK

Designing a Model for (CTSS)

A model is designed for connecting the camera (Cannon EOS 500D) with the Total Station Leica (405). This model consists of the following:

Base

A circular base made of Teflon material is manufactured. It is connected below the camera by screws as shown in figure (2).

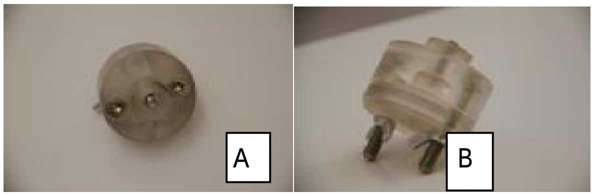

Figure (2) (A) is the top view of the base, (B) is the back view of the base

Holder

Ametal holder is manufactured; it is fixed on the Total Station device by its screws and connected to the circular base that is connected with the camera as shown in figure (3).

Figure (3) The Holder.

Finally, the holder is connected, it is fixed on the Total Station with the base that is connected with the camera to get the Camera Total Station System (CTSS) is connected as shown in figure (4).

Figure (4) the Camera Total Station System (CTSS).

MANUFACTURING CONTROL SYSTEM

The control system is the main issue and it can provide an excellent distribution of control points and it consists of the following parts:

Rulers

Rulers are manufactured, they made of aluminum material and are listed on a regular basis with centimeter and inches on both sides of the length of one meter as shown in figure (5).

Figure (5)The Ruler.

Models

Two models are manufactured, they are made of aluminum in the form of cross and both models have four arms of equal lengths for holding the rulers as shown in figure (6).

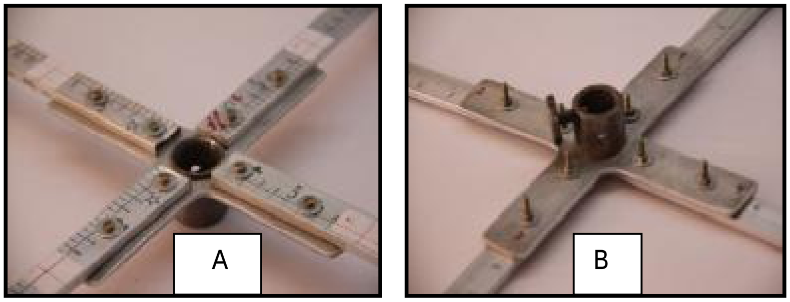

**Figure (6) (A) is the top view of the model,
(B) is the back view of the model**

Base

A base is manufactured; it is on the form of a cube made of aluminum material for the purpose of connecting the models with the tripod, as shown in figure (7).

Figure (7): The Base.

Shaft

A shaft is manufactured made of aluminum material passing through the base fixed on tripod and connected with both models as shown in figure (8).

Figure (8): The shaft.

Finally, two models are connected by the shaft passing through the base to get the complete control system as shown in figure (9).

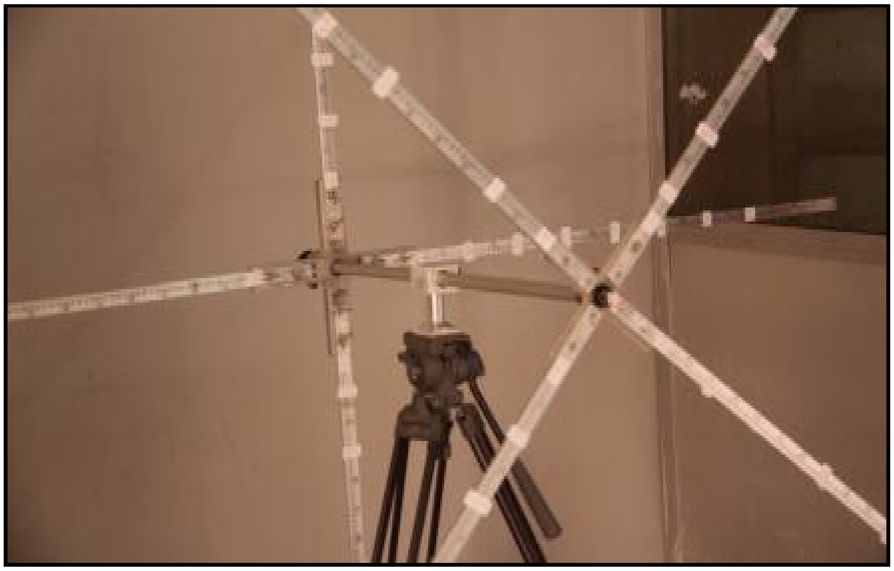

Figure (9): The complete control system.

Select the shapes and measure their lengths

The lengths of selected shapes are measured (as shown in figure (10) by a vernia as shown in table (1).

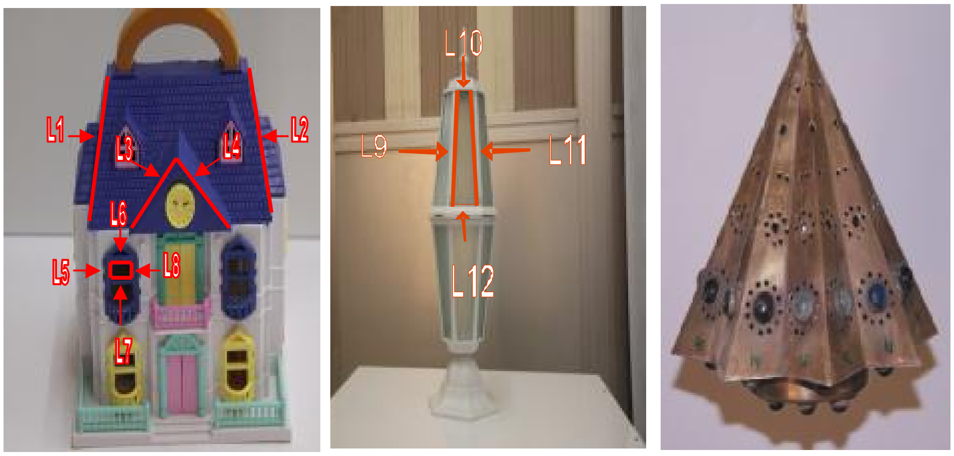

Figure (10): The Shapes.

Table (1) Actual lengths of the Shapes.

Length	Value (cm)
L1	7.2
L2	7.2
L3	5.3
L4	5.3
L5	0.9
L6	1.6
L7	1.6
L8	0.9
L9	14.6
L10	7.2
L11	14.6
L12	7.2
L13	4.3
L14	4.3

LABORATORY EXPERIMENTATION

The steps of this experiment can be summarized as follows:

The solid shapes are placed (which represent the photographed objects) within the control system, then determining the position of the second station for orientation, and checking the distance between the two stations by a tape.

Then connecting the camera with the Total Station to get CTSS, and making centering using zoom and focus in order to get the best photo. Then taking two sequential shots at the first station without touching anything except the shutter button. The photos are covering the whole shapes. then observing the stickers of the control system by the Total Station in the first station. Then Moving the CTSS to the second station. At last taking two sequential shots by the camera without touching anything except the shutter button.

Figure (11): Photo (1) Photo (2) observation by CTSS.

MEASURED 3D COORDINATES OF THE CONTROL POINTS

The stickers of the control system have been measured by the Total Station at the first station as shown in figure (12) and the 3D coordinates of these control points are tabulated as shown in the table (2).

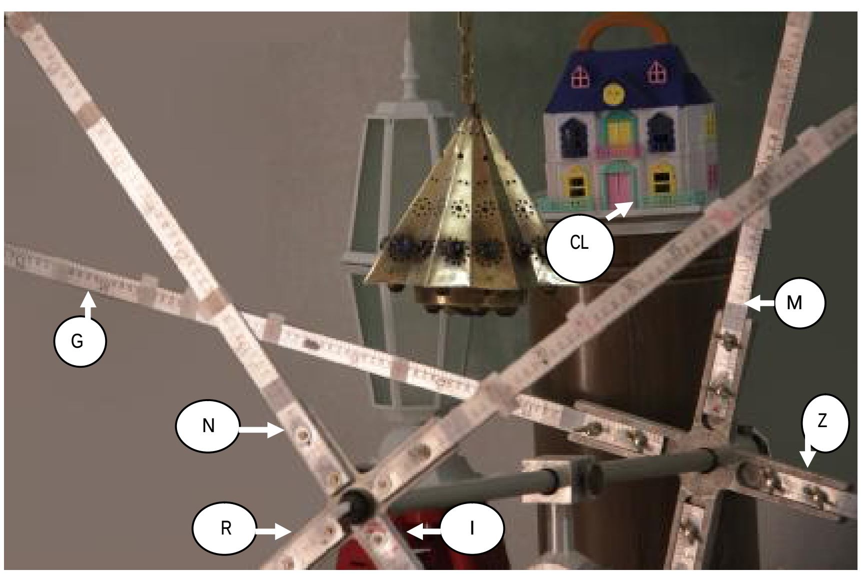

Figure (12) the rulers of the control system.

Table (2) Measured 3D coordinates of the Control Points.

Point ID	X(m)	Y(m)	Z(m)
O2	99.999955	104.62244	9.984937
CL1	95.306486	102.21187	11.342076
G10	95.404648	102.19126	11.138891
G20	95.402790	102.09523	11.164514
G30	95.404950	101.99741	11.189082
G45	95.405975	101.85209	11.227003
G55	95.406558	101.75503	11.251960
G60	95.407177	101.70697	11.265217
G70	95.409096	101.60894	11.290063
G80	95.408932	101.51240	11.314582
M10	95.403248	102.36963	11.237682
M20	95.408210	102.38966	11.334029
M40	95.399116	102.41652	11.432012
M80	95.385965	102.53550	11.917827
N10	96.097041	102.28337	11.219124
N20	96.096670	102.22819	11.301078
N40	96.104550	102.11107	11.465166
N80	96.121729	101.87789	11.792153
R10	96.107663	102.25256	11.048331
R80	96.160242	101.70078	10.617882
I10	96.098629	102.41753	11.023680
I80	96.076764	102.83755	10.462955
F10	96.089108	102.44980	11.186870
F80	96.042228	103.01544	11.595362
Z10	95.406852	102.48511	11.052807
Z80	95.400892	103.16388	10.874230

Computed 3D Coordinates of the Control Points
By using the following equations :-

$$X_{k=X_i} + \left(\frac{D_{ik}}{D_{ij}}\right) \times \Delta x_{ij} \qquad \ldots (1)$$

$$Y_{k=Y_i} + \left(\frac{D_{ik}}{D_{ij}}\right) \times \Delta Y_{ij} \qquad \ldots.. (2)$$

$$Z_{k=Z_i} + \left(\frac{D_{ik}}{D_{ij}}\right) \times \Delta Z_{ij} \qquad \ldots. (3)$$

Table (3) Computed 3D Coordinates for the Control Points.

Point no.	Easting X(m)	Northing Y(m)	Elevation Z(m)
G5	95.404342	102.23975	11.126342
G6	95.404403	102.230052	11.128852
G12	95.404770	102.171864	11.143911
G13	95.404832	102.162166	11.146421
G14	95.404893	102.1523468	11.148930
G15	95.404954	102.14277	11.151440
G16	95.405015	102.133072	11.153950
G22	95.405382	102.074884	11.169009
G24	95.405505	102.055488	11.174029
G25	95.405566	102.045790	11.176539
G26	95.405627	102.036092	11.179049
G27	95.405688	102.02639	11.181588
G28	95.4057496	102.016696	11.184069
G56	95.407463	101.745152	11.254364
G57	95.407524	101.735454	11.256855
M5	95.404483	102.357782	11.189100
M6	95.404236	102.260152	11.198817
M12	95.402754	102.374369	11.257115
M13	95.408191	102.376739	11.266831
M26	95.399298	102.407543	11.393144
M27	95.399051	102.409913	11.402860
M28	95.398804	102.412282	11.412576
M31	95.398063	102.419391	11.441726
M32	95.397816	102.421761	11.451442
M33	95.397569	102.424130	11.461158
M34	95.397322	102.426450	11.470875
M35	95.403253	102.428869	11-480591
N44	96.109032	102.086423	11.497452
N45	96.109385	102.080063	11.505639
N46	96.109737	102.074837	11.513825
N47	96.110090	102.069045	11.52201
N48	96.110443	102.063252	11.530197
N50	96.111148	102.051667	11.546569

THE TESTS RESULTS

We examined the accuracy of the result based on the computed lengths of the selected shapes by using the 3D coordinates of the object points resulted from the LPS program[8].

The First Test

In this test we use eight selected points as shown in figure (13).

Figure (13) photo for the first test.

And the computed lengths in the table (4)

Table(4)Computed lengths of the First test.

No.	Length (cm)
L1	7.1
L2	7.3
L3	5.5
L4	5.2
L5	0.8
L6	1.4
L7	1.5
L8	1.0
L9	14.51
L10	7.1
L11	14.5
L12	7.4
L13	4.39
L14	4.2

The Second Test

In this test we use ten selected points as shown in figure (14).

Figure (14) photo for the second test.

And the computed lengths in the table (5).

Table (5) Computed lengths of the Second Test.

No.	Length (cm)
L1	7.15
L2	7.26
L3	5.35
L4	5.24
L5	0.95
L6	1.65
L7	1.55
L8	0.85
L9	14.56
L10	7.25
L11	14.65
L12	7.15
L13	4.34
L14	4.25

The third test

In this test we use twenty four selected points as shown in figure (15).

Figure (15) photo for the third test.

And the computed lengths in the table (6).

Table (6) Computed lengths of the third Test

No.	Length (cm)
L1	7.22
L2	7.18
L3	5.33
L4	5.28
L5	0.11
L6	1.57
L7	1.58
L8	0.92
L9	14.62
L10	7.18
L11	14.16
L12	7.22
L13	4.28
L14	4.29

The fourth test
In this test we use thirty eight selected points as shown in figure (16).

Figure (16) photo for the fourth test (8)

And the computed lengths in table (7).

Table (7) Computed lengths of the Fourth test.

No.	Length (cm)
L1	7.19
L2	7.21
L3	5.32
L4	5.29
L5	0.91
L6	1.58
L7	1.61
L8	0.89
L9	14.61
L10	7.19
L11	14.61
L12	7.19
L13	4.29
L14	4.31

RESULTS AND DISCUSSION

After using the coordinate points resulted from the LPS program in each test and comparing them with the actual lengths, the accuracy is increased by the increase of the number of the control points used in the tests and we reach to ±0.1 mm in the fourth test.

Table (8) the overall accuracy of the four tests for the laboratory experimentation

Test No.	Accuracy (mm)
Test I	1.0
Test II	0.5
Test III	0.2
Test IV	0.1

CONCLUSIONS

In this research we presented an optimized system Camera Total Station System (CTSS), which is an integration of digital photogrammetric technique(camera) and high accurate engineering surveying equipment (total station). CTSS is much more labor saving, efficient and automatic.

The designed control system contains enough control points fixed on the rulers of the system and having a large coverage field this system minimizes the number of observations by the Total Station by observing only two points on each ruler, therefore it is an important technique in close range photogrammetry.

REFERENCES

[1]Kersten, T. and H. G. Mass (1995). Photogrammetric 3-D point determination for dam monitoring. Optical 3-D Measurement III, Eds. Gruen/Kahmen, Wichmann Verlag, 161-168.

[2] DERENYI, E. E. "**photogrammetry: The Concepts",** 1996.

[3]Sharqi, M., M., (2002). Accuracy Assessment of Digital & Analytical Close Range Photogrammetric Techniques, MSc. Thesis, College of Engineering, Baghdad University

[4]Sheng-ju, J., (2003). Spatial Location on City 3D Modeling with Close Range Stereo Images, Remote Sensing Research Center of Tongi University, Shanghai, China.

[5] Heikkinen, J., (2005). The Circular Image Block in Close Range Photogrammetry, Doctoral Thesis, Helsinki University of Technology, Espoo, Finland, 2005.

[6]Remondino, F., (2006). Image-Based Modeling or Object and Human Reconstruction, Doctoral Thesis, Aristoteles University, Thessaloniki, Greece, Zurich. S. Ikeda, T. Sato, N. Yokoya, 2003, A calibration method for an omnidirectional multi-camera system, IS&T/SPIE's 15th Annual Symposium on Electronic Imaging, 20-24 January 2003, Santa Clara, California, USA

[7]Kavanagh, B. F. and Glenn Bird, S. J. (1996). Surveying principles and applications (4 editions). Prentice Hall. pp. 257–264.ISBN 0-13-438300 1.

[8]ERDAS, Inc., (1999). ERDAS IMAGINE Version 8.4 OrthoBASE Tour Guide, Atlanta, Georgia USA.