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Production of Digital Mosaics from Aerial Images

Ruba Yousif Hussain
Lecturer
Highway and Transportation Engineering Department
College of Engineering
University of Al-Mustansiriya

Abstract :

This research deals with the mosaicking aerial images using Geographic Information System (GIS) . The digital mosaic is assembled from two strips of aerial images. Each strip consists of four images of Jadria in Baghdad city (Iraq) at scale (1 : 3000) . Three methods of mosaics are implemented and compared : controlled , uncontrolled and semicontrolled mosaics . The controlled mosaic is produced from Ground Control Points (GCPs) located in the study area . Eighteen control points are selected at the optimum locations ensure the required distribution and strength of mosaics . The coordinates of GCPs are measured using Total Station instrument. Images are georeferenced to ground control points using ArcGIS 9.3 . Uncontrolled mosaic is prepared by matching the image details of adjacent images . Semicontrolled mosaic is assembled utilizing some combinations of the specifications for controlled and uncontrolled mosaics . The controlled mosaic is the accurate methods. All images must have the same number of bands , the same spatial reference and the same pixel size ; otherwise the mosaic cannot be created . Digital mosaic is extremely useful for preparing updating maps used in engineering projects.

Key Words : *GIS , GCPs , Total Station , Aerial Images , Georeferencing , Digital Mosaics .*

انتاج الموزائيك الرقمي من الصور الجوية

م. ربى يوسف حسين
قسم هندسة الطرق والنقل
كلية الهندسة
الجامعة المستنصرية

الخلاصة :

يتعلق البحث بانتاج الموزائيك الرقمي باستخدام نظام المعلومات الجغرافي (GIS) بتجميع شريطين من الصور الجوية يتكون كل شريط من أربع صور جوية لمنطقة الجادرية في مدينة بغداد بالعراق بمقياس رسم (1 : 3000) . حيث تم انتاج الموزائيك الرقمي بثلاثة طرق ومقارنة النتائج وهي الموزائيك المسيطر عليه (Controlled) وغير المسيطر عليه (Uncontrolled) وشبه المسيطرعليه (Semicontrolled) ، تعتمد الطريقة الاولى تثبيت مجموعة من نقاط الضبط الأرضي وتم اختيار ثمانية عشر نقطة ضبط ارضي موزعة لتغطية منطقة الدراسة

وتقوية الموزائيك وقياس احداثياتها حقليا باستخدام جهاز المحطة الكاملة (Total Station) وتنفيذ الارجاع الارضي (Georeferencing) لكل صورة لتطابق نقاط الضبط الارضي المقاسة وباستخدام (ArcGIS 9.3) بينما تعتمد الطريقة الثانية مطابقة المعالم المشتركة بين الصور المتداخلة اما الطريقة الثالثة تطابق المعالم المشتركة وعدد من نقاط الربط المشتركة في منطقة الدراسة . ان الموزائيك المسيطر عليه المنتج بالاعتماد على نقاط الضبط الأرضي أدق الطرق وان جميع الصور المستخدمة لانتاج الموزائيك يجب ان تحتوي نفس العدد من الحزم ونفس نظام الاحداثيات ونفس أبعاد الوحدة الصورية وإلا لايمكن عمل الموزائيك الرقمي . ويعتبر الموزائيك المنتج بالطرق الرقمية ذو فائدة كبيرة لتوفير الخرائط الحديثة المعالم لانجاز المشاريع الهندسية .

1. Introduction :

Image mosaicking is the process of joining overlapping images together to form a larger image [3] . Aerial images and GCPs are a major source in construction of GIS databases. Because airborne imagery is usually at a much larger scale than is satellite imaging , aerial images are presented more suitable for engineering works. Aerial images recorded with standard mapping cameras are scanned and converted to raster format before mosaics. GIS is able to manipulate aerial images and produces economical image map of mosaics. Raster data is commonly obtained by scanning images. Scanned image datasets do not usually contain information about where the area fits on the surface of the earth. The locational information delivered with raw aerial images and satellite imagery is often inadequate to perform analysis or display in proper alignment with other data. Image often need to georeference it to a map coordinate system . Georeferencing refers to the process of assigning map coordinates to image data [4,5] . The control points are used to build a polynomial transformation that will convert the raster dataset from its existing location to the spatially correct location. The connection between one control point on the raster dataset and the corresponding control point on the aligned target data is a link [1].

Total station surveys are a widely used method to survey topography [12] . Mosaicking is largely dependent on the quality of registration among the constituent input images [15] . Raster data includes images and grids [2] . Once mosaicked , all input raster datasets will have the same set of properties [9] . Images taken from space do have a growing meaning for mapping [6] . The map projection is an essential element for the geometric representation of the data [11] . An aerial mosaic can be used directly as a planimetric map [10] .

At present , wide field range and high resolution image become more and more important in photogrammetry [7] . If a single photo does not contain an extensive enough coverage , or if it cannot be enlarged to the required scale, a mosaic must be prepared [13]. Aerial mosaics generally fall into three classes : controlled , uncontrolled and semicontrolled mosaics. The controlled mosaic is produced from GCPs located in the study area . Number of control points are selected at the optimum locations ensures the required distribution and strength of mosaics. The coordinates of GCPs are measured using Total Station instrument. Uncontrolled mosaic is prepared by matching the image details of adjacent images . Semicontrolled mosaic is assembled utilizing some combinations of the specifications for controlled and uncontrolled mosaics . To achieve photogrammetric mapping and to examine the terrain for air image interpretation purposes, it is essential that each point on the ground appear in two adjacent images along a flight line so that all points can be viewed stereoscopically [8] . Image mosaicing has applications in many fields . Typical examples include photogrammetry , computer vision , image processing , image synthesis , and computer graphics [14].

2. Data Description

The aerial images of Baghdad university in Jadria are obtained at scale (1 : 3000) . The image data are located in Baghdad city , Iraq , bounded by geographic latitudes (33º 15' 30" N - 33º 17' 00" N) and geographic longitudes (44º 22' 00" E - 44º 23' 30" E) . The study area is selected because of aerial images availability for this region and the seldom of aerial photography in the present time. Aerial images are large scale covering a small area in (23 cm × 23 cm) format. The image block consists of two flight strips , strip number 110 and strip number 111 . Each strip contains four overlapped images with 60 % end lap and 30 % side lap. The first strip contains image number 38 , 40 , 42 , and 44 . The second strip contains image number 41 , 43 , 45 , and 47 . The two strips are illustrated in Figure 1 . The images are taken by 152.160 mm focal length of camera and from flying height of 480 m . In this research eight images are glued into single mosaics. The original image data are obtained in analog form . Digitizing is necessary first by scanning systems. One set of digital data is derived from black and white images. Scanned image data sets do not contain information about where the area fits on the surface of the earth. The image data are georeferenced to a map coordinate system. The Iraqi projection is Universal Transverse Mercator (UTM) Zone 38 North based on ellipsoid defined of clarke 1880 .

Image 41

Image 38

Image 43

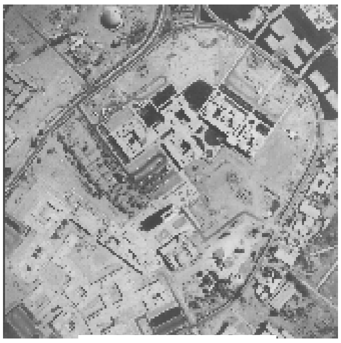

Image 40

Image 45

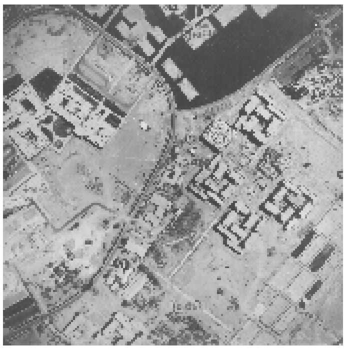

Image 42

Image 47

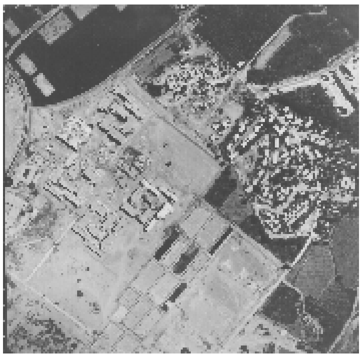

Image 44

Fig.(1) Original input images

3. Field Work :

The coordinates of GCPs are measured using total station instrument (Table 1) . The controlled mosaic is laid by matching the control point images to their respective plotted positions on the base image. The number of GCPs appears in images is illustrated in Table 2 and Figure 2 .

Table 1 Measured coordinates of GCPs by Total Station

Point ID	Coordinates of GCPs		
	Easting , E (m)	Northing , N (m)	Elevation , Z (m)
1	441782.868	3681589.662	36.302
2	442002.207	3681242.582	36.108
3	442467.303	3680839.802	36.124
4	441839.095	3681098.351	36.131
5	442115.219	3680784.765	36.357
100	441947.852	3681819.345	36.555
200	442240.935	3681621.792	36.373
300	442469.588	3681368.631	36.582
400	442706.695	3681203.642	36.630
500	441783.875	3681363.568	37.038
600	442029.277	3681308.255	36.154
700	442235.828	3681030.461	36.329
800	442410.708	3680861.037	36.283
900	441447.016	3681531.254	36.362
1000	441689.700	3680802.195	36.320
1100	441821.286	3680604.021	36.421
1200	441966.201	3680544.453	36.356
1300	442169.593	3680554.132	37.029

Table 2 Number of GCPs appears in images

Strip Number	Image Number	Number of GCPs appear in Image
Strip 110	38	1 , 4 , 100 , 200 , 500, 600 , 900
	40	1 , 2 , 4 , 100 , 200 , 300 , 500 , 600 , 700
	42	2 , 3 , 4 , 200 , 300 , 400 , 600 , 700 , 800
	44	3 , 5 , 300 , 400 , 700 , 800
Strip 111	41	2 , 4 , 500 , 600 , 900 , 1000
	43	2 , 4 , 5 , 500 , 600 , 700 , 1000 , 1100 , 1200
	45	2 , 3 , 5 , 600 , 700 , 800, 1000 , 1100 , 1200 , 1300
	47	3 , 5 , 700 , 800 , 1200 , 1300

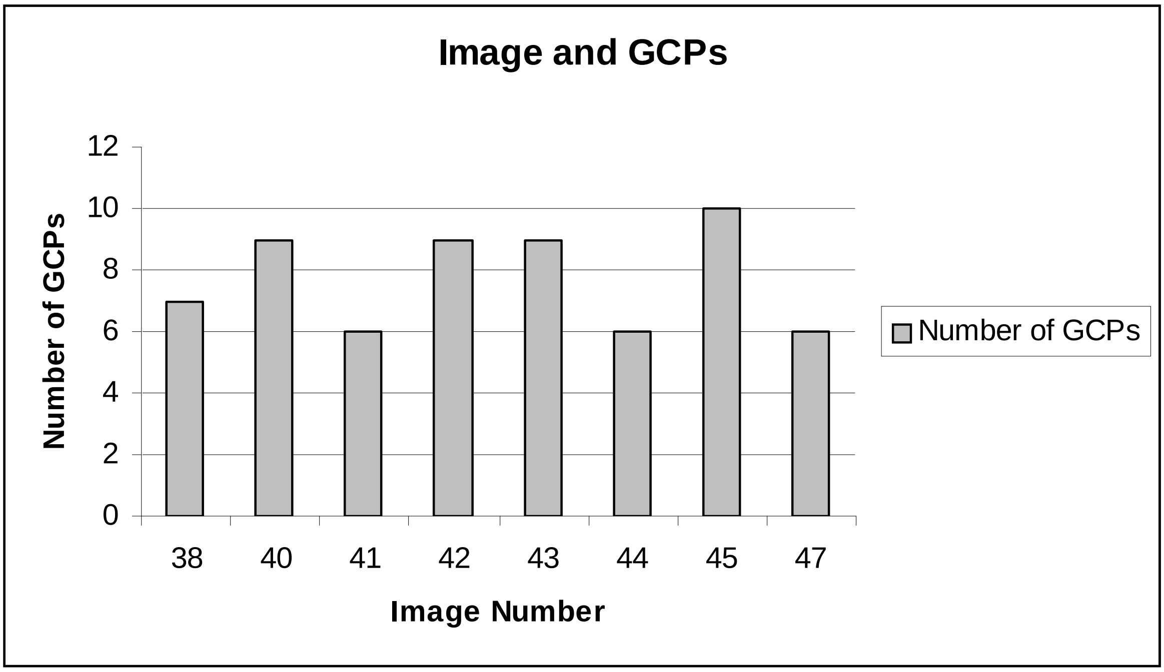

Fig.(2) Image Number versus Number of GCPs

4. Georeferencing Images and Applying Transformation :

By creating enough links , the raster dataset to permanently match the map coordinates of the target data. The polynomial transformation uses a polynomial that is built upon control points and a least square fitting algorithm. It is optimized for global accuracy but does not guarantee local accuracy. The polynomial transformation yields two formulas: one for computing the output x-coordinate for an input (x , y) location and one for computing the y-coordinate for an input (x , y) location. The goal of the least-square fit is to derive a general formula that can be applied to all points, usually at the expense of slight movement of the to positions of the control points. The number of the noncorrelated control points required for this method must be 3 for a first order , 6 for a second order, and 10 for a third order. The user has the choice of using a polynomial, spline , or adjust transformation to determine the correct map coordinate location for each cell in the raster. The first-order polynomial transformation is used to georeference an image. Below is the equation to transform a raster dataset using the affine first order polynomial transformation. The six parameters define how a raster's rows and columns transform onto map coordinates **Figure. (3)** [1] .

$$x' = Ax + By + C \qquad (1)$$

$$y' = Dx + Ey + F \qquad (2)$$

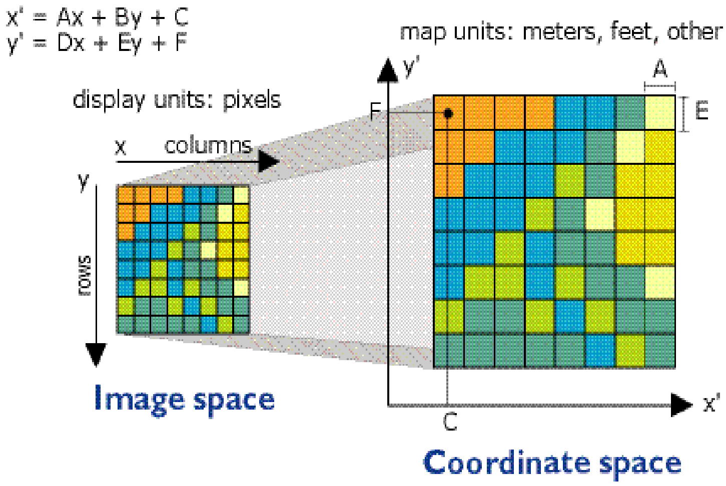

Fig.(3) Image space and coordinate space

Where :

x is the column count in image space

y is the row count in image space

x' is the horizontal value in the coordinate space

y' is the vertical value in the coordinate space

A is the width of cell in map units

B is the rotation term

C is the x' value of the center of upper-right cell

D is a rotation term

E is negative of height of cell in map units.

F is the y' value of the center of upper-right cell

The images of two strips are georeferenced to the GCPs using ArcMap , ArcGIS 9.3 . Image data are georeferenced and rectified by polynomial transformation . The georeferenced images are illustrated in Figures 4 , 5 , 6 , 7 , 8 , 9 , 10 and 11 .

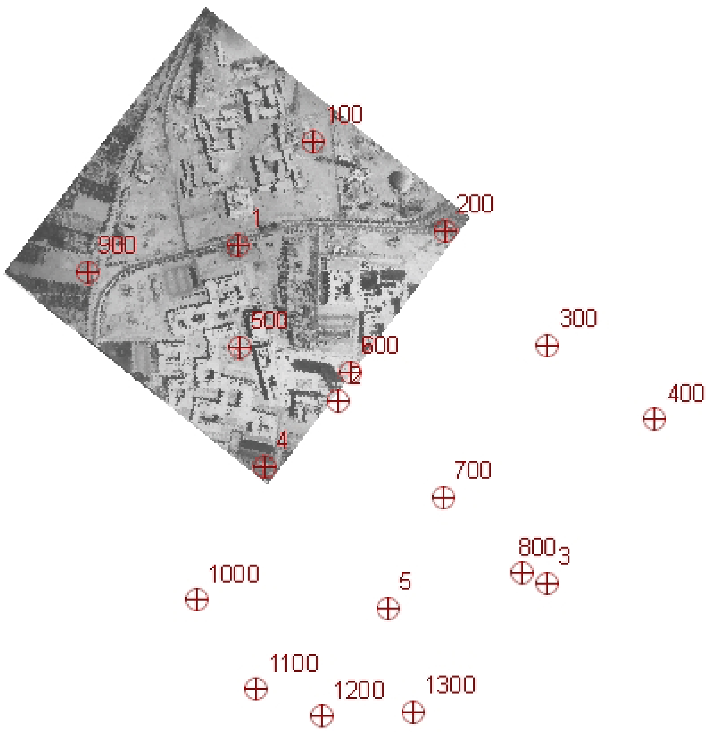

Fig.(4) Georeferencing image 38

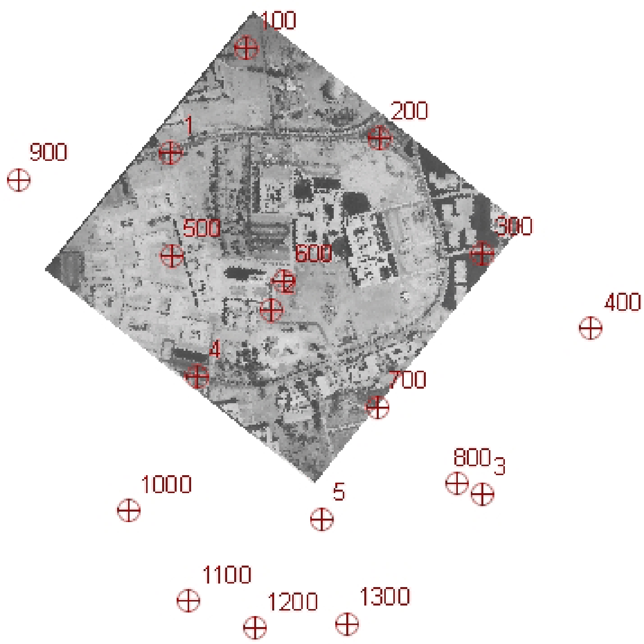

Fig.(5) Georeferencing image 40

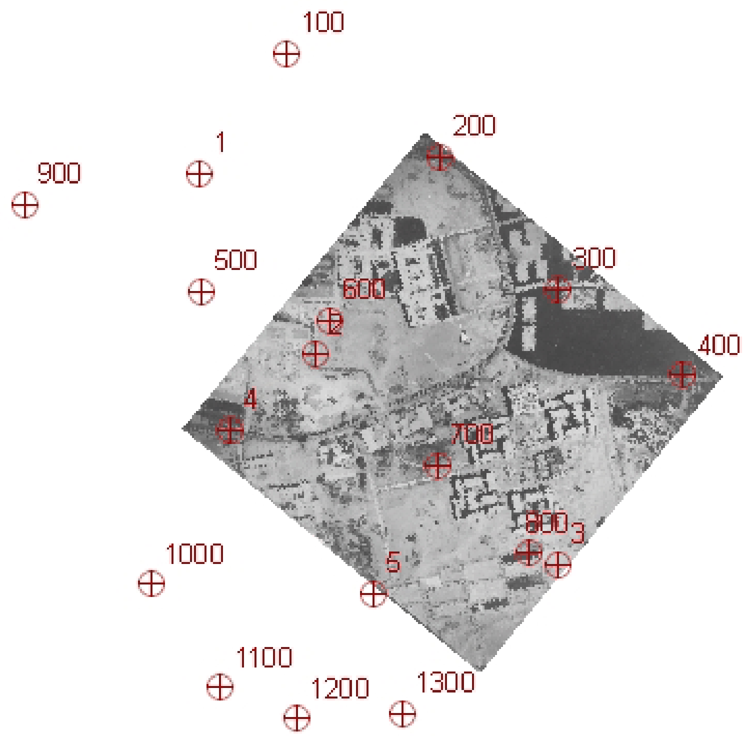

Fig.(6) Georeferencing image 42

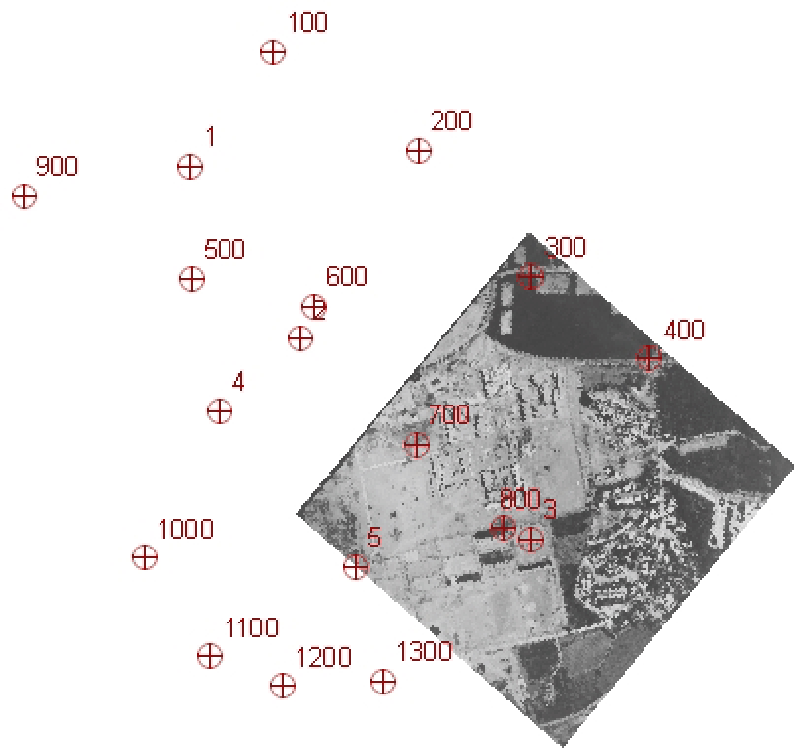

Fig.(7) Georeferencing image 44

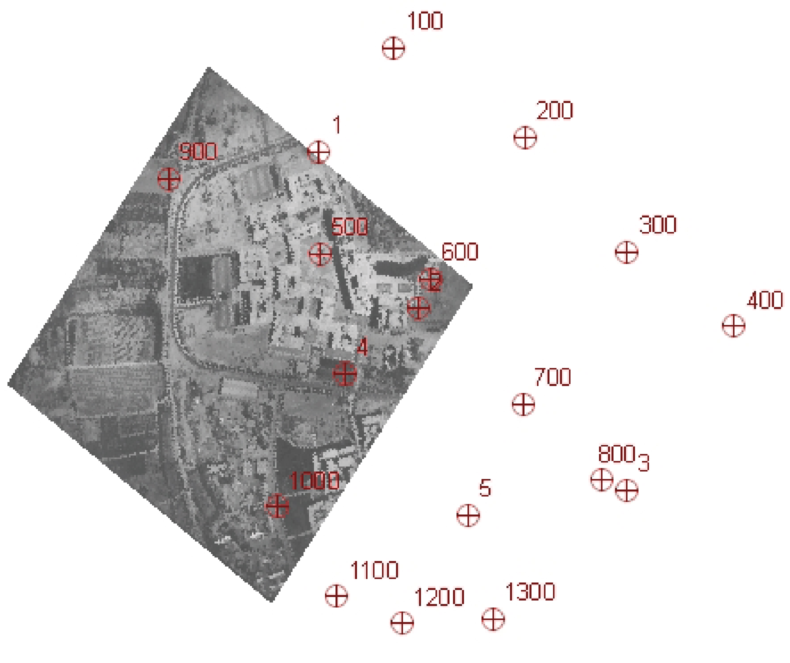

Fig.(8) Georeferencing image 41

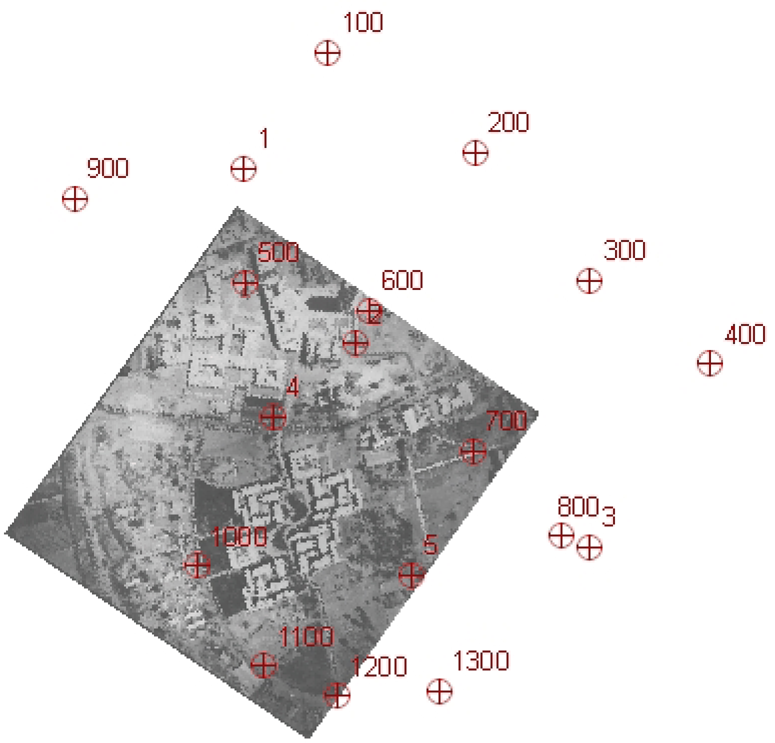

Fig.(9) Georeferencing image 43

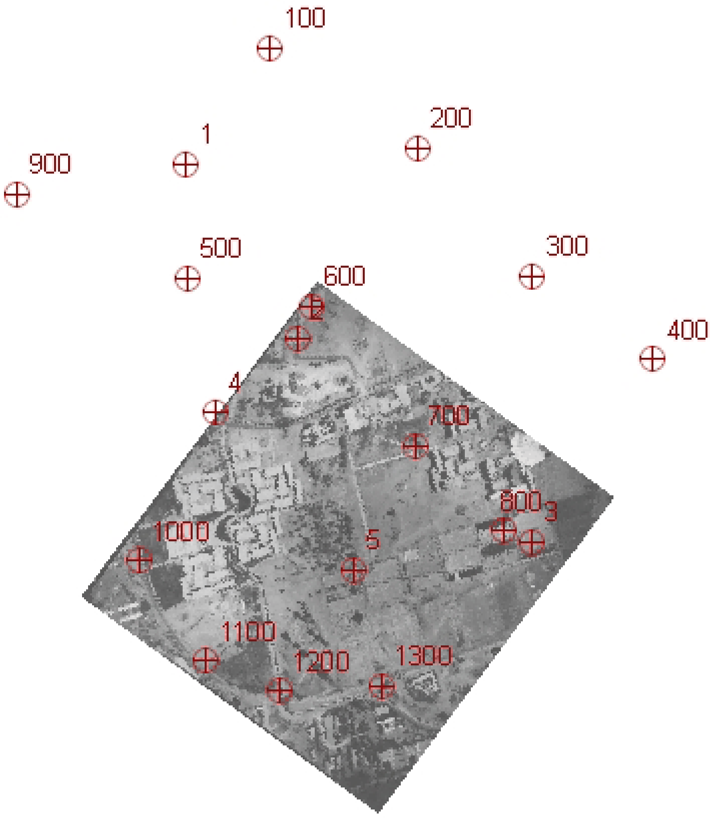

Fig.(10) Georeferencing image 45

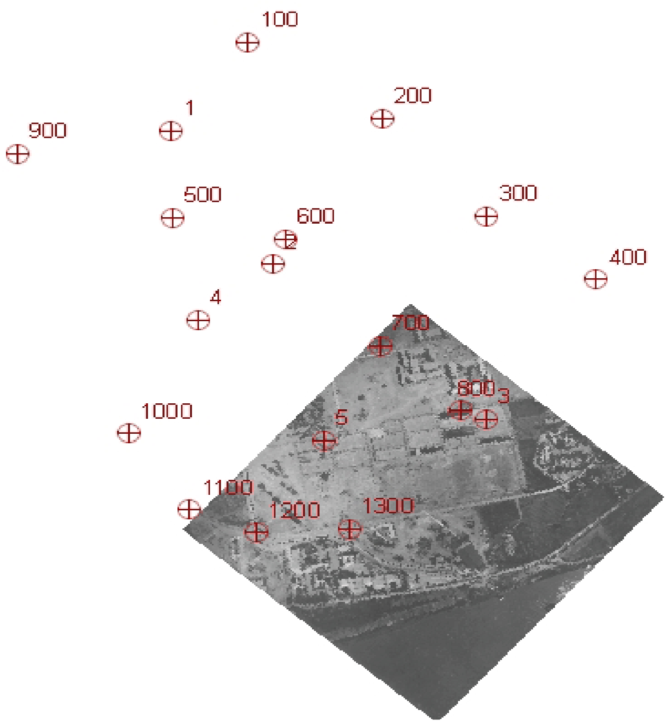

Fig.(11) Georeferencing image 47

5. Implementation and Results :

5.1 Implementation of Controlled Mosaic

Controlled Mosaic is implemented in ArcGIS 9.3 . The resulted mosaic is illustrated in Figure 12 . The aerial images in film format are scanned and converted to raster image. The measured GCPs are located and saved to file. GCPs are markers or features visible on the aerial images for which the (E , N) coordinates are normally defined in the UTM grid coordinate systems. The ground coordinates of GCPs are obtained by conventional ground surveys , from total station. The image locations of the GCPs are located on the scanned image for georeferencing. The digital images are georeferenced to the ground coordinate file. The mosaic is laid by matching the control point images to their respective plotted positions on the base image.

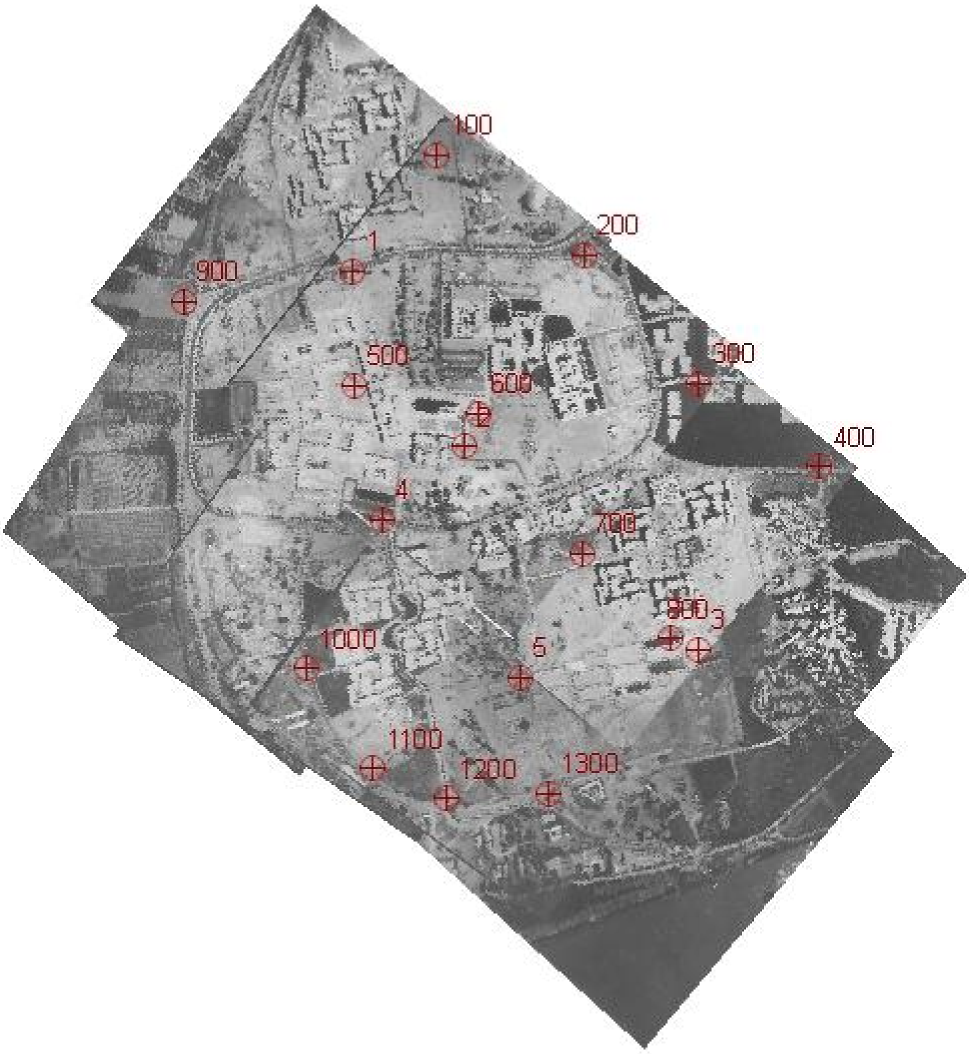

Fig.(12) Controlled mosaic

5.2 Implementation of Uncontrolled Mosaic

Uncontrolled mosaic is implemented from a menu in ArcGIS 9.3 . It is prepared by matching the terrain features on adjacent photographs as closely as possible. The existing raster dataset that contain the mosaic is illustrated in Figure 13 . Because the relief displacement of the same ground point will vary substantially both in direction and magnitude for the reasons discussed previously, this presents a real difficulty in matching identical features on adjacent photographs when assembling a mosaic. A partial solution to this problem involves using only the central portion of each photograph in assembling the mosaic because relief displacement is greatest near the image edges.

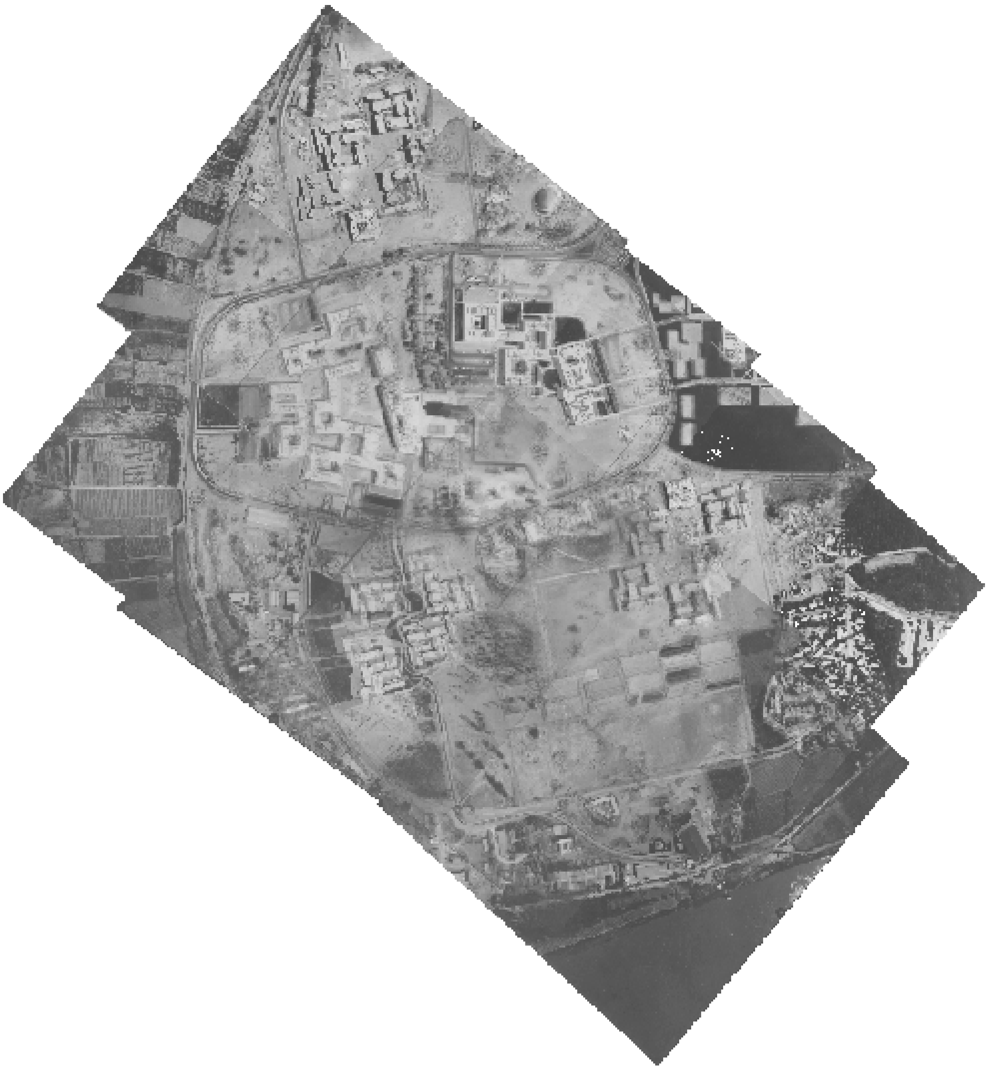

Fig.(13) Uncontrolled mosaic

5.3 Implementation of Semicontrolled Mosaic

Semicontrolled mosaic is assembled utilizing some combinations of the specifications for controlled and uncontrolled mosaics . It is prepared by matching the image details of adjacent images and some control points in ArcGIS 9.3 (**Figure 14).**

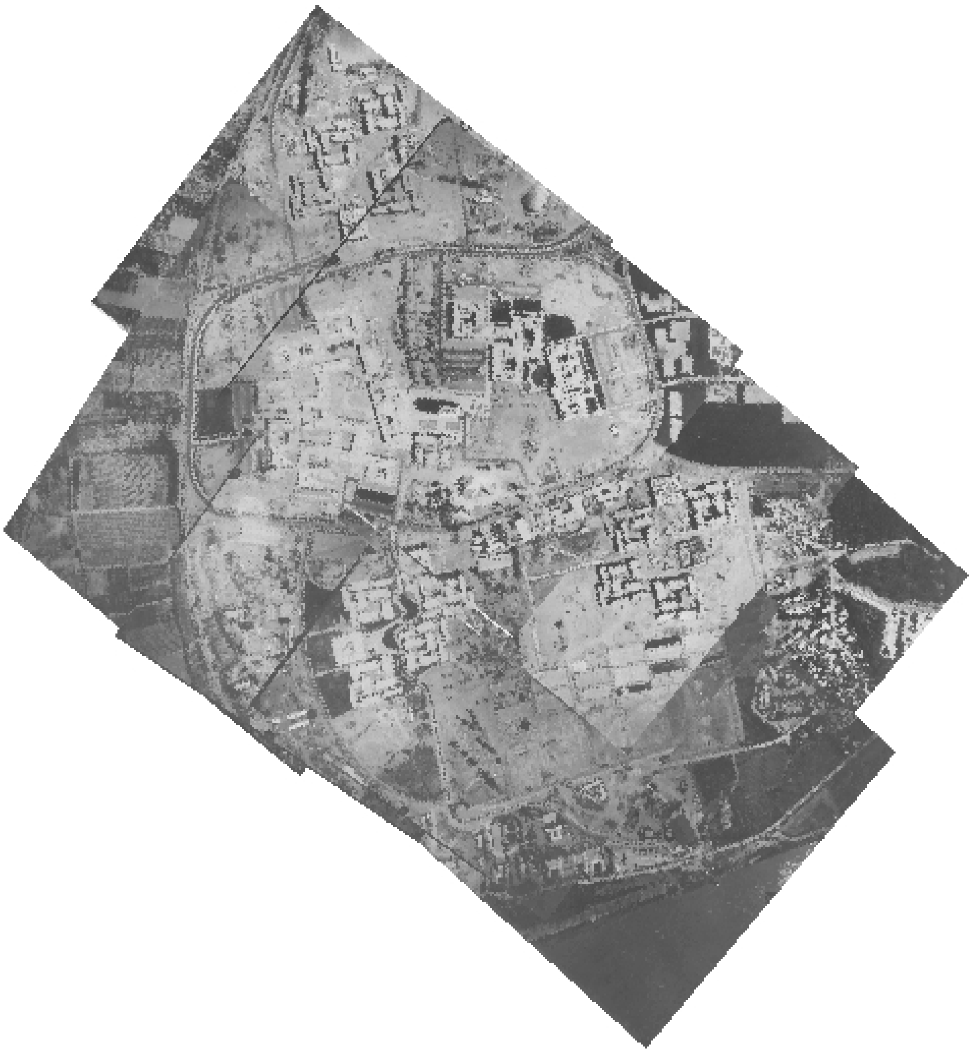

Fig.(14) Semicontrolled Mosaic

6. Discussion and Comparison :

The study area may span several images files . In this case , it is necessary to combine the images to create one large file . This is called mosaicking . All the images to be mosaicked must be georeferenced to the same coordinate system. A controlled mosaic is the most accurate methods. The images of the control points must be recognizable on the images. The mosaic is laid by matching the control point images to their respective plotted positions on the base board. In spite of the precautions taken in preparing controlled mosaics, images of adjacent images will not match perfectly, nor will the scale of the mosaic be constant. Relief displacement is the chief reason for this condition. The map is pasted to the mounting board and the mosaic is assembled by mounting the images so that recognizable photo images coincide with their corresponding map positions[13]. The minimum overlap to ensure that all ground points show on two adjacent photographs is 50 percent. However, at least 60 percent forward overlap is standard because the aircraft is subject to altitude variations, tip, and tilt as the flight proceeds. The problems of mosaic assemblage caused by relief displacement are solved partially by increasing the forward overlap to as high as 80 percent[8]. The basic overlap required for mosaics are for a forward overlap of 60 % and a side overlap of 30 % .

An uncontrolled mosaic is prepared by simply matching the image details of adjacent images. There is no ground control, and vertical images which have not been rectified or ratioed are used. Uncontrolled mosaics are more easily and quickly prepared than controlled mosaics. They are not as accurate as controlled mosaics, but for many qualitative uses they are completely satisfactory. Semicontrolled mosaics are assembled utilizing some combinations of the specifications for controlled and uncontrolled mosaics .

Mosaics are similar to maps in many respects, but they have a number of definite advantages over maps. They show relative planimetric locations of an infinite number of objects, whereas features on maps which are shown with lines and symbols must be limited in number. Mosaics of large areas can be prepared in much less time and at considerably lower cost than maps. They are easily understood and interpreted by people without photogrammetry or engineering backgrounds because objects are shown by their images. For this reason they are very useful in describing proposed construction or existing conditions to members of the general public, who would probably be confused by the same representations on a map. Mosaics have the one serious disadvantage that they are not true planimetric representations. Rather, they are constructed from perspective photographs, which are subject to image displacements and scale variations. The most serious image displacements and scale variations are caused by variations in the terrain elevation, tilting of the camera axis, and variations in the flying heights. Some small distortions result from shrinkage or expansion of the photo papers and camera-lens imperfections, but these are generally negligible[13].

7. Conclusions :

1- All the raster datasets and the output raster mosaic must have the same number of bands ; otherwise the mosaic cannot be created. A raster dataset that has been created from mosaicking has the same schema as any other raster dataset. If two or more rasters have the same spatial reference and the same pixel size , they can be mosaicked into a single raster. If the second raster has a different spatial reference from the first raster dataset, the spatial reference of the second raster dataset will be ignored and its data will be transformed into the spatial reference of the first raster dataset.

2- Mosaic involves matching the terrain features on adjacent images as closely as possible. Because the relief displacement of the same ground point will vary substantially both in direction and magnitude , this presents a real difficulty in matching identical features on adjacent images when assembling a mosaic. A partial solution to this problem involves using only the central portion of each image in assembling the mosaic because relief displacement is greatest near the image edges.

3- Controlled mosaics contain images that are rectified reducing tilt through relief displacement remains . The selection of ground control points at the optimum locations ensures the required distribution and strength of mosaics. Uncontrolled mosaics are simple matching of images without any ground control. These mosaics are quick to produce since the user simply orients the images until one larger image is formed. All numbering and flight information is visible on the images. Semicontrolled mosaics are similar to the uncontrolled however image edges are properly aligned or referenced.

4- In the area covered by the mosaic height differences do exist . The direct linear transformation is used to correct the aerial images geometrically for relief displacement. This can only be done when a Digital Terrain Model (DTM) is available .

5- Because airborne imagery is usually at a much larger scale than is satellite imagery, mosaic aerial images are presented more suitable for engineering works. However, the planning of corridor works such as highways, railways, canals, etc., has been greatly assisted with the advances in satellite imagery. Mosaics are extremely useful for both civilian and military applications. Highway projects, for example, that are engaged in preparing plans for extensive construction projects frequently use mosaics to replace planimetric surveys. This not only eliminates most of the ground surveying but also does away with the painstaking procedure of plotting the planimetry in the office.

References

1- ARCGIS 9 Desktop Help , ESRI Inc. , 2006 .
2- Booth , Bob and Mitchell , Andy , Getting Started with ArcGIS , GIS by ESRI , USA , 2001.
3- Botterill , Tom , Mills , Steven and Green , Richard , Real – Time Aerial Image Mosaicing , IEEE , 2010 .
4- ERDAS Field Guide , Fifth Edition , ERDAS , Ins. , USA , 1999 .
5- ERDAS IMAGINE , Release Notes , V11 , ERDAS , The earth to Business Company , USA , 2010 .
6- Jacobsen , Karsten , Comparison of Information Contents of Different Space Images , Institute for Photogrammetry and Engineering Surveys , University of Hannover , Germany , 2002 .
7- Jin Liu , Zhiyong Chen and Ruilfang Guo , A Mosiac Method for Aerial Image Sequence by R / C Model , Journal of International Conference on Computer Science and Software Engineering , Volume 6 , Pages 58 – 61 , IEEE Publisher , 2008 .
8- Kavanagh , Barry F. , Surveying : Principles and Applications , Eighth Edition , Pearson , Prentice Hall , USA , 2009 .
9- Law , Derek , Simmons , Brenda and Taggart , Marnel , Building Geodatabase I , ESRI , USA , 2004 .
10- Nathanson , Jerry , Lanzafama , Michael T. and Kissam , Philip , Surveying Fundamentals and Practices , Sixth Edition , Pearson Education International , USA , 2011 .
11- Pohl , C. , Geometric Aspects of Multisensor Image Fusion for Topographic Map Updating in the Humid Tropics , Ph. D. Dissertation, University of Hannover, Germany, ITC Publication , No. 39 , 1996 .
12- Wheaton J.M. , Garrard C. , Whitehead K. and Volk C.J. , A Simple , Interactive GIS Tool for Transforming Assumed Total Station Surveys to Real World Coordinates – The CHaMP Transformation Tool , Computers and Geosciences , Volume 42 , Pages 28 – 36 , 2012 .
13- Wolf , Paul R. , Elements of Photogrammetry , Second Edition , McGraw-Hill. International Book Company , USA , 1985 .
14- Yingdong Huang , Jie Li and Nigjun Fan , Image Mosaicing for UAV Application , International Symposium on Knowledge Acquisition and Modelling , Pages 663 – 667 , IEEE Publisher , 2008 .
15- Zhi Q. and Cooperstock J.R. , Toward Dynamic Image Mosaic Generation With Robustness to Parallax , IEEE Transactions on Image Processing , Volume 21 , Pages 366 – 378 , 2012 .