

Palestine Polytechnic University



College of Engineering & Technology

Civil and Architectural Engineering Department

Surveying Engineering

Graduation Project

**AUTOMATIC PHOTOGRAMMETRIC DTM GENERATION
AND ITS EVALUATION**

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Hebron-West Bank

Palestine

May- 2007

CERTIFICATION

Palestine polytechnic university

Hebron-Palestine

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By the guidance of our supervisor, and the approval of members of testing committee, this project is delivered to the department of civil and architectural engineering, in the college of engineering and technology to be as partial fulfillment of the requirements of the department for the degree of B.Sc in surveying and geomatics engineering.

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Hebron-West Bank
Palestine
May-2007

الإهداء

الى الانسان ذو القلب الكبير الذي لا حدود لمحبه ولا نهاية لعطائه
الى مدرستي التي تعلمت فيها حب الوطن والعطاء والصبر والاخلاص
والدينا العزيزان

الى المعلم الأول الهادي البشير عليه الصلاة والسلام
والدي الحبيب إلى نبض روعي المتألقة بالعطاء
أمي الغالية..... إلى تلك الشمعة التي تحترق لتضئ لنا الطريق
فلسطيننا الحبيبة..... إلى من فني في سبيلها الجسد والمال

إلى الذي ضحى و أنكر الذات في سبيل الله

إلى من هم اعز منا جميعا إلى ثوار الأرض أينما وجدوا

إلى القابعين خلف قضبان الحديد ينتظرون يوم الحرية

إلى من أصبحت المستشفيات بيوتهم الثانية

شعبنا الصابر المحتسب

إلى هؤلاء جميعا نهدي عملنا هذا

"قل إن صلاتي ونسكي ومحياي ومماتي لله رب العالمين"

فريق العمل:

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ABSTRACT

AUTOMATIC PHOTOGRAMMETRIC DTM GENERATION AND ITS EVALUATION

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This project aims to evaluate the automatic generated DTM or DSM created by Photogrammetric workstations for chosen areas in Hebron, to evaluate the DTM heights ground surveyed points. Are used in addition, the differences between the Photogrammetric DTM and control point analysed using GIS.

In this project we used different steropairs to create the models with different scan resolutions and different DTM grid sizes.

ملخص

AUTOMATIC PHOTOGRAMMETRIC DTM GENERATION AND ITS EVALUATION

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يهدف هذا المشروع الى تقييم نماذج طبوغرافية الارض (DTM) التي تم بناءها بشكل اتوماتيكي باستخدام التصوير الجوي في عدة مناطق مختارة في مدينة الخليل, حيث يتم الاستعانة بنقاط تم جمعها بالمساحة الارضية, تحليل النتائج يتم عن طريق نظم المعلومات الجغرافية (GIS) .

في هذا المشروع يتم بناء عدة نماذج للطبوغرافية (DTM) لعدد من ازواج الصور الجوية, على عدة مستويات الدقة في المسح الضوئي , و عدة مسافات بين نقاط المناسيب في نماذج الطبوغرافية (DTM) .

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CHAPTER ONE

INTRODUCTION

- 1.1 Overview**
- 1.2 Project importance**
- 1.3 Studying areas**
- 1.4 Previous studies**
- 1.5 Project methodology**
- 1.6 Project out line**

CHAPTER ONE

INTRODUCTION

1.1 Overview

This project aims to evaluate the DTM or DSM created by Photogrammetric workstations for a chosen areas in Hebron to asses the DTM heights using ground surveyed points, in addition the differences between the Photogrammetric DTM and GIS interpolated DTM's that will also be analyzed.

A Digital Elevation Model (DEM) is a digital and mathematical representation of an existing or virtual object and its environment, e.g. terrain undulations within a selected area. DEM is a generic concept that may refer to elevation of ground but also to any layer above the ground such as canopy or buildings. When the information is limited to ground elevation, the DEM is called a Digital Terrain Model DTM and provides information about the elevation of any point on the ground or water surface. When the information contains the highest elevating of each point, coming from ground or above ground areas, the DEM is called the Digital Surface Model or DSM.

In our project we are evaluating the DTM that represents the ground by elevation using the automatic DTM creation tool in Z/I image photogrametric workstation. difference strategies will be used to create the model with different scan resolutions and different DTM grid size.

To evaluate the models, at least 20 check points will be used according to the American national map standards, 95% confidence level will be used to evaluate the vertical accuracy of DTM in each model.

1.2 Project importance

The important of this project is realized by evaluating the automatic DTM's with GIS interpolated DTM's.

This project will help to decide the following when you decide to work in a Photogrammetric survey projects:

- 1 Decide the proper scan resolutions.
- 2 Decide the best grid size.
- 3 Decide if it is sufficient to use the automatic DTM generation to prepare contour map, or it is better to use land surveying and GIS interpolated models.

1.3 Study areas

Study areas are parts of Hebron city, Wadi Al Harrieh , industry area , and Al Bassa area .The study areas are covered by pairs of aerial images that were captured in the year 2004.

1.4 Project methodology

This project deals with ZI imaging digital Photogrammetric workstations and ESRI ArcGIS 9.0 to build an evaluate DTM and DSM models for the study areas in Hebron city, this models depend on the 20-25 vertical check points for each model, for evaluation .

The project work is planned to be achieved by the following steps:

1. Scanning the images of different areas in Hebron by different resolutions. According to the capabilities of the Ultrascan 5000, the selected resolutions are; 20, 50, and 75 micrometers.
2. For each steropair, a model will be built at each scan resolutions.
3. An automatic DTM will be generated from each stereomdel .
4. According to the American National map standard the DTM's will be evaluated using the ground survey check points.
5. Comparison the automatic DTM's and the check through GIS.

1.5 Project out line

This project has the following scope:

Chapter 1: Introduces the project, the objectives, and the methodology.

Chapter 2: Gives an Introduction of Photogrammetric and Digital Photogrammetry.

Chapter 3: The principle of DSM, and DTM.

Chapter 4: Accuracy ,Specification and Standards.

Chapter 5: Results and analysis.

Chapter 6: Conclusions and Recommendations.
References.

Appendices; Shown the use of Z/I Imaging workstation, and the use of GIS in the analysis.

CHAPTER TWO

INTRODUCTION TO PHOTOGRAMMETRY

- 2.1 Definition of photogrammetry
- 2.2 History of Photogrammetry
- 2.3 Photogrammetry principles
- 2.4 Stereoscopic and monoscopic vision
- 2.5 Stereoscopic stereoplotters instruments
- 2.6 Digital photogrammetric workstation

CHAPTR TWO

INTRODUCTION TO PHOTOGRAMMETRY

2.1. Definition of photogrammetry

Photogrammetry is defined as the art, science, and technology of obtaining reliable information about physical objects and the environment by recording, measuring, and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena. Recently photogrammetry has expanded to include analysis of digital images, in photogrammetry the photographs are the basic source of information.

2.2. History of Photogrammetry

The basic start of photogrammetry was about 350 years B.C by Aristotle referred to the process of projecting images optically. 18th century Dr. Brook Taylor published his treatise on linear perspective, and soon afterward, J.H. Lambert suggested that the principles of perspective could be used in preparing maps.

In the last 50 year the advancements in instrumentation and techniques in Photogrammetry have continued at a rapid pace. These advancements have enabled Photogrammetry to become the most accurate and efficient. The Photogrammetry has become a basic tool for compiling maps and generating topographic information .¹

¹ Paul R. Wolf, Elements of Photogrammetry

2.3. Photogrammetry principles

The recent advance in computers and software have enabled the photogrammetry to be automotive , became less costly, more efficient, less effort, and less time consuming.

The photography has two basic classes according to the method of taking photographs:

1. Terrestrial photographs: taken using cameras fixed on the ground, the position and orientation are previously determined using special Instruments like phototheodolite, see figure(2-1).

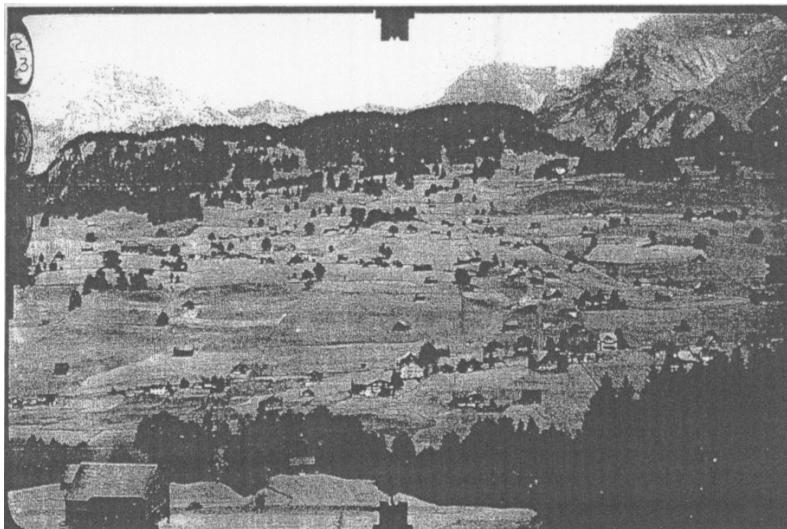
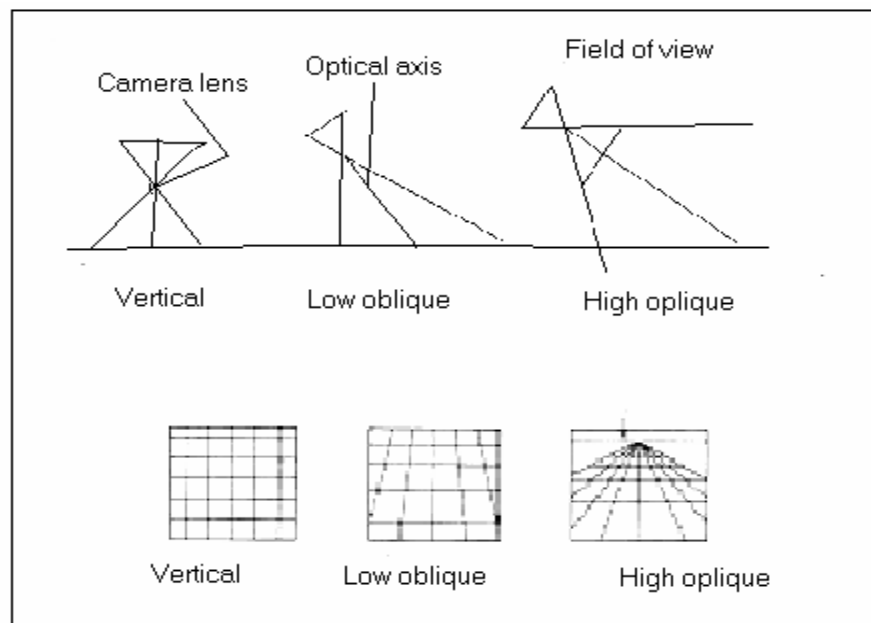


Figure (2-1): Terrestrial photograph using photo theodolite. [1]

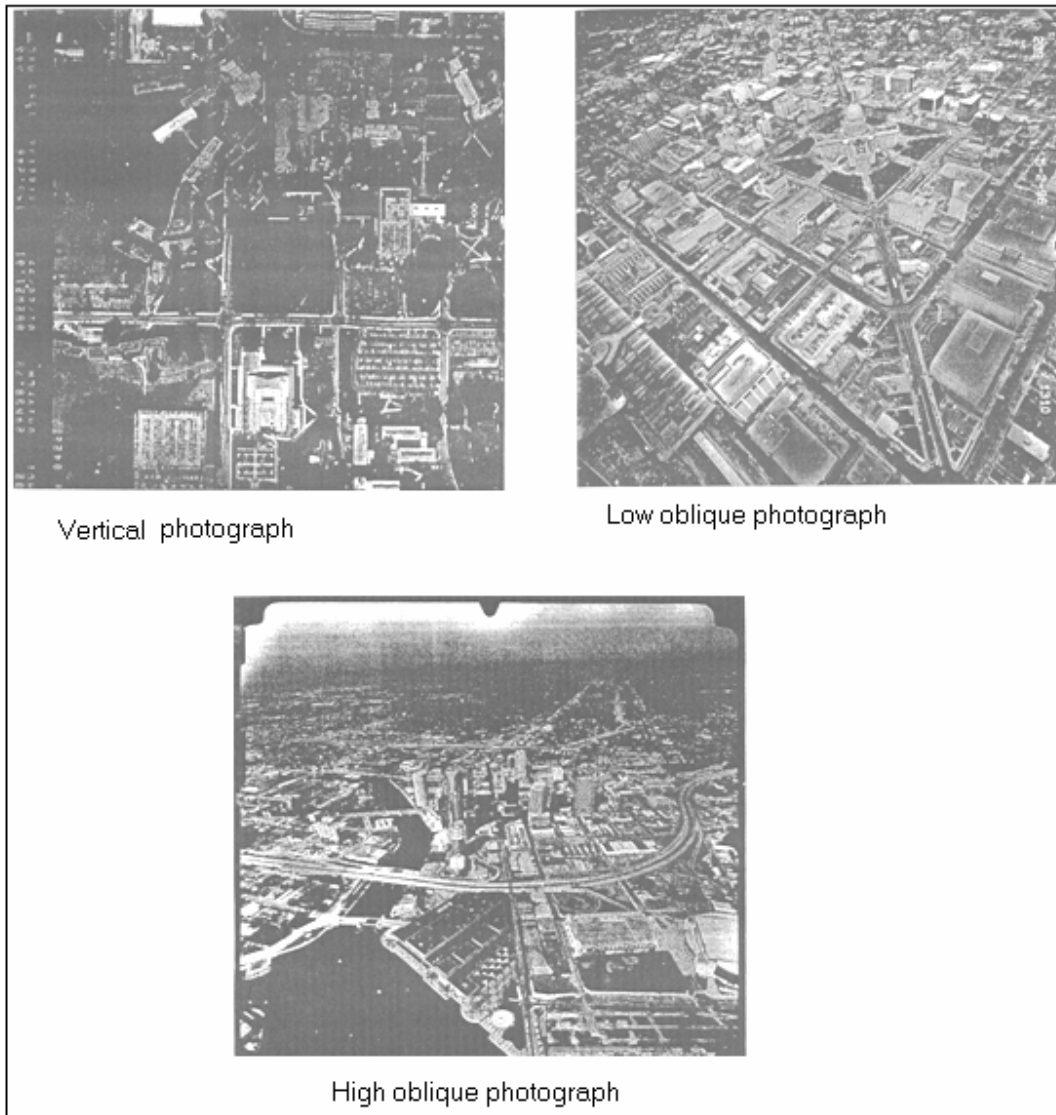
2. Aerial photograph: taken by special cameras fixed on aircraft
These photographs can be classified according to the orientation of the camera, these classes are:

- Vertical photos: are taken with the camera axis directed as nearly vertically as possible. If the camera axis were perfectly vertical when an exposure was made, the photographic plane would be parallel to the datum plane and the resulting photograph would be termed *truly vertical*. When the camera axis is accidentally tilted slightly from vertical, the resulting photograph is called a *tilted photograph*, this tilt is usually between 1° - 3° .
- Oblique aerial photographs: exposed with the camera axis intentionally tilted away from vertical, the photographs are in two types:
 - High oblique photograph: includes the horizon.
 - Low oblique: does not include the horizon.

The principle of the above classes is shown in figures (2-2) and (2-3).



Figure(2-2):Camera orientation for various types of aerial photographs.[1].



Figures(2-3) : Vertical, low oblique and high oblique photographs. .[1]

Aerial photographs normally have the basic principles:

- The over lapping along the flight strip is called ***end lap***, normally 50-60 %.
- The area of coverage common to an adjacent pair of photographs in a flight strip is called the ***stereoscopic overlap area***.
- The overlapping pair of photos is called a ***steropair***..

- The positions of the camera at each exposure ,positions 1, 2, 3 of Figure (2-5), are called the *exposure stations*.

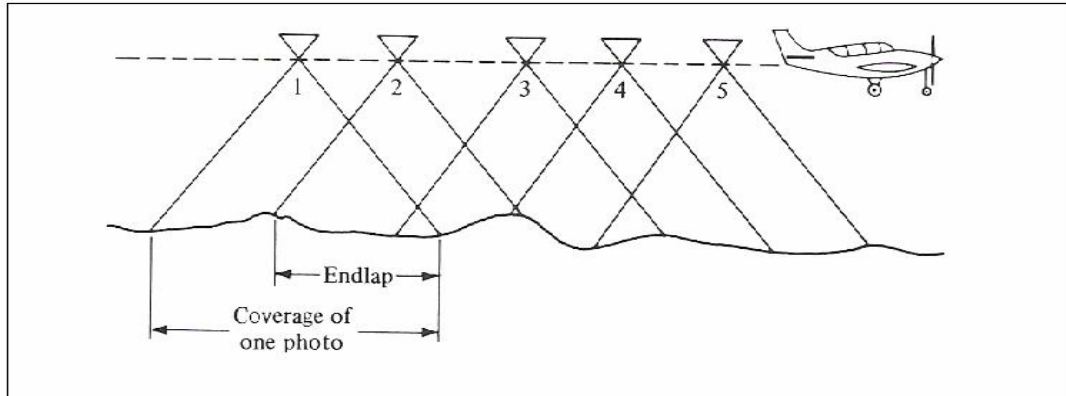


Figure (2-4): End lap of adjacent flight strip.[1]

- The altitude of the camera at exposure time is called the *flying height*.
- Adjacent flight strips are photographed so that there is also a lateral overlapping of adjacent strips. This condition, called *side lap*, and it is normally held at approximately **30 percent** . see figure (2-5).
- The photographs of two or more side-lapping strips used to cover an area are referred to as **a block** of photos.

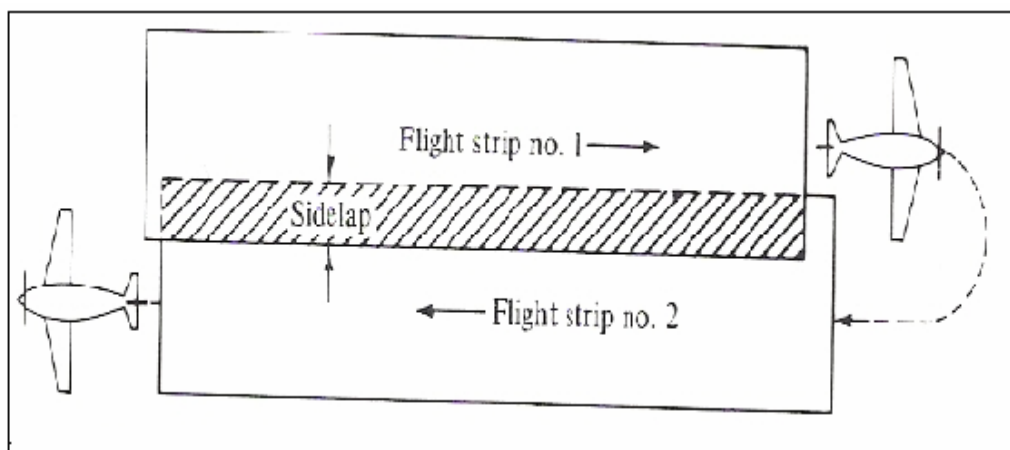


Figure (2-5): Side lap of adjacent flight strips.[1]

2.4 Stereoscopic and monoscopic vision

In measuring the depth or judging distances to a vast number of objects using normal process of vision, two methods are used:

1. Stereoscopic viewing, using binocular viewing (using two eyes) To percept the depth of object ,as shown in figure(2-6).

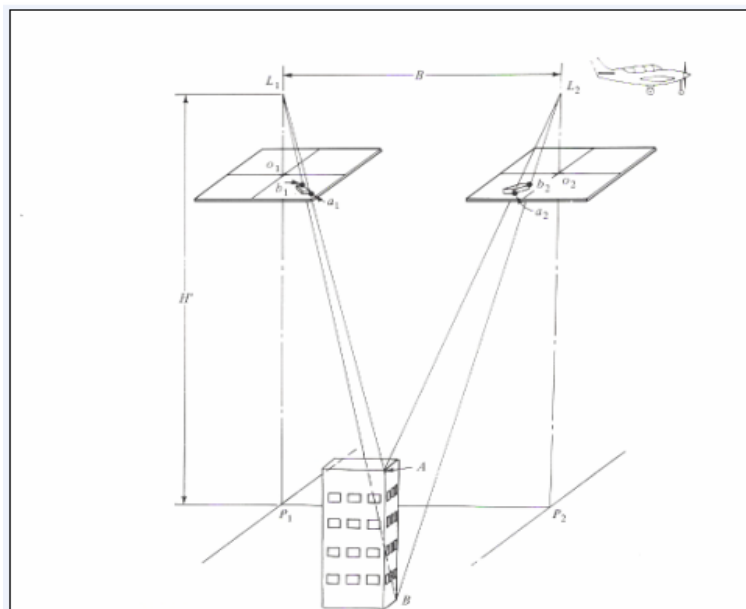
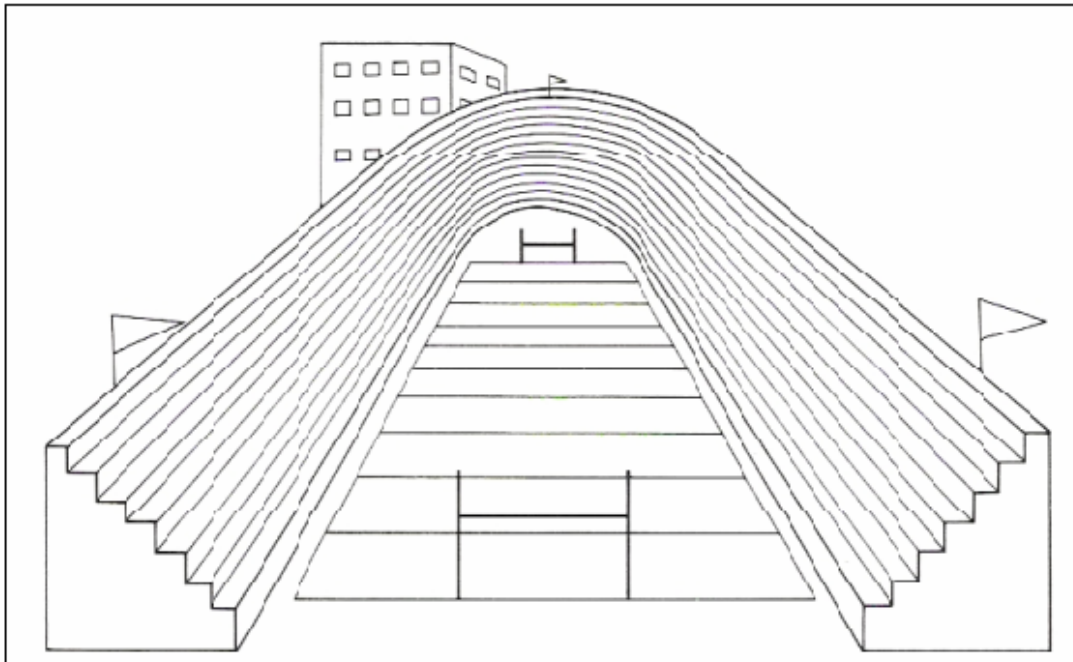


Figure (2-6) :Stereoscopic viewing.[1]

2. Monoscopic viewing, using monocular (using one eye)to judge the distances. Measuring depth and distances of objects can done monoscopically by using one of the following methods:
 1. Relative sizes of objects.
 2. Hidden objects.
 3. Shadows.

4. Differences in focusing of the eye required for various objects at varying distance. Figure (2-7) shows the different methods of monoscopic vision.



Figure(2-7): Depth perception by relative sizes and hidden objects.[1]

2.5 Stereoscopic stereoplotters

2.5.1 Introduction

Stereoplotters or(simply “plotters”) are instruments designed to provide rigorously accurate solutions for object 3D, point positions from their corresponding image positions on overlapping pairs of photos.

Transparencies or diapositives are prepared to exacting standards from the negatives, are placed in two stereoplotter projectors, This process is called

interior orientation. In creating the intersections of corresponding light rays, the two projectors are oriented so that the diapositives bear the exact relative angular orientation to each other in the projectors that the negatives had in the camera at the instants they were exposed. The process is called **relative orientation** and creates, a true three-dimensional stereomodel of the overlap area.

After relative orientation is completed, absolute orientation is performed. In this process the stereomodel is brought to the desired scale and leveled with respect to a reference datum.

2.5.2 Classification of stereoscopic plotters

Classification depend on common characteristics. This classification is divided into four general categories:

1. Direct optical projection instruments. These instruments create a three dimensional model by projecting, light rays from the diapositive. An operator is able to see the model directly by his eyes.
2. Mechanical or optical-mechanical projection: Instruments of create three dimensional model using combination of optical and mechanical projection, an operator can see the model directly by a binocular train. This type and the previous type have nearly disappeared .
3. Analytical stereoplotters: the image measurements are created directly in the images . The model and the 3D point coordinates are mathematically calculated by computers.
4. Soft copy stereoplotters: the image measurements are done on digital or scanned images on computers. The model and the 3D point coordinates are mathematically calculated by computers.

2.5.3 Analytical plotters

Most of operation in photogrammetry have been automated because of the use of computer, which enabled to solve most of mathematics for photogrammetry, examples of these operations are reading data from comparators digitally, and recording the output data digitally . By linking encoders servo systems and computers, the analytical stereoplottter had been developed .

The basic component of the analytical stereoplottter are as follows, see figure 2-8

- 1- Comparator.
- 2- stereocomparator.
- 3- Encoder.
- 4- Servomotors.

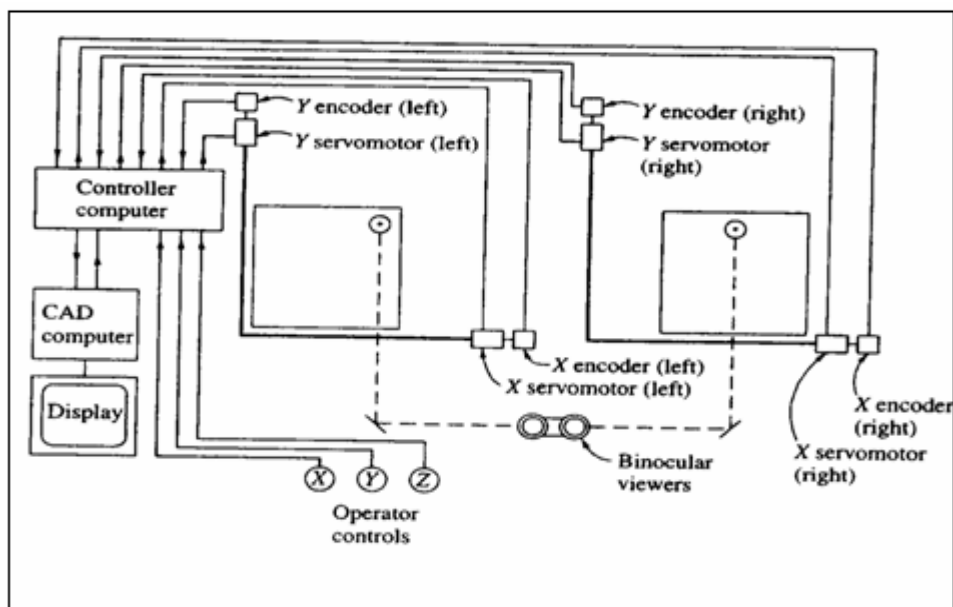


Figure (2-8): Schematic diagram of components and operation of analytical plotter.[1]

Analytical stereoplotters compute mathematical models using collinearity equations, see equation (2-1) and (2-2), instead of using mechanical or optical models.

$$x_a = -f \left[\frac{m_{11}(X_A - X_L) + m_{12}(Y_A - Y_L) + m_{13}(Z_A - Z_L)}{m_{31}(X_A - X_L) + m_{32}(Y_A - Y_L) + m_{33}(Z_A - Z_L)} \right] \dots\dots\dots(2-1)$$

$$y_a = -f \left[\frac{m_{21}(X_A - X_L) + m_{22}(Y_A - Y_L) + m_{23}(Z_A - Z_L)}{m_{31}(X_A - X_L) + m_{32}(Y_A - Y_L) + m_{33}(Z_A - Z_L)} \right] \dots\dots\dots(2-2)$$

The input of analytical stereoplotters can be classified into:

1. External input: to solve collinearity equations which consists of camera interior orientation parameters and ground coordinates of control points.
2. Internal input: using the instrument itself to enter the image coordinates.

Then using these data and collinearity, the computer calculates model and ground coordinates, and the output data are displayed on a screen, or they are printed on a hard copy, or transmitted to the coordinatograph. Have the following advantages over the analog and stereoplotters:



1. No optical and mechanical limitations.
2. Any type of photography, including vertical, tilted, low oblique, convergent, high oblique, panoramic, and terrestrial photos can be used.
3. They can also be used with various types of satellite imagery.
4. They can deal with photography from any focal-length camera.
5. They can simultaneously use two photos of different focal lengths to form a model.

2.6 Digital photogrammetric workstation

2.6.1 Introduction

Nowadays, most of the photogrammetric workstations are digital or analytical systems. The traditional analogue systems with high precision mechanics and optics are obsolete and no more in practical use. In digital workstations the input data are digital images, and image measurement is directly done on screen, the 3D model is created mathematically, this gives advantages for digital workstations above the analytical workstation, by the use of the modern computers capability .

Table (2-1): a comparison between the analytical and the digital workstations.

Type	Analytical Plotter	Digital Photogrammetric Workstation
Hardware	complete photogrammetric workstation 	Computer, screen, Image Separation auxiliary mean 
Software	Photogrammetric programs (analytical solution)	Photogrammetric programs (analytical solution)
Data source	Conventional images, recorded on film	Digital (scanned) images
Measurements	Machine co-ordinates	Screen co-ordinates
Planimetric Accuracy (Standard dev.)	$\pm 5 \mu\text{m}$	Depending on scan pixel size, using $21 \mu\text{m}$ digital image stations are equivalent to analytical systems: $\pm 5 \mu\text{m}$
Height accuracy (Standard dev.)	0,007 % * flying height (all error effects included)	0,01 % * flying height (all error effects included)
Zooming	no	yes
Visualization	Excellent quality, at each time, everywhere in the image	Due to image separation methods as well as refresh rates of the graphics interface and screen (even 120 Hz), there is always a visible flickering, disturbing the 3D vision

2.6.2 Equipment

The properties digital workstations equipments are the following:

- a) Freedom from the high-precision optic and mechanical components, which kept the acquisition and maintenance costs of systems at a very high level.
- b) The size of the machines was considerably reduced.
- c) Systems of digital photogrammetry are based on workstations or, on PCs. The recent computers include almost the whole of the necessary means for photogrammetric restitution.
- d) the manipulated data images generally have sizes of several hundreds of megabytes, sometimes tens, or even hundreds of images are needed. The capacity of storage, and access times, should therefore be especially selected.

2.6.3 Data input

The system must possess the coordinate input, it should be able to address three independent axes, X Y and Z. Solutions are numerous, from arrows on the keyboard, to the cranks and pedal of traditional photogrammetric devices, or controllers of immersion of virtual-reality stations, joysticks, or the specialized mouse.

That the movement of cursors or input devices must be as continuous as possible, and that the control in position is far preferable to speed commands (joysticks).Supplementary buttons may be attached, allowing one to simplify the use of the most frequent commands. Like selecting the point and registering it's coordinates.

2.6.4 Stereoscopic visualization

The system must also allow stereoscopic vision. several solutions exist, and some are under normalization. It is about presenting to each eye the image he has to observe. In order of increasing comfort, the following have to be explained:

- the display of the two images in two separated windows, which the operator will observe with an adequate optic system of stereoscopic type, placed before the screen.
- the simultaneous display of the two images, one in green, the other in red, the operator benefiting from the structural complementarities of such glasses (anaglyphs) whose cost is extremely low.
- The alternative display of the two images, a device using liquid crystals letting the image pass toward the eye to which it is destined. In the professional systems, only this last solution is used. The frequency of the screen conditions the quality of the stereoscopic visualization, because the alternative display divides by two the frequency really discerned by the user (a minimal frequency of 120 Hz is necessary to avoid operator fatigue). The liquid crystals may be placed directly before the eye, a low-cost solution, synchronized by a wire or by infrared link. Or they may be placed on the screen, the operator then using a couple of passive polarized glasses (which allows him or her to look indifferently).

2.6.5 Photogrammetric algorithms

The equations are the same as those on the analytic photogrammetry systems (equations of collinearity or coplanarity). They can not only process aerial images, but also different geometry images, for example the images from scanning sensors or from radar, the possibilities of the automation of photogrammetry are very high.

2.6.6 Image display

Image can have size larger than the display this can be up to 100 times larger than the screen. To displace the display (screen) window within the image there are two possibilities:

1. The image is fixed: The fixed image/mobile cursor configuration is easiest to implement. When the cursor reaches the side of the screen, the system must reload another zone of images.
2. The cursor is fixed: the mobile image/central cursor demands more calculation capacities, image-holders move in a continuous way in front of a fixed mark. The system sometimes proposes a global view for the fast displacements in the model.

2.6.7 Zoom and subpixel displacements

Zooms can be done by bilinear interpolation, or to the nearest neighbour, serve to enlarge all or part of the current screen. Zoom allows to point with a better precision than the real pixel of the image, zoom decreases the field of observation.

2.6.8 Epipolar resampling

The visualization of a stereoscopic model can be tedious for operators, because the two images have too different scales and orientations. Performances of usual image-matching techniques are degraded also by this type of image.

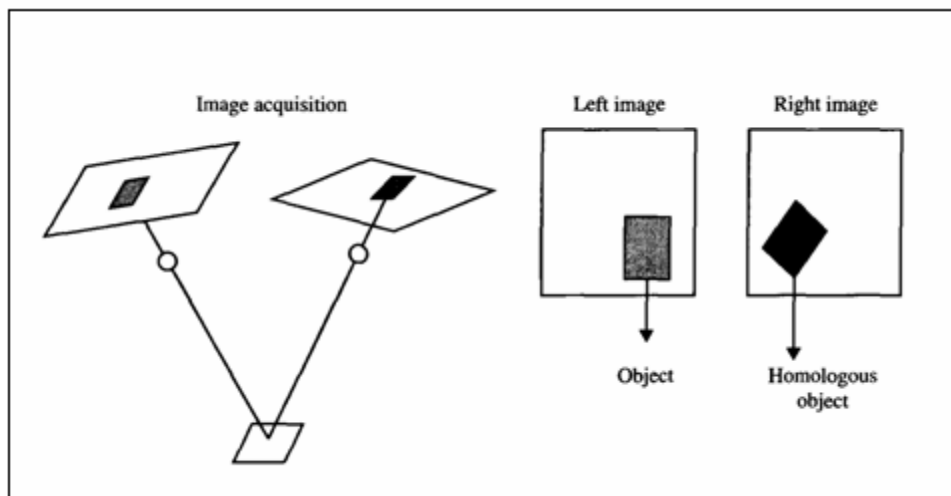


Figure (2-9): Type of image[5]

In this case, it is desirable to make an epipolar resampling: one calculates the homographic plane that allows one to pass from the initial image to the one that would have been obtained if optical axes of photos had been parallel between them and perpendicular to the basis (normal case).

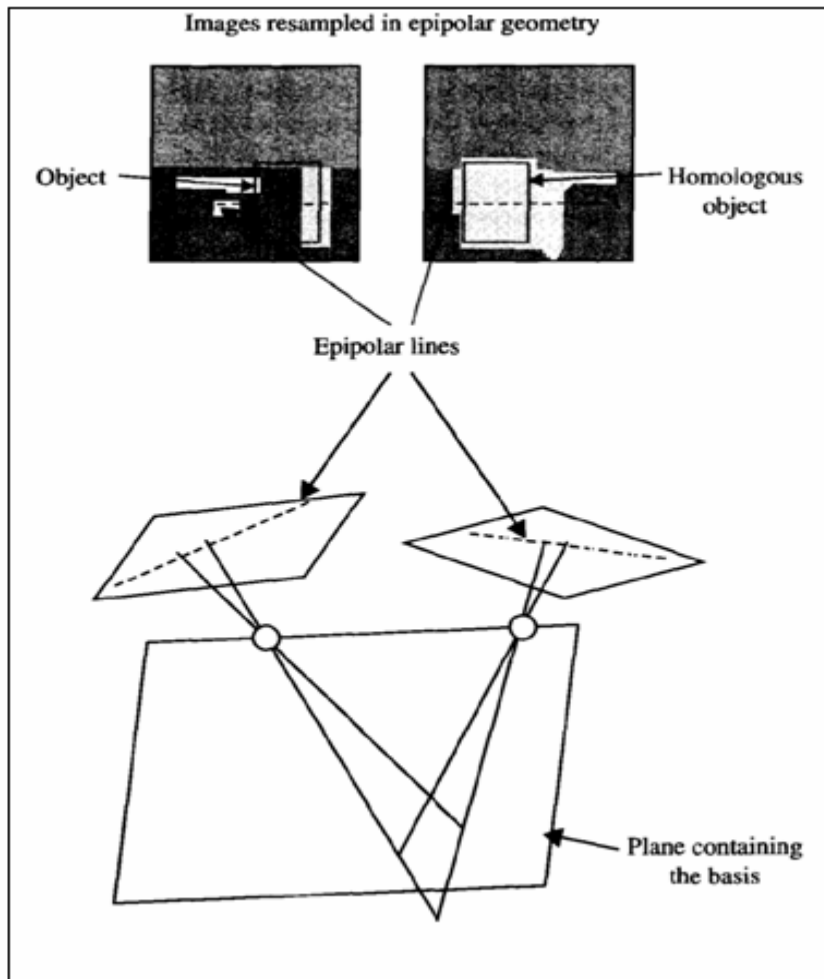


Figure (2-10): Epipolar line and resample images .[5]

After this process, two points of a line of the left image will have their counterparts in one line of the right image, and the transverse parallax is constant.

Epipolar lines are the intersections of the bundle of planes containing the basis and of the two image planes. In the resampled images, these lines are parallel, whereas they were converging in the initial images.

This resampling requires at least the calculation of the relative orientation to generate the new images. Epipolar resampling improves the operator's comfort, accelerates the work of correlators, since the zone of research of the homologous

points is reduced to a one-dimensional space (instead of a two-dimensional space for a systematic correlation of images).

Some systems of digital photogrammetry require working with images in epipolar geometry for the extraction of the DTM; others do this resampling continuously.

2.6.9 Functionalities of the digital photogrammetric workstations

Most of digital photogrammetric workstations have the following function:

- The management of manipulated images; scanned or digital photos, and the ability to deal with different image formats and grey levels.
- The management of photogrammetric database: Directory of model images, Operator parameters, Parameters of the internal orientation for each image, Position of the camera for each image, etc.
- Internal orientation : manual or automatic by the system using the camera calibration sheet.
- External orientation using collinearity equations.
- Measures and acquisition from stereoscopic models of points lines and polygons.
- Aerotriangulation (bundle adjustment).
- Automatic and manual DTM collection.
- Orthophotos production.

The diagram of the digital workstation functionalities is explained in figure (2-11).

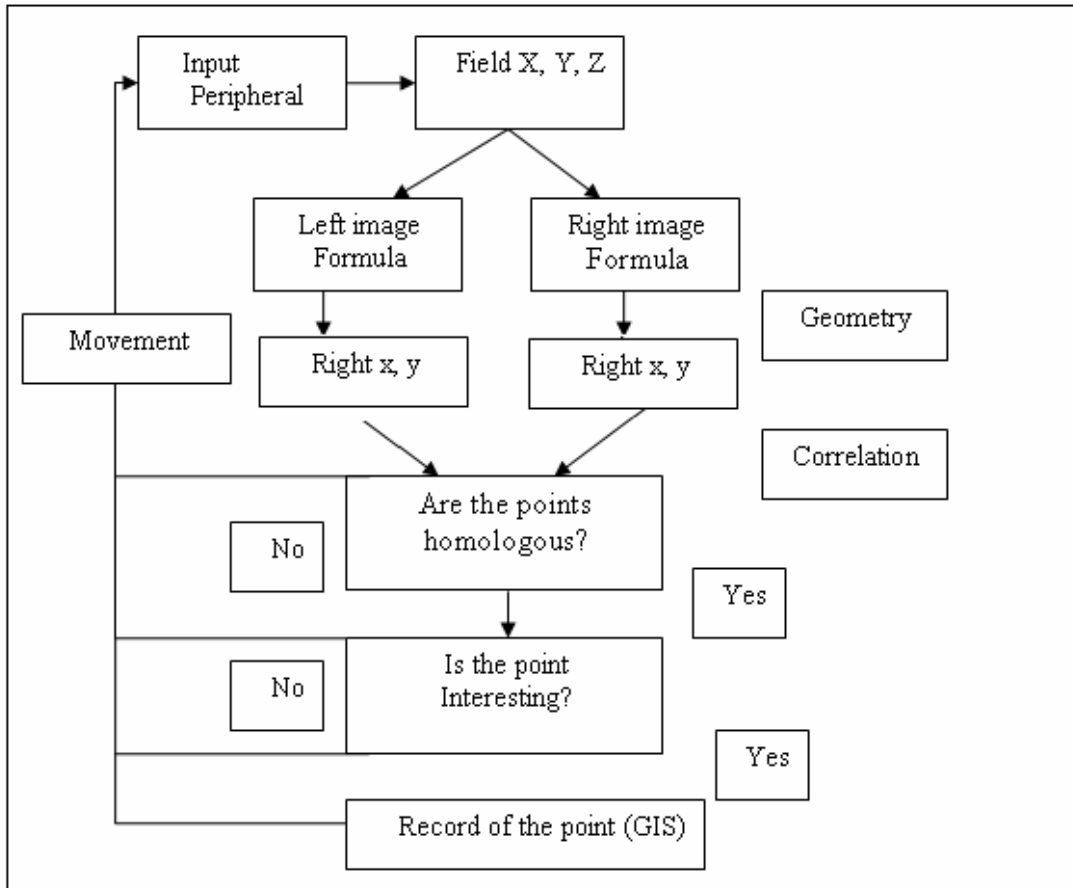


Figure (2-11): Schematic diagram of photogrammetric restitution in the 1980s, a first appreciable.[5]

CHAPTER THREE

THE PRINCIPLE OF DSM AND DTM

3.1 Digital elevation model

3.2 Digital terrain models

3.3 Digital terrain models in civil engineering

3.4 Digital surface models

3.5 DEM representation

3.6 Photogrammetric DSM

CHAPTER THREE**THE PRINCIPLE OF DSM AND DTM****3.1 Digital elevation model**

A Digital Elevation Model (DEM) represents the height of a patch of terrain. Accuracies of DEMs vary depending upon the requirements of different applications. DEMs have been applied to a wide range of civil engineering and military planning task

Besides the conventional methods of creating DEM such as Photogrammetry and manual field survey, airborne laser scanning and radar interferometer are new technologies capable of creating high quality DEMs in a cost-effective manner.

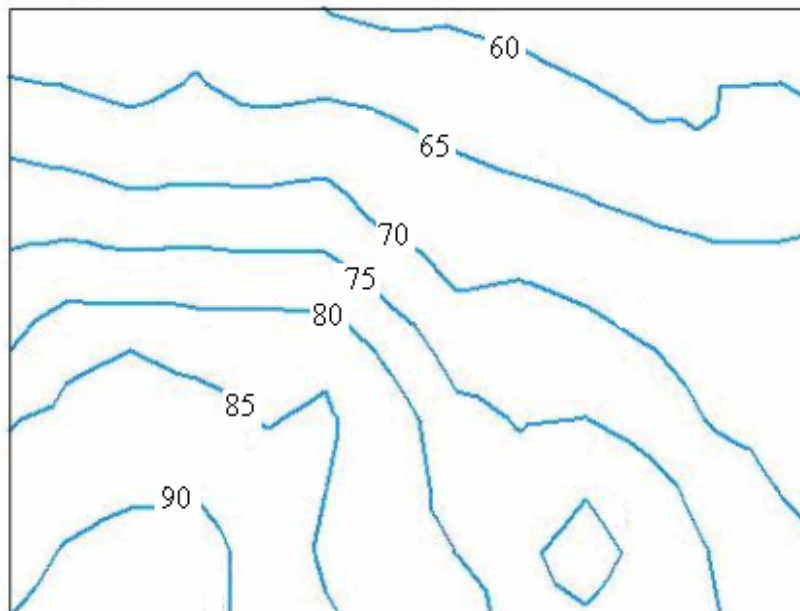


Figure (3-1):DEM represented by contours.

The term “digital elevation model” (DEM) is used generically to mean the digital cartographic representation of the elevation of the earth surface in any form.

3.2 Digital terrain models

A term which is commonly used interchangeably with DEM. Strictly speaking a DTM refers to a model of reality which includes information relating to factors such as surface texture as well as elevations and the method of transferring elevation data into a contoured surface or a three-dimensional display.

The digital terrain models have the following purposes:

- Digital terrain modeling is a powerful tool in GIS analysis and visualization.
- A digital terrain model is a digital representation of part of the earth's surface.
- This may be stored in a GIS in several ways:
 - a set of contour vectors Figure (3-2A).
 - a regular grid of spot heights Figure (3-2B).
 - an irregularly spaced set of points connected as triangles Figure(3-2C), normally called TIN (Triangular irregular networks).

The digital terrain models have the following applications:

- Resource Management
- Earth and Environmental Sciences
- Civil and Military Engineering
- Surveying and Photogrammetry

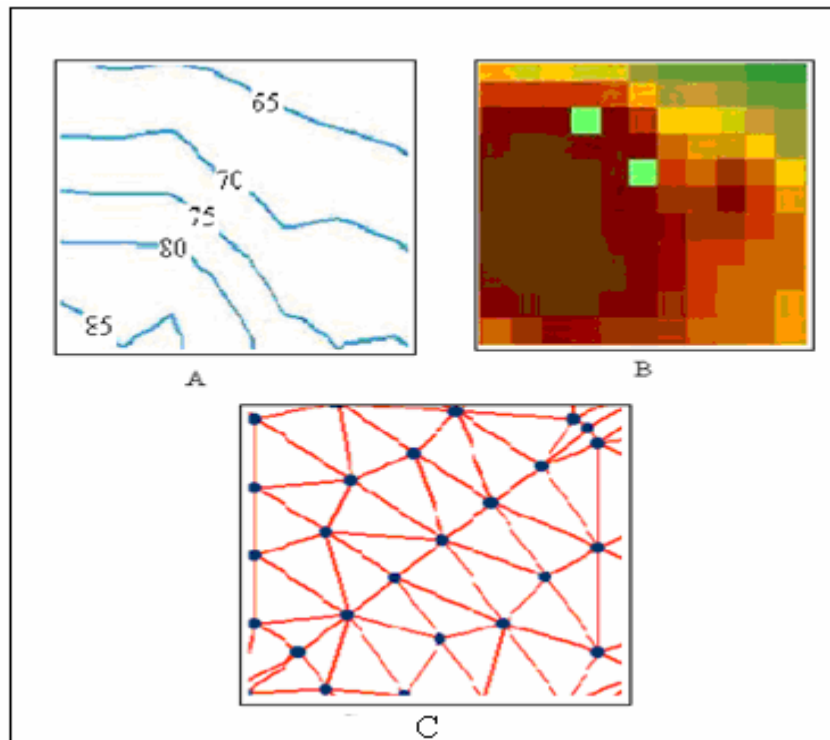


Figure (3-2): Ways to stored the digital terrain model in GIS

3.3 Digital terrain models in civil engineering

Digital Terrain Models are useful tools in both the design and the execution or construction of an engineering project. The surface model derived from photogrammetric data can be used in both phases; design and construction.

Examples of possible manipulations include:

- a- Horizontal, vertical or 3D roadway alignment design.
- b- The creation of design surfaces overlaying the original.
- c- The calculation of optimum earthwork cut-and-fill volumes.
- d- Storm drainage and watershed analysis.

- e- Dam and reservoir sitting (including monitoring once built).
- f- Landscape planning and visual impact analysis.

These various operations are supported by a number of Intergraph application software packages which are designed specifically for use by civil engineers.

3.4 Digital surface models

A digital elevation model (DEM) is a digital and mathematical representation of an existing or virtual object and its environment, e.g. terrain undulations within a selected area. DEM is a generic concept that may refer to elevation of ground but also to any layer above the ground such as canopy or buildings.

When the information is limited to ground elevation, the DEM is called a digital terrain model DTM and provides information about the elevation of any point on the ground or water surface. When the information contains the highest elevating of each point, coming from ground or above ground areas, the DEM is called the digital surface model or DSM.

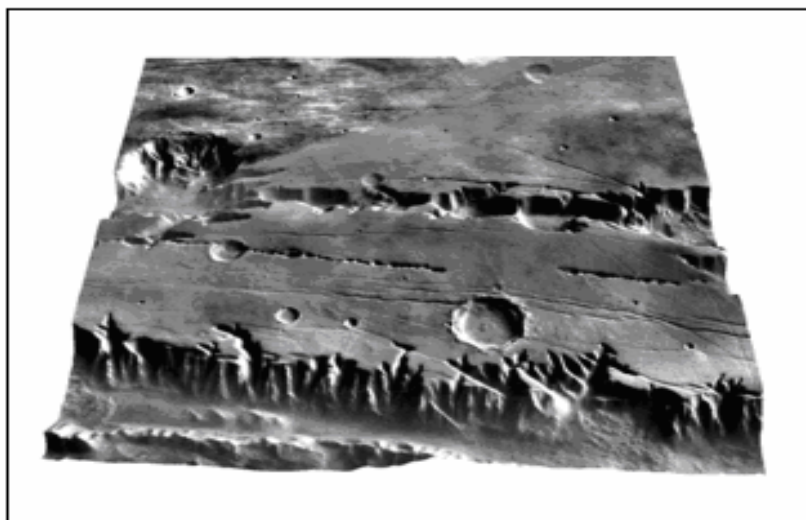


Figure (3-3) Digital surface model example.[5]

3.5 DEM representation

A very large number of program have been devised and written for terrain modelling applications in surveying and civil engineering. And they basically follow one of two main approaches:

- 1- They are based on, or make use of height data which has been collected or arranged in the form of regular interval .
- 2- They are based on, a triangular network.

3.5.1 Grid Representation

Gird models represent the terrain by interpolating from the input data on to affixed grid. this technique has limitations, but it is an easy method to implement and store on microcomputer. The main disadvantages are that the grid size must be fixed and must be small to accurately represent irregular surfaces, which naturally leadsto excess data in smooth areas, figure (3-4) shows principle of grid representation.

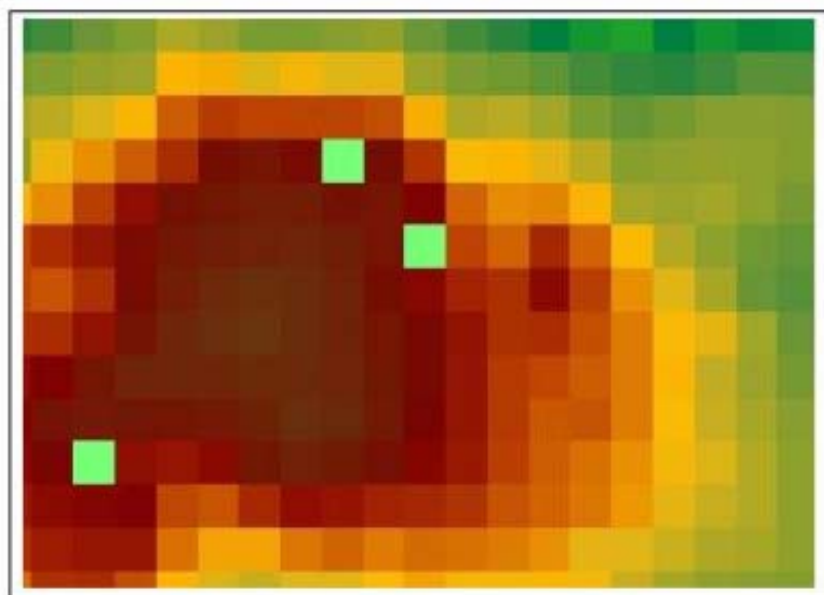


Figure (3-4): grid representation of DTM.

3.5.2 TIN Representation

The generation of the DTM corresponds to setting up a spatial triangular irregular network together with information on the surface normal at each node and on connections to neighboring triangle points.

To form the triangles; first all line segments (break lines round, break lines sharp, structure lines, fault lines or holes) are stored as edges of triangles. Then mass points (points known in XYZ) are introduced in the triangulation. the vertices of the triangles are the measured points these points are used for the construction of the triangular net. In this procedure a triangle is formed if the circle passing through the three points contains no other point. Figure (3-5) shows TIN representation .

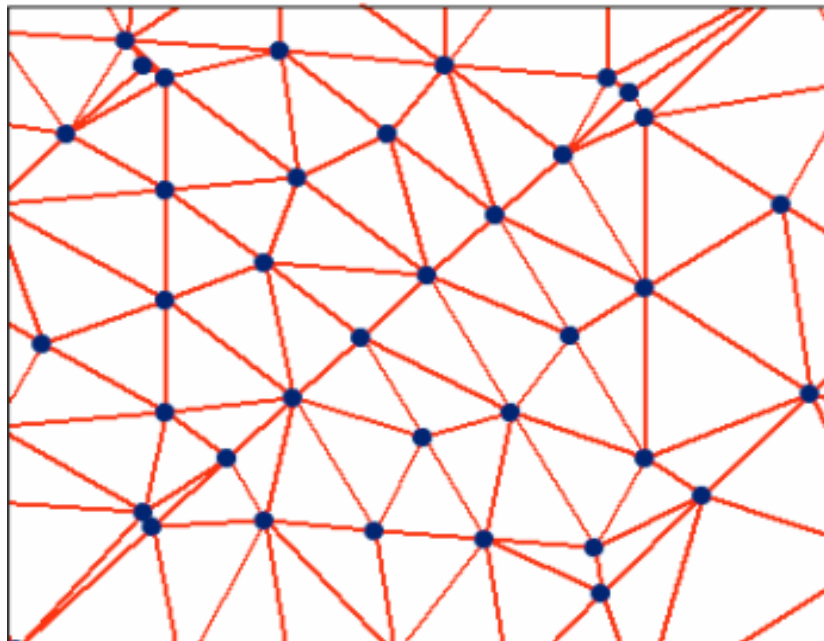


Figure (3-5): TIN representation of DTM.

3.5.3 Contour representation

With the information of the DTM of 3D data, either as a grid model or a triangular model, contours can be interpolated through the area. These contours can be directly interpolated in a GIS software or CAD software using the grid or TIN prepared in the photogrammetric workstations, each contour line has only one elevation, and distance between any two contour lines is constant, it is named the contour interval.

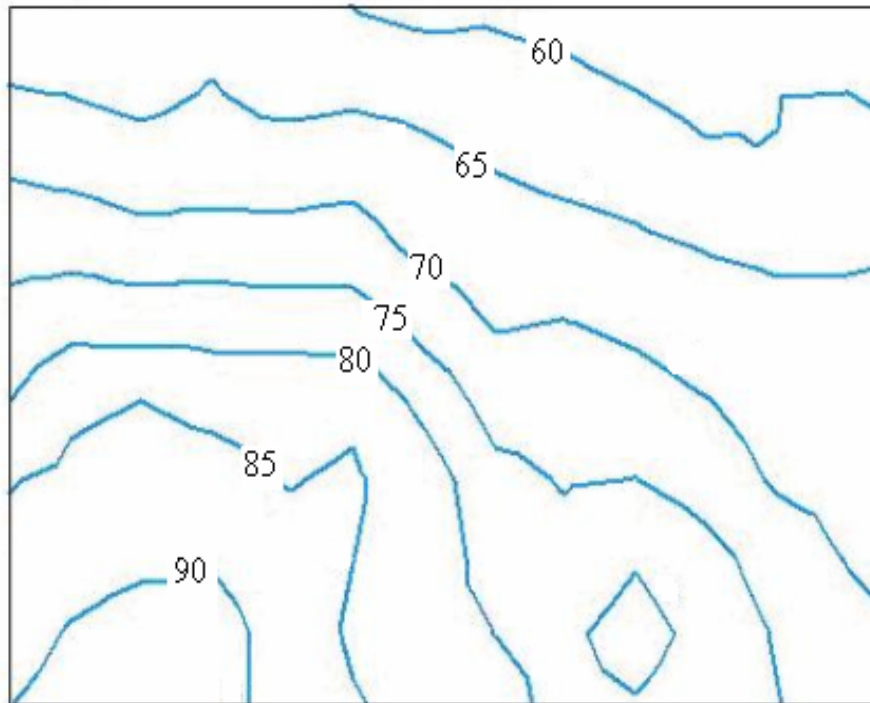


Figure (3- 6): contour representation of DTM.

3.6 Photogrammetric DTM

Production in digital Photogrammetry DTM can be produced either manually or automatic.

3.6.1 Automatic DTM production (Image Matching)

Image matching is a technique, in order to determine identical points in one or several images, to determine an objects position in an image or to reconstruct an object.

Techniques of image matching:

- Area Based matching: We are dealing with gray values, respectively colors, it is simple and easy.
- Feature based matching: We are dealing with features (points, lines, polygons),complex.

For the image matching we have the following workflow as shon in figure (3-7):

- Define the window **A** around the pixel in the first image e.g. 3X3.
- Define the search area in the second image.
- Find the correlation coefficient between the pixel and its window in the first image and with a window **B** with same size around each pixel in the search area in the second image.
- From all calculated correlation coefficients select the pixel with the best correlation coefficient. This pixel is the pixel we need to find.

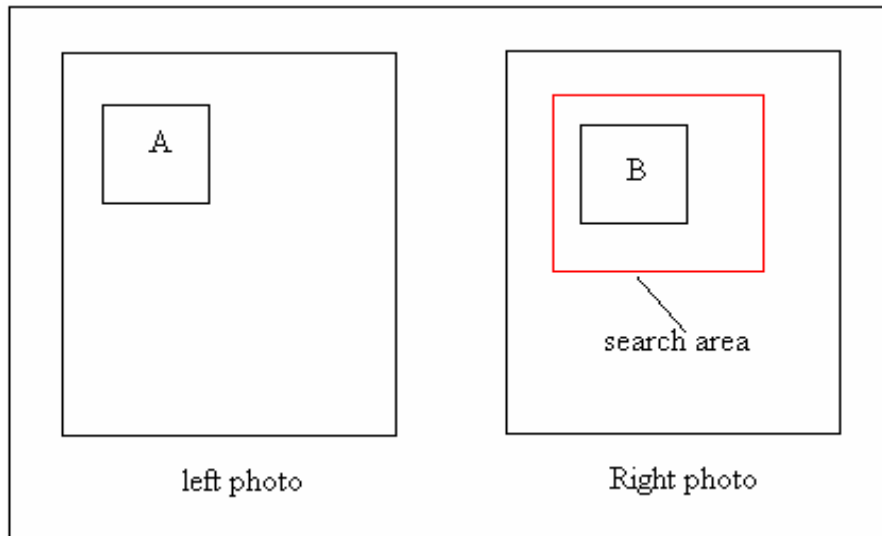


Figure (3-7): image matching between two images.

For Area based matching we have the following methods:

1- linear cross correlation :

$$c_{11} = \frac{\sum_{i=1}^m \sum_{j=1}^n [(A_{ij} - \bar{A})(B_{ij} - \bar{B})]}{\sqrt{\left[\sum_{i=1}^m \sum_{j=1}^n (A_{ij} - \bar{A})^2 \right] \left[\sum_{i=1}^m \sum_{j=1}^n (B_{ij} - \bar{B})^2 \right]}} \dots\dots\dots(3-1)$$

A: the window around the pixel in the first image.

B: the window around the pixel in the second image.

If c:

- = 1 then the windows in A and B are identical
- = 0 then the windows in A and B are uncorrelated
- = -1 then the windows in A and B are inverse (negative image)
- > 0.7 the points have good correlation

2- Least squares differences:

The two windows A and B form two vectors V1 and V2 respectively.

$$c_1 = ((i_1, j_1), (i_2, j_2)) = \left\| \frac{v_2(i_2, j_2)}{\|v_2(i_2, j_2)\|} - \frac{v_1(i_1, j_1)}{\|v_1(i_1, j_1)\|} \right\|^2 \dots\dots\dots(3-2)$$

C=0 , the two vectors are identical.

The pixels with minimum correlation is the matching pixel.

3- Centered least squares:

$$c_1((i_1, j_1), (i_2, j_2)) = \left\| \frac{v_2(i_2, j_2) - \mu_1}{\sigma_1} - \frac{v_1(i_1, j_1) - \mu_2}{\sigma_2} \right\| \dots\dots\dots(3-3)$$

C=0 , the two vectors are identical.

The pixels with minimum correlation is the matching pixel.

4- Scalar product:

This defines the cosine of the angle between the two vectors , if the cosine is 1 , this means the angle is 0 and the two vectors are identical.

$$c_2((i_1, j_1), (i_2, j_2)) = \left\| \frac{v_1(i_1, j_1)v_2(i_2, j_2)}{\|v_1(i_1, j_1)\| \|v_2(i_2, j_2)\|} \right\|^2 \dots\dots\dots(3-4)$$

C=1 , the two vectors are identical.

C=0, the vectors are are uncorrelated.

C >0.7 , they have good correlation.

3.6.2 Definition of the search area

1. Image space: Defining the search area on one of the two images depending the epipolar line where image coordinates in the left photo (x_1, y_1) are fixed. While the right image coordinates are changes along the eppipolar line slowly, and each time find the ground X,Y,Z AND the correlation coefficient. The point along the eppipolar line with best correlation coefficient value in the matching point (x_2, y_2) . the X,Y,Z coordinates of point in the left photo (x_1, y_1) and the right photo (x_2, y_2) .

The estimated error in the elevation is:

$$\sigma_z = \frac{H}{B} * r_0 * \sigma_{match} \dots\dots\dots(3-5)$$

Where: H: flying height
 B: air base
 r_0 : The ground pixel size in meters.

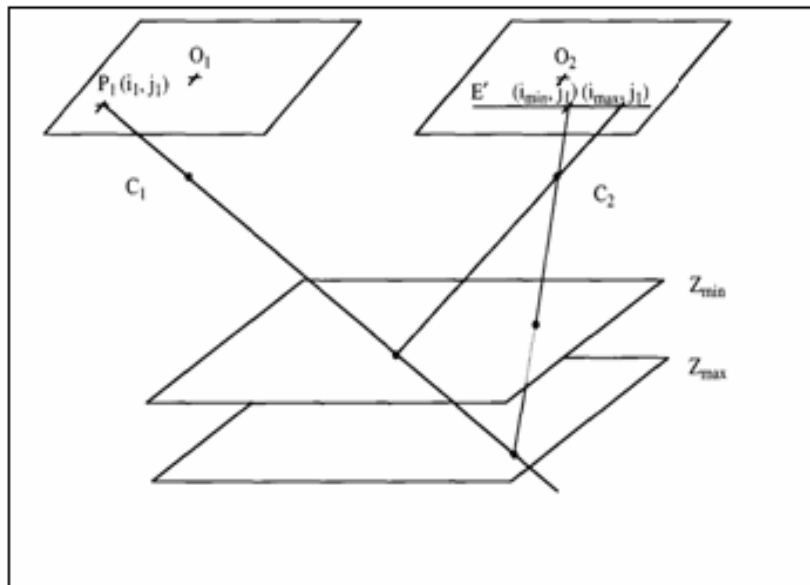


Figure (3-8):definition of search area using image space method.

2. **Object space:** The search is done by moving the 3D object coordinates. In this method the XY ground coordinates of the point are fixed, z value change by small increment d_z .

$$d_z = \frac{H}{4B} * r_0 \dots\dots\dots(3-6)$$

Where: H: flying height

B: air base

r_0 : The ground pixel size in meters.

As the (z) changes we get using collinearity equation the values of the point coordinates in the left and right photo, $(x_1, y_1), (x_2, y_2)$ also the correlation coefficient is determined, (z) is still changing starting from the minimum to the maximum z-value. The point with the best correlation coefficient is the matching point.

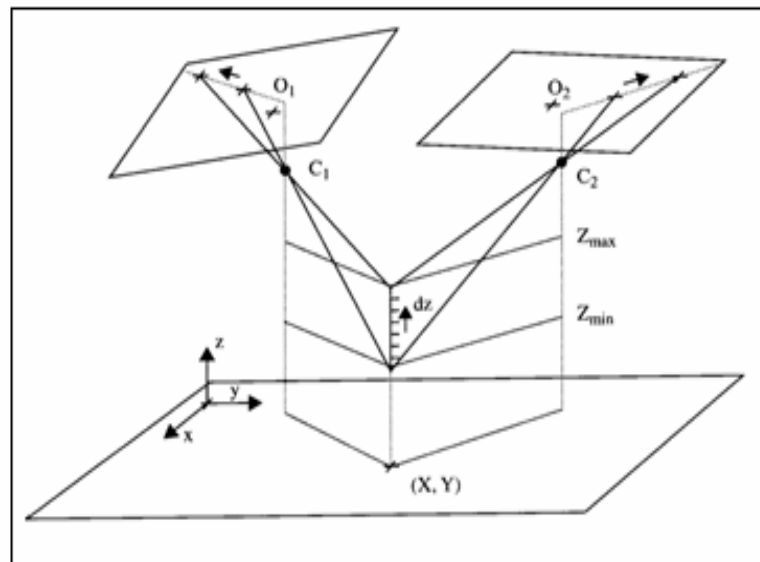


Figure (3-9): definition of search area using object space method.

3.6.2 Manual DTM production

You can manually collect and edit DTM elevation points from a pair of overlapping digital aerial images that are displayed in stereo.

To collect DTM elevation points means to measure or to edit the Z value of a point by clicking data (on the input device) where a specified point meets the ground. The software uses known X and Y values and established algorithms to calculate the Z value. See figure (3-10).



Figure (3-10) : Manual DTM .

CHAPTER FOUR

***GEOSPATIAL POSITIONING ACCURACY
STANDARD***

- 4.1 Introduction**
- 4.2 National standards for spatial data accuracy (NSSD)**
- 4.3 American society for Photogrammetry and remote sensing accuracy standards (ANPR)**
- 4.4 Check point and their distribution**

CHAPTER FOUR

GEOSPATIAL POSITIONING ACCURACY STANDARDS

4.1 Introduction

The National Standard for Spatial Data Accuracy (NSSDA) implements a statistical and testing methodology for estimating the positional accuracy of points on maps and in digital geospatial data, with respect to georeferenced ground positions of higher accuracy.

The NSSDA applies to fully georeferenced maps and digital geospatial data, in raster, point, or vector format, derived from sources such as aerial photographs, satellite imagery, and ground surveys. It provides a common language for reporting accuracy to facilitate the identification of spatial data for geographic applications.

4.2 National standards for spatial data accuracy (NSSDA)

Use the NSSDA to evaluate and report the positional accuracy of maps and geospatial data produced, revised, or disseminated by or for the Federal Government

4.2.1 Introduction

This standard does not define threshold accuracy values. Agencies are encouraged to establish thresholds for their product specifications and applications and for contracting purposes. Ultimately, users identify acceptable accuracies for their applications. Data and map producers must determine what accuracy exists or is achievable for their data and report it according to NSSDA.

$$RMSE_x = \sqrt{\sum (X_{data,i} - X_{check,i})^2 / n} \dots (4-1)$$

$$RMSE_y = \sqrt{\sum (Y_{data,i} - Y_{check,i})^2 / n} \dots (4-2)$$

$$RMSE_z = \sqrt{\sum (Z_{data,i} - Z_{check,i})^2 / n} \dots (4-3)$$

$$RMSE_{total} = \sqrt{RMSE_x^2 + RMSE_y^2} \dots (4-4)$$

Where:

- $X_{data,i}, Y_{data,i}$ are the coordinates of the i th check point in the dataset
- $X_{check,i}, Y_{check,i}$ are the coordinates of the i th check point in the independent source of higher accuracy
- $Z_{data,i}$ is the vertical coordinate of the i th check point in the dataset.
- $Z_{check,i}$ is the vertical coordinate of the i th check point in the independent source of higher accuracy.
- n is the number of check points tested.
- i is an integer ranging from 1 to n .

The NSSDA uses root-mean-square error (RMSE) to estimate positional accuracy. Accuracy reported at the 95% confidence level means that 95% of the positions in the dataset will have an error with respect to true ground position that is equal to or smaller than the reported accuracy value.

4.2.2 Accuracy test guidelines

The NSSDA presents guidelines for accuracy testing by an independent source of higher accuracy. The independent source of higher accuracy shall be the highest accuracy feasible and practicable to evaluate the accuracy of the dataset. The data producer shall determine the geographic extent of testing.

4.2.3 Accuracy reporting :

A dataset may contain themes or geographic areas that have different accuracies. If data of varying accuracies are composited and cannot be separately identified and the dataset is tested, report the accuracy value for the composited data.

If a composited dataset is not tested, report the accuracy value for the least accurate dataset component. Positional accuracy values shall be reported in ground distances.

Accuracy reporting in ground distances allows users to directly compare datasets of differing scales or resolutions. A simple statement of conformance (or omission, when a map or dataset is non-conforming) is not adequate in itself. Measures based on map characteristics, such as publication scale or contour interval, are not longer adequate when data can be readily manipulated and output to any scale or to different data formats. Report accuracy at the 95% confidence level for data tested for both horizontal and vertical accuracy as:

Tested _____ (meters, feet) horizontal accuracy at 95% confidence level
_____ (meters, feet) vertical accuracy at 95% confidence level

4.2.4 Horizontal accuracy

Horizontal accuracy shall be tested by comparing the coordinates of well-defined points in the dataset with coordinates of same points from an independent source of higher accuracy.

4.2.5 Vertical accuracy

Vertical accuracy shall be tested by comparing the elevations in the dataset with elevation of the same points as determined from an independent source of higher accuracy.

4.3 American Society for Photogrammetry and Remote Sensing (ASPRS) Accuracy Standards

ASPRS Accuracy Standards for Large-Scale Maps (ASPRS Specifications and Standards Committee, 1990) provide accuracy tolerances for maps at 1:20,000-scale or larger “prepared for special purposes or engineering applications.” RMSE is the statistic used by the ASPRS standards. Accuracy is reported as Class 1, Class 2, or Class 3. Class 1 accuracy for horizontal and vertical components is discussed below. Class 2 accuracy applies to maps compiled within limiting RMSE’s twice those allowed for Class 1 maps. Similarly, Class 3 accuracy applies to maps compiled within limiting RMSE’s three times those allowed for Class 1 maps.

ASPRS Accuracy Standards for Large-Scale Maps (ASPRS Specifications and Standards Committee, 1990) evaluates positional accuracy for the x-component and the y-component individually. Positional accuracy is reported at ground scale. Table (4-1) shows Class 1 planimetric limiting RMSE in feet associated with typical map scales.

Table (4-1) : ASPRS Accuracy Standards for Large-Scale Maps Class 1 horizontal (x or y) limiting RMSE for various map scales at ground scale for feet units.

Class1 Planimetric Accuracy, limiting RMSE (feet)	Map Scale
0.05	1:60
0.1	1:120
0.2	1:240
0.3	1:360
0.4	1:480
0.5	1:600
1	1:1,200
2	1:2,400
4	1:4,800
5	1:6,000
8	1:9,600
10	1:12,000
16.7	1:20,000

Vertical map accuracy is defined by the ASPRS Accuracy Standards (ASPRS Specifications and Standards Committee, 1990) as the RMSE in terms of the project's elevation datum for well-defined points only.

For Class 1 maps according to the ASPRS Accuracy Standards, the limiting RMSE is set at one-third the contour interval. Spot elevations shall be shown on the map with a limiting RMSE of one-sixth the contour interval or less

4.4 Check Point and their distortion

Minimum of 20 check points shall be tested, distribution to reflect the geographic area of interest and the distribution of error in the dataset. When 20 points are tested, the 95% confidence level allows one point to fail the threshold given in production specifications.

A well-defined point represents a feature for which the horizontal position is known to a high degree of accuracy and position with respect to the geodetic datum. For the purpose of accuracy testing, well-defined points must be easily visible or recoverable on the ground, on the independent source of higher accuracy, and on the product itself. Graphic contour data and digital hypsographic data may not contain well-defined points.

The selected points will differ depending on the type of dataset and output scale of the dataset. For graphic maps and vector data, suitable well-defined points represent right-angle intersections of roads, railroads, or other linear mapped features, such as canals, ditches, trails, fence lines, and pipelines. For orthoimagery, suitable well-defined points may represent features such as small isolated shrubs or bushes, in addition to right-angle intersections of linear features. For map products at scales of 1:5,000 or larger, such as engineering plats or property maps, suitable well-defined points may represent additional features such as utility access covers and intersections of sidewalks, curbs, or gutters.

Due to the diversity of user requirements for digital geospatial data and maps, it is not realistic to include statements in this standard that specify the spatial distribution of check points. Data and/or map producers must determine check point locations. This section provides guidelines for distributing the check point locations.

Check points may be distributed more densely in the vicinity of important features and more sparsely in areas that are of little or no interest. When data exist for only a portion of the dataset, confine test points to that area. When the distribution of error is likely to be nonrandom, it may be desirable to locate check points to correspond to the error distribution.

For a dataset covering a rectangular area that is believed to have uniform positional accuracy, check points may be distributed so that points are spaced at intervals of at least 10 percent of the diagonal distance across the dataset and at least 20 percent of the points are located in each quadrant of the dataset. As shown in figure (4-1).

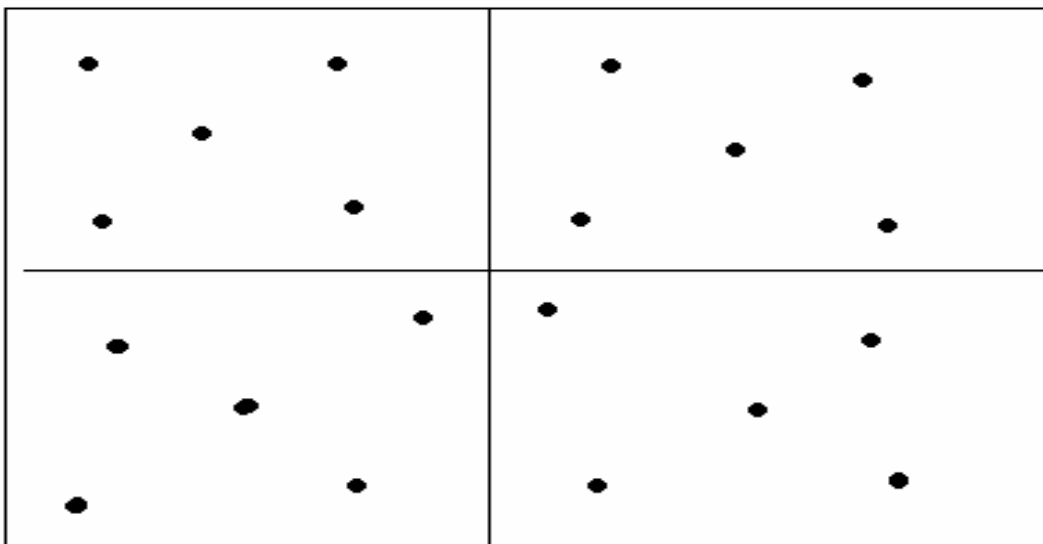


Figure (4-1) Check point distribution.

CHAPTER FIVE

RESULTS AND ANALYSIS

5.1 Introduction

5.2 First model (Industry Area)

5.3 Second model (Wadi Al Harriah Area)

5.4 Third Model (Albassa Area)

CHAPTER FIVE

RESULTS AND ANALYSIS

5.1 Introduction

For creating the DTM model, Z/I photogrammetry workstations (see appendix-A,B,C,D,E) were used . Photos with different scan resolution were scanned with Ultra scan 5000 photogrammetric scanner , these photo were used to create Digital Terrain Models (DTM) with different grid sizes. Using ArcGIS 9.2 we were able to analyze DTM's vertical accuracy (see appendix- F) .

The results and their analysis of the created DTM's from different stereo models are discussed in the coming sections:

5.2 First model (Industry Area)

This model is located in the southern part of Hebron city. Where the industrial area is located. The photos for this model were taken in 2004 the photos numbers are 96 for the right photo, and 95 for the left photo, these photos were taken with camera type RMKA30/23, having focal length of 305.004 mm.

This model was scanned by different scan resolutions (20, 50, and 75) micrometer and with different grid sizes (5, 10, and 10) meters.

The results of those different scan resolutions and grid sizes are discussed in the next sections.

5.2.1 Resolution (20 μ m) Grid (5m)

In this model an example of the solution of The Interior orientation is shown in figure (5-1) and below in the figure the parameters of The Interior orientation are also shown for left photo.

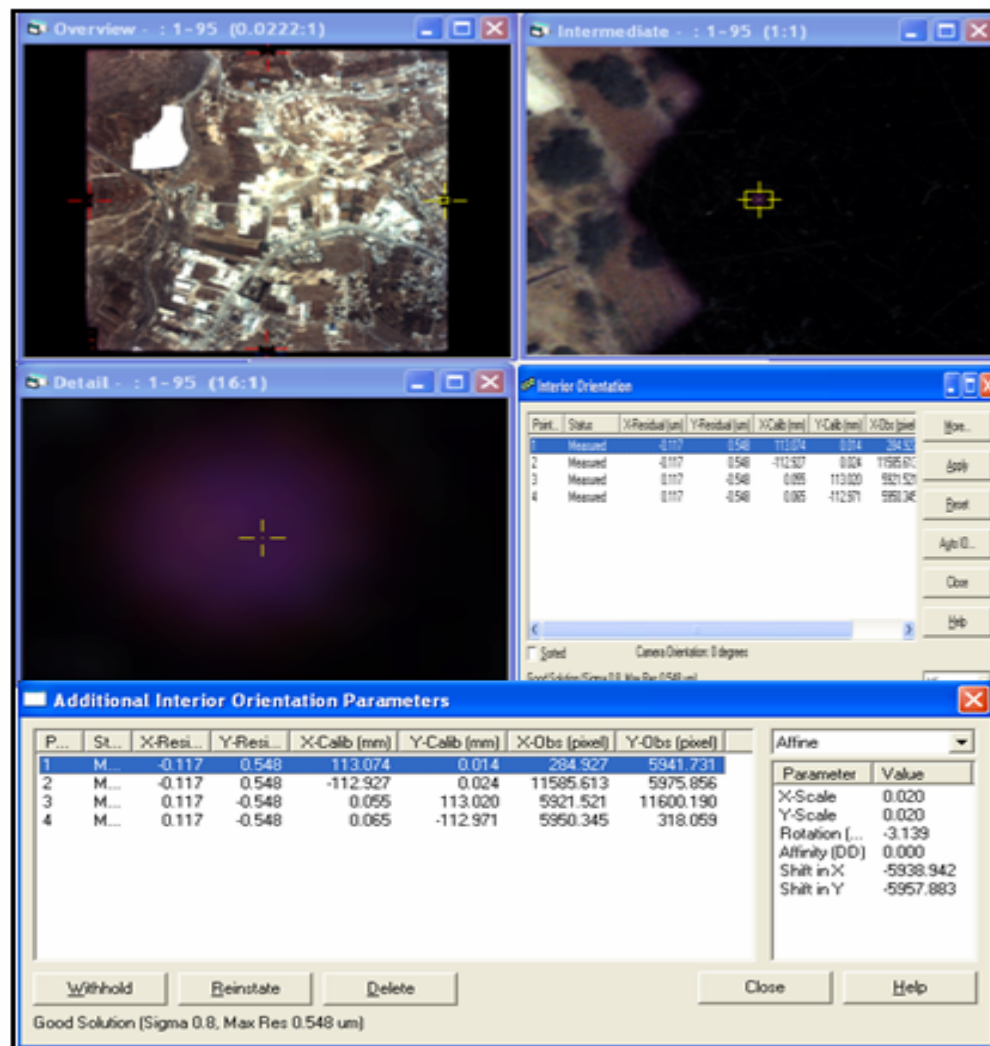


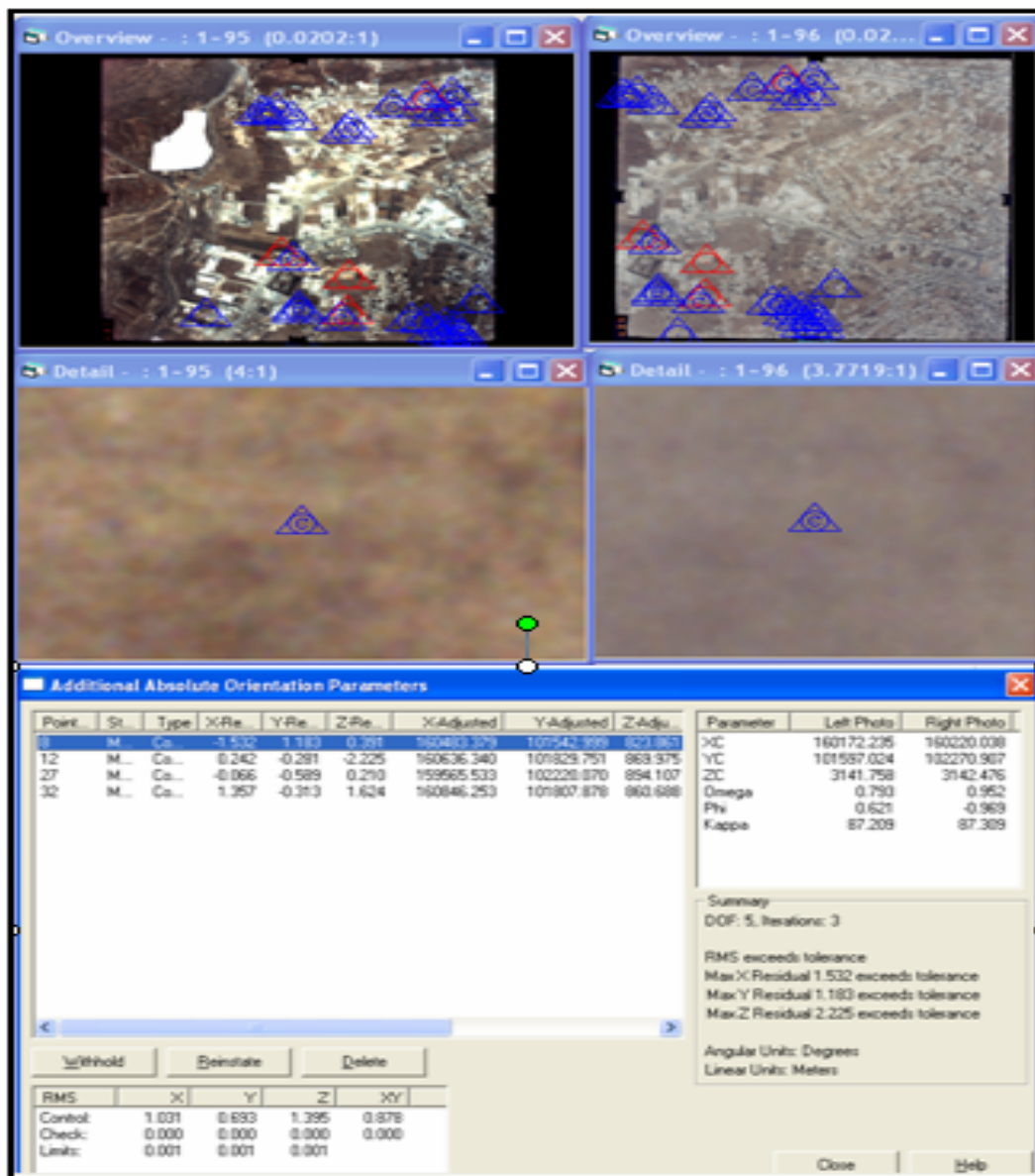
Figure (5-1): Interior orientation of the left photo in industry area model using scan resolution 20 μ m and grid size 5m.

The solution for this model in the Relative orientation steel is shown in figure (5-2), and below in the figure are the parameters of The Relative orientation.



Figure (5-2): Relative Orientation solution for the industry area model using scan resolution 20µm and grid size 5m.

The solution of The Absolute orientation of the Industry area model is shown in figure (5-3), and below those are the parameters of The Absolute orientation .



Figure(5-3) : Absolute orientation solution for the industry area model using scan resolution 20 μ m and grid size 5m.

Table (5-1) shows the horizontal coordinates of the check points and their elevations from both land survey and Photogrammetric DTM heights for the same points the differences between the measured and calculated elevations are also shows using 95% the RMSE is calculated and the vertical accuracy is determined .

Table (51): differences between DTM heights and land survey height (20µm,5m).

point	X	Y	Z - Survey	DTM	dZ
1	159566.00	102221.00	894.01	893.00	1.00
2	160845.00	101808.00	859.03	857.40	1.60
3	159559.00	102208.00	885.03	885.20	0.20
4	160884.00	101783.00	865.00	865.80	0.20
5	159542.00	102327.00	897.00	897.40	0.40
6	160813.00	101596.00	839.11	838.40	0.60
7	159749.00	101852.00	877.06	875.00	2.00
8	160914.00	102157.00	862.00	861.20	0.80
9	159656.00	101622.00	854.02	853.20	0.80
10	159599.00	102067.00	877.03	877.80	0.80
11	159639.00	102311.00	902.02	903.70	1.68
12	159664.00	102250.00	897.00	896.00	1.00
13	159717.00	101879.00	877.22	878.00	1.00
14	160485.00	101542.00	823.01	822.00	1.00
15	160516.00	101588.00	826.02	826.80	0.20
16	160838.00	101602.00	843.01	842.02	0.99
17	160636.00	101830.00	872.00	871.80	0.20
18	160922.00	102105.00	807.00	807.40	0.40
19	160945.00	102235.00	860.02	859.00	1.02
20	160942.00	102230.00	855.30	853.4 0	1.90

$$RMSE_z = \sqrt{\sum (Z_{datai} - Z_{checki})^2 / n} = 0.995m.$$

According National Standards for spatial data accuracy (NSSDA) , we have :

Tested: 0.995 meters vertical accuracy at 95% confidence level.

5.2.2 Resolution (50µm) Grid (10m)

In this model an example of the solution of The Interior orientation is shown in figure (5-4), and below in the figure the parameters of The Interior orientation are also shown for left photo.

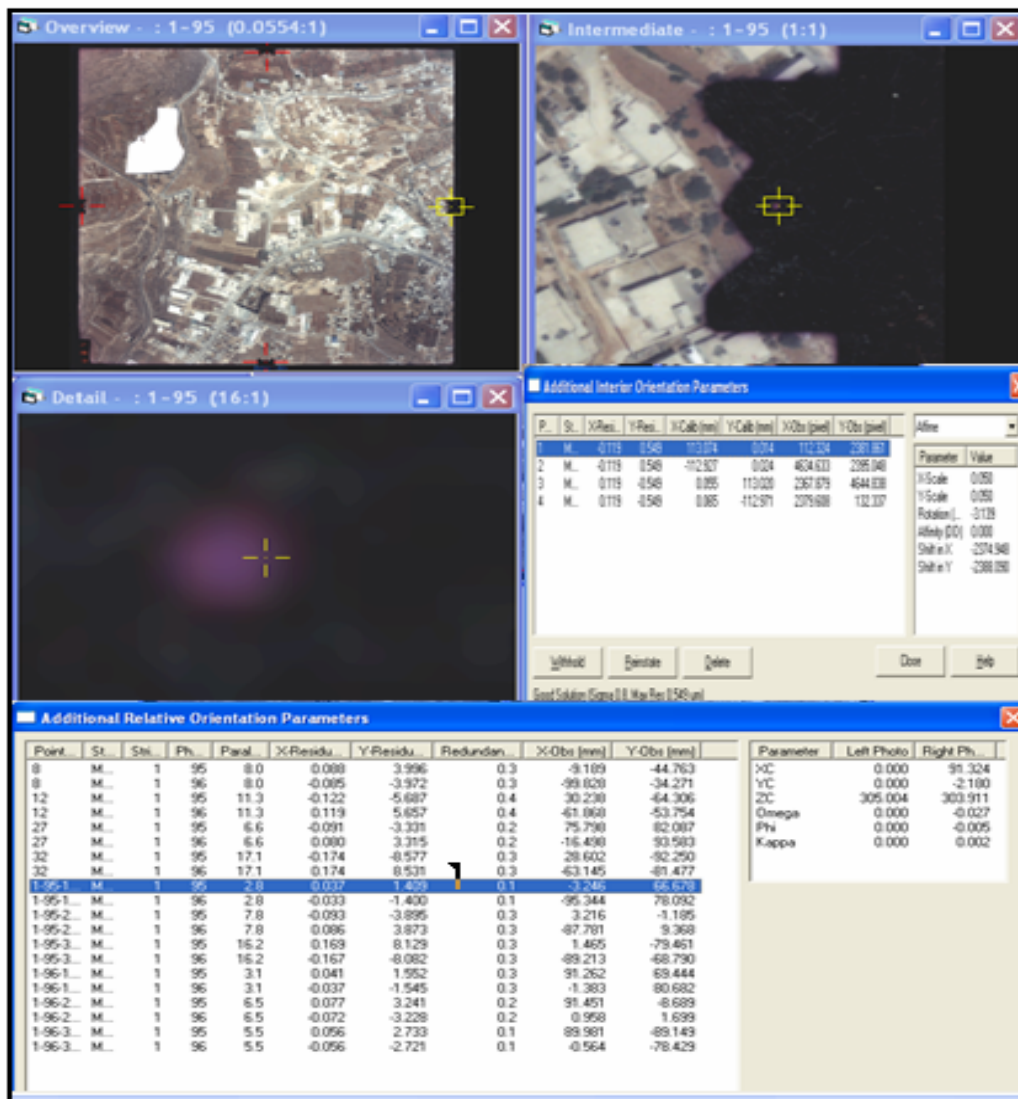


Figure (5-4) : Interior orientation of the left photo in industry area model using scan resolution 50µm and grid size 20m.

The solution for this model in the Relative orientation steel is shown in figure (5-5), and below in the figure are the parameters of The Relative orientation.



Figure (5-5): Relative Orientation solution for the industry area model using scan resolution 50µm and grid size 10m.

The solution of The Absolute orientation of the Industry area model is shown in figure (5-6), and below those are the parameters of The Absolute orientation .



Figure (5-6) : Absolute orientation solution for the industry area model using scan resolution 50µm and grid size 10m.

Table (5-2), shows the horizontal coordinates of the check points and their elevations from both land survey and Photogrammetric DTM heights for the same points the differences between the measured and calculated elevations are also shows using 95% the RMSE is calculated and the vertical accuracy is determined .

Table (5-2): differences between DTM heights and land survey height (50µm,10m).

point	X	Y	Z_Survey	DTM	dZ
1	159566.00	102221.00	894.01	893.00	1.00
2	160845.00	101808.00	859.03	856.40	2.60
3	159559.00	102208.00	885.03	885.20	0.20
4	160884.00	101783.00	865.00	864.80	1.20
5	159542.00	102327.00	897.00	895.60	1.40
6	160813.00	101596.00	839.11	837.40	1.60
7	159749.00	101852.00	877.06	875.70	1.30
8	160914.00	102157.00	862.00	858.20	3.80
9	159656.00	101622.00	854.02	857.20	3.20
10	159599.00	102067.00	877.03	877.80	0.80
11	159639.00	102311.00	902.02	906.80	4.80
12	159664.00	102250.00	897.00	895.00	2.00
13	159717.00	101879.00	877.22	878.00	1.00
14	160485.00	101542.00	823.01	820.00	3.00
15	160516.00	101588.00	826.02	825.80	1.20
16	160838.00	101602.00	843.01	841.00	2.00
17	160636.00	101830.00	872.00	869.80	2.20
18	160922.00	102105.00	807.00	807.40	0.40
19	160945.00	102235.00	860.02	854.00	6.00
20	160942.00	102230.00	855.30	853.00	2.00

$$RMSE_z = \sqrt{\sum (Z_{datai} - Z_{checki})^2 / n} = 2.20m.$$

According National Standards for spatial data accuracy (NSSDA) , we have :

Tested: 2.20 meters vertical accuracy at 95% confidence level.

5.2.3 Resolution ($75\mu\text{m}$) Grid (10m)

In this model an example of the solution of The Interior orientation is shown in figure (5-7), and below in the figure the parameters of The Interior orientation are also shown for right photo.

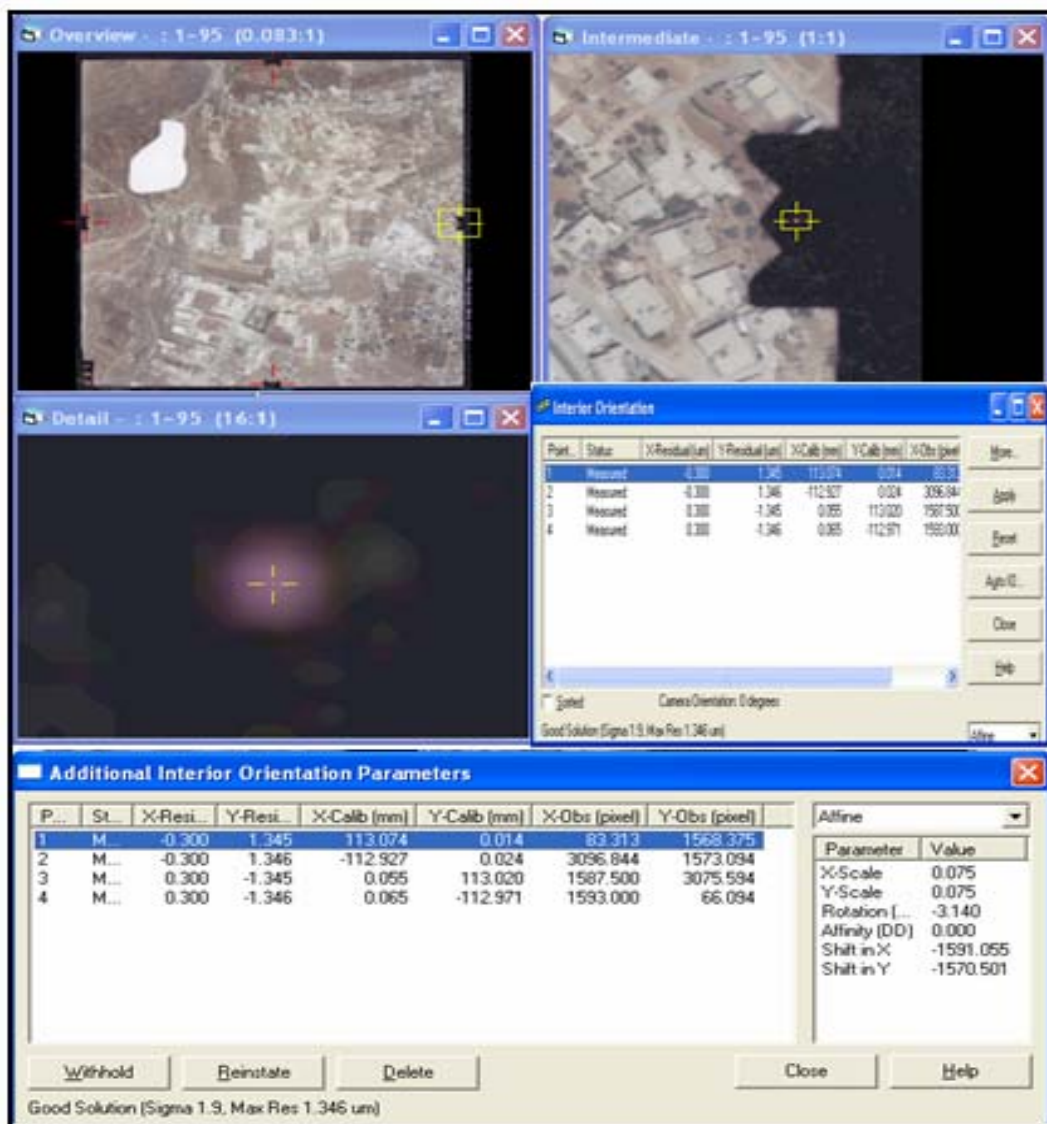


Figure (5-7) : Interior orientation of the left photo in industry area model using scan resolution $75\mu\text{m}$ and grid size 10m.

The solution of The Relative orientation of the Industry area model is shown in figure (5-8), and below those are the parameters of The Relative orientation

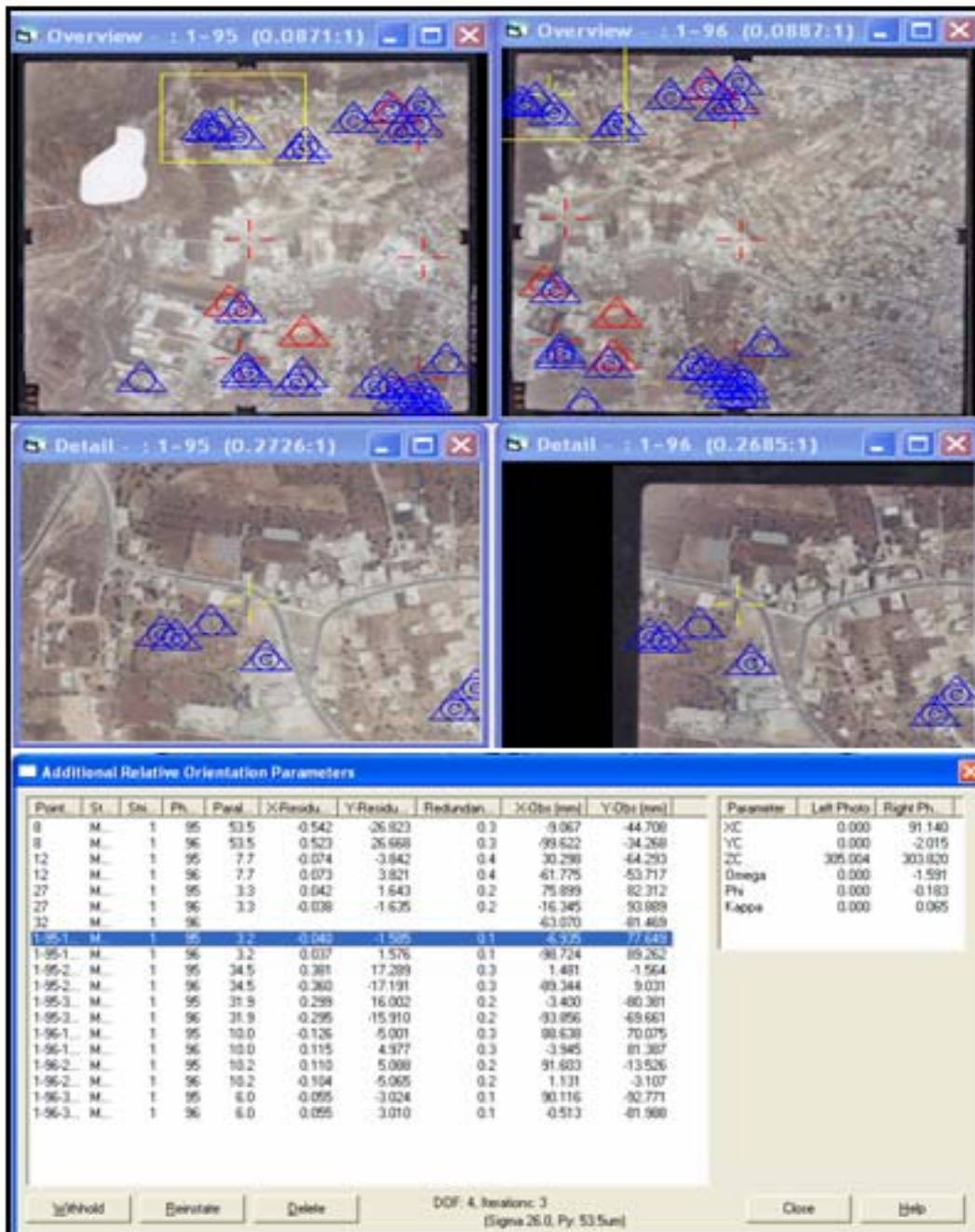


Figure (5-8): Relative Orientation solution for the industry area model using scan resolution 75µm and grid size 10m.

The solution of The Absolute orientation of the Industry area model is shown in figure (5-9), and below those are the parameters of The Absolute orientation .

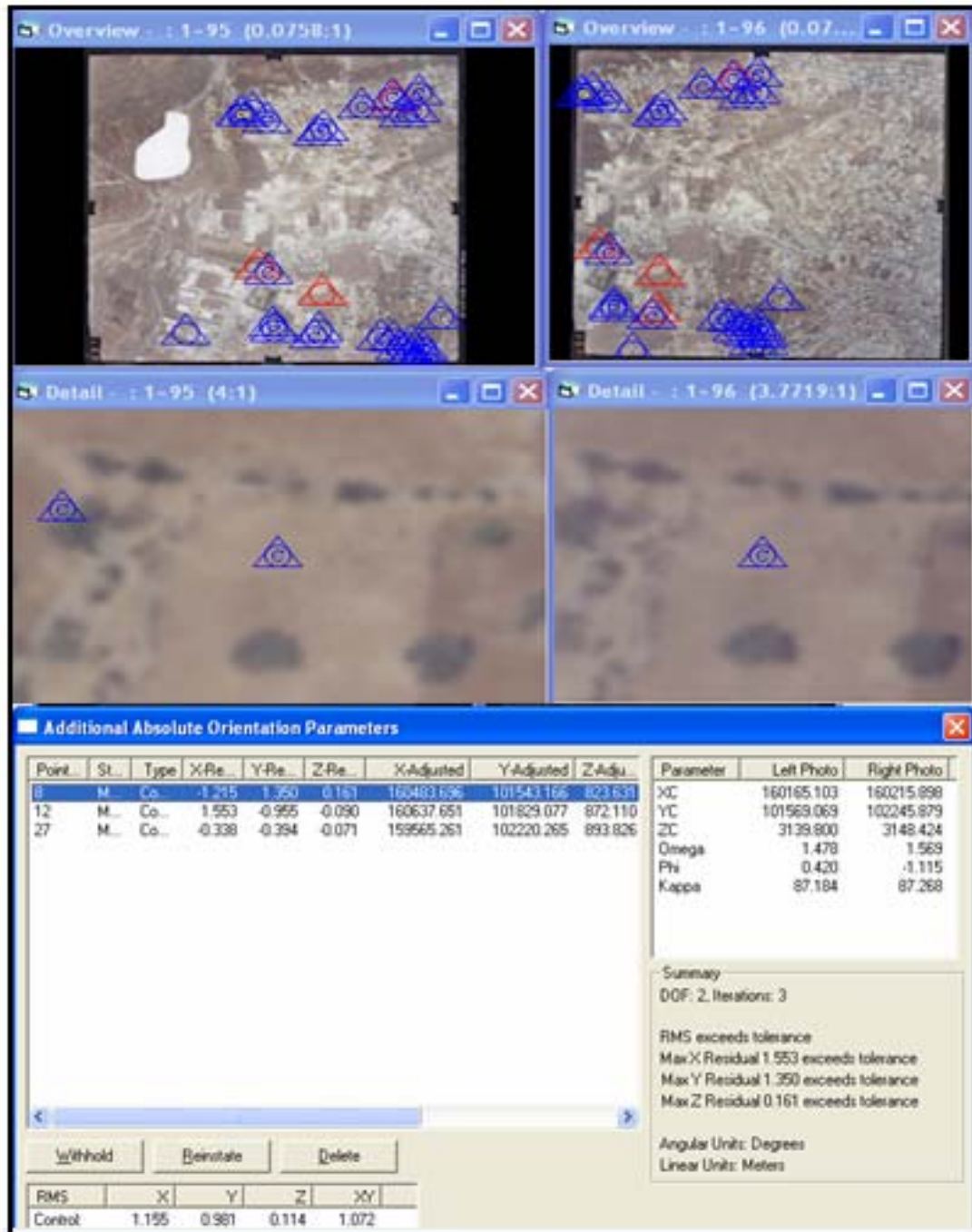


Figure (5-9) : Absolute orientation solution for the industry area model using scan resolution 75µm and grid size 10m.

Table (5-3), shows the horizontal coordinates of the check points and their elevations from both land survey and Photogrammetric DTM heights for the same points the differences between the measured and calculated elevations are also shown using 95% the RMSE is calculated and the vertical accuracy is determined .

Table (5-3): differences between DTM heights and land survey height (75µm,10m).

point	X	Y	Z_Survey	DTM	dZ
1	159566.00	102221.00	894.01	893.10	0.90
2	160845.00	101808.00	859.03	862.70	3.70
3	159559.00	102208.00	885.03	891.00	5.97
4	160884.00	101783.00	865.00	859.80	5.20
5	159542.00	102327.00	897.00	902.00	5.00
6	160813.00	101596.00	839.11	835.30	3.70
7	159749.00	101852.00	877.06	872.50	4.56
8	160914.00	102157.00	862.00	857.00	5.00
9	159656.00	101622.00	854.02	850.20	3.80
10	159599.00	102067.00	877.03	886.00	8.97
11	159639.00	102311.00	902.02	906.20	4.18
12	159664.00	102250.00	897.00	90250	5.50
13	159717.00	101879.00	877.22	874.90	2.10
14	160485.00	101542.00	823.01	819.60	3.40
15	160516.00	101588.00	826.02	821240	3.62
16	160838.00	101602.00	843.01	840.80	2.20
17	160636.00	101830.00	872.00	871.40	0.60
18	160922.00	102105.00	807.00	807.10	0.10
19	160945.00	102235.00	860.02	854.00	6.02
20	160942.00	102230.00	855.30	853.00	2.00

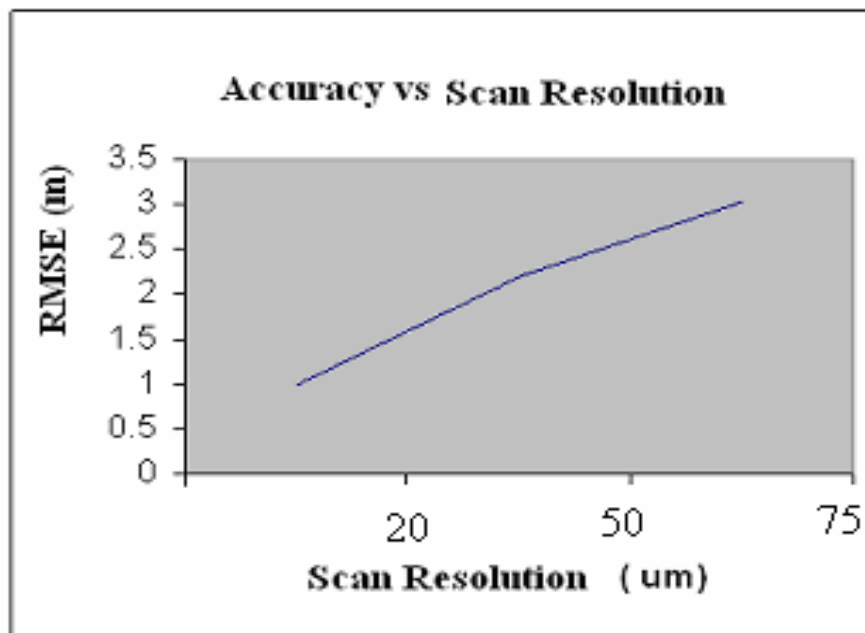
$$RMSE_z = \sqrt{\sum (Z_{datai} - Z_{checki})^2 / n} = 3.04m$$

According National Standards for spatial data accuracy (NSSDA) , we have :

Tested: **3.04** meters vertical accuracy at 95% confidence level.

5.2.4 Accuracy results

According to the result shown in tables (5-1, 5-2, 5-3), it is found that accuracy in the DTM increases with the higher scan resolution, as shown in figure (5-10).



Figure(5-10) : The relationship between scan resolution and RMSE.

5.3 Second model (Wadi Al Harriah Area)

This model is located in the southern part of Hebron city. Where the Palastin Polytechnic University is located. The photos for this model were taken in 2004 the photos numbers are 30 for the right photo, and 29 for the left photo, these photos were taken with camera type RMKA30/23, having focal length of 305.004 mm.

This model was scanned by different scan resolutions (20, 50, and 75) micrometer and with different grid sizes (5, 10, and 10) meters.

The results of those different scan resolutions and grid sizes are discussed in the next sections:

5.3.1 Resolution (20 μm) Grid (5m)

In this model an example of the solution of The Interior orientation is shown in figure (5-11), and below in the figure the parameters of The Interior orientation are also shown for left photo.

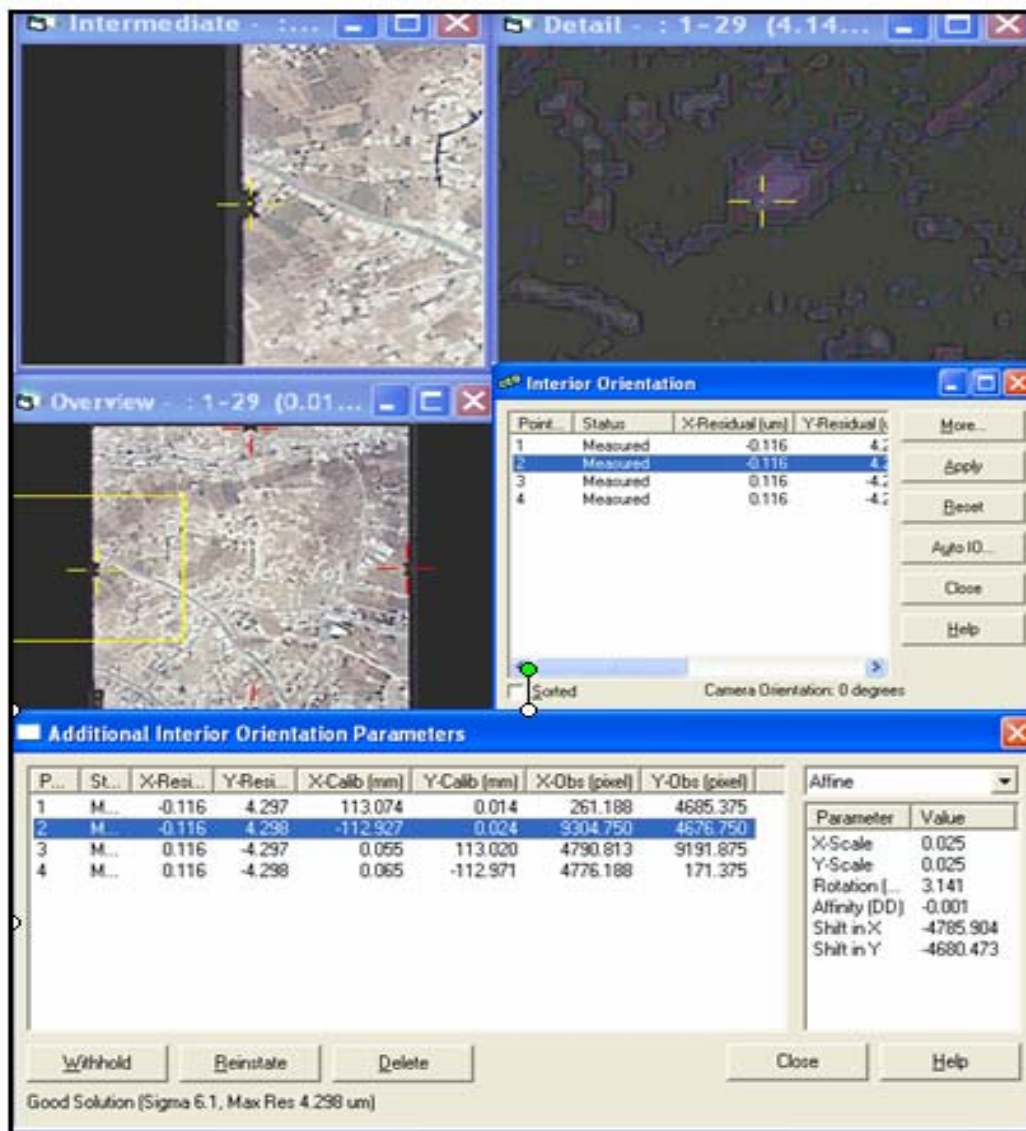


Figure (5-11): Interior orientation of the left photo in Wadi Al Harriah Area model using scan resolution 20 μm and grid size 5m.

The solution for this model in the Relative orientation steel Area model is shown in Figure (5-12), and below those are the parameters of The Relative orientation.

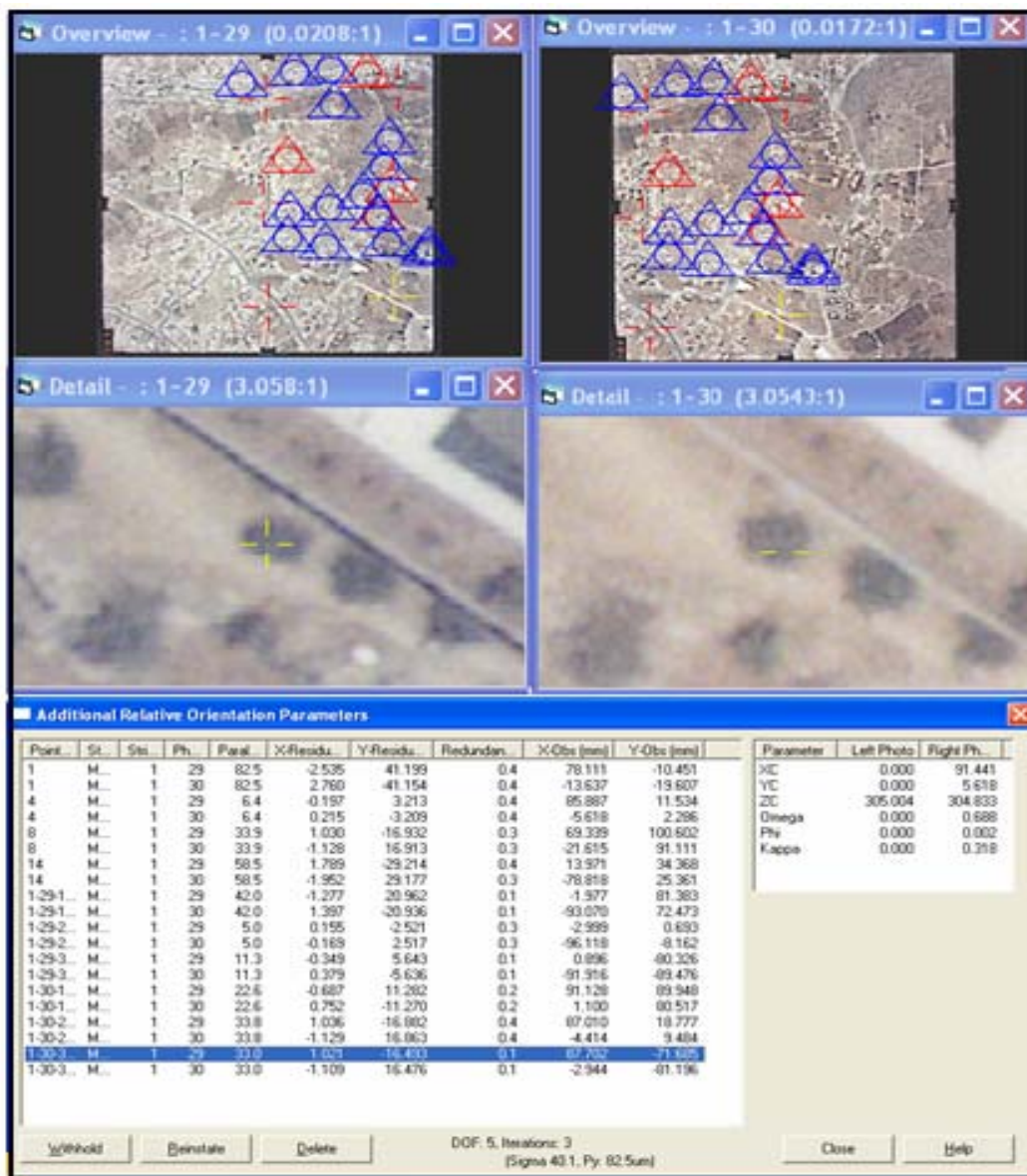


Figure (5-12): Relative Orientation solution for the Wadi Al Harriah Area model using scan resolution 20 μ m and grid size 5m.

The solution of The Absolute orientation of the Wadi Al Harriah Area model is shown in Figure (5-13), and below those are the parameters of The Absolute orientation .



Figure (5-13): Absolute orientation solution for the Wadi Al Harriah area model using scan resolution 20 μ m and g size 5m.

Table (5-4), shows the horizontal coordinates of the check points and their elevations from both land survey and Photogrammetric DTM heights for the same points the differences between the measured and calculated elevations are also shows using 95% the RMSE is calculated and the vertical accuracy is determined .

Table (5-4): differences between DTM heights and land survey height (20μm,5m).

Point	X	Y	Z_SURVEY	DTM	dZ
1	158779.33	101725.33	896.92	896.50	0.42
2	158784.09	101737.98	896.88	895.98	0.90
3	158905.43	101801.98	902.53	901.00	1.53
4	158932.59	101659.40	884.17	884.85	0.68
5	159057.18	101682.34	887.36	887.58	0.22
6	159201.07	101647.95	876.81	874.27	2.54
7	159417.23	101906.70	855.44	854.00	1.44
8	159602.79	102095.19	888.16	887.39	0.77
9	159125.35	102164.76	917.27	917.19	0.08
10	158825.15	102172.49	928.67	926.00	2.67
11	158849.15	101980.22	914.12	914.00	0.12
12	158690.20	102193.44	927.33	928.00	0.67
13	158639.81	102005.69	910.77	907.52	3.25
14	158479.09	101534.63	880.33	880.98	0.65
15	158463.51	101535.10	890.35	890.32	0.97
16	158322.14	102196.71	899.03	899.00	0.03
17	158848.81	101820.44	898.09	998.80	0.71
18	158803.88	101823.68	899.36	902.95	3.59
19	158633.11	101696.98	889.15	891.00	1.85
20	158827.06	101821.90	917.56	917.47	0.09

$$RMSE_z = \sqrt{\sum (Z_{datai} - Z_{checki})^2 / n} = \mathbf{1.38m}$$

According National Standards for spatial data accuracy (NSSDA) , we have :

Tested: 1.38 meters vertical accuracy at 95% confidence level.

5.3.2 Resolution (50 μ m) Grid (10m)

In this model an example of the solution of The Interior orientation is shown in figure (5-14), and below in the figure the parameters of The Interior orientation are also shown for left photo.

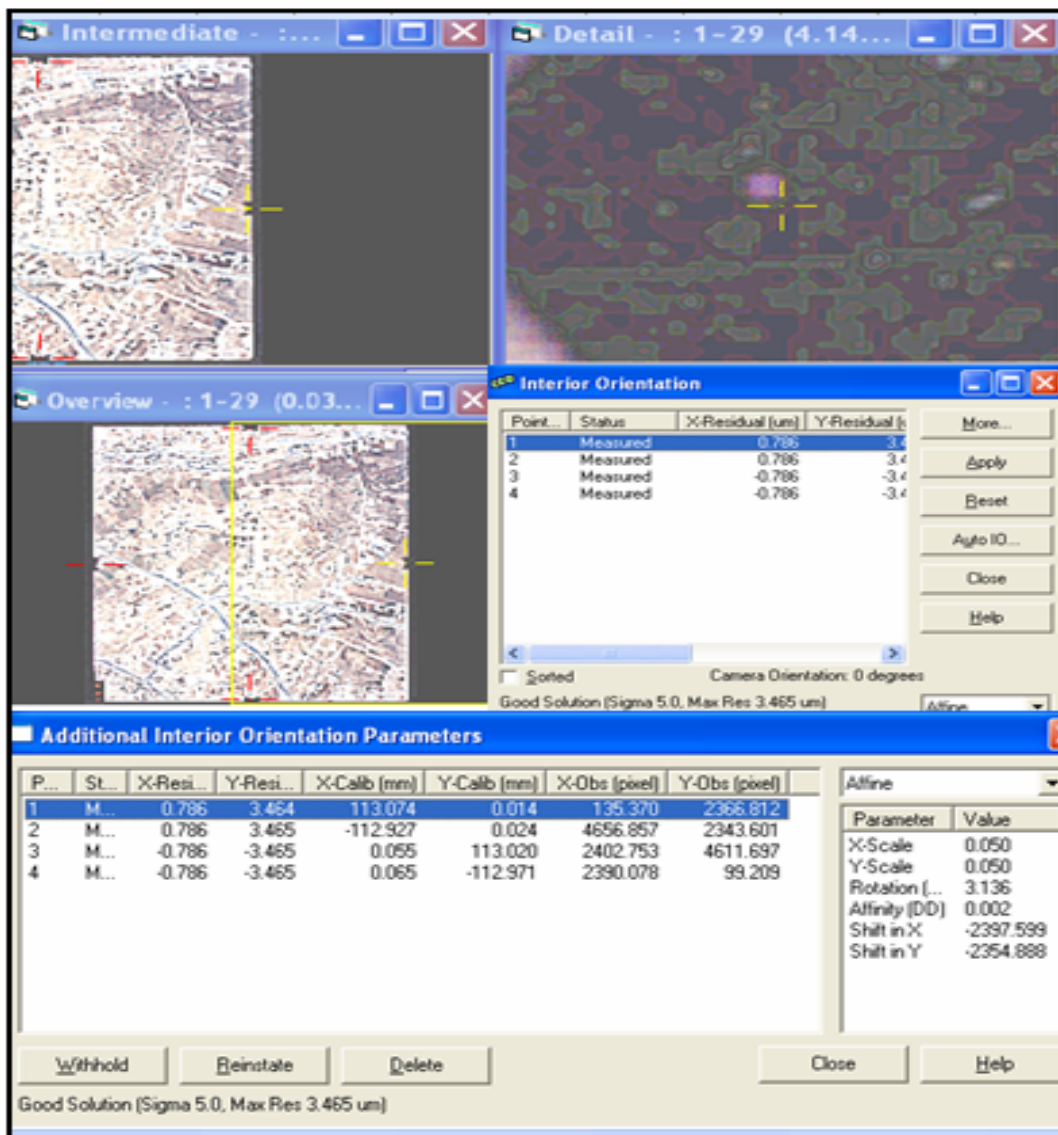


Figure (5-14): Interior orientation of the left photo in Wadi Al Harriah area model using scan resolution 50 μ m and grid size 10m.

The solution of The Relative orientation of the Wadi Al Harriah area model is shown in Figure (5-15), and below those are the parameters of The Relative orientation



Figure (5-15): Relative Orientation solution for the Wadi Al Harriah area model using scan resolution 50 μ m and grid size 10m.

The solution of The Absolute orientation of the Wadi Al Harriah area model is shown in figure (5-16), and below those are the parameters of The Absolute orientation.

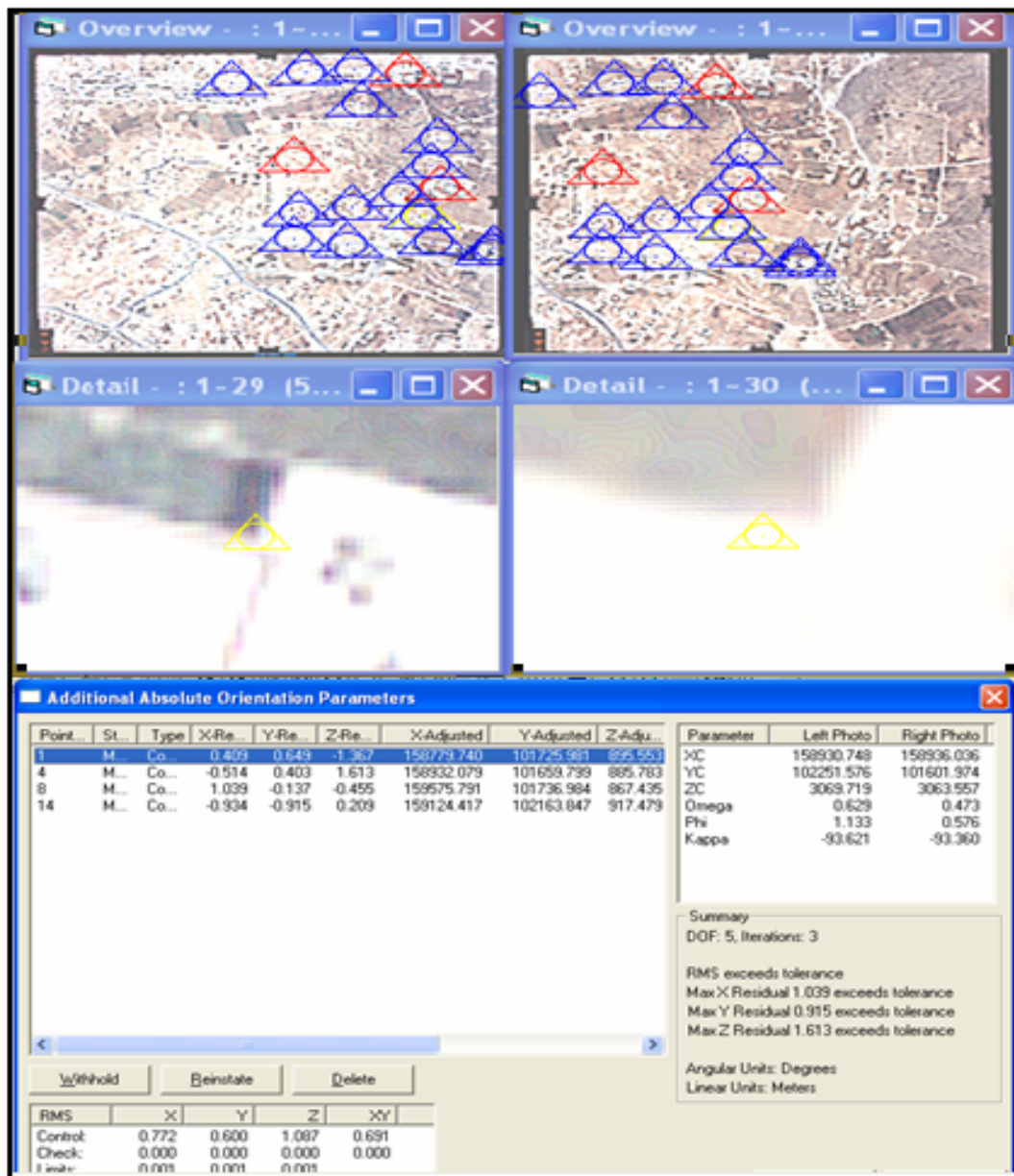


Figure (5-16): Absolute orientation solution for the Wadi Al Harriah area model using scan resolution 50 μ m and grid size 10m.

Table (5-5,) shows the horizontal coordinates of the check points and their elevations from both land survey and Photogrammetric DTM heights at the same points the differences between the measured and calculated elevations are also shows using 95% the RMSE is calculated and the vertical accuracy is determined .

Table (5-5): differences between DTM heights and land survey height (50μm,10m).

point	X	Y	Z_Survey	DTM	dZ
1	158779.33	101725.33	896.92	894.13	2.79
2	158784.09	101737.98	896.88	894.00	2.88
3	158905.43	101801.98	902.53	900.46	2.07
4	158932.59	101659.40	884.17	882.88	1.29
5	159057.18	101682.34	887.36	885.52	1.84
6	159201.07	101647.95	876.81	873.50	3.31
7	159417.23	101906.70	855.44	855.28	0.16
8	159602.79	102095.19	888.16	887.87	0.29
9	159561.33	102229.55	894.87	895.27	0.40
10	159125.35	102164.76	917.27	917.48	0.21
11	158825.15	102172.49	928.67	927.25	1.42
12	158690.20	102193.44	927.33	928.04	0.71
13	158639.81	102005.69	910.77	908.59	2.18
14	158803.88	101823.68	899.36	901.24	1.88
15	158633.11	101696.98	889.15	888.69	0.46
16	158848.81	101820.44	898.09	902.30	4.31
17	158849.15	101980.22	914.12	910.20	3.92
18	158848.81	102005.69	910.77	908.59	2.18
19	158322.14	102196.71	899.03	907.46	8.43
20	158463.51	101546.06	839.26	843.21	3.95

$$RMSE_z = \sqrt{\sum (Z_{datai} - Z_{checki})^2 / n} = 2.32m$$

According National Standards for spatial data accuracy (NSSDA) , we have :

Tested: 2.32 meters vertical accuracy at 95% confidence level.

5.3.3 Resolution (75 μ m) Grid (10m)

In this model an example of the solution of The Interior orientation is shown in figure (5-17), and below in the figure the parameters of The Interior orientation are also shown for left photo.

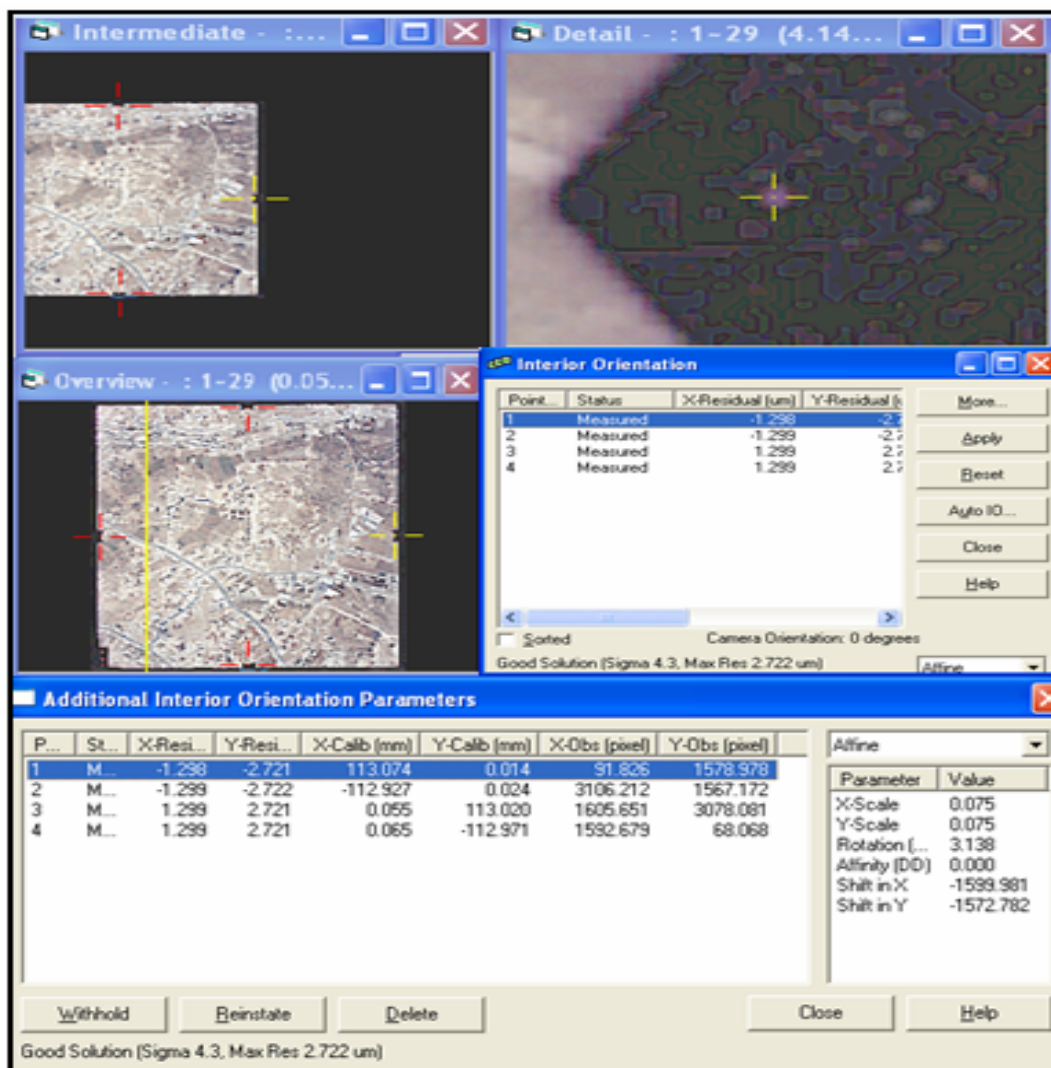


Figure (5-17): Interior orientation of the left photo in Wadi Al Harriah area model using scan resolution 75 μ m and grid size 10m .

The solution of The Relative orientation of the Wadi Al Harriah area model is shown in figure (5-18), and below those are the parameters of The Relative orientation.

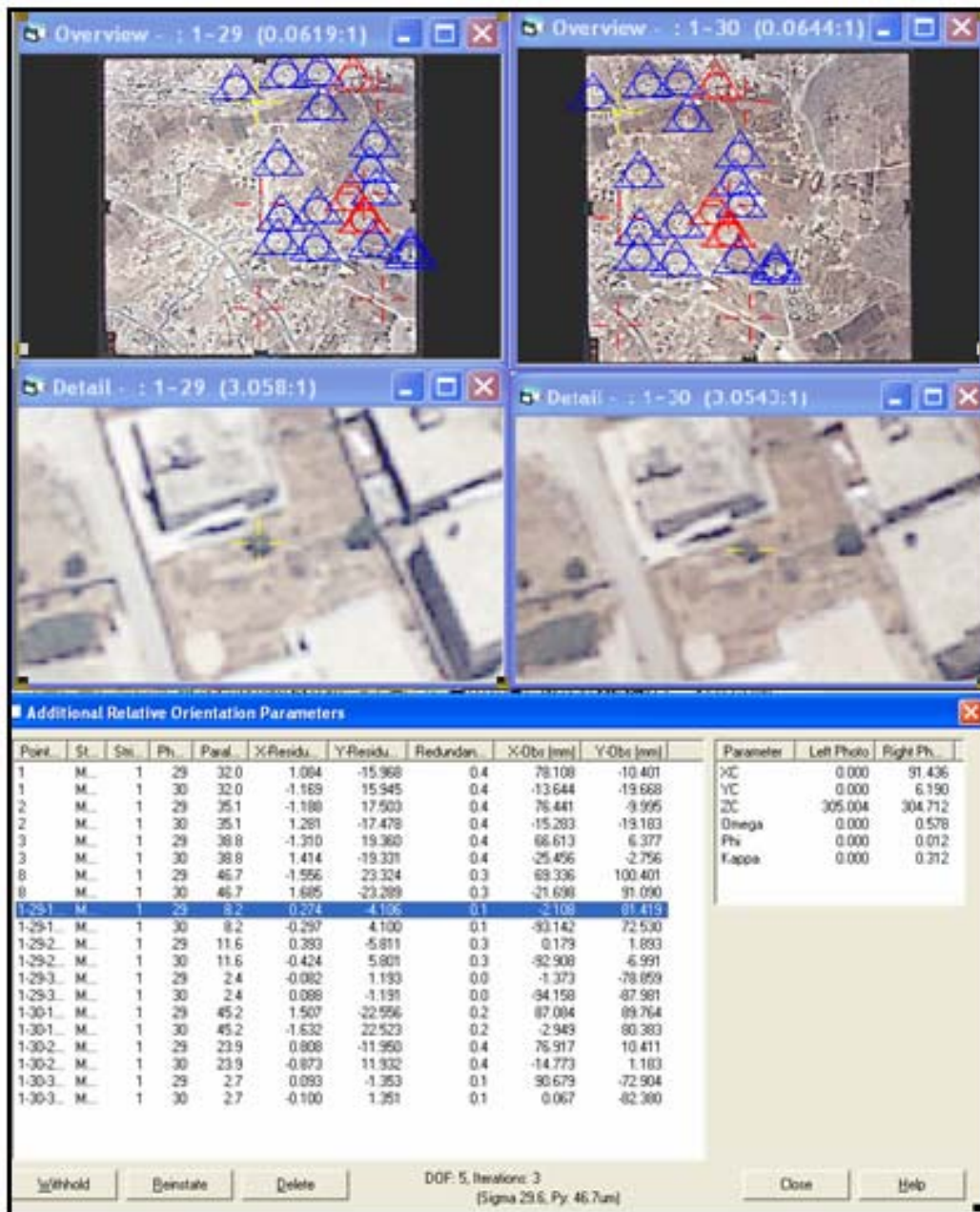


Figure (5-18): Relative Orientation solution for the Wadi Al Harriah area model using scan resolution 75 μ m and grid size 10m.

The solution of The Absolute orientation of the Wadi Al Harriah area model is shown in figure (5-19), and below those are the parameters of The Absolute orientation.

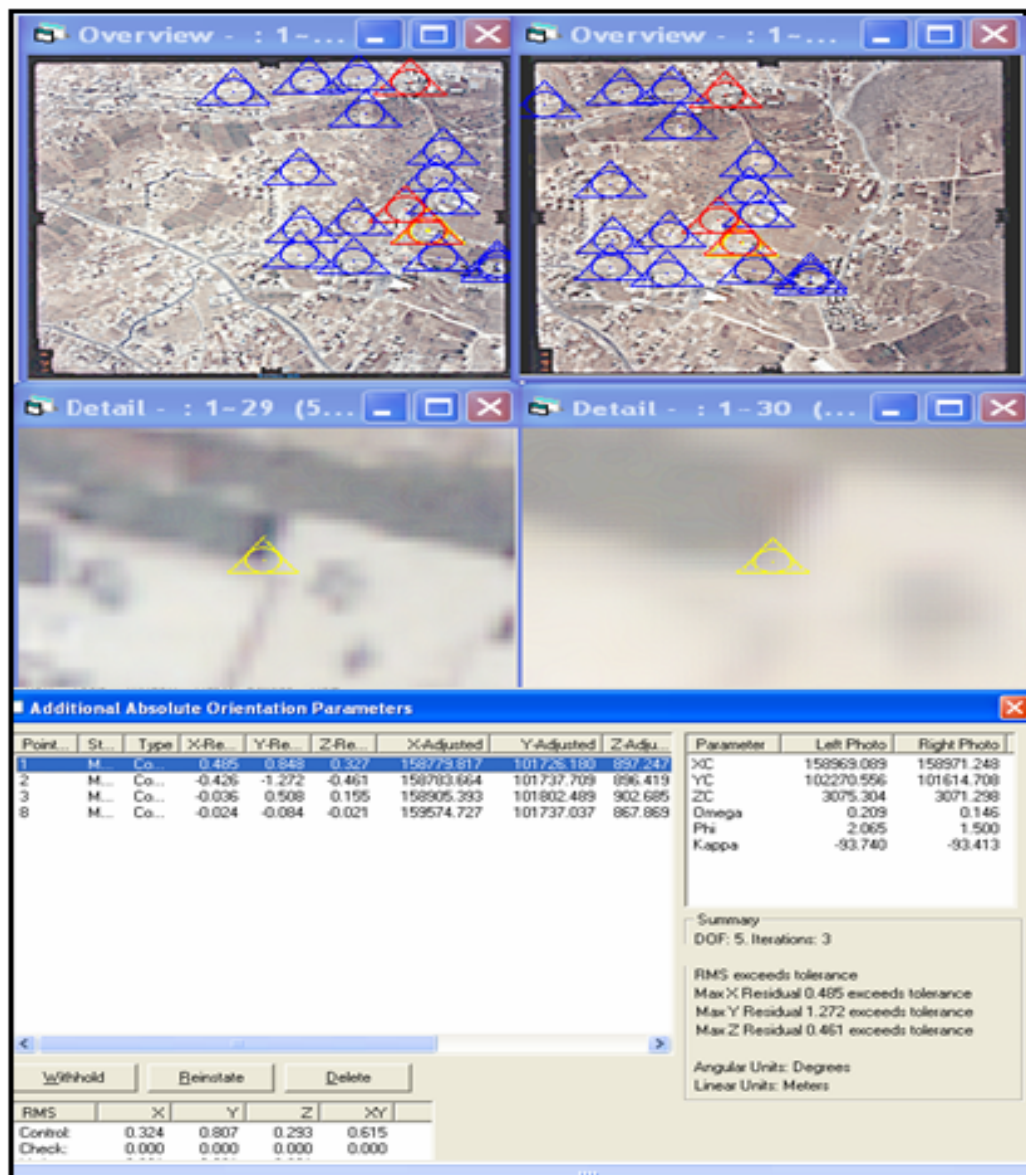


Figure (5-19): Absolute orientation solution for the Wadi Al Harriah area model using scan resolution 75 μ m and grid size 10m.

Table (5-6), shows the horizontal coordinates of the check points and their elevations from both land survey and Photogrammetric DTM heights at the same points the differences between the measured and calculated elevations are also shows using 95% the RMSE is calculated and the vertical accuracy is determined .

Table (5-6): differences between DTM heights and land survey height (75µm,10m).

point	X	Y	Z_Survey	DTM	dZ
1	158779.33	101725.33	896.92	897.60	0.68
2	158784.09	101737.98	896.88	896.38	0.50
3	158905.43	101801.98	902.53	902.46	0.07
4	158932.59	101659.40	884.17	886.74	2.57
5	159057.18	101682.34	887.36	887.80	0.44
6	159201.07	101647.95	876.81	875.22	1.59
7	159417.23	101906.70	855.44	853.67	1.77
8	159602.79	102095.19	888.16	881.84	6.32
9	159561.33	102229.55	894.87	889.00	5.87
10	159125.35	102164.76	917.27	914.98	2.29
11	158825.15	102172.49	928.67	928.28	0.39
12	158849.15	101980.22	914.12	910.11	4.01
13	158690.20	102193.44	927.33	929.00	1.67
14	158639.81	102005.69	910.77	910.63	0.14
15	158633.11	101696.98	889.15	894.39	5.24
16	158479.09	101534.63	880.33	881.47	1.14
17	158322.14	102196.71	899.03	900.46	1.43
18	158463.51	101546.06	839.26	842.90	3.64
19	158848.81	101820.44	898.09	902.50	4.41
20	158803.88	101823.68	899.36	907.47	8.11

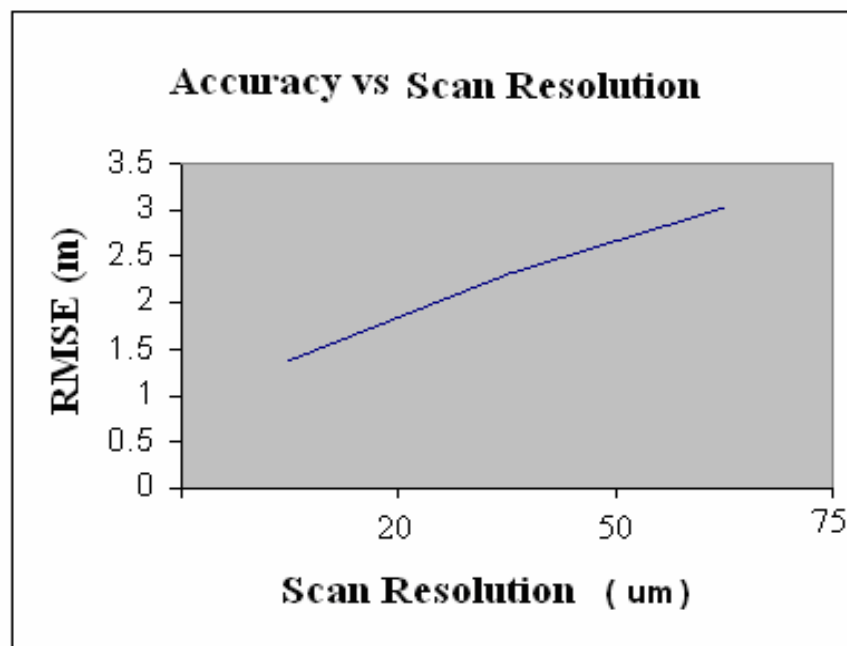
$$RMSE_z = \text{sqrt} \left[\sum (Z_{datai} - Z_{checki})^2 / n \right] = 3.04\text{m}$$

According National Standards for spatial data accuracy (NSSDA) , we have :

Tested: 3.04 meters vertical accuracy at 95% confidence level.

5.3.4 Accuracy results

According to the result shown in tables (5-4, 5-5, 5-6), it is found that accuracy in the DTM increases with the higher scan resolution, as shown in figure (5-20).



Figure(20) : The relationship between scan resolution and RMSE.

5.4 Third Model (Albassa Area)

This model is located in the southern part of Hebron city. The photos for this model were taken in 2004 the photos numbers are 37 for the right photo, and 36 for the left photo, these photos were taken with camera type RMKA30/23, having focal length of 305.004 mm.

This model was scanned by different scan resolutions (20, 50, and 75) micrometer and with different grid sizes (5, 10, and 10) meters.

The results of those different scan resolutions and grid sizes are discussed in the next sections:

5.4.1 Resolution (20 μ m) Grid (5m)

In this model an example of the solution of The Interior orientation is shown in figure (5-21), and below in the figure the parameters of The Interior orientation are also shown for left photo.

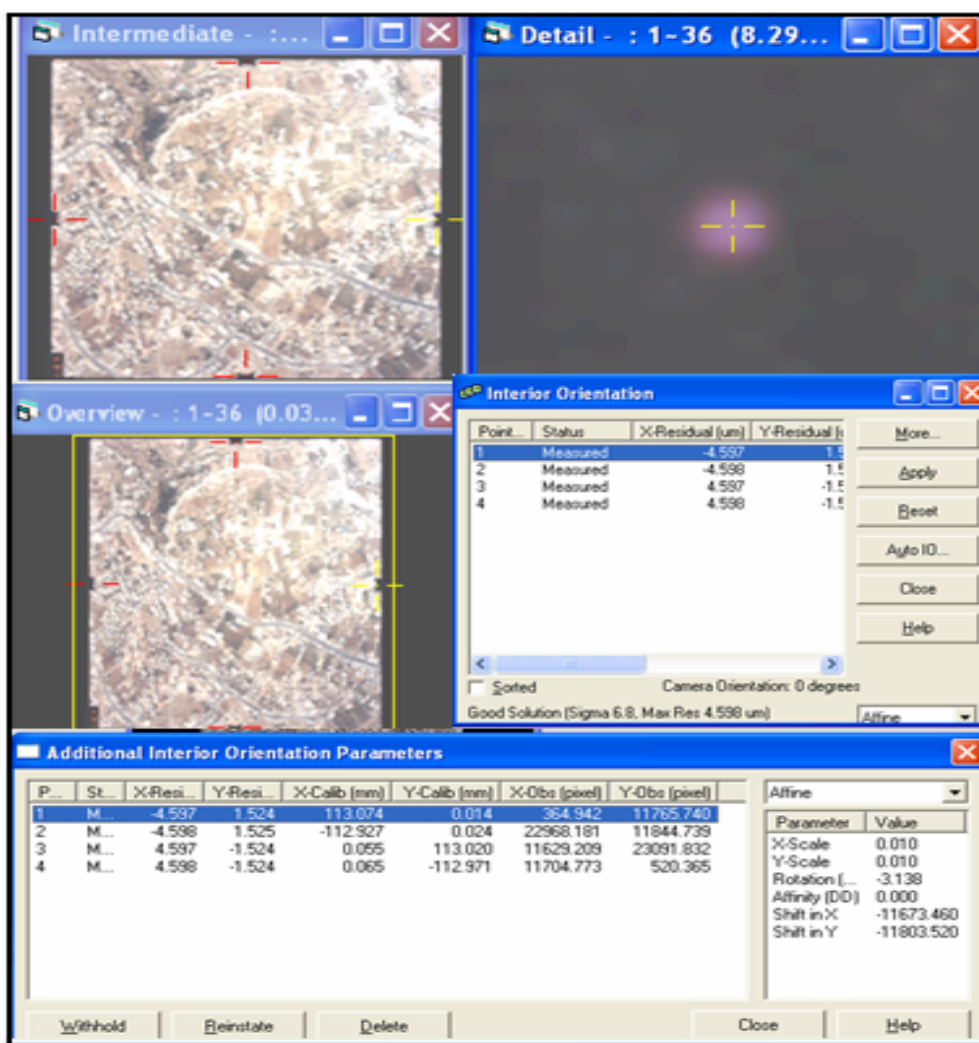


Figure (5-21): Interior orientation of the left photo in Albassa area model using scan resolution 20 μ m and grid size 5m .

The solution of The Relative orientation of the Albassa area model is shown in figure (5-22), and below those are the parameters of The Relative orientation

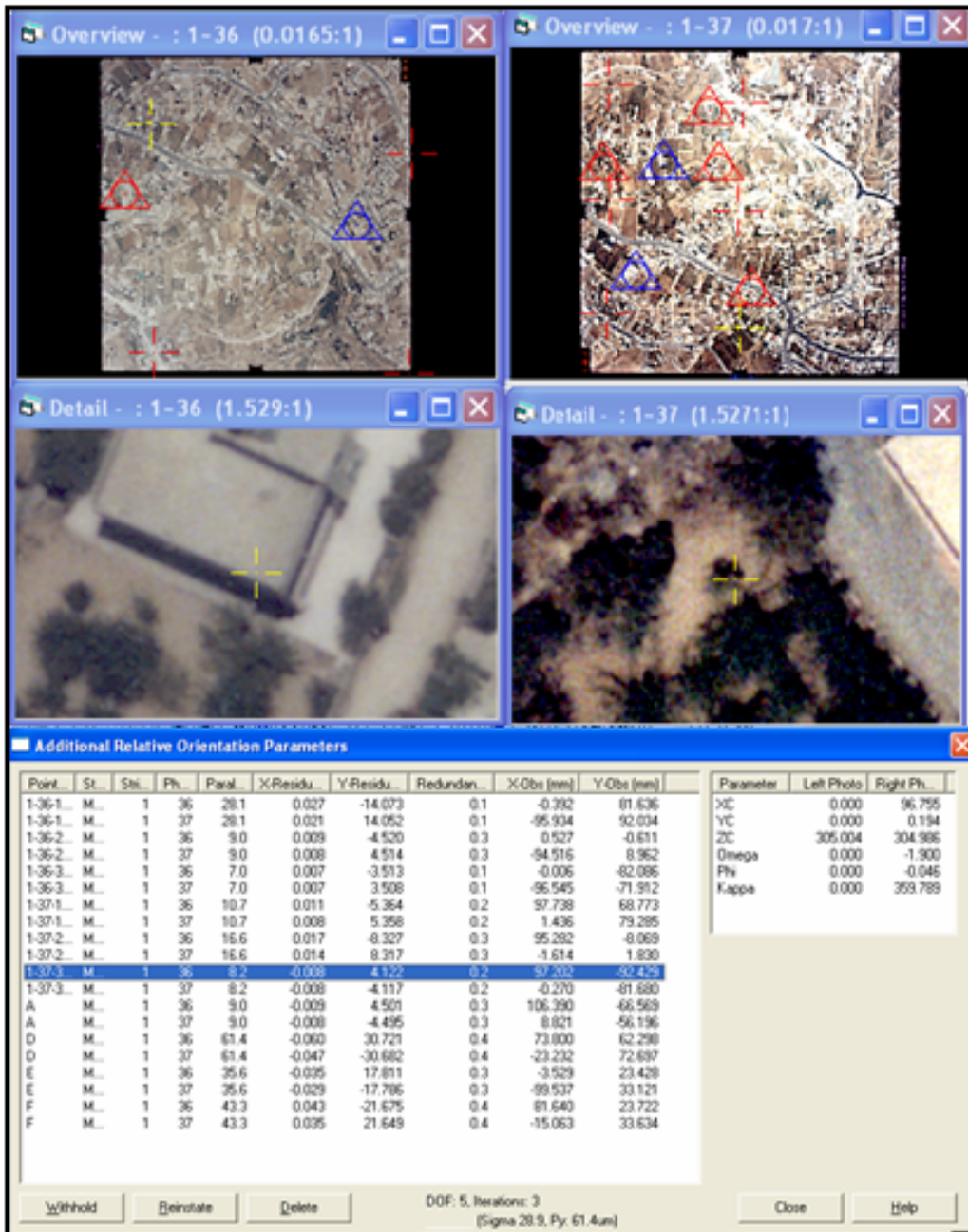


Figure (5-22) : Relative Orientation solution for the Albassa area model using scan resolution 20μm and grid size 5m.

The solution of The Absolute orientation of the Albassa area model is shown in figure (5-23), and below those are the parameters of The Absolute orientation.



Figure (5-23): Absolute orientation solution for the area model Albassa using scan resolution 20 μ m and grid size 5m.

Table (5-7), shows the horizontal coordinates of the check points and their elevations from both land survey and Photogrammetric DTM heights at the same points the differences between the measured and calculated elevations are also shows using 95% the RMSE is calculated and the vertical accuracy is determined .

Table (5-7): differences between DTM heights and land survey height (20μm,5m).

point	X	Y	Z_SURVEY	DTM	DZ
1	157833.97	102963.07	899.29	899.60	0.60
2	157661.05	102943.10	908.30	910.00	2.00
3	157671.76	103719.36	953.58	917.00	1.00
4	157763.33	102621.66	893.36	921.00	2.00
5	157686.22	102715.91	900.25	930.00	0.00
6	157600.71	102591.89	896.42	953.18	1.82
7	157808.12	102640.11	894.40	850.08	0.92
8	157676.79	102478.94	900.01	933.56	1.44
9	157624.04	102497.68	905.72	935.18	1.82
10	157390.28	102721.92	909.35	916.01	2.01
11	157402.78	102553.94	915.84	895.90	0.90
12	157392.27	102465.97	925.39	922.00	1.00
13	157526.84	102896.29	914.95	923.00	2.00
14	157481.71	102940.19	917.78	943.00	1.00
15	157450.45	103019.19	922.95	947.64	0.36
16	157376.89	103130.24	930.46	931.00	1.00
17	157220.08	102567.21	925.23	921.00	1.00
18	157075.83	102521.79	944.87	907.23	0.23
19	157115.49	102563.65	942.19	937.00	1.00
20	157336.19	102725.12	916.78	919.00	2.00

$$RMSE_z = \sqrt{\sum (Z_{datai} - Z_{checki})^2 / n} = 1.3m$$

According National Standards for spatial data accuracy (NSSDA) , we have :

Tested: 1.3 meters vertical accuracy at 95% confidence level.

5.4.2 Resolution (50 μ m) Grid (10m)

In this model an example of the solution of The Interior orientation is shown in figure (5-24), and below in the figure the parameters of The Interior orientation are also shown for left photo.

The screenshot displays the interior orientation process in a software application. It features several windows: 'Intermediate' showing a photo with corner markers, 'Detail' showing a magnified view of the photo's center, 'Overview' showing the photo with a grid, and 'Interior Orientation' showing a table of measured points and residuals. Below these is the 'Additional Interior Orientation Parameters' dialog box, which contains a table of detailed parameters and a list of values.

Point	Status	X-Residual (μ m)	Y-Residual (μ m)
1	Measured	-3.791	-1.4
2	Measured	-3.792	-1.4
3	Measured	3.791	1.4
4	Measured	3.792	1.4

P...	St...	X-Resi...	Y-Resi...	X-Calb (mm)	Y-Calb (mm)	X-Obs (pixel)	Y-Obs (pixel)
1	M...	-3.791	-1.428	113.074	0.014	72.320	2358.136
2	M...	-3.792	-1.429	-112.927	0.024	4592.412	2373.313
3	M...	3.791	1.428	0.055	113.020	2325.143	4623.195
4	M...	3.792	1.429	0.065	-112.971	2339.826	108.362

Parameter	Value
X-Scale	0.050
Y-Scale	0.050
Rotation [...]	-3.138
Affinity (DD)	0.000
Shift in X	-2333.762
Shift in Y	-2365.321

Figure (5-24): Interior orientation of the left photo in Albassa area model using scan resolution 50 μ m and grid size 10m .

The solution of The Relative orientation of the Albassa area model is shown in figure (5-25), and below those are the parameters of The Relative orientation

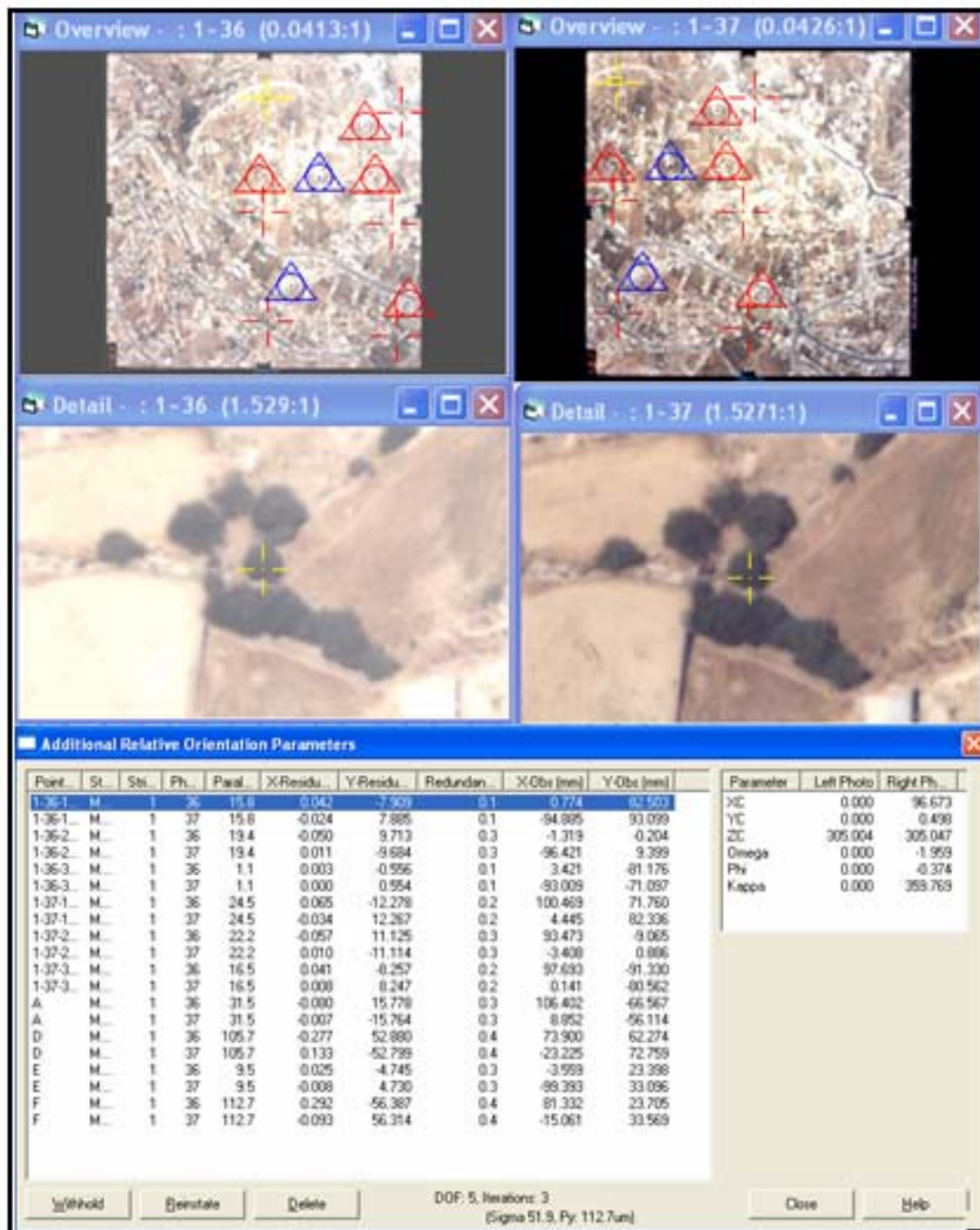


Figure (5-25): Relative Orientation solution for the Albassa area model using scan resolution 50 μ m and grid size 10m.

The solution of The Absolute orientation of the Albassa area model is shown in figure (5-26), and below those are the parameters of The Absolute orientation.

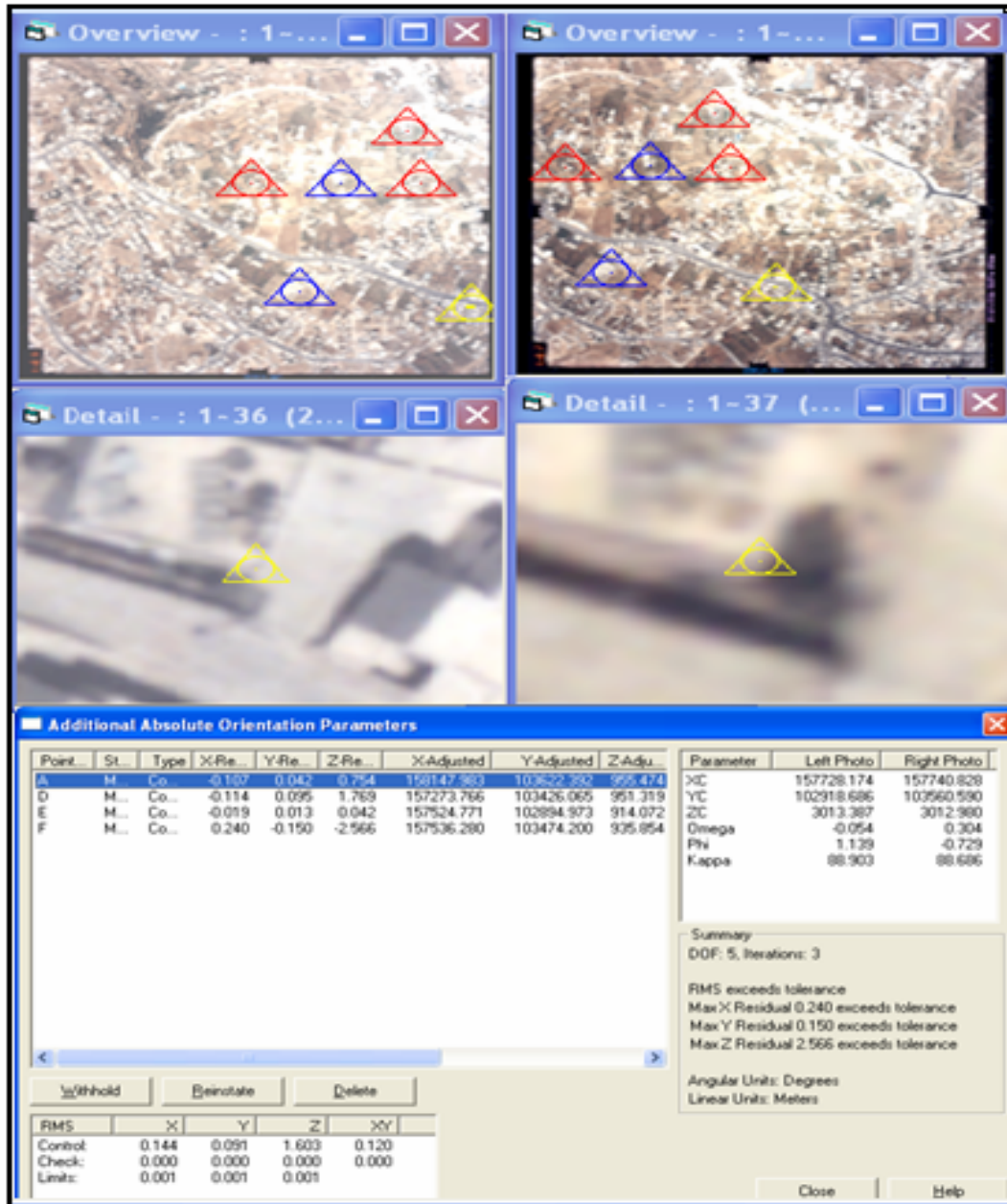


Figure (5-26): Absolute orientation solution for the area model Albassa using scan resolution 50µm and grid size 10m.

Table (5-8), shows the horizontal coordinates of the check points and their elevations from both land survey and Photogrammetric DTM heights for the same points the differences between the measured and calculated elevations are also shows using 95% the RMSE is calculated and the vertical accuracy is determined

Table (5-8): differences between DTM heights and land survey height (50µm,10m).

point	X	Y	Z_SURVEY	DTM	DZ
1	157833.97	102963.07	899.29	898.70	1.70
2	157661.05	102943.1	908.30	908.80	0.80
3	157671.76	103719.36	953.58	918.60	0.60
4	157763.33	102621.66	893.36	927.90	4.90
5	157686.22	102715.91	900.25	932.70	2.70
6	157600.71	102591.89	896.42	955.57	3.57
7	157808.12	102640.11	894.40	952.90	2.90
8	157676.79	102478.94	900.01	937.70	3.70
9	157624.04	102497.68	905.72	940.07	4.07
10	157390.28	102721.92	909.35	915.72	1.72
11	157402.78	102553.94	915.84	898.40	3.40
12	157392.27	102465.97	925.39	921.98	0.98
13	157526.84	102896.29	914.95	924.90	3.90
14	157481.71	102940.19	917.78	945.33	1.33
15	157450.45	103019.19	922.95	948.21	1.21
16	157376.89	103130.24	930.46	933.87	1.87
17	157220.08	102567.21	925.23	923.22	3.22
18	157075.83	102521.79	944.87	907.18	0.18
19	157115.49	102563.65	942.19	938.30	0.30
20	157336.19	102725.12	916.78	917.63	0.63

$$RMSE_z = \sqrt{\sum (Z_{datai} - Z_{checki})^2 / n} = 2.04m$$

According National Standards for spatial data accuracy (NSSDA) , we have :

Teasted: 2.04 meters vertical accuracy at 95% confidence level.

5.4.3 Resolution (75 μ m) Grid (10m)

In this model an example of the solution of The Interior orientation is shown in figure (5-27), and below in the figure the parameters of The Interior orientation are also shown for left photo.

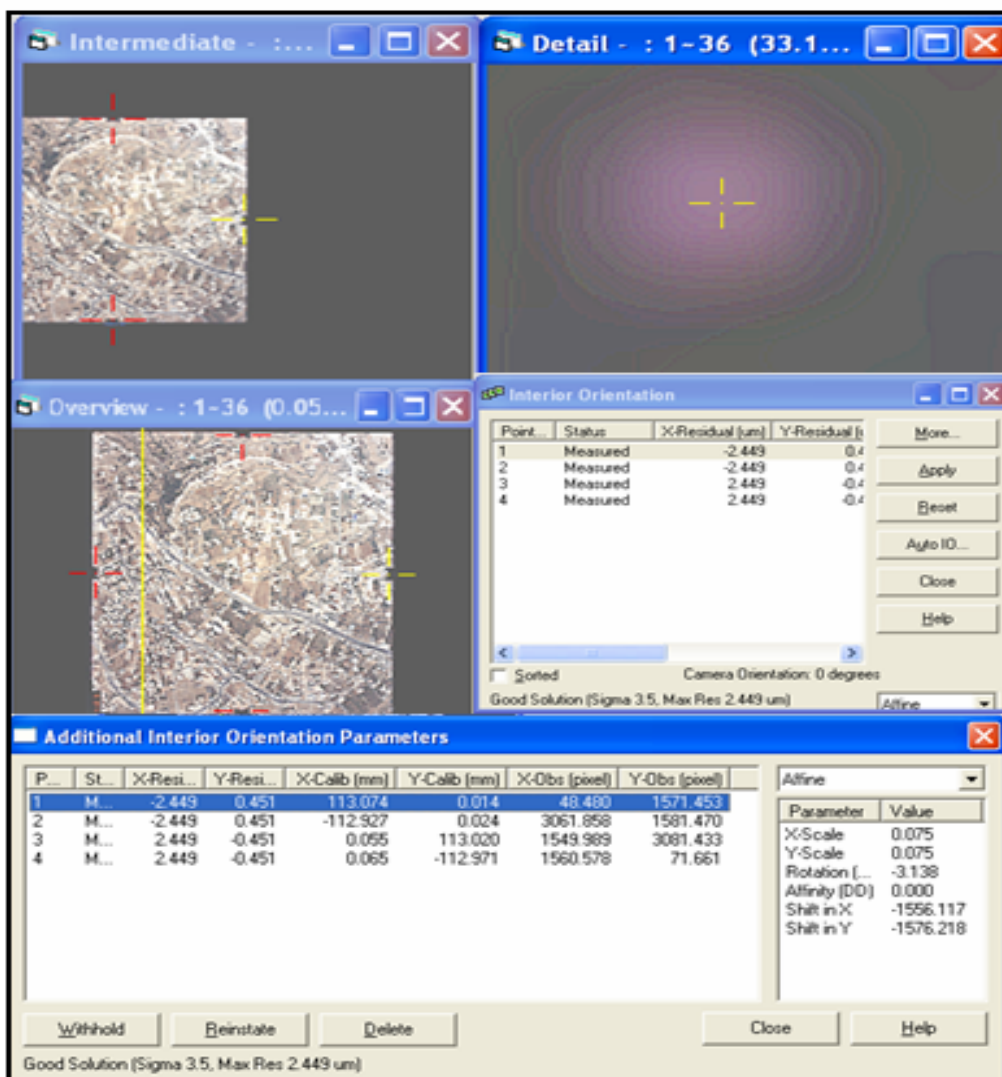


Figure (5-27): Interior orientation of the left photo in Albassa area model using scan resolution 75 μ m and grid size 10m .

The solution of The Relative orientation of the Albassa area model is shown in figure (5-28), and below those are the parameters of The Relative orientation

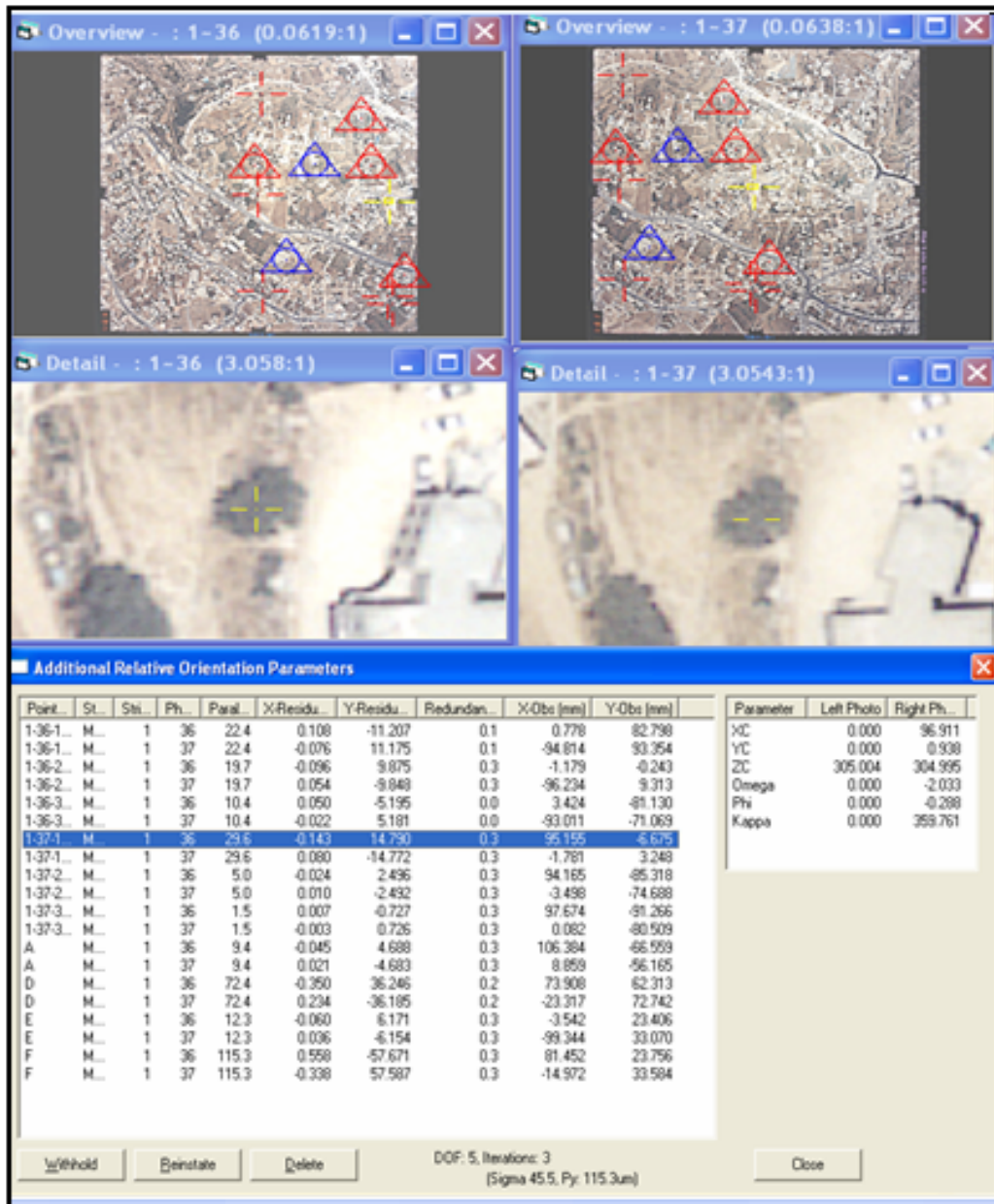


Figure (5-28): Relative Orientation solution for the Albassa area model using scan resolution 75µm and grid size 10m.

The solution of The Absolute orientation of the Albassa area model is shown in figure (5-29), and below those are the parameters of The Absolute orientation.

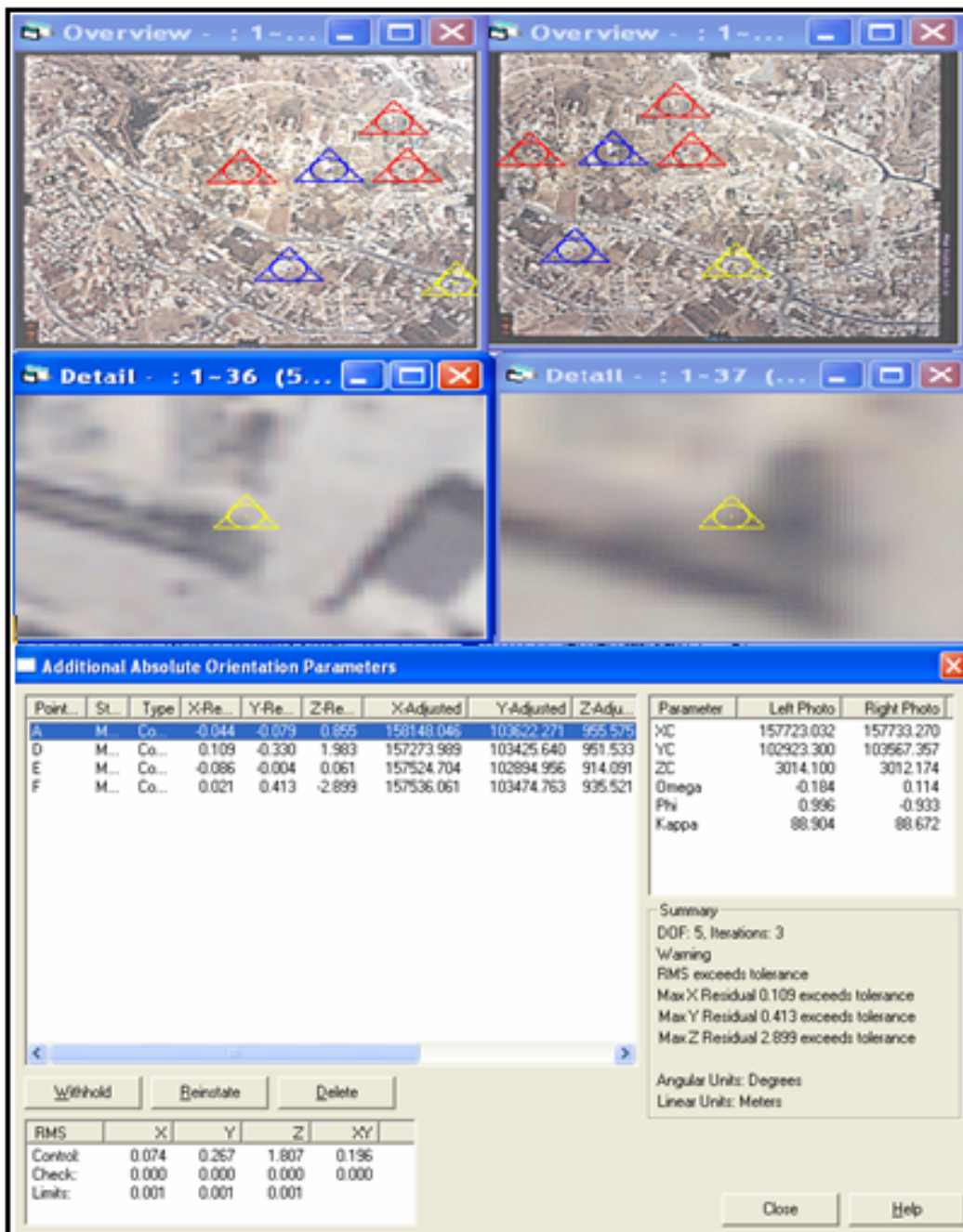


Figure (5-29): Absolute orientation solution for the area model Albassa using scan resolution $75\mu\text{m}$ and grid size 10m.

Table (5-9), shows the horizontal coordinates of the check points and their elevations from both land survey and Photogrammetric DTM heights for the same points the differences between the measured and calculated elevations are also shows using 95% the RMSE is calculated and the vertical accuracy is determined .

Table (5-9): differences between DTM heights and land survey height (75µm,10m).

point	X	Y	Z_SURVEY	DTM	dZ
1	157834	102963.1	899.29	903.1	3.81
2	157661.1	102943.1	908.30	909.8	1.50
3	157671.8	103719.4	953.58	950.3	3.28
4	157763.3	102621.7	893.36	895.9	2.54
5	157686.2	102715.9	900.25	903.4	3.15
6	157600.7	102591.9	896.42	892.8	3.62
7	157808.1	102640.1	894.40	890.76	3.64
8	157676.8	102478.9	900.01	899.9	0.11
9	157624.2	102497.7	905.72	904.3	1.42
10	157390.3	102721.9	909.35	915.86	6.51
11	157402.8	102553.9	915.84	914.00	1.84
12	157392.3	102466.2	925.39	921.98	3.41
13	157526.8	102896.3	914.95	915.87	0.92
14	157481.7	102940.2	917.78	920.60	2.82
15	157450.5	103019.2	922.95	920.50	2.45
16	157376.9	103130.2	930.46	931.44	0.98
17	157220.1	102567.2	925.23	921.22	4.01
18	157075.8	102521.8	944.87	941.89	2.98
19	157115.5	102563.7	942.19	938.34	3.85
20	157336.2	102725.1	916.78	920.21	3.43

$$RMSE_z = \sqrt{\sum (Z_{datai} - Z_{checki})^2 / n} = 3.2m$$

According National Standards for spatial data accuracy (NSSDA) , we have :

Tested: 3.20 meters vertical accuracy at 95% confidence level.

5.4.4 Accuracy results

According to the result shown in tables (5-7, 5-8, 5-9), it is found that accuracy in the DTM increases with the higher scan resolution, as shown figure (5-30).

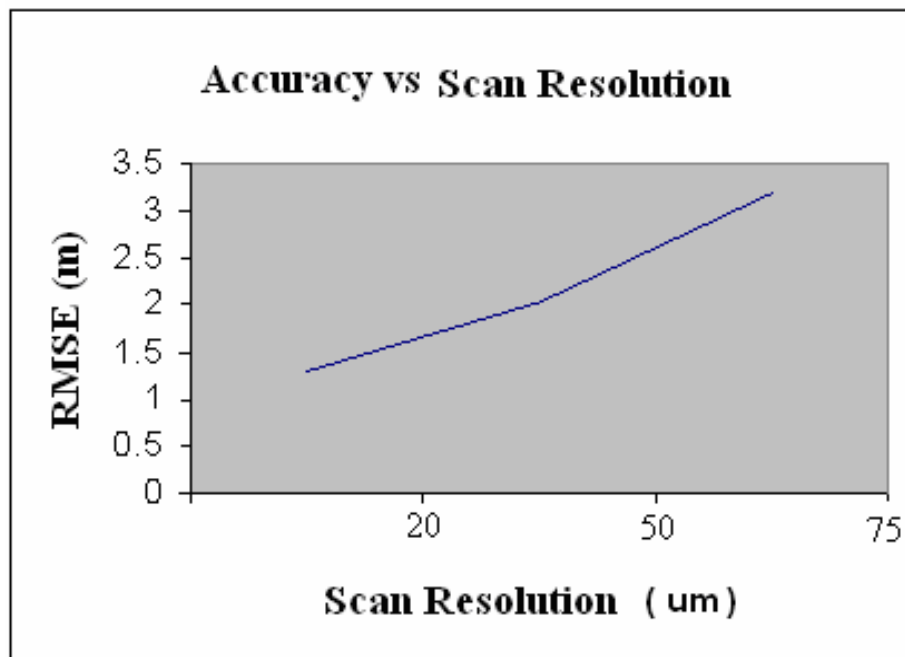


Figure (5-30) : The relationship between scan resolution and RMSE.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.2 Recommendations

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Referring to the practical work and the results discussed in chapter five, we conclude the following

1. In Z/I Imaging stereoplottter the grid size is limited to the user by the software, this means that the user can not select any grid size he need .
2. There are limitations in the Ultra scan 5000 scan resolutions, theoretically it is able up to 5 μ m, but in practice only up to 20 μ m was done memory and storage problems.
3. It was cleat that as smaller scan resolution is used the software gives the ability to use smaller grid size for the DTM.
4. Rreferring to the tests and results in chapter five, it was found the DTM accuracy gets better with smaller scan point and the same user for the model

6.2 Recommendations

Through the work in this project ,we would like to recommend the following for the coming project in this field:

1. The use of other software than Z/I Imaging, and comparing the results from the different software.
2. Testing the effect of the ground control distribution on the accuracy of the automatically collected DTM .
3. Comparison between the land survey interpolated DTMs by survey or GIS software with the automatic DTM collection, cost time, and the accuracy.
4. Applying more tests on accuracy on different terrain types; flat terrain, moderate hills, hilly mountains, and urban areas, to find the effect of terrain it self on the DTM accuracy.

APPENDIX-A

Z/I IMAGING

A.1 ImageStation Software Products

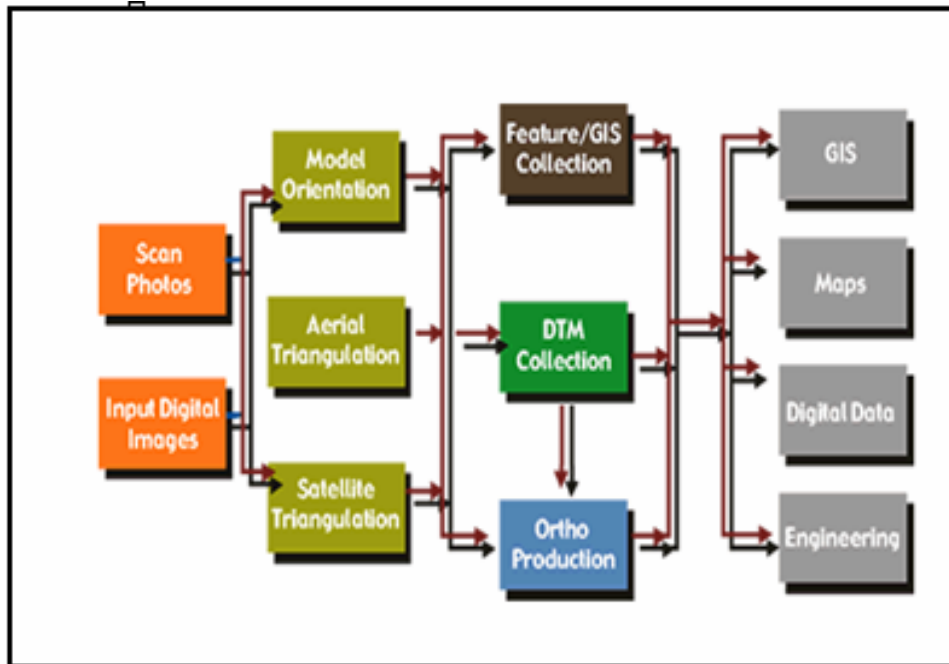


Figure (A-1) : Production workflow of Z/I Imaging [7]

Z/I provide a comprehensive suite of digital photogrammetric software for your production needs. Z/I products line includes applications for your entire production workflow:

1. Project & Data Management

- ImageStation Photogrammetric Manager - Photogrammetric data management tools required for a production workflow.

2. Orientations & Triangulation

- ImageStation Model Setup - Photogrammetric measurement for smooth, real-time, stereo model measurement .
- ImageStation Digital Mensuration - Powerful multi-image point transfer and measurement environments for photogrammetric triangulation.
- ImageStation Automatic Triangulation - Fully automated aerial triangulation from interior orientation to the determination of tie points to the final block adjustment analysis with delivery of orientation parameters .
- ImageStation Satellite Triangulation Modules - Powerful multi-image point transfer and measurement environment for several satellite image types.

3. Feature Collection

- ImageStation Stereo Display - Display and manipulation of stereo imagery with photogrammetrically accurate 3D cursor tracking, stereo vector superimposition, stereo roam, and image contrast and brightness adjustments within the MicroStation graphics environment.
- ImageStation Feature Collection - Low-cost, easy-to-use map feature data collection product that provides tools for interactively collecting map feature geometry (2D and 3D) and attributes in the MicroStation graphics environment .
- ImageStation Stereo for GeoMedia - Interactive 2D and 3D feature collection and attribution from aerial or satellite mono/stereo images for map revision/updating based on GeoMedia® platform for a direct geographic information system (GIS) application .

4. Digital Terrain Model Generation

- ImageStation DTM Collection - Interactive tools for collecting digital terrain model (DTM) data, elevation points, breaklines, and other geomorphologic features in stereo models in the MicroStation graphics environment ImageStation Automatic Elevations – Automatic generation of elevation models from aerial or satellite stereo imagery, creating accurate and reliable DTM data in a very efficient way.
- ImageStation Automatic Elevation - Automatic generation of elevation models from aerial or satellite stereo imagery, creating accurate and reliable DTM data in a very efficient way.

5. OrthoPhoto Generation

- ImageStation Base Rectifier - Batch-oriented program for orthorectification of aerial photographs and satellite images, which can serve the needs of both small- and large-scale GIS and map production organizations.
- ImageStation OrthoPro - Integrated orthorectification product that addresses the complete ortho production workflow, including ortho project planning, rectification, dodging, true ortho, tone balancing, automatic seamline generation, “one-button ortho,” mosaicking, and quality assessment. The whole ortho workflow can be achieved in a distributed processing environment, increasing throughput and reducing computation time.
- ImageStation PixelQue - A unique application based on GeoMedia that provides the tools needed in orthophoto production for image inspection/quality control, image enhancement, and image editing – all in one product.

6. Geographic Imaging

- Image Viewer - Low-cost, high-powered solution for displaying orthophotos and other preprocessed (e.g. map-registered) binary, gray-scale, or color raster imagery.
- I/RAS C - Complete image display and manipulation solution – whether your applications include cartographic updating, aerial image mapping, GIS, or civil engineering – for manipulation and display of binary, gray-scale, and color raster images and maps .
- Image Analyst - Full set of image display, enhancement, image processing, and remote sensing tools that are suitable to meet the intensive demands of production image mapping, cartographic, and image analysis environments.
- ImageStation Stereo for GeoMedia – provides stereo viewing capabilities for GeoMedia in conjunction with photogrammetry projects.

APPENDIX-B ISAE

B.1 What is ISAE?

ImageStation Automatic Elevation (ISAE), produced by Z/I Imaging company generates DTM points from digital aerial and satellite stereo imagery. ISAE has a high overall accuracy because it generates a large number of points, ISAE needs less effort to measure single elevation points with extreme accuracy. ISAE provides a large number of terrain points by matching identical features in each photo of the stereo pair.

ISAE then uses these points to create a very precise DTM. This approach is useful for avoid areas that have insufficient information about the terrain surface. Normally, it is not always necessary to collect breaklines because ISAE generates DTM data with very high density.

ISAE can define a boundary to collect DTM elevation points on a project; this is called a collection boundary. If you do not define a collection boundary, ISAE generates points for the entire model, which costs more time and storage space.

The ImageStation DTM Collection (ISDC) can be used in the same time with ISAE. ISDC is used to manually measure elevation points in problem areas and to display the DTM grid that ISAE generates. ISDC or ISFC (Image Station Feature Collection) can be used to customize feature symbologies such as color and line weight of boundaries.

B.2 What You Should Know Before Using ISAE

To use ISAE and the *ImageStation Automatic Elevations (ISAE)* , you should have a good working knowledge of photogrammetry and be able to work with the following:

- Microsoft Windows
- MicroStation
- ImageStation Stereo Display (ISSD)
- ImageStation DTM Collection (ISDC)

B.3 Starting ISAE

To start ISAE follow these steps:

1. Click the Start button.
2. point to Programs.
3. point to ImageStation Automatic Elevations (ISAE).
4. click ImageStation Automatic Elevations to open the ImageStation Automatic Elevations dialog box ,see figure (B-1).

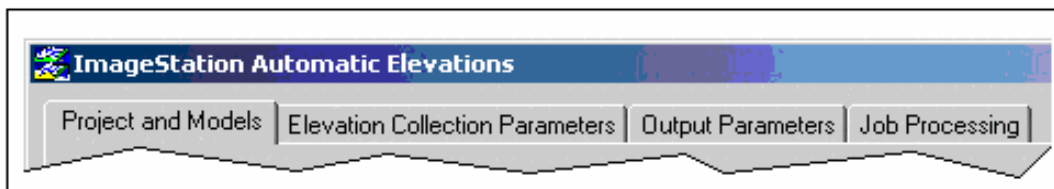


Figure (B-1): ISAE dialog box , [7] .

B.4 Project and Models Property Page


Use this property page to:

- ❖ Specify which ISPM project to use and which models to process.
- ❖ Select the input design file(s) that contain coordinate system information, collection boundaries, and morphological data.
- ❖ Specify the output design file(s) in which you want to store the elevation data that ISAE generates.
- ❖ Specify which pathway to process for each model.

When the ISPM project is specified to process, ISAE lists the models from that project that contain valid image paths and sufficient orientations data so that ISAE will be able to process them if they are selected.

You must either manually select the desired models from the text list or check the Use Footprint Viewer option or Blockwise Matching option and select the models graphically in the Footprint Viewer control. You may also select the Auto-generate Collection Boundaries option if you want ISAE to automatically generate and place collection boundaries into your input design files for each of the selected models; this option and the Use Footprint Viewer option are automatically selected for you when you check the Blockwise Matching option. Once you have selected which models to process, you must specify the input and output design files as well as the pathway number to use to identify which collection boundary to use for each model.

B.4.1 To specify the models to process by list selection

1. In the Project box, type, or click  to select, the path and file name of the project that contains the models you want to process. If you intend to work with the same project in the next session, select Automatically Open Last Project so that you will not have to repeat this step when you start ISAE.
2. In the Strip Filter box, select a strip ID to specify that only the models of a particular strip be listed in the Available Models box. You can press Ctrl while clicking to select more than one strip.
3. If you want to show only models whose left and right photos are on the same strip, select the Exclude Cross Strip Models check box to filter the Available Models list.
4. You can move the models back and forth between the Available Models and Selected Models boxes in the following ways:
 - ❖ To move one or more models from the Available Models box to the Selected Models box, select the models and then click Add.
 - ❖ To move all of the models from the Available Models box to the Selected Models box, click Add All. You do not have to select the models first.
 - ❖ To move one or more models from the Selected Models box to the Available Models box, select the models and then click Remove.
 - ❖ To move all models from the Selected Models box to the Available Models box, click Remove All. You do not have to select the models first.

The models in the Selected Models box are the models that will be processed.

To make the footprints easier to tell apart, you may first want to turn off the model labels by clicking the Footprint Labels button in the toolbar, see figure (B-4).

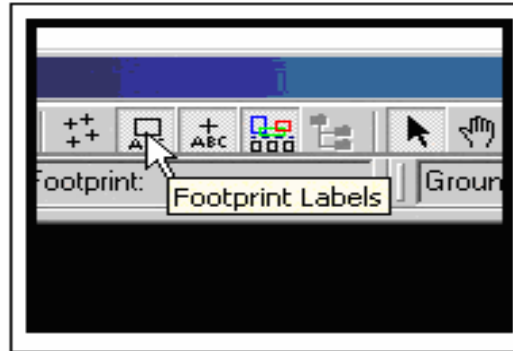


Figure (B-4):selecting models by footprint, [7].

3. Highlight the model that you want by dragging the pointer onto it, and then left-click to select it, see figure (B-5).

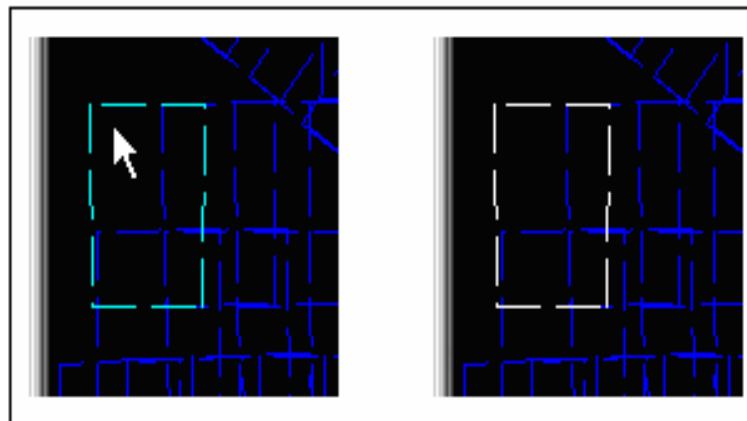


Figure (B-5): required model high lighting , [7].

Select a block of models by holding down the CTRL key as you click their footprints one by one, see figure (B-6).

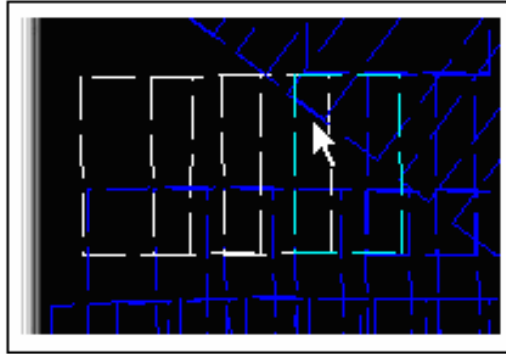


Figure (B-6): selecting block of models, [7].

B.4.3 To generate collection boundaries automatically

In the Project and Models property page, select Auto-generate Collection Boundaries to specify automatic generation of DTM collection boundaries for the selected models when they are processed. ISAE will prevent redundancy in DTM collection by automatically creating a shared boundary at the best position.

B.5 Blockwise Matching

If you select Blockwise Matching and draw a polygon to define an area of interest in one model or a polygon that contains a block of two or more overlapping models, ISAE will determine which models to process, automatically generate collection boundaries, and output the elevation data to the output design file specified for each model that was processed. For each model processed, ISAE will also clip the overlapping morphological data to the collection boundary and copy the clipped data to the output design file along with the collection boundary and the

generated grid. The collection of output design files will collectively define the DTM for the area you specified, see figure (B-7).

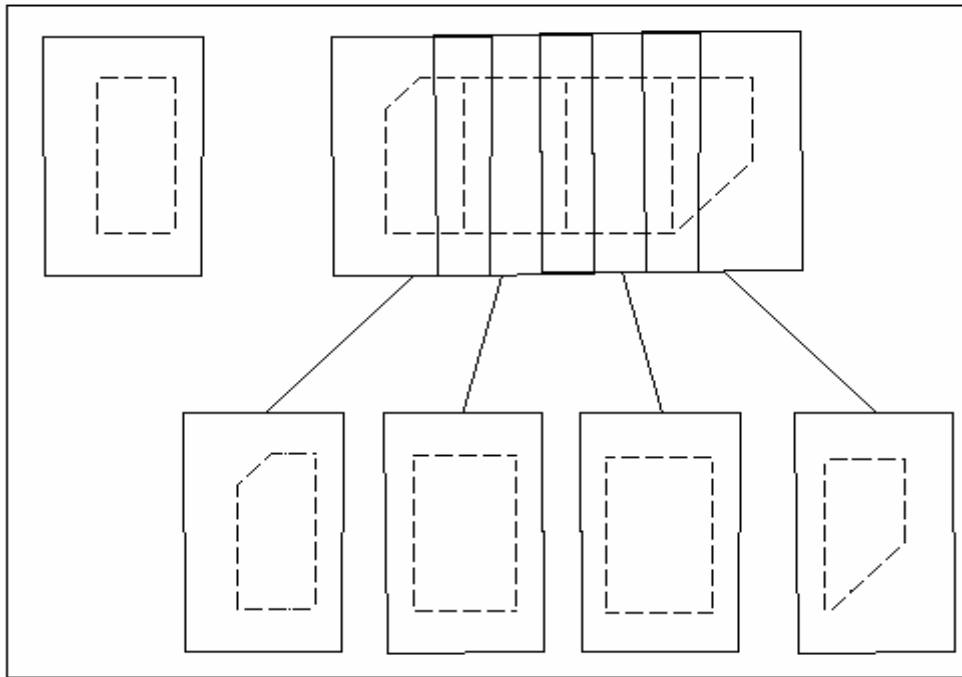


Figure (B-7):block wise matching, [7].

B.5.1 To perform block wise matching

1. In the Project and Models property page, select Blockwise Matching, see figure (B-8).

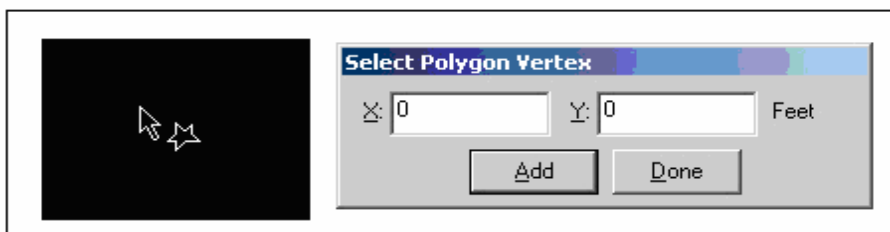


Figure (B-8): Block wise matching, [7].

2. In the footprint display, use the Zoom In, Window Area, or other command on the toolbar to enlarge the area of interest.
3. Click the right mouse button to return to the Select Polygon mode, and then do one of the following:
 - ❖ Position the pointer and click the left mouse button to enter the first vertex, repeat for the second vertex, and so on. You will see the polygon boundary extend to each vertex as you enter it, see figure (B-9).

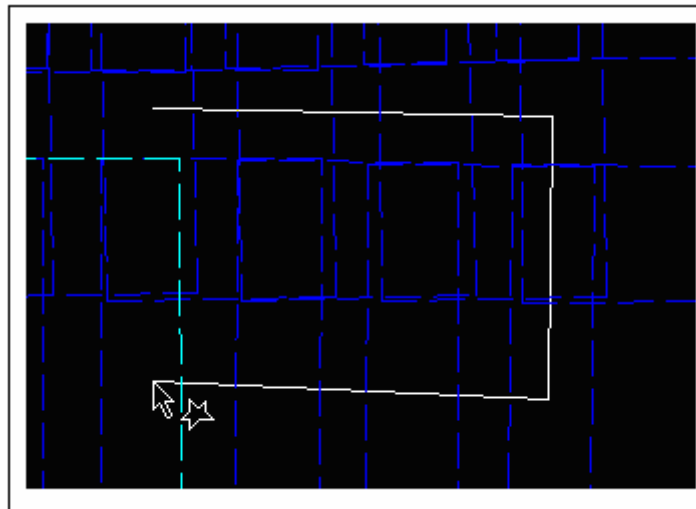


Figure (B-9): Block wise matching select polygon model, [7].

Click the right mouse button when you are ready to close the polygon between the first and last entered vertex.

B.5.2 To assign processing properties manually

1. If you want to edit the processing properties for one or more models, select and right-click those models, and then click Properties to open the Selected Model Properties dialog box, see figure (B-10).

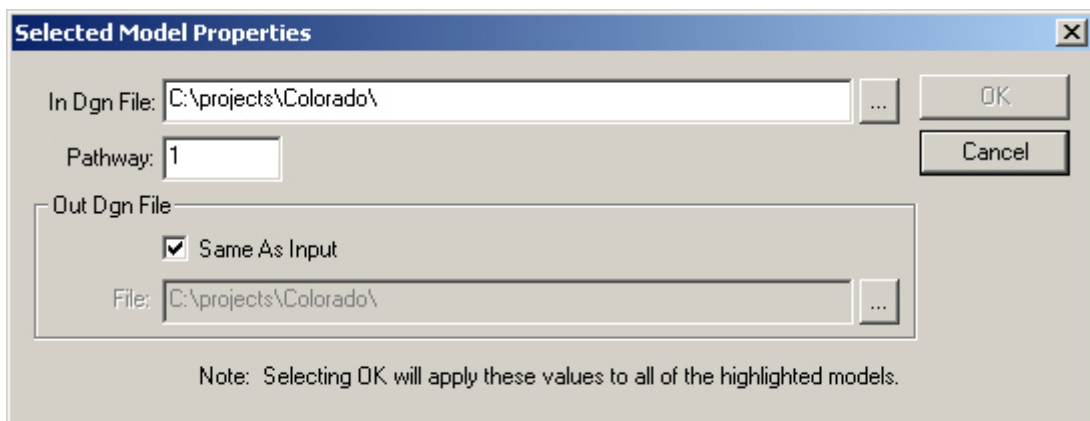


Figure (B-10): selected models dialog box, [7].

2. In the In Dgn File box, enter the path and name of the design file that is associated with the selected models.
3. In the Pathway box, type the pathway number for the pathway that you want to process.
4. If you want the result of the processing to be stored in the input design file (thereby overwriting it), select the Same As Input check box.
5. If you want the result of the processing to go to a design file other than the input file, clear the Same As Input check box, and enter a name for the output file in the File box.

B.5.3 To assign processing properties using wizards

1. For assistance in assigning input or output design file names, click In Dgn Files or Out Dgn Files to open the Design File Naming wizard, see figure (B-11).

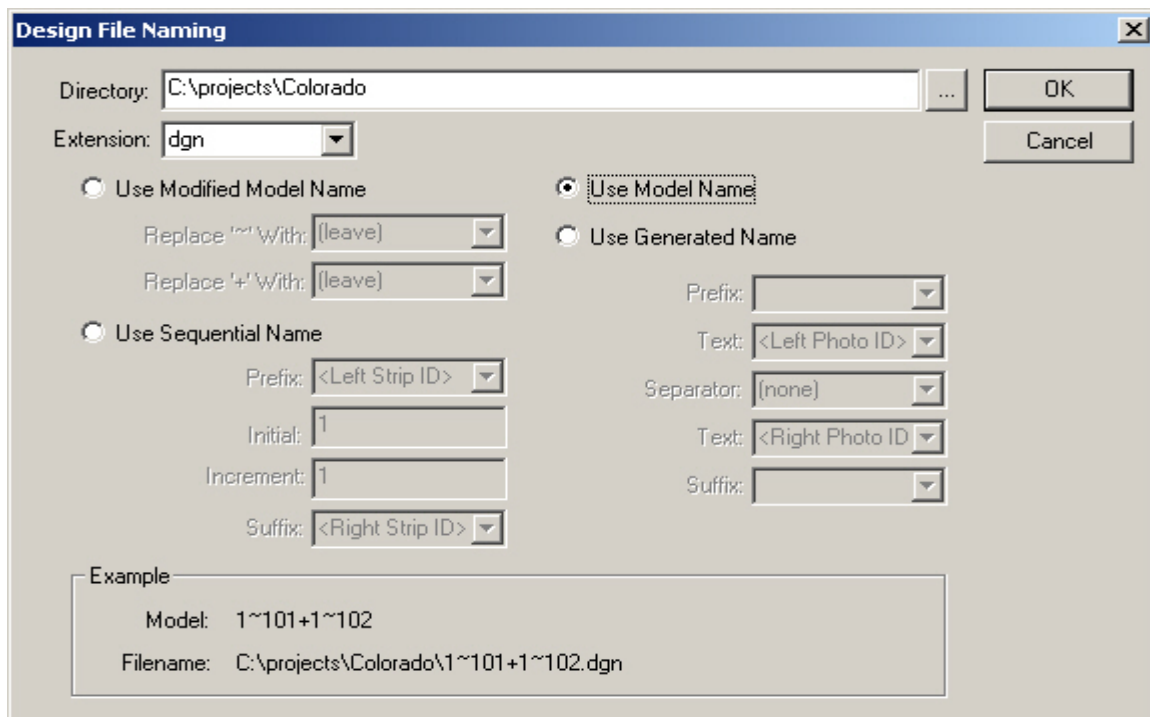


Figure (B-11): Design file naming dialog box, [7].

2. In the Directory box, enter the path of the directory where the design files are or will be located.
3. Select one of the following options:
 - Use Model Name. This is the default option.
 - Use Modified Model Name.
 - Use Sequential Name.
 - Use Generated Name.

- When you are through, click OK to return to the Project and Models property page.

To select a seed file, click Yes to open the Save As dialog box, select the design file that you want to use, and then click Save.

B.6 Elevation Collection Parameters Property Page

The screenshot shows the 'ImageStation Automatic Elevations' dialog box with the 'Elevation Collection Parameters' tab selected. The dialog is divided into several sections:

- Preferences:** Preference Set: Default (dropdown), Load, Save buttons.
- Terrain Type and Matching:** Adaptive Parallax: ; Parallax Bound: 8.000; Terrain Type: Hilly (dropdown); Epipolar Line Distance: 2; Adaptive Matching: .
- Surface Reconstruction:** Keep Grid Widths Equal: ; Grid Width X: 6.000; Smoothing Filter: User-Defined (dropdown); Grid Width Y: 6.000; Smoothing Weight: 4.000; Sigma: 0.377; Hold Grid to Multiples of Grid Width: ; Adaptive Grid: ; Sampling Factor: 2 (dropdown).
- Collection Boundary:** Boundary: Entire Model Area (dropdown).
- Geomorphic Information:** Use Breaklines: ; Use Obscured Areas: ; Densification Distance: 3.000; Expansion Distance: 18.000; Standard Deviation: 0.189; Use Elevation Points: ; Suppression Distance: 0.000; Standard Deviation: 0.126.
- More DTM Extraction Parameters:** Cols, Rows for Correlation Coeff: 5; Threshold for Correlation Coeff: 0.75; Threshold for Weights: 0.35; Int. Pnt Reduction: ; Factor: 0.005.
- Feature Pyramid Parameters:** Cols for Convolution: 5; Color Band: Green (dropdown); Rows for Convolution: 3; Largest OV to Use: Full Res (dropdown); Cols for Non Max. Supp: 5.

Buttons at the bottom: OK, Cancel, Help.

Figure (B-12):Elevation collection parameters page, [7].

B.6.1 To save elevation collection preferences

- 1) In the Elevation Collection Parameters tabbed page, enter the settings that you want to save.
- 2) In the Preference Set box, enter a name for the saved settings.
- 3) Click Save.

B.6.2 To load saved elevation collection parameters

1. In the Preference Set box, type or select the name of the saved preferences that you want to load into the Elevation Collection Parameters tabbed page.
2. Click Load.

B.6.3 To reset elevation collection parameters to the default values

To reset the elevation collection parameters to the default values computed on the basis of photo scale, resolution, and so on, do the following:

1. In the Preference Set box, type or select Default.
2. Click Load.

B.6.4 To specify the Terrain Type and Matching properties

1. From the Terrain Type list, select the terrain type of the DTM grid.
2. Do one of the following:
 - ❖ Select the Adaptive Parallax check box to automatically calculate the search space, or parallax bound, for matching homologous points in

the image. The parallax bound is determined for each image by estimating the maximum height difference from the DEM of the previous image in the image pyramid. Thus, the parallax bound is adapted to the local terrain automatically. If you select this check box, the Parallax Bound box is not available.

- ❖ In the Parallax Bound box, type the number of pixels that are to define the search space for matching homologous points in the image.
- ❖ During the matching process, ISAE accepts only points that are located within this value.

- ❖ Parallax bound specifies a height bound in object space in which measured 3-D points are accepted. A smaller parallax bound means a smaller height bound in object space. This parameter is dependent upon the terrain type. Recommended values are equal to an average variance of terrain heights.

- ❖ For flat terrain, the Parallax Bound property can filter out 3-D outliers such as single trees and houses because the tops of those objects are not located within the small height bound. The Parallax Bound property is not as efficient for detecting 3-D outliers in mountainous terrain since you must set this property to a larger height bound to prevent ISAE from cutting off the tops of mountains.

3. In the Epipolar Line Distance box, type the density of the feature points that ISAE matches.
4. To adaptively match 3D points, select the Adaptive Matching check box. This will cause ISAE to re-filter imagery in areas of poor texture in an attempt to obtain more matches.

B.6.5 To specify the Surface Reconstruction properties

1. In the Grid Width X and Grid Width Y boxes, type the widths of the DTM grid in master units. If you want to enter different values for X and Y, first clear the Keep Grid Widths Equal check box.
2. In the Sigma box, type a threshold for computation.

For SPOT imagery where the image scale is 1:800,000 and the base-to-height ratio is 1, the default value is 10 meters (1 pixel).

3. If you want to automatically vary grid spacing within a given range, select the Adaptive Grid check box.
4. If you selected Adaptive Grid, the Sampling Factor list becomes available. If the list is available, select a sampling factor (2.0 or 4.0) from the list.
5. If you want to force grid points to be placed evenly on a multiple of the grid spacing, select the Hold Grid to Multiples of Grid Width check box.
6. In the Smoothing Filter list, select the filtering degree of the DTM.
7. To specify how much the DTM smoothes the terrain surface, in the Smoothing Weight box, type a number from 1.0 to 5.0.

B.6.6 To specify Geomorphic Information

1. If you want to specify that you have breaklines, drains, or ridges in your model, select the Use Breaklines check box. If you do not want to consider any breaklines, drains, or ridges that are included in the design file, clear this check box.
2. When you select this check box, three additional properties are made available: Breakline Densification Distance, Breakline Std. Dev., and Breakline Suppression Distance. Do the following:
 - ❖ If the Breakline Densification Distance box is available, type a distance to compute additional points along vertices of the breaklines.
 - ❖ If the Std. Dev. box (under Use Breaklines) is available, type the standard deviation of the densified points. the default standard deviation.
 - ❖ If the Suppression Distance box is available, type the minimum distance allowed from the grid points to the breakline.
3. If you have obscured areas in your model and you want to include them in the process, do the following:
 - ❖ Select the Use Obscured Areas check box.
 - ❖ In the Expansion Distance box, type the value by which to expand the obscured areas. This value is used in computation to give less weight to DTM points near obscured areas.
4. If you have elevation points in your model and you want to use them, do the following:
 - ❖ Select the Use Elevation Points check box. When you select this check box, the Standard Deviation property is made available

- ❖ In the Standard Deviation box (under Use Elevation Points), type the standard deviation for the elevation points in your model. The standard deviation of the mass points is one third (1/3) of the generated DTM points. It is recommended that you use the default value.

If you do not want to use any existing elevation points to compute the DTM, clear the Use Elevation Pts. check box.

B.7 Output Parameters Property Page

Use this property page to specify the output directories and other output parameters for the results of the processing, see figure(B-13).

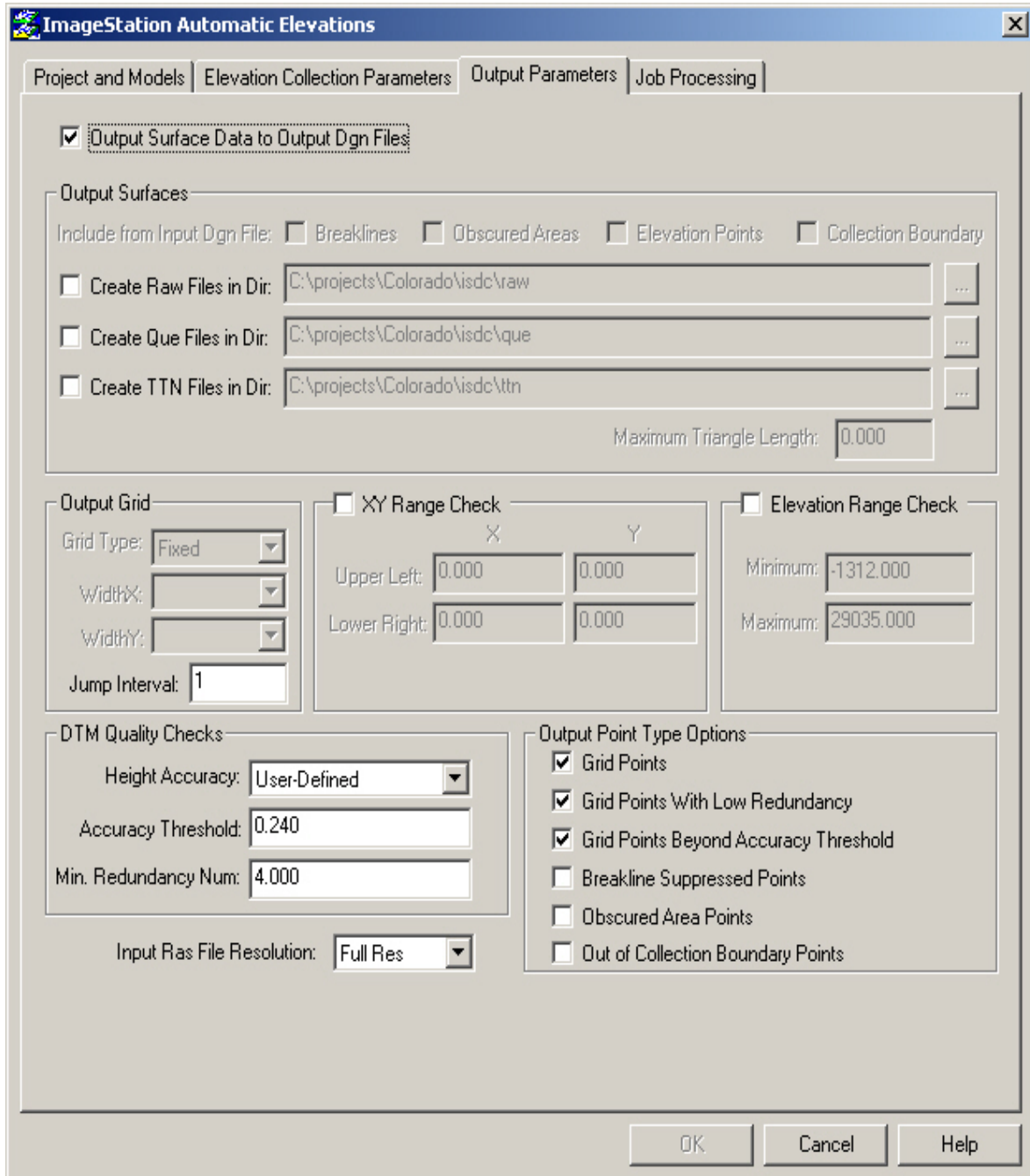


Figure (B-13) : Output parameters property page, [7].

B.7.1 To specify surface data output to design files

Select Output Surface Data to Output Dgn Files to specify that the output surface data be written to the output design file(s) that you specified in the Selected Models box on the Project and Models property page.

B.7.2 To specify input-file features to include in the output

You can include breaklines, obscured areas, elevation points, and collection boundaries from the input design file in the output surfaces by doing the following after specifying one or more surface type and its output location:

- ❖ Select one or more of the Breaklines, Obscured Areas, Elevation Points, and Collection Boundaries check boxes.
- ❖ Select from the Input Ras File Resolution list the input file resolution you want to use in the processing. You can choose from Full Res, 1/2, or 1/4.

B.7.3 To specify the Output Grid properties

- ❖ If the Adaptive Grid check box is selected on the Elevation Collection Parameters property page, the Output Grid options Grid Type, WidthX and WidthY become active on the Output Parameters property page. In the Grid Type box, select Fixed or Variable.
- ❖ In the WidthX box (if Fixed is selected), select one of the available sampling widths (in master units) for the DTM grid. In the WidthY box, also select one of the available sampling widths.
- ❖ If the Adaptive Grid check box on the Elevation Collection Parameters property page is cleared, the Jump Interval box is made available. In the Jump

Interval box, type the jump interval, which limits the number of points written back into the design file. For example, 1 means all 3D points are transferred to the output file and 2 means that every second 3D point is transferred to the output file.

B.7.4 To specify the XY Range Check properties

- 1) If you want to set the XY Range Check properties, select the XY Range Check check box to make these properties available.
- 2) In the Upper Left X and Upper Left Y boxes, type the values for the x, y coordinates of the upper left corner of a range-checking box.
- 3) In the Lower Right X and Lower Right Y boxes, type the values for the x, y coordinates of the lower right corner of a range-checking box.

B.7.5 To specify the Elevation Range Check properties

- 1) If you want to set the Elevation Range Check properties, select the Elevation Range Check check box to make these properties available.
- 2) In the Minimum box, type the minimum elevation of points.
- 3) In the Maximum box, type the maximum elevation of points.

B.7.6 To specify the DTM Quality Checks properties

- 1) Select a height accuracy method from the Height Accuracy list.
- 2) In the Accuracy Threshold box, type a threshold for the height accuracy.
- 3) In the Minimum Redundancy Num box, type the minimum number of points within a mesh that are required to determine a grid post. The default value is 4, but you should set this value to 2 if you have selected the Adaptive Matching check box on the Elevation Collection Parameters property page.

b.7.7 To specify the Output Point Type Options properties

- 1) If you want to write the grid points to the design file or output surface, select the Grid Points check box.
- 2) If you want to write the grid points that fall below the minimum redundancy number to the design file or output surface, select the Grid Points With Low Redundancy check box.
- 3) If you want to write the grid points that fail to meet the height accuracy threshold to the design file or output surface, select the Grid Points Beyond Accuracy Threshold check box.
- 4) If you want to write the points that are suppressed by breaklines to the design file or output surface, select the Breakline Suppressed Points check box.
- 5) If you want to write the grid points that lie within obscured areas to the design file or output surface, select the Obscured Area Points check box.
- 6) If you want to write the grid points that lie outside the collection boundary to the design file or output surface, select the Out of Collection Boundary Points check box.

B.8 Job Processing Property Page

Use this property page to specify job-processing properties for each model to be processed.

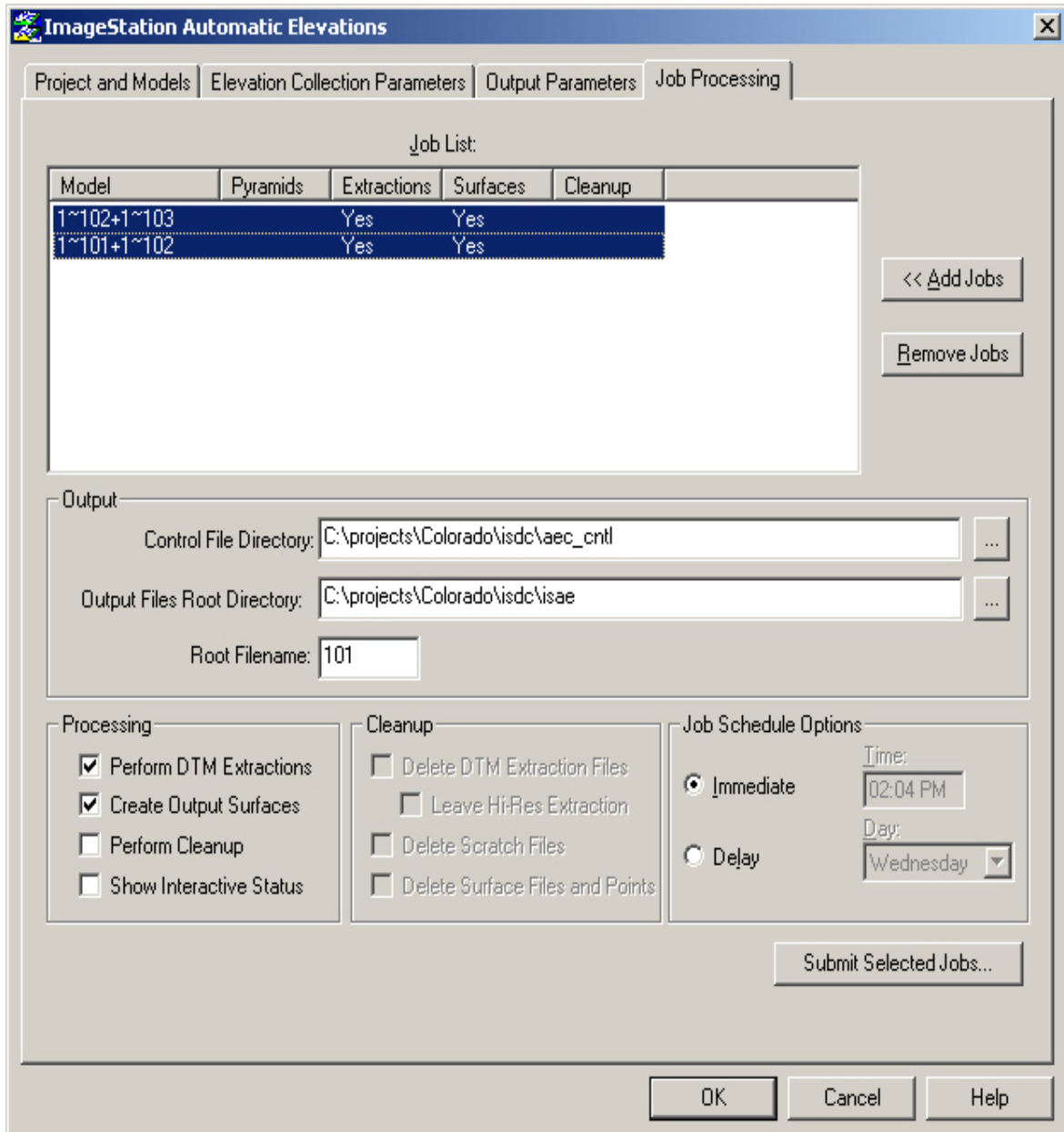


Figure (B-14) : Job-processing dialog, [7].

B.8.1 To specify Output properties

1. In the Control File Directory box, enter the path of the directory where all of the ISAE control files are located.
2. In the Output Files Root Directory box, enter the path of the root directory for the ISAE output files. ISAE will create a separate subdirectory in this location for each model.
3. In the Root File Name box, type the root name for all of the files ISAE creates.

B.8.2 To specify ISAE Processing properties

1. If you want to perform DTM extractions, select the Perform DTM Extractions check box. Selecting this check box enables the Add Jobs option.
2. If you specified on the Output Parameters property page that Raw, ASCII Queue, or TTN files are to be created or that surface data is to be written to the output design files, the Create Output Surfaces check box is made available. Select the check box if you want a processing job to create output surfaces according to these settings.
3. If you want to perform cleanup after DTM extraction, select the Perform Cleanup check box. If you select this check box, the Cleanup Properties are made available. You will typically perform cleanup *after* you verify the DTM results in the design file.

B.8.3 To specify ISAE Cleanup properties

1. If you want to delete the DTM extraction files in the subdirectory for each of the models selected, select the Delete DTM Extraction Files check box. If you select this option but want to keep the high-resolution .RAS and .STA files, select Leave Hi-Res Extraction.
2. If you want to delete the ISAE scratch files in the subdirectory for each of the models selected, select the Delete ISAE Scratch Files check box.
3. If you want to delete the TTN/Que files and the design files in the subdirectory for each of the models selected, select the Delete Output Surfaces check box.
- 4.

B.8.4 To add jobs to the Jobs List

Click Add Jobs to add the selected models (on the Project and Models property page) to the Jobs List box.

The list displays the model names and shows which processing properties are selected.

B.8.5 To submit jobs for processing

1. From the Jobs list, select the jobs you want to submit.
2. Do one of the following:
 - ❖ To submit all of the selected jobs for immediate processing, select Immediate.

- ❖ To delay the processing of the selected jobs, select Delay. When you select Delay, the Day and Time boxes are made available.
3. If the Day and Time properties are available, enter the day and time that you want the processing of the selected jobs to take place.
 4. Do one of the following:
 - ❖ To submit the selected jobs for processing while you continue working with ISAE, click Submit Selected Jobs.
 - ❖ To submit the selected jobs for processing and to exit ISAE, click OK.

APPENDIX-C ISDM

C.1 ISDM.

The ImageStation Digital Mensuration (ISDM) software provides you with the capability to measure points from scanned photography on a standard Intel®-based PC with Windows NT 4.0 (or later version). In addition, the ISDM product prepares digital images for the stereo resampling process. Stereo resampling creates new images (epipolar stereo images) for optimal stereo viewing in preparation for stereo data collection. ISDM allows you to:

- Input and edit project, camera, photo, model, strip, and control point data through a dialog box interface.
- Display digital images.
- Display simple point-symbol graphics over images.
- Set up and store screen configurations.
- Enter and edit data.
- Perform interior, single-photo resection, relative, absolute, and multi-photo orientations.
- Perform single- or multi-cursor mensuration.
- Perform coordinate refinements such as lens distortion, atmospheric refraction, and earth curvature.
- Perform interior, relative, absolute, and multiphoto orientations, point transfer, and photo triangulation.
- Perform bundle adjustment.
- Perform automated correlation and least squares refinement.

- Modify the contrast and brightness of images.
- Apply histogram adjustments to images.
- Flip, rotate, and transpose images.
- Dynamically display row, column scan coordinates; x,y image coordinates; and xyz ground coordinates.
- Measure points once, then manually or automatically transfer the measurements to other photos.
- Drive to points in the model.

C.2 New Project Command (File Menu)

The New Project command creates a new ImageStation project of photogrammetric data from one of the following specified sources:

- aerial photography
- close-range photography
- satellite imagery.

The New Project wizard guides you through the steps of creating a new project. As you proceed, the wizard uses the information you provide to record and structure the baseline data for the project. When your computer is a client of a TerraShare data management system, you can also add the project to the TerraShare database for access by TerraShare Ortho Manager and other TerraShare products.


The same dialog boxes and their definitions are explained in appendix D.

APPENDIX-D ISPM

D.1 What is ImageStation Photogrammetric Manager (ISPM)?

ImageStation Photogrammetric Manager (ISPM) is a single, consistent, easy-to-use, photogrammetric data manager and central data store product.

D.2 Using the New Project Wizard

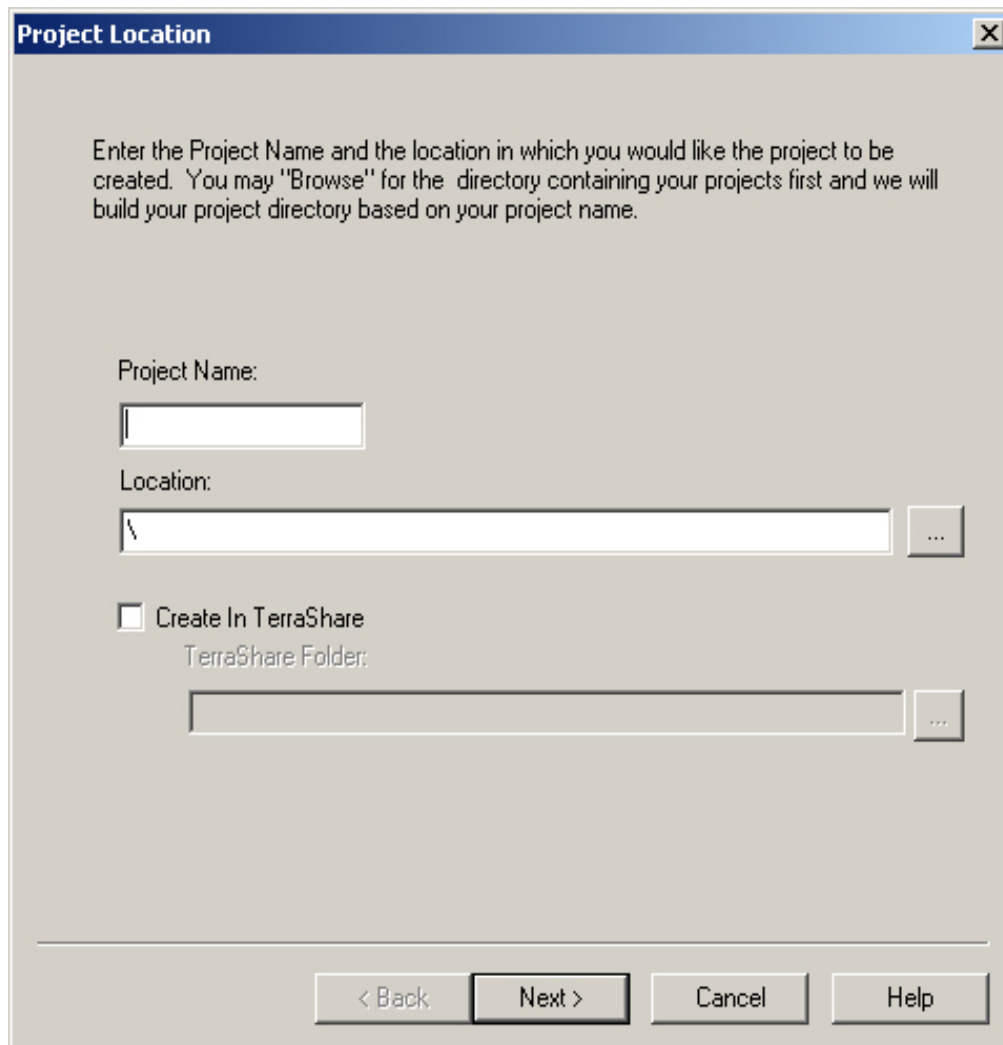
Selecting the New Project command from the File menu or clicking  on the toolbar starts a wizard that lets you create a new ImageStation project of photogrammetric data from one of the following specified sources:

- aerial photography
- close-range photography
- satellite imagery.

The New Project wizard guides you through the steps of creating a new project. As you proceed, the wizard uses the information you provide to record and structure the baseline data for the project. When your computer is a client of a TerraShare™ data management system, you can also add the project to the TerraShare database for access by TerraShare Ortho Manager and other TerraShare products.

D.2.1 Defining the Project Location

Selecting New Project from the File menu opens the Project Location page of the New Project wizard, see figure (D-1).



The screenshot shows a dialog box titled "Project Location" with a close button (X) in the top right corner. The dialog contains the following text and controls:

Enter the Project Name and the location in which you would like the project to be created. You may "Browse" for the directory containing your projects first and we will build your project directory based on your project name.

Project Name:

Location:
 ...

Create In TerraShare
TerraShare Folder:
 ...

At the bottom of the dialog, there are four buttons: "< Back", "Next >", "Cancel", and "Help".

Figure (D-1): new project wizard window, [7].

D.2.2 Selecting the Project Type

Clicking Next on the Project Location page of the New Project wizard opens the Project Type page, see figure (D-2).

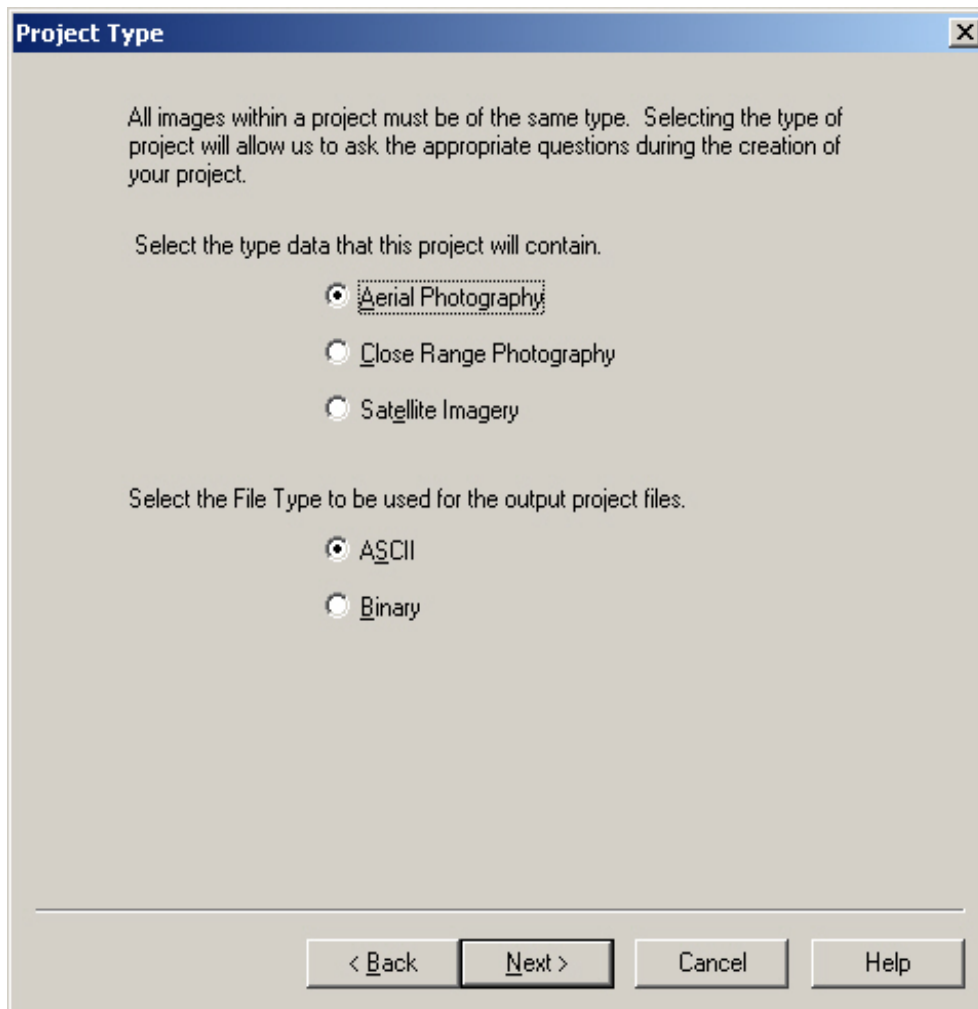


Figure (D-2): Selecting project type page , [7].

D.2.3 Selecting the Project Units and Coordinate System:

If you selected either Aerial Photography or Close Range Photography as the project type on the Project Type page, clicking Next opens the Project Units page. (Satellite imagery projects skip this page because their units are preset.), See figure (D-3).

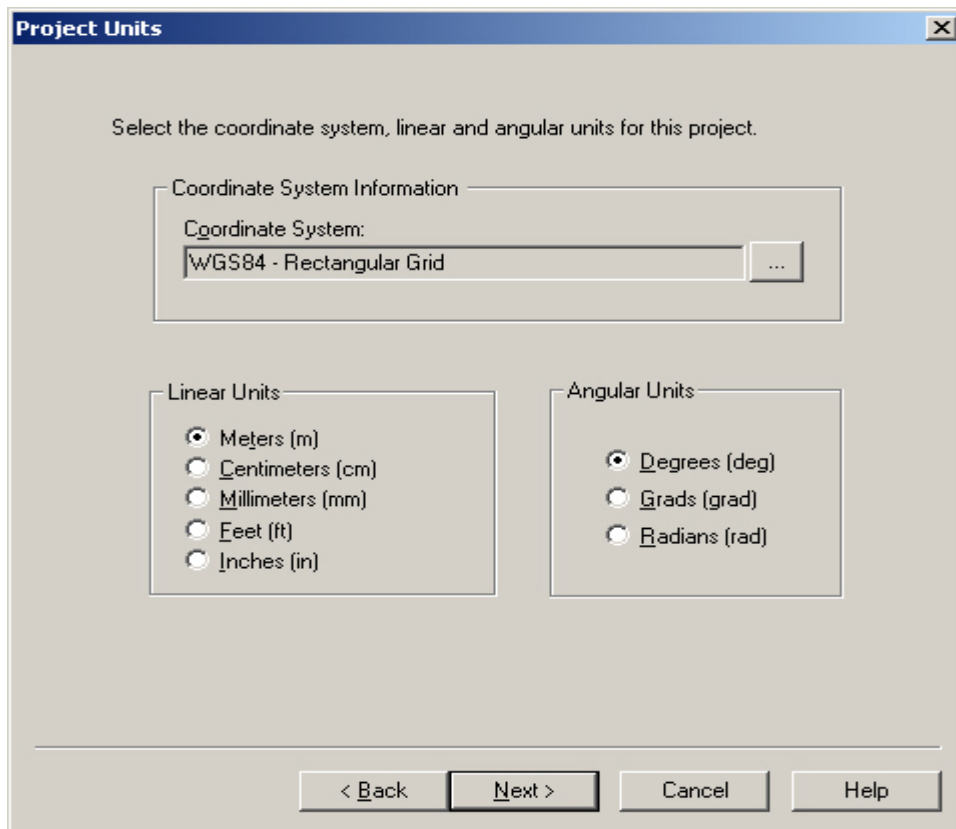


Figure (D-3) : Chosen Project Units and Coordinate System , [7].

Select the linear, angular, and coordinate system units for the new project, based on the coordinate system and units of the survey data that you intend to use in the project. The project units you select for the new project are used for all work in the new project. If you change the project units later, you may invalidate data collected in the units you originally selected. Current project units are shown on dialog boxes in which you may make adjustments to these kinds of data.

D.2.4 Entering Project Parameters

Clicking Next on the Project Units page of the New Project wizard opens the Project Parameter Settings page. see figure (D-4).

Project Parameter Settings

Enter the following project parameters, correction options, and convergence tolerances for this project.

Default Project Parameters

Std. Dev. of Measurement:	Flying Height (AMSL):
<input type="text" value="5"/> (um)	<input type="text" value="7800"/> (ft)
Earth Radius:	Ground Elevation (AMSL):
<input type="text" value="6378000"/> (m)	<input type="text" value="5400"/> (ft)

Coordinate Refinement Settings

- Enable Atmospheric Refraction
- Enable Earth Curvature
- Enable Water Refraction

Refractive Index:

Chart Datum Offset (AMSL): (m)

Convergence Tolerances

Max Iterations:	<input type="text" value="10"/>
Delta Position (x,y,z):	<input type="text" value="0.001"/> (ft)
Delta Attitude (w,p,k):	<input type="text" value="0.0001"/> (deg)

< Back **Next >** Cancel Help

Figure (D-4): Project Parameter Settings page , [7].

D.2.5 Entering User Parameters

Clicking Next on Project Parameter Settings page of the New Project wizard opens the User Settings page. See figure (D-5).

User Settings

During calculations of the various orientations, certain limits need to be defined in order to determine successful or non-successful solutions. Enter the following settings and limits to be used for this project.

Acceptable IO Limits

Max Sigma: 10 (um)

Max Residual: 10 (um)

Acceptable RO Limits

Max Sigma: 10 (um)

Max Y-Parallax: 10 (um)

Acceptable AO/Bundle Adjustment Limits

Max Sigma: 10 (um)

	X	Y	Z	
Max RMS:	.25	.25	.25	(ft)
Max Residual:	.50	.50	.50	(ft)

< Back Next > Cancel Help

Figure (D-5): User Settings page , [7].

On this page you can enter settings and limits to be used during calculations of the various orientations for the new project. They do not affect the results of any calculation but merely flag the results with a warning if they exceed your specified limits. These values are typically the key items used to determine the quality of the adjustment performed for each individual orientation.

D.2.6 Defining User Points

Clicking Next on the User Settings page of the New Project wizard opens the Default User Points page. see figure (D-6).

Default User Points

You can optionally define a set of default "User" points to be generated for each image. These points may be used during Relative Orientation to facilitate the measurement process.

The naming convention for the User Points during the orientation process is "Strip"? "Photo"? "ID", where ? are single character user-defined delimiters. Enter Strip/Photo and Photo/ID delimiters here.

Strip/Photo Delimiter: Photo/ID Delimiter:

Enter user point information and select the "Add" button. Coordinates may be selected from the preview diagram below or from pre-defined pattern.

ID: X: Y:

ID	X	Y

Preview Diagram: A square with origin (0,0) at the bottom-left and corner (100,100) at the top-right.

User Point Patterns: Coordinate Readout:

<

Figure (D-6): User Points page , [7].

D.2.7 Finishing the Project

To finish creating the new project, click the Finish button at the bottom of the page. The new project will also be added to TerraShare if you entered the required information in the first page of the wizard.

APPENDIX-E

ISSD

E.1 What is ISSD?

Introducing ImageStation Stereo Display (ISSD) provides a full set of commands that let you display, enhance, and manipulate stereo graphics data in raster format. This includes commands for displaying and manipulating continuous tone raster data in MicroStation® views and displaying data from aerial photographs that have been scanned into a file. Pixels in these files are displayed in a wide range of colors and shades. You can also display monochromatic images (black and white) and color composite images (displayed with red, green, and blue components in one 24-bit color file). ISSD uses MicroStation for its base runtime environment, and ISSD can be configured to run with other products, such as ImageStation Feature Collection (ISFC).

The image or scanned raster file serves as a backdrop to the vector design file. You can produce engineering or mapping graphics using the raster file for reference points.

E.2 Using ISSD in a Production Workflow

Z/I Imaging Corporation's ImageStation family of photogrammetry products supports a complete production workflow, from the scanning of aerial photographs into digital images to their conversion to vector graphics for map production or input to other processes.

By using ISSD in conjunction with other Z/I Imaging photogrammetry products (purchased separately), you can produce a map from two scanned overlapping images.

The following is a generalized production workflow that uses Z/I Imaging photogrammetry products for the Windows NT operating system. However, these products are interoperable with existing Intergraph CLIX production systems. See figure (E-1) .

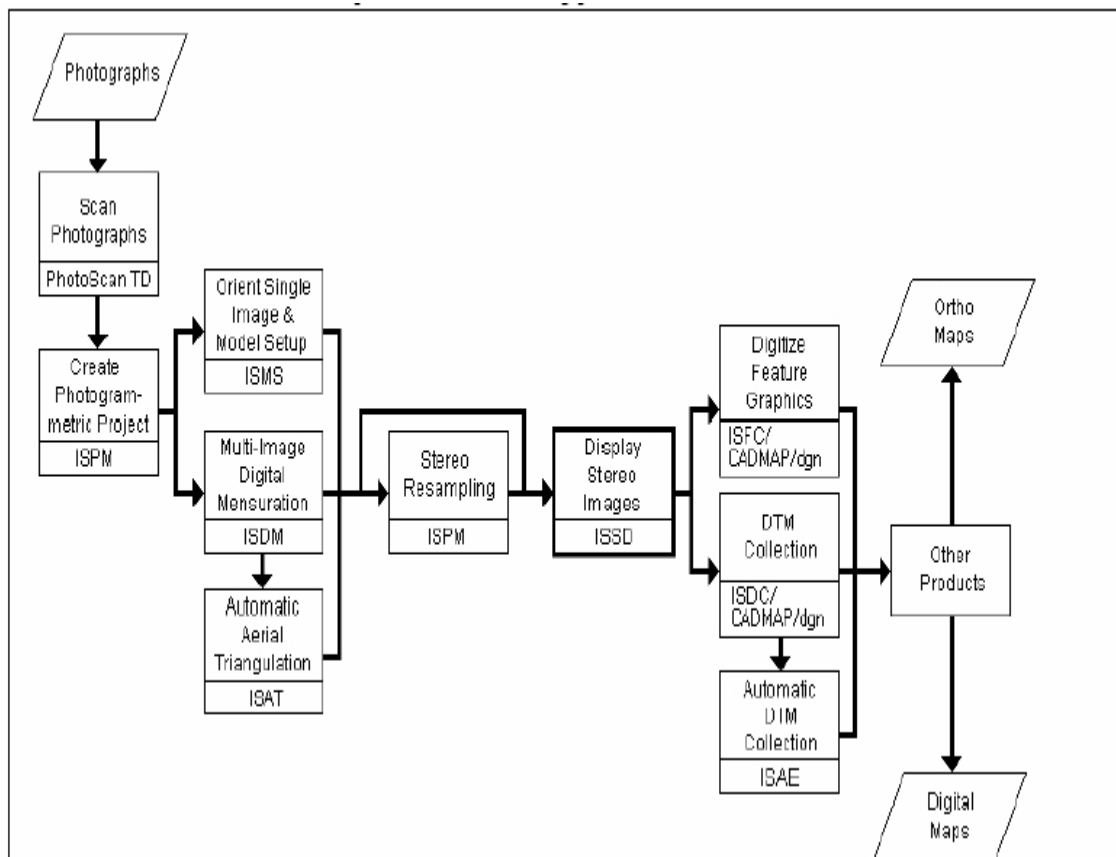


Figure (E-1) :Z/I imaging work flow , [7] .

APPENDIX-F GIS

F.1 what is GIS ?

GIS (Geographic Information System) is designed to work with data referenced by spatial / geographical coordinates. In other words, GIS is both a database system with specific capabilities for spatially referenced data as well as a set of operations for working with the data. It may also be considered as a higher order maps.

F2 The steps of analyzing the DTM using ArcGIS 9.2

1. Add grid data which we obtained by ISAE , see figure (F-1).

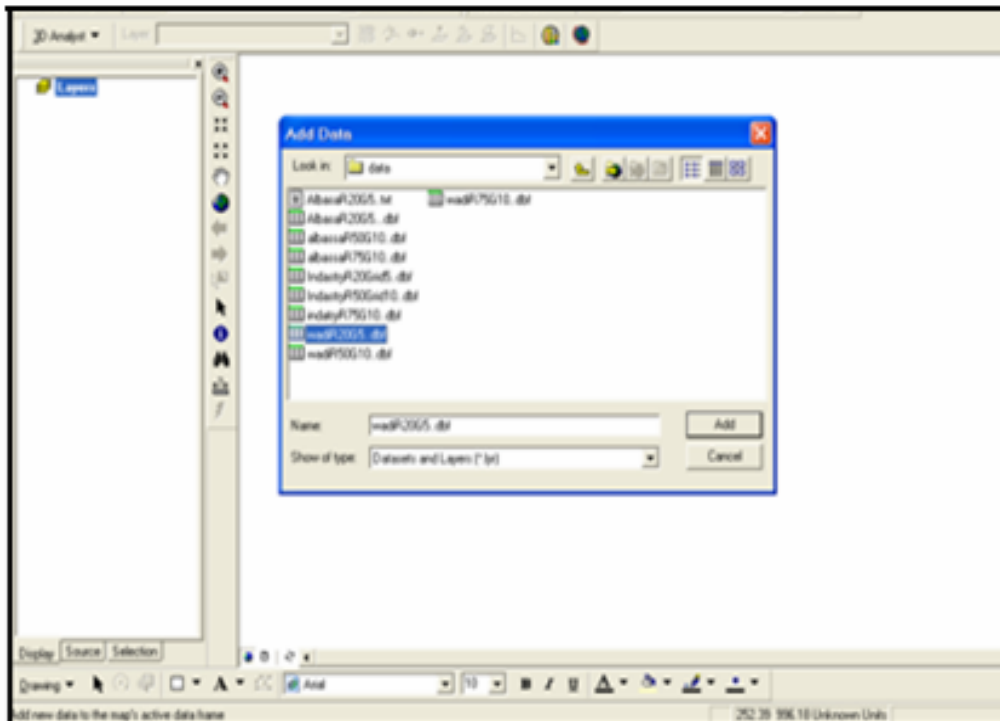


Figure (F-1):Adding Grid to ArcGIS 9.2.

- The data is shown as follow, see figure (F-2).

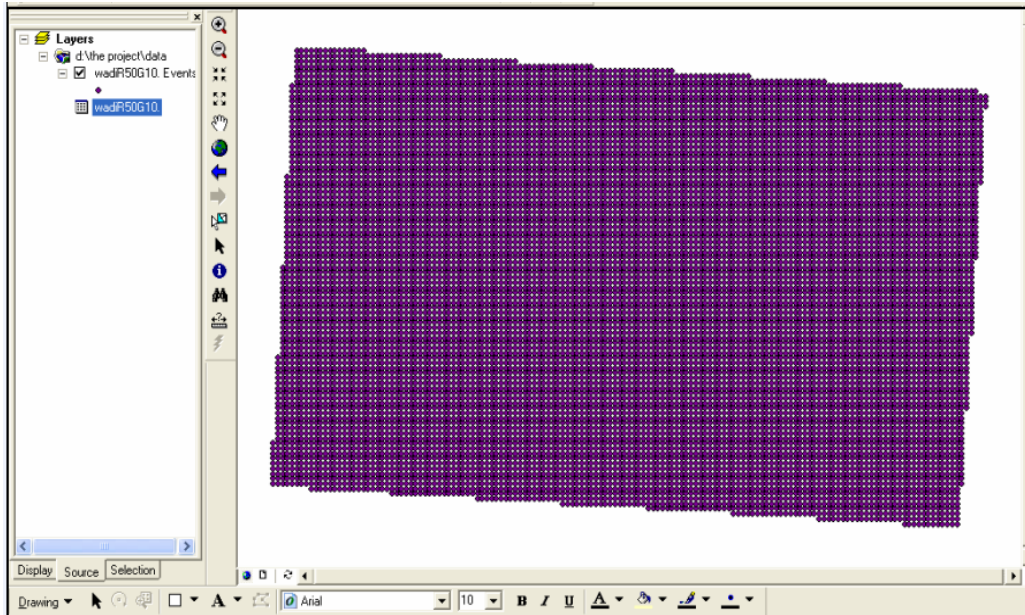


Figure (F-2) : The grid data representation.

- The grid representation zoomed is shown in Figure (F-3).

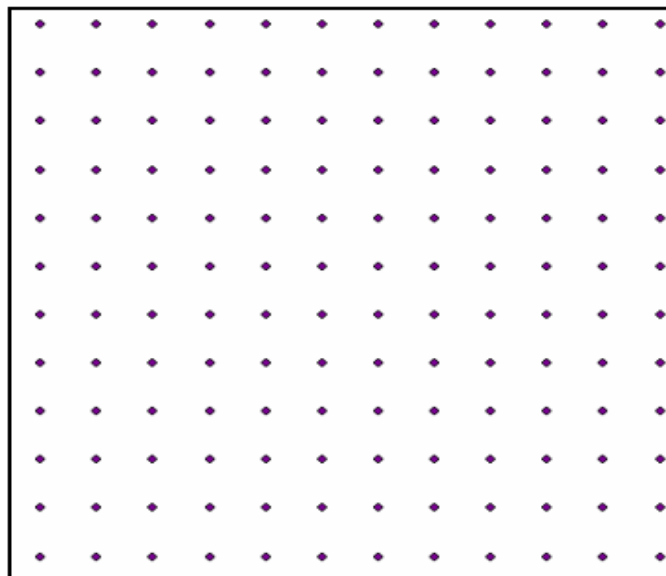


Figure (F-3) : The DTM Grid points.

4. Click on the 3D analysis than create/ modify TIN and now choose create TIN surface from feature , see figure (F-4).

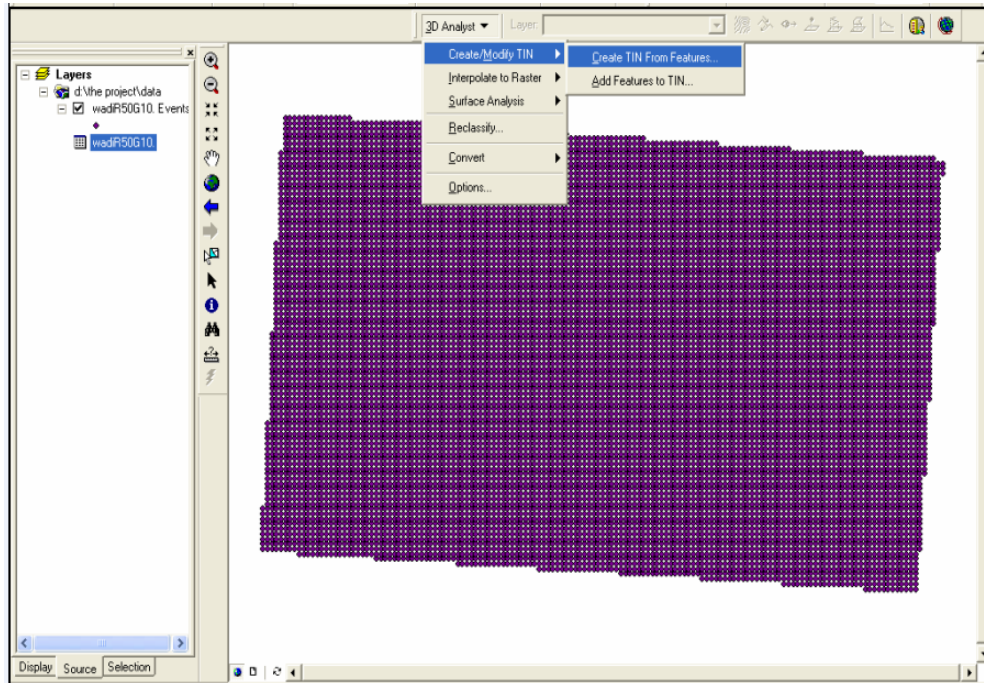



Figure (F-4): Build surface using TIN.

5. put  on your data file which was saved as DBF file than choose where to save it on your computer, See figure (F-5).

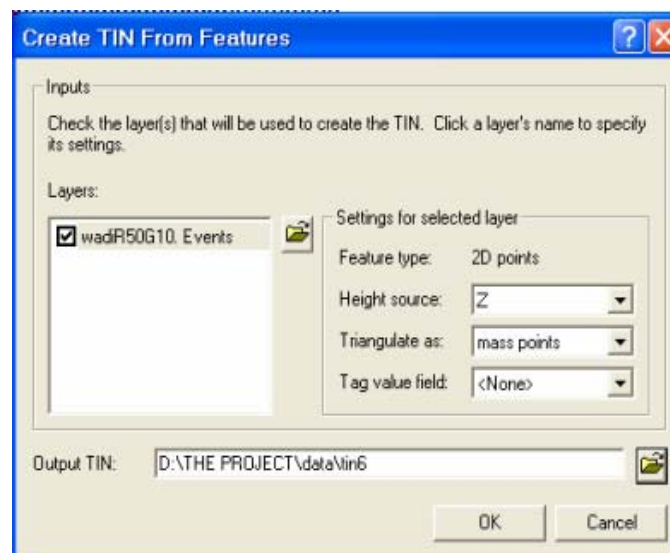


Figure (F-5): TIN creation window.

- The created TIN is shown in figure (F-6).

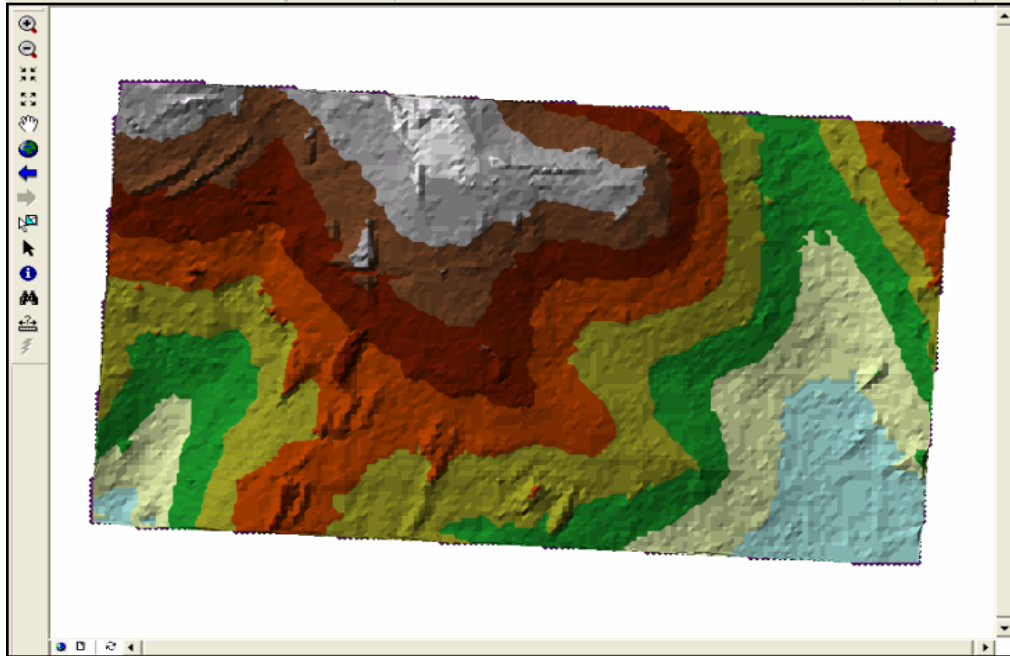


Figure (F-6): The created TIN.

- Add the check points shapefile , see figure (F-7).

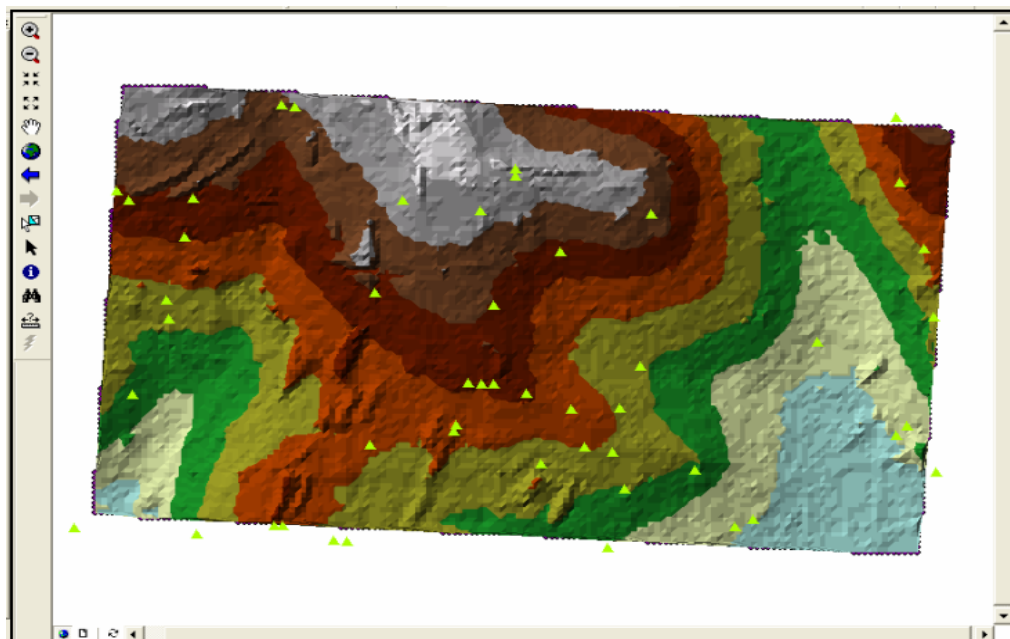


Figure (F-7): The check points overlaid with the TIN surface.

- Click on 3D analysis and choose convert features to 3D, see figure (F-8).

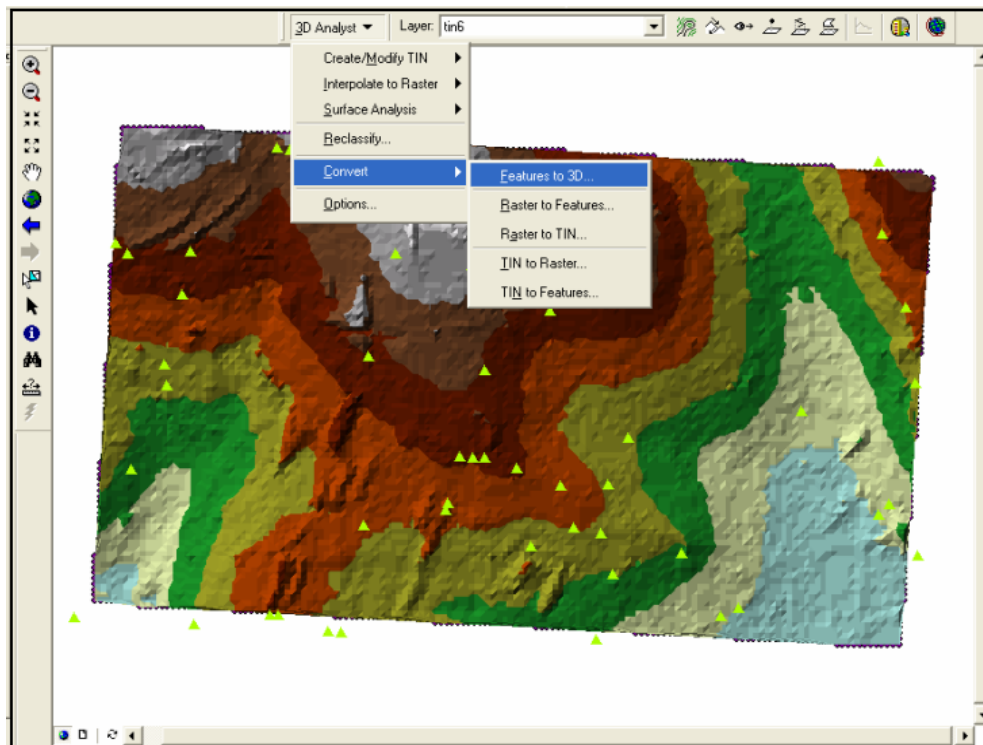


Figure (F-8): Converting features to 3D menu.

- Choose the check point as input features and TIN surface tin which we created before as source of heights, and save the results on your computer, see figure (F-9).

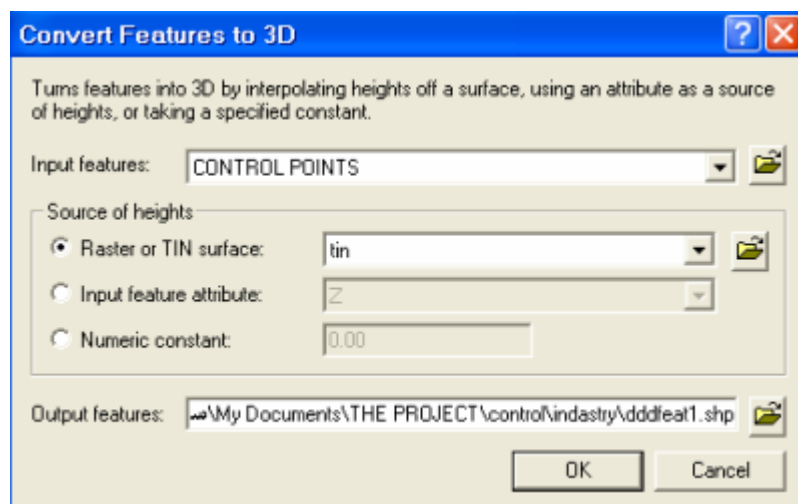


Figure (F-9): Converting features to 3D dialog box.

10. Now click on the icon / add projected XYZ icon for the convert file to get the DTM heights in the attribute table , see figure (F-10).

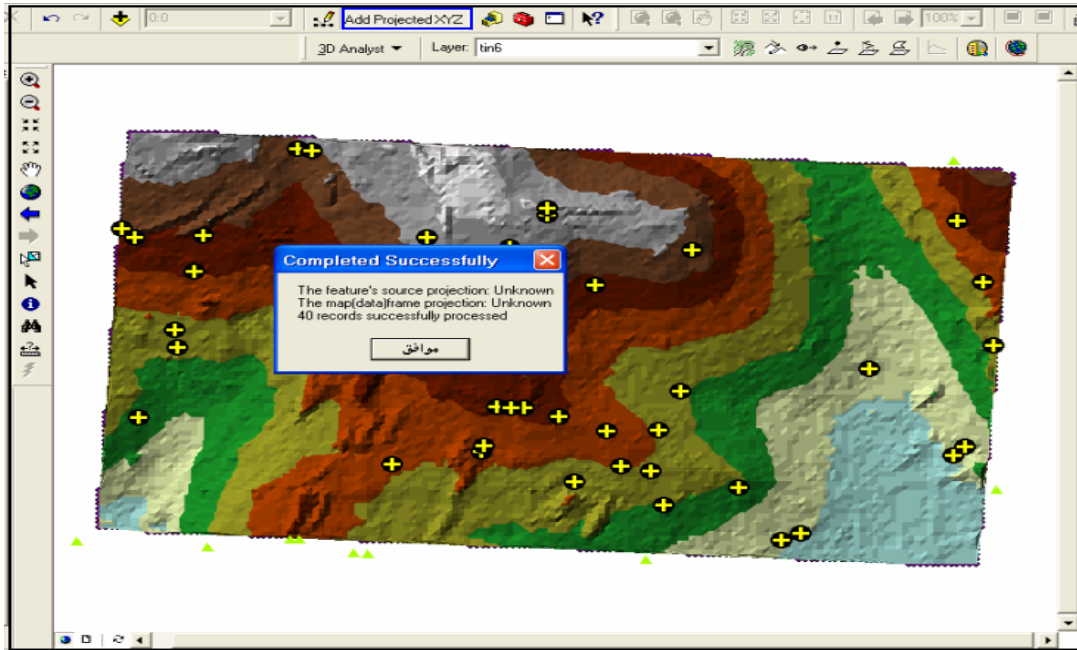


Figure (F-10):Adding the DTM heights to the attribute table of the check points.

-The fields (x-orig, y-orig, z-orig) are added to the attribute table as shown in figure (F-11).

X	Y	Z	x_orig	y_orig	z_orig	x_proj	y_proj
158779.3313	101725.3316	896.92	158779.3313	101725.3316	894.133179	158779.3313	101725.3316
158784.09	101737.9815	896.88	158784.09	101737.9815	892.571167	158784.09	101737.9815
158905.4293	101801.9813	902.53	158905.4293	101801.9813	900.457092	158905.4293	101801.9813
158932.5936	101659.3962	884.17	158932.5936	101659.3962	882.879211	158932.5936	101659.3962
159057.1825	101682.3364	887.36	159057.1825	101682.3364	885.515381	159057.1825	101682.3364
159201.0675	101647.9529	876.81	159201.0675	101647.9529	872.795288	159201.0675	101647.9529
159070.7562	101773.2789	891.93	159070.7562	101773.2789	883.848755	159070.7562	101773.2789
159574.7512	101737.1212	867.89	159574.7512	101737.1212	856.475098	159574.7512	101737.1212
159106.3397	101857.7801	902.22	159106.3397	101857.7801	877	159106.3397	101857.7801
159417.2251	101906.6997	855.44	159417.2251	101906.6997	855.277466	159417.2251	101906.6997
159602.7861	102095.1885	888.16	159602.7861	102095.1885	887.873535	159602.7861	102095.1885
159561.3278	102229.5469	894.87	159561.3278	102229.5469	895.271851	159561.3278	102229.5469
159125.351	102164.7623	917.27	159125.351	102164.7623	917.476257	159125.351	102164.7623
158825.1455	102172.4934	928.67	158825.1455	102172.4934	927.249329	158825.1455	102172.4934
158849.1467	101980.223	914.12	158849.1467	101980.223	909.107605	158849.1467	101980.223
159000.7015	102102.4476	927.22	159000.7015	102102.4476	928.040922	159000.7015	102102.4476

At the bottom of the table, there is a status bar showing 'Show: All Selected' and 'Records: (0 out of 40 Selected.)' along with an 'Options' dropdown menu.

Figure (F-11): attribute table of The fields (X-orig, Y-orig, Z-orig)

11. Click on option / add new filed to calculate the height differences. see figure (F-12).

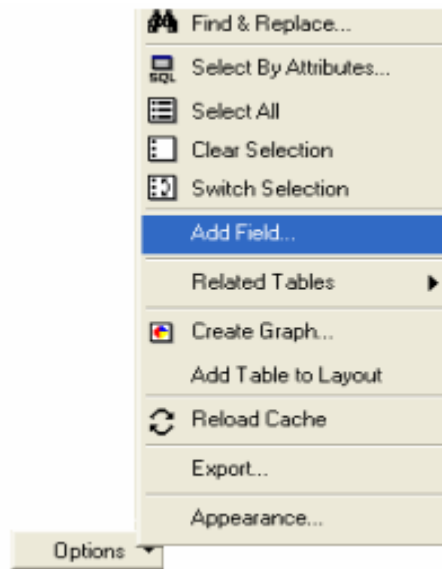


Figure (F-12): Adding new field to the table .

- Write the field name and type, as shown in figure (F-13).



Figure (F-13): Adding new field dialog box .

12. Calculate the heights difference between the DTM and surveying points by clicking on Calculate values in the created field options , see figure (F-14).

FID	Shape	X	Y	Z	z_orig	dZ
0	Point ZM	158779.3313	101725.3316	896.92	894.133179	
1	Point ZM	158784.09	101737.9815	896.88	892.571167	
2	Point ZM	158905.4293	101801.9813	902.53	900.457092	
3	Point ZM	158932.5936	101659.3962	884.17	882.879211	
4	Point ZM	159057.1825	101682.3364	887.36	885.515381	
5	Point ZM	159201.0675	101647.9529	876.81	872.795288	
6	Point ZM	159070.7562	101773.2789	891.93	883.848755	
7	Point ZM	159574.7512	101737.1212	867.89	856.475098	
8	Point ZM	159106.3397	101857.7801	902.22	877	0
9	Point ZM	159417.2251	101906.6997	855.44	855.277466	0
10	Point ZM	159602.7861	102095.1885	888.16	887.873535	0
11	Point ZM	159561.3278	102229.5469	894.87	895.271851	0
12	Point ZM	159125.351	102164.7623	917.27	917.476257	0
13	Point ZM	158825.1455	102172.4934	928.67	927.249329	0
14	Point ZM	158849.1467	101980.223	914.12	909.107605	0
15	Point ZM	158690.2015	102193.4426	927.33	928.040283	0

Figure (F-14): Calculating field values.

- Write the code as shown in figure (F-15)

Field Calculator

Fields:

- dtm
- FID
- Id
- Shape
- X
- Y
- Z
- z_orig

Type:

- Number
- String
- Date

Functions:

- Abs ()
- Atn ()
- Cos ()
- Exp ()
- Fix ()
- Int ()
- Log ()
- Sin ()
- Sqr ()

dtm =

Abs ([z_orig] - [Z])

Advanced

OK

Cancel

Figure (F-15):Field calculator.

- Then the calculated height differences are added to the field dZ as shown in figure (F-16)

FID	Shape	X	Y	Z	z_orig	dZ
0	Point ZM	158779.3313	101725.3316	896.92	894.133179	2.78682
1	Point ZM	158784.09	101737.9815	896.88	892.571167	4.30883
2	Point ZM	158905.4293	101801.9813	902.53	900.457092	2.07291
3	Point ZM	158932.5936	101659.3962	884.17	882.879211	1.29079
4	Point ZM	159057.1825	101682.3364	887.36	885.515381	1.84462
5	Point ZM	159201.0675	101647.9529	876.81	872.795288	4.01471
6	Point ZM	159070.7562	101773.2789	891.93	883.848755	0.401851
7	Point ZM	158690.2015	102193.4426	927.33	928.040283	0.710283
8	Point ZM	159106.3397	101857.7801	902.22	877	25.22
9	Point ZM	159417.2251	101906.6997	855.44	855.277466	0.162534
10	Point ZM	159602.7861	102095.1885	888.16	887.873535	0.286465
11	Point ZM	159561.3278	102229.5469	894.87	895.271851	0.401851
12	Point ZM	159125.351	102164.7623	917.27	917.476257	0.206257
13	Point ZM	158825.1455	102172.4934	928.67	927.249329	1.42067
14	Point ZM	158849.1467	101980.223	914.12	909.107605	5.01239
15	Point ZM	158690.2015	102193.4426	927.33	928.040283	0.710283

Figure (F-16): The added height differences.

13. Export all records and save them to a database file , see figure (F-17).

Figure (F-17): Exporting attribute table to a DBF file.

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APPENDICES

تتم بحمد الله