Protect Digital Elevation Model (DTM) from Aerial Photographs by Using (ERDAS IMAGINE)

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Abstract

The Digital Terrain Model (DTM) is considered a common tool in producing topographic maps, orthophotos and civil engineering projects besides other different engineering applications. As a result, many software packages were developed and used to produce (DTM) from different sources like filed surveys, scanned topographic maps and stereo photos exposed from air or space .

This research is devoted to evaluate the most suitable and accurate in producing digital elevation model from two different sources' the first source is ground surveys for the area north of Iraq (Iraqi Iran borders) by using Global Position System (**GPS**) the second source is the aerial photos. The basic topic is producing Digital Elevation Modal (DEM), and orthorectify images, and how new technique and software in aerial photogrammetry can be useful to produce topographic maps and also, getting idea with detail about what these software need to run aerial triangulation.

The (DTM) has been produced from strip of aerial photos in the North of Iraq (Iraqi Iran borders). Also, the orthometric corrections for these photos have been done so that we can use these images to produce topographic map. The type of the used camera was (Ziess rc10_1975) and the date for these images is 1975, the scale of these photos is 1/30000, and the average of flying height is 4500m above mean sea level.

The software we used in this research was ERDAS Imagine LPS (Lieca photogrammetric system).

Keywords: Photogrammetry- Digital elevation modeling (DEM) - Digital Terrain Models (DTM)- The Production of Photo-Textured DEM- Production of DTM for area study.

انتاج النموذج (DTM) للصور الجوية باستخدام برنامج (ERDAS IMAGINE) الارتفاع الرقمي

الخلاصة

اصبح نموذج الارتفاع الرقمي (DTM) في الوقت الحاضر شائع الاستعمال في مجال انتاج الخرائط الطبوغرافية و مشاريع الهندسة المدنية وبالإضافة الى استخدامه بشكل واسع في المجالات الهندسية الأخرى وكنتيجة لذلك فان العديد من البرامج الجاهزة قد تم تطويرها واستخدامها لانتاج نموذج الارتفاع الرقمي من مختلف المصادر مثل المسوحات الارضية و النماذج المجسمة للصورة الجوية او الفضائية و الخرائط

الطبوغرافية الممشطة وتماشيا مع هذا التوجه فان البحث تناول انتاج النموذج التضاريس الرقمية (DTM) باستخدام برنامج (ERDAS Imagine) ومن مصدرين مختلفين المصدر الاول هو المسوحات الارضية لمنطقة شمال العراق (الحدود العراقية الايرانية) باستخدام GPS والمصدر الثاني الصور الجوية . ولإنتاج نموذج الارتفاعات الرقمية (DEM) من الصور الجوية تم اجراء التصحيحات الاورثومترية لهذه الصور حتى نتمكن من استخدامها لإنتاج الخرائط الطبوغرافية وكان نوع الكاميراالمستخدمة هو Ziess) rc10_1975) وتاريخ هذه الصور هو عام 1975 و مقياسها هو (30000/1) ومتوسط ارتفاع الطيران هو 4500م فوق مستوى سطح البحر وبعد اجراء التصحيح الهندسي عليها وباستخدام برنامج ال (ERDAS Imagine Software LPs). فقد تم دمجها مع النموذج التضاريس الصوري (DEM) ولنفس المنطقة للحصول على صورة ثلاثية الابعاد ذات معالم حقيقية (Photo – Textured DEM)

INTRODUCTION

Photogrammetry is the “art, science and technology of obtaining reliable information about physical objects and the environment through the process of recording, measuring and interpreting photographic images and patterns of electromagnetic radiant imagery and other phenomena[1]. Photogrammetry was invented in 1851 by Colonel Aimé Laussedat, and has continued to develop over the last 150 years. Over time, the development of photogrammetry has passed through the phases of plane table photogrammetry, analog photogrammetry, analytical photogrammetry, and has now entered the phase of digital photogrammetry [2]. The traditional, and largest, application of photogrammetry is to extract topographic information (e.g., terrain models) from aerial images. Photogrammetric techniques have also been applied to process satellite images and close-range images in order to acquire topographic or nontopographic information of photographed objects. Topographic information includes spot height information, contour lines, and elevation data. Planimetric information includes the geographic location of buildings, roads, rivers, and so forth. Digital elevation modeling is one of the modern methods for representing the topographic surface of the terrain, (i.e., how the elevation of the ground surface is changing with position) [3]. The term DEM originally referred to the use of cross sectional height data to describe the terrain. Nowadays, however, the definition is including both grid and non-grid data sets. Several other terms are also used to describe the terrain surface. Among the more common are Digital Elevation Model (DEM), Digital Height Model (DHM), Digital Terrain Model (DTM), and Digital Ground. DTM model is mostly related as raster data type (opposed to vector data type), stored usually as a rectangular equal-spaced grid, with space (resolution) of between 50 and 500 meters, mostly presented in Cartesian coordinate system – i.e. x, y, z (there are DTMs presented in geographic coordinate system – i.e. angular coordinates of latitude and longitude). For several applications a higher resolution is required (as high as 1 meter spacing). A DTM can be used to guide automatic machinery in the construction of a physical model or even in computer games, where is describes the relief map. Modeling terrain relief via DTM is a powerful tool in GIS (Geographic Information System) analysis and visualization. Prior to the invention of the airplane, photographs taken on the ground were used to extract the relationships between objects using geometric principles. This was during the phase of plane table photogrammetry. In analog photogrammetry, starting with stereo measurement in 1901, optical or mechanical instruments were used to reconstruct three-dimensional geometry from two overlapping photographs.. The main product during this phase was topographic maps. [4]

In analytical photogrammetry, the computer replaced some expensive optical and mechanical components. The resulting devices were analog/digital hybrids.

Analytical aerotriangulation, analytical plotters, and orthophoto projectors were the main developments during this phase. Outputs of analytical photogrammetry can be topographic maps, but also can be digital products, such as digital maps and DEMs.

The studying area in the north of Iraq (Iraqi Iran border) . The ortho metric correction for these photos is done so that we can use these images to produce topographic map. The type of camera was (Ziess rc10_1975) and the date of these images is 1975 the scale in this photo is 1/30000, and average height 4500m above mean sea level.

The Methodology

The entire methodology has been divided int six steps:

1. Scan the diapositive image with photo scanner and design GCPs on the photos and observe them on the ground by survey mode GPS.
2. Adding scan high resolution Image to the software with GCPs Specify the coordinate system and projection (WGS 84, UTM, Zone 38).
3. Enter the calibration parameters for the camera in software. Measuring fiducial marks with the software
4. Enter Exterior orientation (e.o) parameters and approximate value for X_0 , Y_0 and Z_0 (translation parameters) of the principle point for the image and ω, φ , κ Define GCPs on the photos and running auto tie point.
5. Performing Arial triangulation and extract DTM (Digital Terrain Model).
6. ortho rectify Image with extracted DTM we extract2
7. Data acquisition is so important to all practitioners of terrain modeling. This immediately poses the question as to which techniques should be considered for use in the collection of elevation data. The variety in the acquisition of DEM passed through three stages (Kennie, 1993). Using the existing topographic maps and field survey represents first stage. The second stage witnessed the use of the aerial photos as new source, where as the third stage the satellite images are used as additional new source.Thus, there are many sources can be used to acquire DEM data, GPS, Radar, Lidar, Cables, Geographic Data, Video, Multimedia, Field Survey, Existing Topographic Maps and Photogrammetry.[5]

Field Survey

In the case of ground survey, the data will nowadays, normally be acquired using the total station. It's also possible to acquire data for DEM work using the traditional optical instrumentation theodelites and tacheometers or even surveyors levels to carry out grid leveling through the same speed or efficiency. The accuracy of all field survey method is very high but they are really practical and economical to be implemented over relatively small area of terrain.[6]

Use of Digital Terrain Models (DTM) in Route location

A Digital Terrain Models (DTM) are numerical representation of the configuration of the terrain consisting of a very dense network of points of known X,Y,Z coordinates. Modern surveying and photogrammetric equipment enables rapid three dimensional data acquisition [7].

The data that comprise the DTM are generally recorded on magnetic tape or stored in the solid- state memory of an electronic computer. It is possible to use data from all sources to form the DTM, for example, field survey data, data taken from topographic maps ,and photogrammetrically determined data . It can be digitized and combined to form a DTM [8]. In this way all existing techniques and information are employed to the fullest extent. In order to use the DTM for rout alignment ,it is necessary to develop electronic computer programs ,which permit extraction of profiles ,and cross –section data from the DTM stored [9].

on magnetic tape. These extracted data can be used in the route alignment procedure in the same way as terrain data obtained by traditional methods .Thus .a proposed alignment and

Many optional locations can be thoroughly studied without access to additional data other than that obtained from the DTM.

The primary requirements for utilization of the DTM in this way are:-

1. A system for compiling and recording the data used to form the DTM,
2 .Sufficient ground control data to permit absolute orientation of the DTM,
3. A set of electronic computer programs normally called software, which allows the design engineer(s) to extract the information needed for the route location [10].

The Production of Photo-Textured DEM

With the rapid development of computers and software, many computer products which were considered difficult to be produced in the past became easy and possible. One of these complicated products is the so-called photo textured DEM which combines the graphical DEM with the real photo for the area covered by digital elevation model see figure .(1) Many applications could be gained from the photo texture DEM especially for military purposes, also for interpretation purposes and in geomorphology and earth science [4].

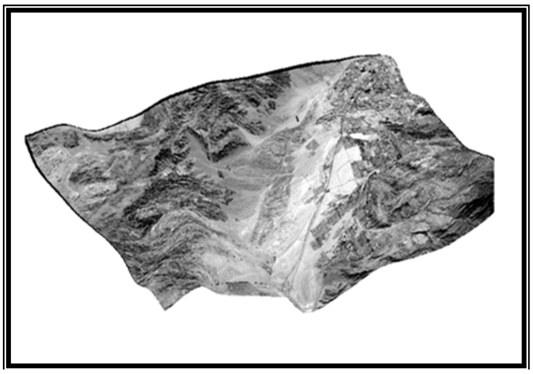


Figure (1): Photo-textured DEM.

Simultaneous Bundle Adjustment

Block triangulation is the process of defining the mathematical relationship between the images contained within a block, the camera or sensor model, and the ground. Once the relationship has been defined, accurate imagery and geographic information concerning the Earth’s surface can be created. When processing frame camera, digital camera, videography, and nonmetric camera imagery, block triangulation is commonly referred to as aerial triangulation (AT). When processing imagery collected with a push broom sensor, block triangulation is commonly referred to as triangulation. There are several models for block triangulation. The common models used in photogrammetry are block triangulation with the strip method, the independent model method, and the bundle method. Among them, the bundle block adjustment is the most rigorous of the above methods, considering the minimization and distribution of errors. Bundle block adjustment uses the collinearity condition as the basis for formulating the relationship between image space and ground space. LPS Project Manager uses bundle block adjustment techniques. [2]

In order to understand the concepts associated with bundle block adjustment, an example comprising two images with three GCPs whose X, Y, and Z coordinates are known is used. Additionally, six tie points are available. (Figure 3) illustrates the photogrammetric configuration.

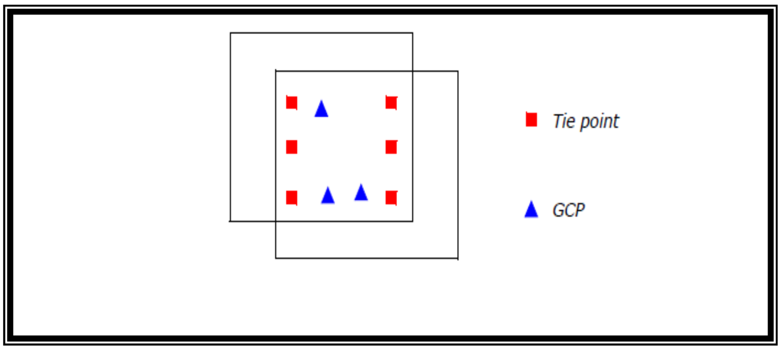


Figure (2): Photogrammetric Configuration

GCP and Tie Points Requirements

The minimum GCP requirements for an accurate mapping project vary with respect to the size of the project. With respect to establishing a relationship between image space and ground space, the theoretical minimum number of GCPs is two GCPs having X, Y, and Z coordinates (six observations) and one GCP having a Z coordinate (one observation). This is a total of seven observations. In establishing the mathematical relationship between image space and object space, seven parameters defining the relationship must be determined. The seven parameters include a scale factor (describing the scale difference between image space and ground space); X, Y, and Z (defining the positional differences between image space and object space); and three rotation angles (omega, phi, and kappa) defining the rotational relationship between image space and ground space. In order to compute a unique solution, at least seven known parameters must be available. In using the two XYZ GCPs and one vertical (Z) GCP, the relationship can be defined. However, to increase the accuracy of a mapping project, using more GCPs is highly recommended. [11].The following descriptions are provided for various projects. A tie point is a point whose ground coordinates are not known, but is visually recognizable in the overlap area between two or more images. The corresponding image positions of tie points appearing on the overlap areas of multiple images are identified and measured. Ground coordinates for tie points are computed during block triangulation.[12] . Because of the large amount of image data, the image pyramid is usually adopted during the image matching techniques to reduce the computation time and to increase the matching reliability. The pyramid is a data structure consisting of the same image represented several times, at a decreasing spatial resolution each time. Each level of the pyramid contains the image at a particular resolution. The matching process is performed at each level of resolution. The search is first performed at the lowest resolution level and subsequently at each higher level of resolution. (Figure 3) shows a four-level image pyramid[2]

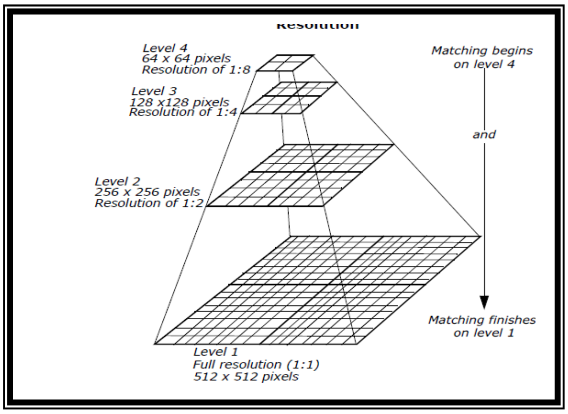


Figure (3): Image Pyramid for Matching at Coarse to Full Resolution

Triangulation

Triangulation, or block triangulation, is the process of establishing mathematical relationship between the images contained in a project, the camera or sensor model, and the ground. The information resulting from triangulation is required as input for the orthorectification process. Classical aerial triangulation using optical-mechanical analog and analytical stereo plotters was primarily used for the collection of ground points using the control point extension technique. This involved the manual measurement of tie points for the subsequent determination of their corresponding ground coordinates. These points were then identified as being GCPs for other applications. With the advent of digital photogrammetry, classical aerial triangulation has been extended to provide greater functionality [13].

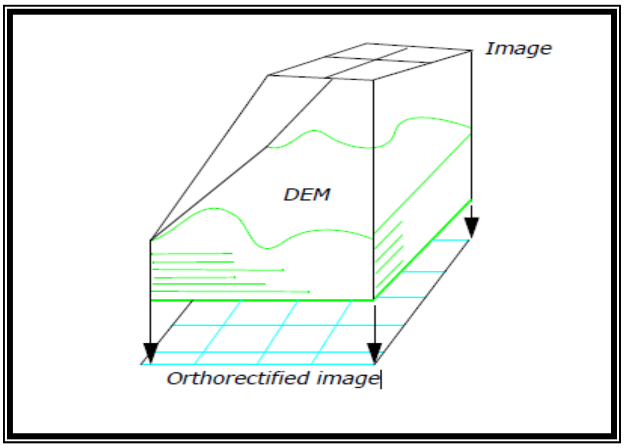
Orthorectification

Orthorectification is the process of reducing geometric errors inherent within photography and imagery. The variables contributing to geometric errors include, but are not limited to:

• Camera and sensor orientation
• Systematic error associated with the camera or sensor
• Topographic relief displacement
• Earth curvature

By performing block triangulation or single frame resection, the parameters associated with a camera and sensor orientation are defined. Utilizing least squares adjustment techniques during block triangulation minimizes the errors associated with a camera or sensor instability. Additionally, the use of self-calibrating bundle adjustment (SCBA) techniques along with Additional Parameter (AP) modeling accounts for the systematic errors associated with camera interior geometry. The effects of the Earth’s curvature are significant if a large photo block or satellite imagery is involved. They are accounted for during the block triangulation procedure by setting the proper option. The effects of topographic relief displacement are accounted for by utilizing a DEM during the orthorectification procedure [2]

The orthorectification process takes the raw digital imagery and applies a DEM and triangulation results to create an orthorectified image. Once an orthorectified image is created, each pixel within the image possesses geometric fidelity [1]. Thus, measurements taken off an orthorectified image represent the corresponding measurements as if they were taken on the Earth's surface (see Figure 4) [2].



Figure(4): Orthorectification

The ground control points have been measured (Easting ,Northing, and Elevation) by using differential GPS .The coordinates of photo have been calculated by using Georeference method with exist imagery (already Georeferencing). These points have been used to produce the digital elevation model (DEM).The coordinates of the control points and their standard deviation illustrated In table (1) as follows:

Table(1) . Point Summary Report(GDS)

Name	WGS84 Latitude	WGS84 Longitude	WGS84 Ell. Height (m)	Grid Easting (m)	Grid Northing(m)	Elevation (m)	Std Dev Hz (m)
13092A1	35°35'32	46°01'05	1392.229	592226.61	3939219.11	1381.179	0.013
13092A2	35°35'32	46°01'05	1388.164	592226.881	3939207.109	1377.115	0.013
13092B1	35°34'34	46°01'44	1688.816	593249.069	3937428.396	1677.848	0.043
13092B2	35°34'34	46°01'47	1698.478	593305.111	3937427.116	1687.508	0.009
13092C1	35°34'42	45°59'12	1517.221	589412.471	3937629.805	1506.400	0.069
13092C2	35°34'41	45°59'12	1515.962	589407.357	3937613.816	1505.143	0.049
13103A1	35°19'42	46°11'19	1684.664	608038.840	3910120.920	1674.326	0.006
13103A2	35°19'42	46°11'17	1688.086	607998.874	3910121.519	1677.750	0.006
13103B1	35°21'18	46°09'45	1671.145	605626.649	3913060.478	1660.861	0.010
13103B2	35°21'19	46°09'44	1669.592	605600.142	3913070.979	1659.309	0.070
13103D1	35°19'29	46°07'52	2294.381	602814.144	3909662.640	2284.450	0.012
13103D2	35°19'29	46°07'52	2297.491	602825.691	3909643.421	2287.560	0.013
13103D3	35°19'27	46°07'48	2311.491	602727.044	3909598.781	2301.570	0.003
14097A1	35°14'44	46°09'50	1653.300	605906.031	3900910.130	1643.457	0.007
14097A2	35°14'41	46°09'49	1671.535	605880.896	3900805.912	1661.700	0.014
14097B1	35°14'12	46°07'29	1260.895	602342.362	3899899.281	1251.423	0.005
14097B2	35°14'13	46°07'30	1259.412	602383.461	3899907.844	1249.937	0.004
14097D1	35°15'35	46°09'35	1612.107	605515.436	3902484.202	1602.231	0.014
14097D2	35°15'30	46°09'48	1637.449	605827.264	3902333.592	1627.550	0.009
NCC1012	35°31'19	46°10'32	1323.111	606591.547	3931569.204	1311.987	0.000

The studying area in the north of Iraq (Iraqi Iran border) . We do ortho metric correction for these photos so that we can use these images to produce topographic map. The type of camera was (Ziess rc10_1975) and the date for these images is 1975 the scale in this photo is 1/30000, and average height 4500m above mean sea level deviation illustrated In figure (5) as follows:

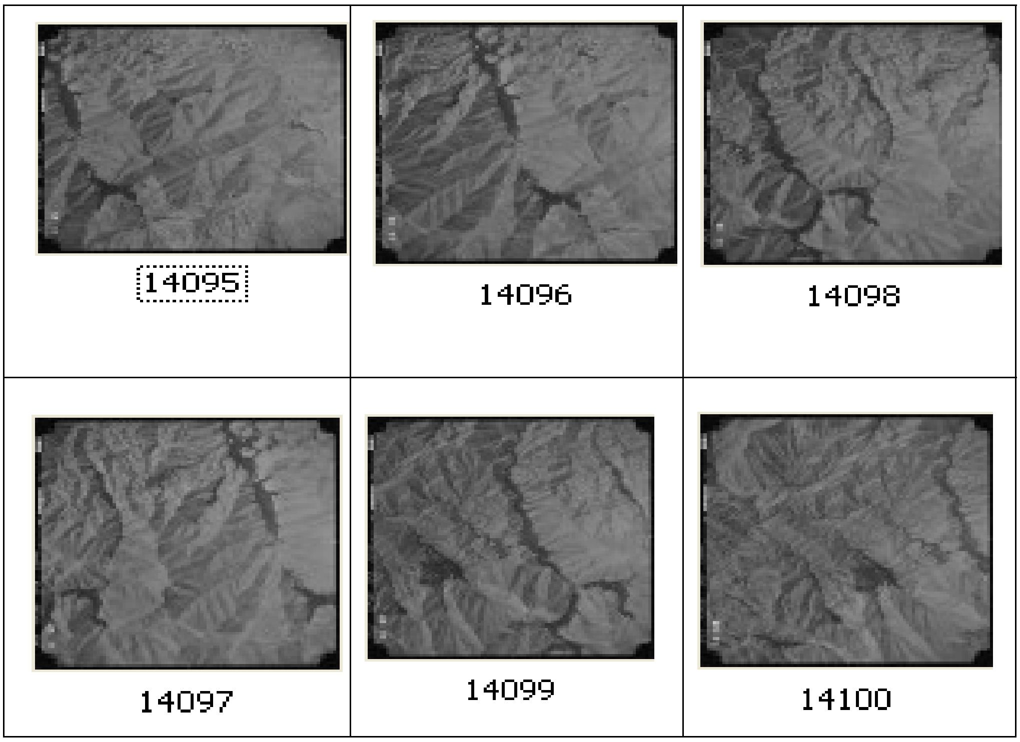
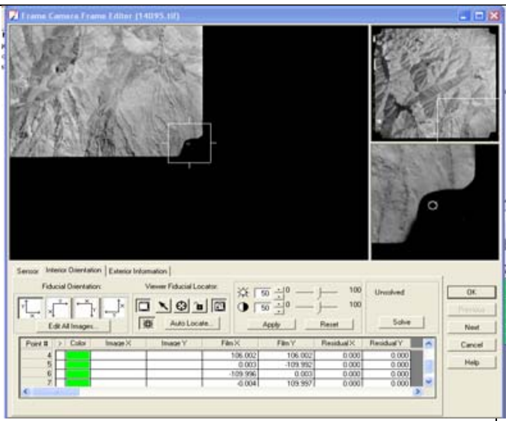
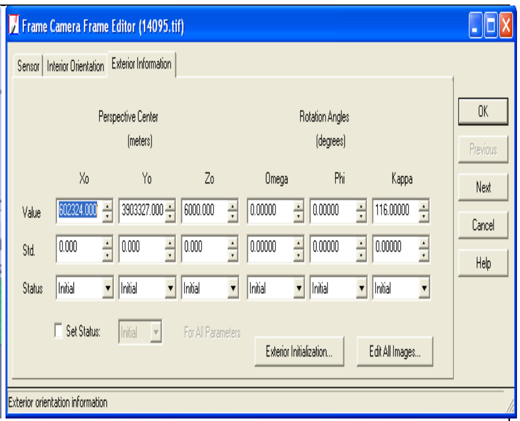


Figure (5): Aerial Photos of Iraqi- Iran border (GDS 1975)

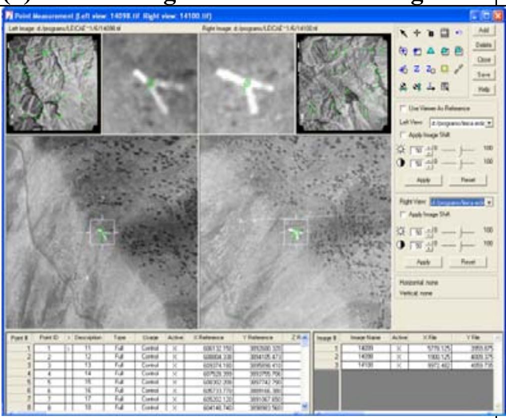
Figure (6-a) represents the measuring presses of the fiducial marks, in figure (6-b) the exterior and interior information from camera report have been entered ,figure (6-c) represents measurement of photo coordinates of the ground control point , figure (6-d) in this figure the Aerial triangulation was attended depending on the photo coordinates and the ground coordinates of GCPs after the above steps the DTM could be generated by opening the DTM extracted dialoged as in figure (6-e). Ortho Resample or orthorectifcation must be done to have fewer relief displacement and minimum geometric error and thus are consider more accurate where that display object in their real-world X, Y and Z positions.



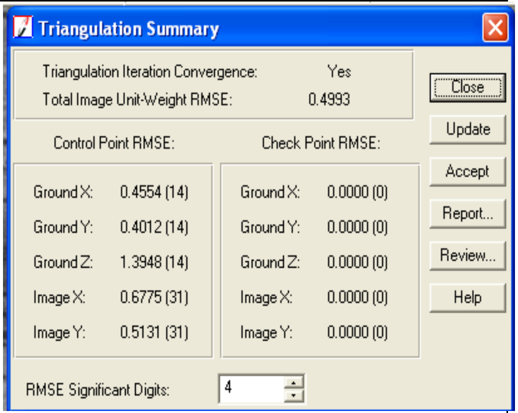
(a):Measureing Fiducials of the Images



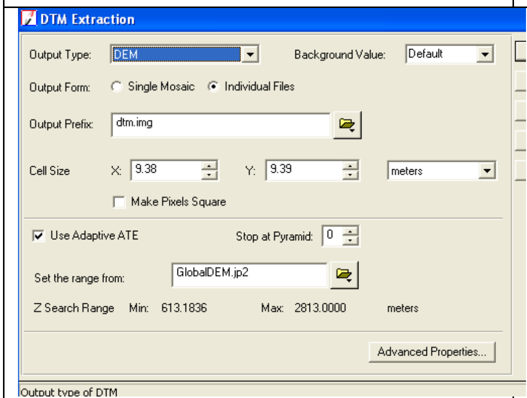
(b): camera report



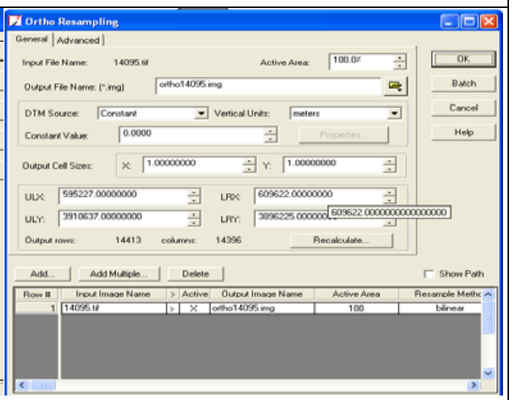
(c): Measure GCPs and Check Points



(d): Aerial Triangulation



(e): The DTM Extraction Dialog



(f): Ortho Resample of the Imagery

Figure (6): Steps of DTM extraction by ERDAS Imagine.

After of all steps of figure (6) the DTM and the topographic map of the study area would be produced as in figure (7).

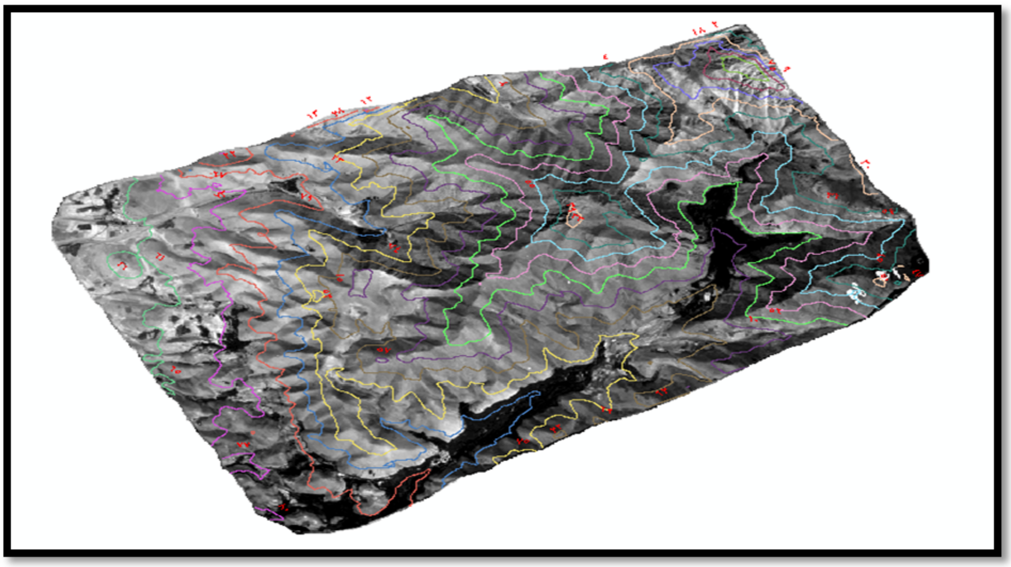


Figure (7): Production of DTM for area study

Conclusions

1- The Digital Elevation Model (DEM) considered a common tool in producing topographic maps, orthophotos and civil engineering projects besides other different engineering applications. As a result many software packages were developed and used to produce DEM from different sources like field surveys, scanned topographic maps and stereo photos exposed from air or space.

2- This research is devoted to evaluate the most suitable and accurate interpolation method in producing digital elevation model from two different sources the first source is the field survey to the north of Iraq (Iraqi Iran borders) by using **GPS** the second source is the aerial photos .

3- From the results obtained in this research it is concluded that the produced DTM by using LPS made the digitization operation to the feature very accurate because the geometric corrections for images done with 3d coordinates but many researches depended on satellite image with mono georeference which have been done with 3d coordinates and that will made distortion and very bad geometric correction especially the study area (Iraqi- Iran border) have a high difference level topography and that would need orthoreotity correction to get accurate geometric corrections and that would make the aerial photogrammetry is more accurate to produce the (DTM) of the high deference level area.

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