ORTHOPHOTO PRODUCTION FROM AERIAL PHOTOGRAPH BY USING MATLAB AND GIS

Yousif H. Khalaf
Instructor, Department of Surveying Engineering, University of Baghdad, Iraq

Nagham A. Abdulateef
Instructor, Department of Surveying Engineering, University of Baghdad, Iraq

ABSTRACT

According to development in map production from aerial and satellite image for engineering applications which need high resolution, many programs have been appeared which process the digital image for this purpose. The aerial and satellites images contain errors which need treatments before the processes of maps production, one of these errors is the tilt in the moment of exposure, which must be removed to get the orthophoto. This study depending on two methods to obtained the orthophoto which is used to produce high accurate map, the first method is depending on the analytical procedure to product orthophoto from oblique photo by using a number of prepared Matlab program. The second procedure is depending on Geographic Information System (GIS) to produce the orthophoto then to produce maps. This study discuss the positional accuracy obtained from the protected orthophoto within the accepted rang, and choose the most appropriate method among the methods used in the study. The study area has been chosen as an architectural model for a residential area, which is designed in architectural department - university of Baghdad. A digital photo has been taken for the model by using Nikon 5200 camera. The total station instrument has been used to measure the position of exposure station and the ground coordinates of the control points which is fixed on the model. After computing the root mean square error (RMSE) for the two methods, it is concluded that the first method which representing by the use of analytical rectification give a higher accuracy (0.001m) than the second method which it accuracy (0.010m).

Key words: Orthophoto, Matlab, GIS, Digital orthophoto map, Root mean square error (RMSE).

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1. INTRODUCTION
An orthophoto is a product which has pictorial qualities of a photograph and the plan metric correctness of a map. Orthophotos are produced through the process of differential rectification for which softcopy systems are particularly well suited.

Digital orthophoto maps (DOM) have great advantages of high precision, plentiful information, fine intuition and visualization, and convenient acquisition, as one of the most important part of National Spatial Data Infrastructure (NSDI) [1].

The essential inputs for the process of differential rectification is the digital aerial photo having known exterior orientation parameter (G, Ф, K, XL, YL, ZL). It also necessary to obtain the digital image coordinates (row and column) of the fiducially so that a transformation can be computed to relate photo coordinates to digital image coordinates [2,3].

Rectified photos can be produced by digital techniques that incorporate a photogrammetric scanner and computer processing is a special case of the more general concept of Georeferencing [4]. The feature that distinguishes digital rectification from other georeferenced images is that requires that a projective transformation be used to relate the image to the ground coordinates system, whereas Georeferencing often uses simpler transformation such as the two-dimensional conformal or the two-dimensional affine transformation [5].

There are several methods available for performing analytical (numerical) rectification. Each of the analytical methods performs rectification point by point and each requires that sufficient ground control appear in the tilted photo. Basic input required for the numerical methods, in addition to ground coordinates of control points, x and y photo coordinates of all control point plus those of the point that to be rectified, which are normally measured in a comparator coordinates system [2]. Due to the lengthy calculation required, numerical rectification is generally performed through use of a computer program of the available methods of analytical rectification, the one that uses the two-dimensional projective transformation is the most convenient, the transformation equation represented in equation (1) and (2):

\[
X = \frac{a1x + b1y + c1}{a3x + b3y + 1} \ldots \ldots (1)
\]

\[
Y = \frac{a2x + b2y + c2}{a3x + b3y + 1} \ldots \ldots (2)
\]

X and Y are ground coordinates, x and y are photo coordinates (in the fiducially axis system), and the a's, b's and c's are the eight parameters of the transformation. The use of these equations to perform analytical rectification is a two-step process.

Two deferent techniques were used in this research to product the orthophoto the first technique was represented by product the orthophoto by using a Matlab program and by adopting the mathematical model of analytical rectification method, and the second technique which was adopted in this research was the production of orthophoto by using GIS [6].

2. METHODOLOGY
The study area has been chosen as an architectural model for a residential area, which is designed in architectural department - university of Baghdad as shown in figure (1).
2.1. Preparing the Ground Control Points
For the purpose of measuring coordinates, the adopted model was placed on the ground and select a number of point on the model as a control and check points. The coordinates of the control and check points was measured in local coordinate system by using total station instrument, table (1) shows the ground coordinates of these points.

<table>
<thead>
<tr>
<th>Point</th>
<th>x (m)</th>
<th>y (m)</th>
<th>z (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>1996.0226</td>
<td>1000.3438</td>
<td>35.5529</td>
</tr>
<tr>
<td>P2</td>
<td>1996.0602</td>
<td>1000.7641</td>
<td>35.4911</td>
</tr>
<tr>
<td>P3</td>
<td>1996.0417</td>
<td>1001.0559</td>
<td>35.5457</td>
</tr>
<tr>
<td>P4</td>
<td>1995.5382</td>
<td>1001.0857</td>
<td>35.5381</td>
</tr>
<tr>
<td>P5</td>
<td>1995.5087</td>
<td>1000.9576</td>
<td>35.5446</td>
</tr>
<tr>
<td>P6</td>
<td>1995.5715</td>
<td>1000.3527</td>
<td>35.5668</td>
</tr>
<tr>
<td>P7</td>
<td>1995.5842</td>
<td>1000.3000</td>
<td>35.5657</td>
</tr>
<tr>
<td>P8</td>
<td>1995.7909</td>
<td>1000.3321</td>
<td>35.5536</td>
</tr>
</tbody>
</table>

2.2. Preparing the Aerial Photograph
After the processes of measuring the control and check points a digital photo was taken to the model by using digital camera (Nikon 5200) at a height equal to (1.2m), with tilt angle (32°) and the focal length of the used camera was (24mm). This digital photo is used in the two adopted techniques in this research.

2.3. Measurement of Image Coordinates
Measuring the digital photo coordinates which represent one of the important steps to produce the orthophoto. The digital photo coordinates for large number of point in the model have been measured by using Photoshop Software and recorded and then must be transformed the measured coordinates to the principle point (p.p) system [7]. The location of these points in the model shown in figure (2).
3. MATLAB PROGRAM

Matlab is a powerful language for technical computing. The name MATLAB stands for Matrix Laboratory, because its basic data element is matrix (array). MATLAB can be used for math computations, modeling and simulations, data analysis and processing, visualization and graphics, and algorithms development [8]. In industry the software is used in this research. The flow chart of prepared Matlab program illustrated in figure (3) and (4):

A number of programs have been prepared for producing orthophoto, these programs have been written in Matlab language, which can easily displayed and understood.
3.1. Transformation Program to (p.p)

The first program that converts the coordinates from the machine system to the principle point system, the program work shown in figure (5).

![Figure 5 Matlab program to transformation photo coordinates to (p.p) system.](image)

3.2. Analytical Rectification Program

This program is depending on the equations of analytical rectification to compute the ground coordinates. The input data required to run this program is represented by the output of the transformation program to (p.p). After applying this program the tilted photograph would be equivalent to the vertical photograph. Each of analytical rectification methods performs rectification point by point, figure (6) show the program.

![Figure 6 Analytical Rectification Program.](image)
After rectified point have been computed in the ground coordinate system in this program, the computed ground point can be plotted at scale desired for the rectified photo as show in figure (7).

Figure 7 The plot of the computed ground coordinates.

4. GIS GEOREFERENCE

The second procedure of produce the orthophoto is depending on Geographic Information System (GIS). Software of ArcGIS-10 by ESRI was used for this purpose. four control points have been selected on the digital image after imported to ArcGIS. The ground coordinate have been interred in the (GIS), then the processes of Georeference has been done as shown in figure (8).

Figure 8 Steps of georeference
4.1. Measuring coordinates and Map production in GIS

The coordinates of the architectural model have been measured in ArcGIS software to compare them with the coordinates obtained from the Matlab program. Figure (10) show the measurement processes. The processes of Georeference and the measurement of ground points have been done. The final step is product a map to the adopted model by producing the shape file to the digital image in (GIS), as shown in figure (11).

Figure 9 Digital photo after Georeference

Figure 10 Measuring coordinates in (GIS)  
Figure 11 The shape file produced from the digital image
5. CALCULATE THE ACCURACY OF THE WORK

After calculating the ground coordinates of the points specified on the model with the two adopted methods. Five check points have been selected and the accuracy has been calculated by using the equation of the root mean square error (RMSE), the following tables (2) and (3) shows the value of (RMSE):

Table 2 Calculate (RMSE) to measured coordinate in Matlab

<table>
<thead>
<tr>
<th>Point</th>
<th>Coordinate measured in Matlab</th>
<th>Coordinate measured by total station</th>
<th>XΔ</th>
<th>YΔ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>Y</td>
<td>X</td>
<td>Y</td>
</tr>
<tr>
<td>1</td>
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</tr>
<tr>
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<td>1000.3300</td>
<td>1995.7909</td>
<td>1000.3321</td>
</tr>
<tr>
<td>3</td>
<td>1996.0227</td>
<td>1000.3447</td>
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</tr>
<tr>
<td>4</td>
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<td>1000.7641</td>
</tr>
<tr>
<td>5</td>
<td>1995.5706</td>
<td>1000.3540</td>
<td>1995.5715</td>
<td>1000.3527</td>
</tr>
<tr>
<td></td>
<td>RMSE</td>
<td>±0.0066</td>
<td>±0.0011</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total RMSE</td>
<td>±0.0013</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 Calculate (RMSE) to measured coordinate in GIS

<table>
<thead>
<tr>
<th>Point</th>
<th>Coordinate measured in GIS</th>
<th>Coordinate measured by total station</th>
<th>XΔ</th>
<th>YΔ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>Y</td>
<td>X</td>
<td>Y</td>
</tr>
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<td>1000.3690</td>
<td>1995.5715</td>
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<tr>
<td></td>
<td>RMSE</td>
<td>±0.0073</td>
<td>±0.0068</td>
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</tr>
<tr>
<td></td>
<td>Total RMSE</td>
<td>±0.0101</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. CONCLUSIONS

From the results obtained by this research the main conclusion have been illustrated as follows:

- The adopted method of analytical rectification gives a good accuracy which is suitable for engineering application.
- The use of Matlab program have best benefit in orthophoto production.
- The value of (RMSE) which computed for the analytical method was (0.0101) and (0.0013).
- The advantages of (GIS) in orthophoto production reducing the time and effort but give a low accuracy and cause a distortion in the image after the proses of Georeference.

REFERENCES


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