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Production of Three Dimension Model by Using Agisoft and Matlab Program

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Abstract— Close range Photogrammetry is an important topic in surveying engineering and heritage documentation, which preserves archaeological heritage in general by creating three-dimensional models, so a study was prepared on this topic. With the progress of three-dimensional modelling from digital images, many programmers have emerged to analyze digital images for technical applications that require high accuracy. For this purpose, this study is based on two methods to calculate three-dimensional coordinates (x, y, z) using MATLAB programs, where a special code has been prepared for ground monitoring and photogrammetric surveying operations. The second method relies on Agisoft for three-dimensional modelling and calculating three-dimensional coordinates (x, y, z). This study discusses the positional accuracy obtained from the code using MATLAB and the selection of the optimal method among the methods available in this study. The study area was selected as "Al-Mustafa Mosque" located in Al-Jadriya area of Al-Nahrain University, and a digital image of the model was taken using a Nikon D750 camera with 90 % coverage. A Topcon ES-105 total station was used to measure the position of the exposure stations and ground control points, which were six ground control points distributed over the study area. After calculating the root mean square error (RMSE) of the two methods, it was concluded that the second method gives a higher accuracy (±0.088m) than the first method, which is the use of direct linear transformation (±0.464m), which is the accuracy of the coordinates of the fixed points on the model based on the value of the root mean square error (RMSE).

Keywords— Close range Photogrammetry, Three-dimension model, RMSE, Agisoft, Matlab.

1. Introduction

Use of drones to monitor, analyze, and detect hazards in large open archaeological areas. Cultural heritage needs regular monitoring and restoration to ensure its preservation. Due to the high level of accuracy and reliability required for the measurements, surveying, photogrammetry, and geospatial professionals are typically at the forefront of such monitoring. "In recent years, valuable cultural heritage sites have been deliberately destroyed or demolished in countries such as Syria and Iraq"[4, 13, 8]. Two different methods were used in this study to evaluate the product of the three-dimensional (3D) model and the calculated coordinates. The first method was to create a close-up photograph using a Matlab program and the Direct Linear Transformation (DLT) mathematical model. The second method used in this study was to create a three-dimensional (3D) model and use Agisoft Photoscan to calculate the ground coordinates. A stand-alone software program called Agisoft Photo Scan processes digital photographs photogrammetrically and produces 3D spatial data that can be used for indirect measurement of objects of different sizes, GIS applications, cultural heritage documentation, and visual effects creation [10, 14, and 15]. Flow chart for Agisoft procedure as shown in (Figure 1).

Figure 1: Flow chart Agisoft procedure.

2. Methodology of the reserch

Due of its additional religious and spiritual significance to the local population, mosques, churches, and shrines rank highest on the list of heritage items that require attention [5, 11].

2.1 *Choice of research area*

One of the university's monuments, the AL-Mustafa Mosque at Al Nahrain University, serves as the the mosque, along with the other university buildings, was designed in 1958 and opened in the 1980s. A watercourse, part of a stream that runs around the university, surrounds the mosque, which is a massive dome supported by just three pillars. Study area (Figure 2).

Figure 2: AL-Mustafa mousque (Study area)

2.2 *Preparation of ground control points*

The total station (Topcon ES-105) is an electronic/optical instrument used in modern surveying and building construction. (EDM) is used for reflector less distance measurement with high accuracy and is part of the ES series. In a pre-planned network, the coordinates of the control points and baselines are determined with high accuracy using total station instruments [5, 2]. Select several points on the model to serve as control points and use a total station to measure the coordinates of the points in the presumed coordinate system. To consistently verify the accuracy of the orientation and the generated point cloud, more control points must be added [11, 7]. The ground coordinates of these points are given in (Table 1).

2.3 *Preparing the image*

Image-based methods are used to apply photogrammetric approaches. The accuracy of these methods [10, 5] varies from centimeters to sub-centimeters, depending on the type of camera, the preplanning of the image network, the accessibility of the object, the lighting, etc. After measuring the control and check points, several digital images of the model were taken using a Nikon 750 digital camera at a height of 1.85 meters. The focal length of the camera was 70 mm. The two methods used in this study take advantage of these digital images (Figures 3, 4).

Tabel 1: Ground Control Points.

Point	N(m)	E(m)	Z(m)
1	81.044	186.735	35.836
2	77.756	182.281	35.773
3	76.983	182.953	39.210
4	78.664	184.984	39.202
5	80.164	187.320	39.168
6	82.008	192.107	39.155

Figure 3: First camera location for the study area

Figure 4: Second camera location for the study

2.4 *Calculation of image coordinates*

By bypassing the intermediate step of converting image coordinates from a reference system to a photo coordinate system, the DLT model - a mathematical model that is used - is based on the idea of direct transformation from image point reference coordinates to object space coordinates [1,6,13]. One of the crucial prerequisites for determining the DLT parameters and the ground coordinates is the digital photo coordinates. The digital photo coordinates were measured for several points in the model using the Photoshop application. The measured coordinates were then converted to the Principal Point (P.P.) system and the measurement of sparse target control points on the surface body points is the basis of this method. The location of these points in the model is shown in (Figure 5).

Figure 5: The location of measured point

2.5 *Setting up the Matlab application*

Several programs have been written for the DLT. These programs are written in Matlab, which makes them easy to view and understand.

2.6 *The Direct Linear Transformation*

The observed ground control points are the input data required to run this program, which uses DLT equations to calculate the ground coordinates. Once the program is running, the 11 DLT parameters, shown in Equation (1) and modified Equation (2), are defined where the ground points are derived from the left and right image coordinates. A flowchart of the developed Matlab program is shown in Figures (6 and 7). Matlab is a powerful language for technical computing. Since the matrix (matrix) is the basic data element in MATLAB, the abbreviation stands for Matrix Laboratory. Mathematical calculation, modeling, simulation, data processing, analysis, graphics, visualization,

And method development can be performed using MATLAB [9, 12, 3].

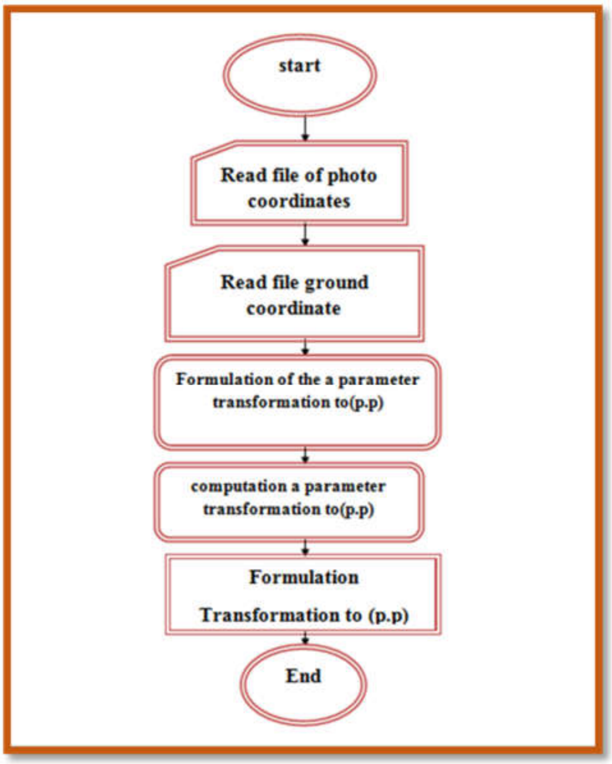

Figure 6: Flow chart for transformationto (p.p)

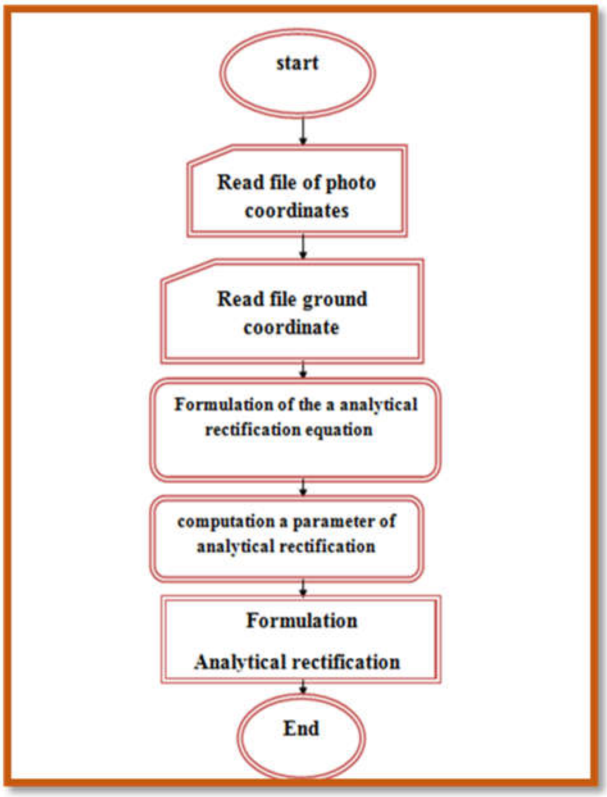

Figure 7: Flow chart for analytical rectification.

$$x = \frac{L_1X + L_2Y + L_3Z + L_4}{L_9X + L_{10}Y + L_{11}Z + 1}; \quad (1)$$

$$y = \frac{L_5X + L_6Y + L_7Z + L_8}{L_9X + L_{10}Y + L_{11}Z + 1}, \quad (2)$$

The ground coordinates calculated from Table 1. Plotting the calculated ground points at the chosen scale is possible once the points in the ground coordinate system have been calculated in this software, as shown in Figure (8).

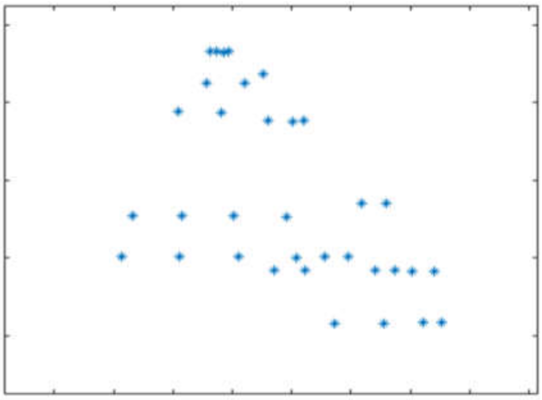

Figure 8: plot to the ground coordinate computed

2.7 *Using the Agisoft program*

Six control locations were selected and their ground coordinates entered when the digital photographs were opened in Agisoft. The 3D modelling process was then completed as indicated [3, 8].

2.7.1 Aligning and adding images

In order to determine the exposure stations, three photographs from the workflow were inserted. And their alignment processed,

2.7.2 Build dens points cloud:

After aligning the camera photos, a dense point cloud was created to determine the three-dimensional coordinates of the model, as shown in Figure (9).

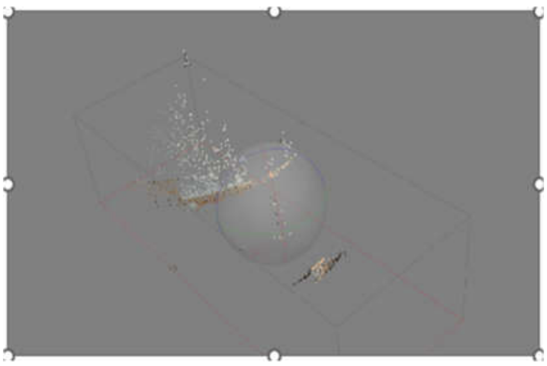

Figure9: Building dense cloud of points

2.7.3 Filtering and building mesh

The ground coordinates calculated from Table 1. Plotting the calculated ground points at the chosen scale is possible once the points in the ground coordinate system have been calculated in this software, as shown in Figure (8).

.The 3D structure of the model is created by creating dens points, cloud building mesh and filtering to remove unnecessary noise, as shown in (Figure 10).

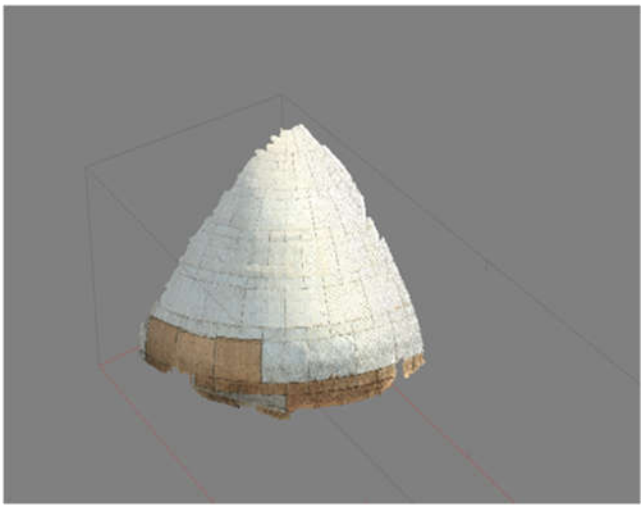

Figure 10: Filtering and Building Mesh.

2.7.4 Measuring coordinates in (Agisoft)

The coordinates of Al-Mustafa mosques have been measured in (Agisoft) to compare them with the coordinate obtained from the Matlab program (figure 11) shows the measurement processes.

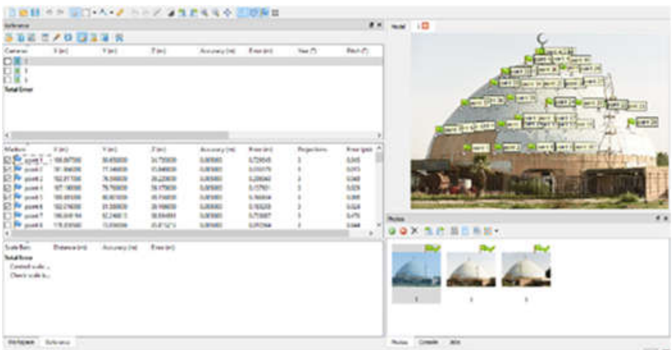

Figure11: Placing markers and calculating ground coordinates.

2.7.5 3D Model production

The final step after measuring the ground points is to create the 3D model by adding texture using Agisoft, as shown in (Figure 12and 13).

Figure 12:3D model for Al-Mustafa Mosque.

Figure 13: Three-dimension Model for Al-Mustafa Mosque.

3. Determining the accuracy of the work.

Five points were selected and the accuracy was calculated using the Root Mean Square Error equation after determining the ground coordinates of the points on the model using the first method, the Matlab program, and the second method, the Agisoft program. The RMSE is presented below [Tables 2, 3].

Table 2 : Calculate (RMSE) of the measured coordinate in Matlab.

Point	Coordinate measured in Matlab		Coordinate measured by total station		ΔY	ΔX
	Ym	Xm	Ym	Xm		
1	81.044	186.733	81.044	186.735	0.002	0.0001
2	77.756	182.282	77.756	182.281	0.002	0.001
3	76.989	182.957	76.983	182.953	0.004	0.007
4	78.615	184.917	78.664	184.984	0.067	0.049
5	80.247	187.472	80.164	187.320	0.152	0.083
RMSE					±0.077	±0.043
Total RMSE					±0.088	

Table 3. Calculate (RMSE) measured coordinate in Agisoft.

Point	Coordinate measured in Agisoft		Coordinate measured by total station		YΔ	XΔ
	Ym	Xm	Ym	Xm		
1	80.658	186.667	81.044	186.735	0.386	0.068
2	77.346	181.966	77.756	182.281	0.410	0.315
3	76.598	182.817	76.983	182.953	0.385	0.136
4	78.760	184.74	78.664	184.984	-0.096	0.242
5	80.801	187.450	80.164	187.32	-0.637	-0.130
RMSE					0.420±	0.199±
Total RMSE					0.464±	

4. Conclusion

The following are the preliminary conclusions drawn from this research:

The Direct Linear Transformation (DLT) approach used in this study demonstrated satisfactory accuracy and suitability for engineering applications in the production of 3D models for archaeological site documentation purposes.

The use of Agisoft software also showed significant advantages in close-range photogrammetry, especially in terms of saving time and effort in producing a 3D model and providing more details for the study area represented by Al-Mustafa Mosque in Al-Jadriya area, University of Nahrain.The Matlab application proved to be an effective tool in programming mathematical equations for close-range photogrammetry to calculate the coordinates (X, Y, Z) of the model.The accuracy of the first model resulting from the use of the Direct Linear Transformation (DLT) equations, represented by the value of (RMSE) calculated root mean square error, was ±0.088.The accuracy of the second model resulting from the use of (Agisoft) software was ±0.464.

This proves that using the first model gives a higher accuracy than the second model through the results (RMSE).

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إنتاج نموذج ثلاثي الأبعاد باستخدام برنامج Agisoft و Matlab

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الخلاصة – يُعتبر المسح التصويري ذو المدى القريب موضوعًا هامًا في هندسة المساحة وتوثيق التراث، حيث يُسهم في الحفاظ على التراث الأثري بشكل عام من خلال إنشاء نماذج ثلاثية الأبعادولهذا قد أُعدت دراسة حول هذا الموضوع. مع تقدم النمذجة ثلاثية الأبعاد من الصور الرقمية، ظهرت العديد من البرامج لتحليل الصور الرقمية للتطبيقات التقنية التي تتطلب دقة عالية. تحقيقًا لهذا الغرض، تستند هذه الدراسة إلى طريقتين لحساب الإحداثيات ثلاثية الأبعاد (س، ص، ع) الاولى باستخدام برامج MATLAB، حيث تم إعداد كود برمجي خاص لعمليات الرصد الأرضي و المسح التصويري. وتعتمد الطريقة الثانية على برنامج Agisoft للنمذجة ثلاثية الأبعاد وحساب الإحداثيات ثلاثية الأبعاد (س، ص، ع). تناقش هذه الدراسة الدقة الموضعية التي تم الحصول عليها باستخدام MATLAB واختيار الطريقة المثلى من بين الطرق المتاحة في هذه الدراسة.تم اختيار منطقة الدراسة "مسجد المصطفى" الواقع في منطقة الجادرية بجامعة النهرين، وتم التقاط صور رقمية للنموذج باستخدام كاميرا Nikon D750 وبتداخل 90%. تم استخدام محطة الرصد المتكامل Topcon ES-105 لقياس مواقع محطات التصوير ونقاط الضبط الأرضي، والتي كانت ست نقاط ضبط أرضي موزعة على منطقة الدراسة. بعد حساب جذر متوسط مربع الخطأ (RMSE) للطريقتين، تم الاستنتاج بأن الطريقة الثانية تعطي دقة أعلى (±0.088) مقارنة بالطريقة الأولى، وهي استخدام التحويل الخطي المباشر (±0.464)، وهي دقة إحداثيات النقاط الثابتة على النموذج بناءً على قيمة جذر متوسط مربع الخطأ (RMSE).

الكلمات الرئيسية – التصوير الفوتوغرامتري ذو المدى القريب، النموذج ثلاثي الأبعاد، برنامج Agisoft وMatlab، RMSE