Determination of the Position and the Area of Any Spot Using Satellite Images

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ABSTRACT

The position and the area of any spot can be determined in different modes and using satellite image is one of them. For this mode there are many applications like in determining the positions and the areas of the water pollution spots (the rivers, the streams, the marshes….etc.), the air pollution spots, for different agriculture lands ….etc. In this mode, the area of any spot on the satellite image can be determined by finding the planimetric (Grid) coordinates (x, y) for the periphery points of the spot using ERDAS Imagine Software Programme Ver. 9.2 if the satellite image is rectified , but if it isn't a special method is used for the rectification of the satellite image then the positions and the areas can be determined.

تحديد الموقع والمساحة لأية بقعه بأستخدام الصور الفضائية

الخلاصة

يمكن ايجاد الموقع والمساحة لأية بقعة بطرق مختلفة منها بأستخدام الصورة الفضائية. ولهذه الطريقة تطبيقات كثيرة منها في تحديد المواقع والمساحات لبقع التلوث في الماء (الانهار ، الجداول ، المستنقعات... الخ), كذلك لبقع التلوث في الهواء, وللاراضي الزراعية المختلفة...الخ. وفي هذه الطريقة يمكن تحديد مساحة اية بقعة على الصورة الفضائية وذلك من الأحداثيات الأفقية التربيعية (X,Y) لنقاط محيط البقعة في الصورة الفضائية باستخدام برنامج (ERDAS Ver. 9.2) اذا كانت الصورة مصححة, اما اذا كانت غير مصححة فقد تم استعمال طريقة خاصه للتصحيح ومن ثم ايجاد المواقع والمساحات.

INTRODUCTION
THE IMPORTANCE OF REMOTE SENSING

Remote sensing, which is a newer branch of interpretative photogrammetry, includes not only the analysis of photography but also the use of data gathered from a wide variety of sensing instruments, including multispectral cameras, infrared sensors, thermal scanners, and side looking airborne radar. Remote sensing instruments, which are often carried in vehicles as remote as orbiting satellites, are capable of providing quantitative as well as qualitative information about objects. At the present time, with our recognition of the importance of preserving our environment and natural resources, photographic interpretation and remote sensing are both being employed extensively as tools in management and planning.

From the beginning persons writing about this field have faced the difficult task of finding the proper balance between uncritical presentations of remote sensing as a panacea for most environmental problems of which there have been many and an equivalent, almost nihilistic, negativism.

It now appears that remote sensing is here to stay and will continue to serve as a useful tool in the management of natural resources of many types.

This field has proved in the contribute to marketplace of ideas and the realm of operations that it can significantly man's knowledge of his environment and can assist in its management [1].

THE RECTIFICATION & THE IMAGE GEOREFERENCING

Every aerial photograph or satellite image (imagery) needs to a rectification. If the imagery is consistent with the map of the same area and in the same scale as the imagery , the targets don't coincide where there are little shift because of many reasons .This shift is always in the imagery and can't get rid of it unless doing the rectification .Rectification is the process of projecting the data onto a plane and making it conform to a map projection system. Assigning map coordinates to the image data is georeferencing. Since all map projection systems are associated with map coordinates, rectification involves georeferencing. In rectifying the image, we will use these basic steps:

RECORD GROUND CONTROL POINT

A ground control point (GCP) is a location within an image for which the map coordinates are known .To be useful in rectification ,the coordinates of a GCP must be known in the system to which the data are being rectified .GCPs can be recorded from a raster image ,digitizing tablet or from a GPS file.At least three GCPs must be digitized to create a transformation matrix ,and more than three if calculating an RMS error is wanted .The GCPs should be spread out across the image to form a large triangle (i.e., they should not lie in a line).

COMPUTE THE TRANSFORMATION MATRIX

A transformation matrix is a set of numbers that can be plugged into polynomial equations .These numbers are called the transformations coefficients .The polynomial equations are used to transform the coordinates from one system to another .A minimum number of ground control points is necessary to calculate the transformation ,depending on the order of the transformation.

$$\frac{(t+1)(t+2)}{2}$$ Where t is the order of the transformation.

RESAMPLE THE IMAGE

Resampling is the process of calculating the file values for the rectified image and creating the new file .All of the raster data layers in the source will be resampled .The output image will have as many layers as the input image .The source is the data to be rectified to the destination coordinate system.

After the rectification of the imagery all the grid and geographic coordinates of any point on the imagery are known and correct as on the map, and any required calculations can be done correctly on the imagery in the (GIS – System) as the calculation of the area from the grid coordinates of the periphery points of the spot[2] .

The image georeferencing is a process of transforming an uncorrected, raw image from an arbitrary coordinate system into a map projection (geographic) coordinate system namely, image pixels are positioned and rectified to align and fit into real-world map coordinates.

REASONS FOR GEOREFERENCING AND RECTIFICATION

1. Due to inherent geometric distortions, aerial and satellite images generally need to be geocoded before they can be used in geo-scientific analysis.
2. Data fusion: overlay a number of different images of the same area to combine their bands containing data into a single image dataset. The individual images must be georeferenced to a compatible coordinate system.
3. Comparing images for change detection.
4. Creating composite image maps.
5. Making measurements.
6. Mosaicking images[2] .

GEOMETRIC DISTORTIONS

Any remote sensing image, regardless of whether it is acquired by a photographic system in an aircraft, a multispectral scanner on board a satellite, or any other platform/sensor combination, will have various geometric distortions.

SOURCES OF GEOMETRIC DISTORTIONS

Imaging geometry of remote sensing systems
Mechanical or optical imperfections of the sensor
Earth rotation effects: rotation of the earth during image acquisition;
The curvature of the earth surface;
Atmospheric effects: bending of the light beams due to refraction;
Motion and Insatiability of platform: variations in platform altitude, attitude and velocity; Topography effects: terrain relief distortion.

CORRECTION OF GEOMETRIC DISTORTIONS

Geometric distortions are often systematic (predictable) and may be identified and corrected using pre-launch or in-flight platform ephemeris (ie, information about the geometric characteristics of the sensor system and the Earth at the time of data acquisition) Geometric distortions in imagery can be corrected through analysis of sensor characteristics and ephemeris data[3]

IMAGE-TO-MAP RECTIFICATION

This procedure is commonly used to rectify remotely sensed data to a standard map projection whereby it may be used in conjunction with other spatial information in a GIS to solve problems.

GROUND CONTROL POINTS

Ground control points are also known as tie points, tick points, conjugate points in other contexts.
Candidate features for GCPs :
1. Locations that can be easily and clearly identified and precisely located are good candidates to be chosen as control points
2. Visible, small, stable, permanent, and well-defined landmarks.

GROUND CONTROL POINT (GCP) ACQUISITION

The distribution of tic points should be fairly uniform across your study area.
The number of GCPs required depends on the terrain, the size of the image, and the rectification method and the order of mathematical equation utilized. The greater the terrain variations and geometric distortion, the more GCPs that are required.

The geographic coordinates of ground control points are often determined from topographic map, ground survey, or GPS measurement[4] .

POLYNOMIAL METHOD

The Polynomial method model distortions by fitting a polynomial mathematical function through Ground Control Points. It does not require knowledge of the sensor geometry or how the image was captured.

A polynomial is essentially a mathematical equation which links the uncorrected raw image to the georeferenced database based on the input ground-control points.

Rectification Type: Linear (Affine), Quadratic or cubic polynomial

Generally, for moderate distortions in a relatively small area of an image (e.g., a quarter of a Landsat TM scene), a first-order, six-parameter, affine (linear) transformation is sufficient to rectify the imagery to a geographic frame of reference[5].

A 1st order transformation is a linear transformation, which can change location , scale, skew, and rotation. In most cases, first order polynomial used to project raw imagery to a object for data covering small areas .

Transformations of the 2nd-order or higher are nonlinear transformations that can be used to convert Lat/Long data to object or correct nonlinear distortions such as Earth curvature, camera lens distortion. The following equations are used to express the general form of the polynomial models in 2D and 3D cases[4] :

Two-dimensional general polynomials Linear polynomial

$$x=a0+a1X+a2Y \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$y=b0+b1X+b2Y \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Quadratic polynomial -

$$x=a0+a1X+a2Y+a3XY+a4X2+a5Y2 \quad \ldots.. \quad (3)$$

$$y=b0+b1X+b2Y+b3XY+b4X2+b5Y2 \quad \ldots... (4)$$

Cubic polynomial

$$x=a0+a1X+a2Y+a3XY+a4X2+a5Y2+a6\ X2Y+a7X\ Y2+a8X3+a9Y3 \quad (5)$$

$$y=b0+b1X+b2Y+b3XY+b4X2+b5Y2+b6\ X2Y+b7X\ Y2+b8X3+b9Y3 \quad (6)$$

AFFINE TRANSFORMATIONS

The Affine transformation scales, skews, rotates, and translates all coordinates in the image using the same equation Namely, this type of transformation can model six kinds of distortion in the remote sensor data,

including: translation in x and y, scale changes in x and y, skew, and rotation. Keep parallel lines parallel, it does not perform 'rubber sheeting'[5] .

ERROR OF GEOREFERENCING AND RECTIFICATION

A least squares fit method is used to fit the transformation parameters
 At least one ground control point more than the minimum required is needed to generate an RMS error.
Root Mean Squared Error is a statistical measure of the error between the calculated coordinates of a GCP from the fitted polynomial equation and the measured (true) coordinates of the GCP from GPS, topographic map, or a georeferenced image.

The polynomial will not transform every GCP with 100 per cent accuracy and it is important before the full rectification proceeds to ensure that the errors are within acceptable limits.
The RMS error value for each GCP affects and is affected by other GCPs[4] .

RESAMPLING METHOD

When georeferencing (geocoding) and rectification is performed, the output grid (image) will commonly have different cell (pixel) size, orientation, and coordinates from those in the input image. To determine the DN values for cells (pixels) in output grid (image), the resampling (intensity interpolation) process is required.

Resampling is the process of determining new values for output pixels after geometric transformation of input image It is based on the original image.

The three resampling techniques commonly used: nearest neighbor assignment, bilinear interpolation, and cubic convolution.
The nearest neighbor assignment will identify the location of the closest input cell, then assign the value of the nearest input cell to the output cell.
Cubic convolution uses the 16 nearest input cells to determine the output cell value A smooth cubic polynomials are fitted along the four lines of the four pixels surrounding the point in the image [6].

THE USED MATERIALS IN THE RESEARCH
1. Satellite image for the area which includes the required spot or spots.
2. Map for the same area above ,and it is better to be the same scale as the scale of the satellite image (in case the imagery not rectified) .
3. GIS – System.

THE PROCEDURE
1. Determining the required spot or spots on the satellite image (the imagery).

2. The used imagery is coloured and rectified in Iraq ,in Karbala, and its scale is 1:100 000 as in (Fig.-1) .

3. The geographic coordinates (φ, λ) of the center point of the imagery (P.P.) are given, and they are written on the lowest edge of the imagery (in addition to other informations).

4. The (φ, λ) of (P.P.) are converted into grid coordinates (X, Y) using any mode for that like using special programme (Am2. bas) as in (Fig.-2) which is programmed for this purpose[7] or using ERDAS Imagine Software programme[4] or any other known mode. The geographic coordinates (φ, λ) of (P.P.) of the used imagery are:

$\varphi = 32^{\circ}\, 41'\, 13''.08$

$\lambda = 44^{\circ}\, 00'\, 32''.58$ w

After using the ERDAS Programme ver. 9.2 the grid coordinates:

X ≡ E = 407 102.1m

Y ≡ N = 3 617 018.7 m

The Projection: UTM

Zone = 38

Spheroid: Clarke 1866

5. When the imagery is rectified all the grid and geographic coordinates of any point on the imagery are known and correct as on the map, and any required calculations can be done correctly on the imagery in the (GIS – System) as the calculation of the area from the grid coordinates of the periphery points of the spot . In this research a rectified imagery is used , but if the imagery not rectified ,the (GCPs) are selected in different places on the imagery of the tested area .The selected (GCPs) must be clear on the imagery . The four corners of the rectangle which one of its' corners is (P.P.) must be selected as (GCPs).This rectangle includes the tested area as in (Fig.-3). The dimensions of this rectangle are ΔX and ΔY. ΔX and ΔY are measured then the grid coordinates of the three corners must be calculated.

6. Points on the periphery of the tested spot are determined. Whenever the number of the taken points on the periphery of the required spot is larger, the accuracy of calculating the area of the spot will be bigger too.

7. The grid coordinates of the corners of the selected rectangle which includes the tested spot are entered to the (GIS-System) as input. The grid coordinates of the points on the periphery of the spot on the earth in meter and the area of the tested spot are given as output from the (GIS-System) and in different units like hectare. The output of the (GIS-System) is the grid coordinates of the determined points on the periphery of the spot and the area of the tested spot as in (Table -1).

DISCUSSION

1. Whenever the number of the selected points on the periphery of the wanted spot is larger, the accuracy of determining the position and then the area of the spot will be increased too.
2. Whenever the selected points on the periphery of the wanted spot are the deflection points of its figure, the determining of the position and then the area of the spot will be more accurate.
3. This research is used to determine the positions and the areas of any spot for example to determine the positions and the areas of the spots of water pollution, air pollution, in agriculture and in many other applications using the aerial image or the satellite image.

4. To facilitate researches in the remote sensing field, it is recommended to provide the specialists in this field with the necessary materials like aerial photographs, satellite image and equipments.
5. In Iraq the interpreters of the aerial photograph and satellite image are very little, therefore the researchers and workers in the remote sensing field should take up part in courses and high studies (MSc & PhD) to guide up the knowledge. It is very necessary to arrange with the Arab and Universal Universities and Centers in this field like the Technology University of Budapest and ITC in Holland.

CONCLUSIONS
1. In this research the position of the points of the periphery of any spot and its area on the satellite image can be founded using ordinary satellite image or digital image and ERDAS programme in GIS technique.
2. A rectified satellite image is used in this research and if the satellite image is not rectified, it can be rectified using a method with a map in the same scale with the satellite image.

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Table (1) The Gird Coordinates of The Determined Points on The periphery of The Spot and The Area of The Tested Spot.

P N	X (m)	Y (m)
1	406 820.10	3 617 169.30
٢	406 833.90	3 617 162.70
٣	٤٠٦ 832.70	3 617 149.50
٤	406 825.50	3 617 142.30
٥	406 816.50	3 617 143.50
٦	406 817.10	3 617 149.50
٧	406 810.50	3 617 147.10
٨	406 815.90	3 617 137.50
٩	406 810.50	3 617 130.30
١٠	406 797.90	3 617 129.70
١١	406 794.30	3 617 141.10
١٢	406 798.50	3 617 150.10
١٣	406 804.50	3 617 162.10
١٤	406 804.50	3 617 169.90
١٥	406 808.70	3 617 174.10
١٦	406 812.90	3 617 182.50
١٧	406 823.10	3 617 180.10
١٨	406 818.90	3 617 172.30
١٩	406 813.50	3 617 169.30
٢٠	406 818.30	3 617 172.90
٢١	406 826.70	3 617 167.50

Area = 0.3035 acres
Periphery = 199.06 m

Figure (1) The Used Imagery.

THE FLOW CHART OF THE PROGRAMME (Am2.bas)

(A Programme converts geographic coordinates into grid coordinates on the UTM projection, and computes the parametric constants and coefficients of any reference ellipsoid).

Variables

|	
a	Semi-major axis of the spheroid in m
$a1$	
$a2$	
$a3$	Coefficients (functions of the known latitude (QP))
$a4$	
$a5$	
$a6$	
b	Semi-minor axis of the spheroid in m
c	Polar radius of curvature in m
ep=e'	Second eccentricity of the ellipse
ESQ = e	First eccentricity of the ellipse
FE	False easting
HJ	Zone number
HO	Central meridian
HO1	Central meridian in radians
HP	The point longitude in radians
L	Grid distance from the central meridian in radians
Nr	Number of readings
QA	The point latitude in degrees only
QB	The point latitude in minutes only
QC	The point latitude in seconds only
QP	The point latitude in radians
XB	The point longitude in minutes only
XC	The point longitude in seconds only

Am2.bas Programme
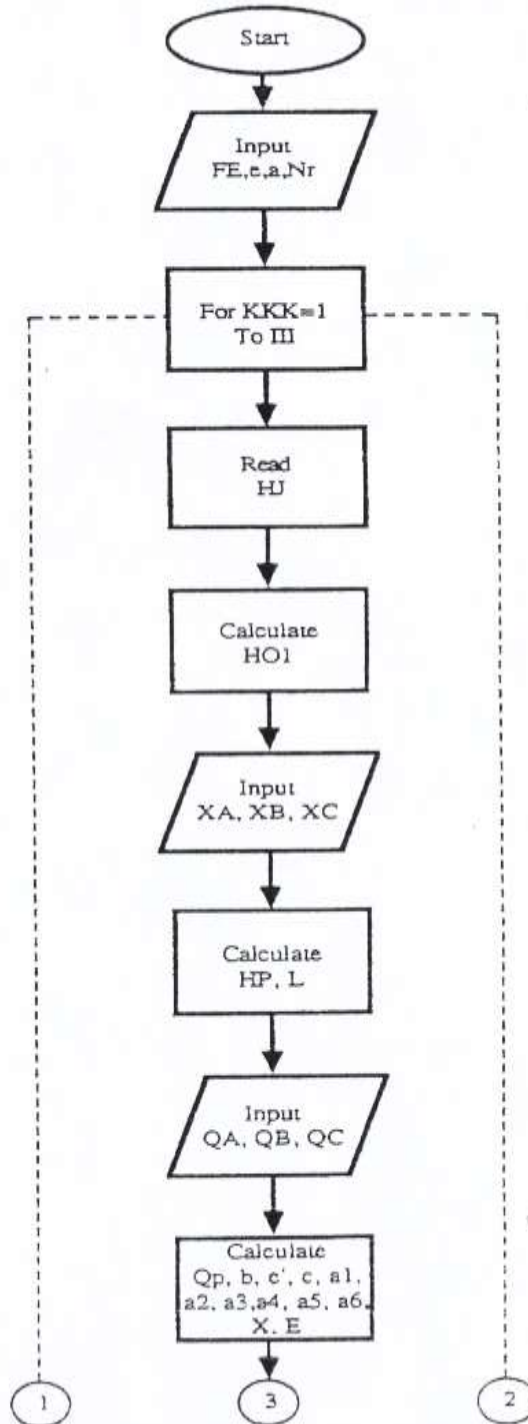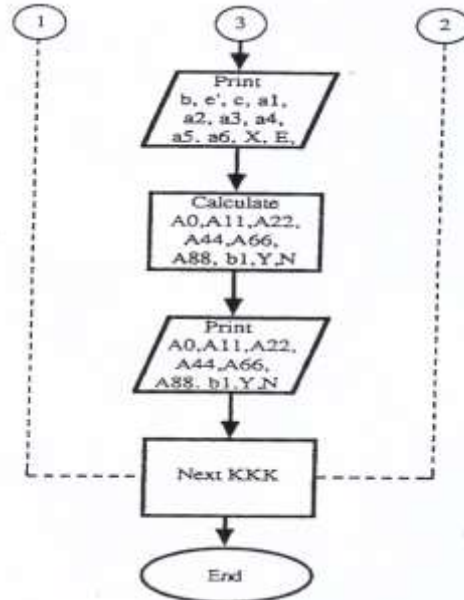
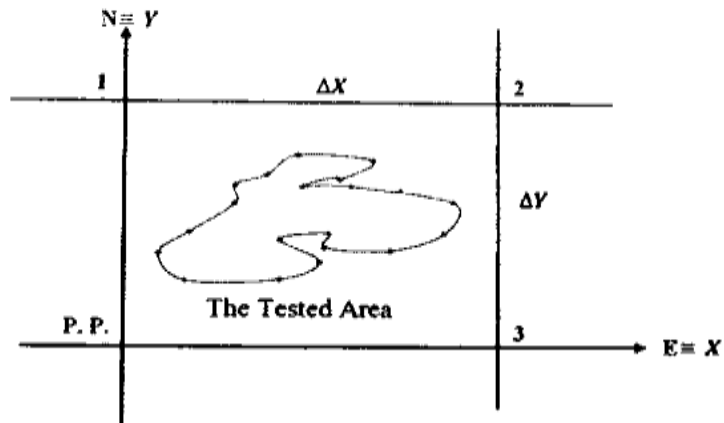**Figure (2)The Flow Chart of The Programme (Am2.bas).**

Figure (3) the Spot of the Tested Area

THE FOLLOWING NOTATIONS ARE USED IN THIS RESEARCH

A	Area
GCP	Ground Control Point
GIS	Geographical Information System
PN	Point Number
P. P.	Principal Point (Center Point)
X,Y	Grid Coordinates
φ, λ	Geographic Coordinates
Lat.	Latitude
Long.	Longitude