Using of Geographical Information System and Global Positioning System to Establish   Coordinate System for the Remote Sensing Data

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ABSTRACT

A GPS measurement is developed for the purpose of establishing ground control points (GCP's) for rectifying medium and high resolution satellite imageries. These GCP's could be also used as a data overlays on the GIS maps. The acquired data (such as aerial photography and satellite imagery) from the remote sensing techniques can be correlated with GPS

allowing the measurement locations to be shown on a GIS map, then the data can be analyzed geographically.

This paper presents a procedures to establish a geographical coordinate system for the acquired remote sensing data (aerial photography) from the topographic map's coordinate (scale of 1:100000) covered the same study area by using GPS techniques and GIS software. The rectify process was applied with the Clarke1880 reference ellipsoid that have been adopted for the selected study area in Mosul city. The results show, best agreement between the establish coordinate of the aerial photography and the coordinate of topographic map of the same study area. Also, the accuracy of the final results depend on the accuracy of the GPS receiver readout.

Introduction

In the recent years, aerial and satellite images have become an essential tools for a continuous monitoring of the complex processes on the earth's surface. The generated images prove most valuable when they share the geometry which is used for maps of the represented area.

Geographical Information System (GIS) is a computer-based tool that provide the ability to register the map to a given map geometry (Projection, ellipsoid, and datum) in the vector model(ref.1).

GIS-to-Global Positioning System (GPS) link is now greatly benefit such that many GPS receivers and their data loggers can write data directly into GIS format or even overlap satellites images and air photo in the field (ref.2).

The objective of this study was to apply the ArcViewGIS and the Image Analysis Extension software with link to GPS data, to establish a coordinate system for an aerial photography image (as a sample) at the same projection system which apply for topographic map of the same study area.

GPS measurements

The global positioning system (GPS) has change the task of surveying in many countries in the world. When the GPS is used in the relative positioning mode, the three-dimensional Cartesian coordinates of the occupied locations can be accurately determined. These in turn can be transformed into ellipsoidal coordinates, i.e., latitude, longitude and ellipsoidal height (ref.3).

The GPS technique is extensively used for a GCP establishment of medium and high resolusion satellite imageries since this technique can provide accurate positioning results.

In this study, a GARMIN:GPS12 receiver of a position accuracy of (4m) were used to measure the geographical locations of GCP's (with

respect to Clarke1880 reference ellipsoid) for the purpose of image rectification of an arial photography by using ArcViewGIS3.3 software.

Table (1) listed the geographical and Universal Transverse Mercator (UTM) coordinate systems of the measured GCP's adopted in this study. This GCP's will be projected on the obtained registered image from the registration process through the image rectification.

Table (1): geographical and UTM coordinate system of the control points measured by GPS receiver (Clarke1880 reference ellipsoid)

Point no.	Geographical coordinate system (decimal degree)		UTM coordinate system (meter)	
	Latitude	Longitude	Easting	Northing
1	36.398610	43.143890	333544	4029472
2	36.323610	43.120560	331290	4021192
3	36.373330	43.143610	333465	4026668
4	36.381560	43.145670	333665	4027577
5	36.311390	43.118060	331039	4019841
6	36.358630	43.082320	327934	4025145
7	36.386830	43.182220	336957	4028100
8	36.364650	43.121530	331465	4025743

Image registration

The satellite images are usually affected by a number of distortions which are left uncorrected. One of these distortions can be characterized by the geometrical distortions (ref.4). The best method for correcting these distortions is called "image registration".

The image registration is a procedure to determine the best spatial fit between two or more image (or map) from the same scene acquired with the same or different sensors, with or without the same ground (spatial) resolution, at the same or different time (ref.5). Therefore, the image registration is an important step to obtained a correct remote sensing data.

In this study, image registration process was applied on the image and the map of the same scene that have been adopted for the final image rectification.

"Interactive software for image registration (ISIR)" program (ref.6) was used for the registration process, figure (1) show the input image (left) of the study area which is called (test image) according to the program definition, and the map (right) of the same scene which is called (reference map) .
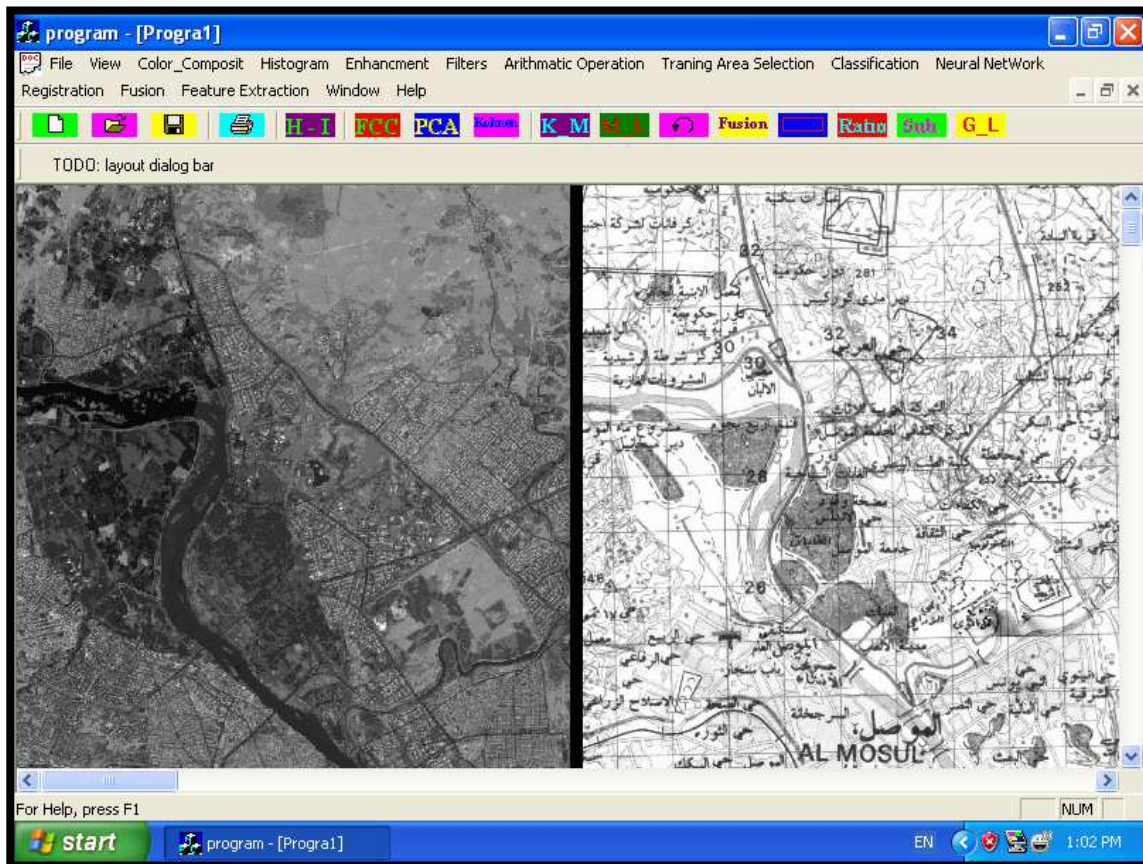
Figure (1): The image and map applied in the image registration process

From this program, a set of GCP's which have located at the same features in both test and reference image, have been chosen from the map and the image (i.e., not measured by GPS). The next step, derived the deformation model by specifying a mathematical model defining the relation between the coordinates in the test and reference image. At the last, constructed the registed image (corrected image) by output-to-input mapping order, which consist of two steps: spatial and spectral interpolation (ref.6). However, a large number of well-placed GCP's could result in an almost complete correction for any geometrical errors (ref.7). The accuracy level obtained for the image registration applied for the image and map is (0.0921).   Figure (2) shows final output image (registered image) that have been corrected from the geometrical distortions.

Figure (2): The correct output image (registered image)

Image Rectification Process

To make effective use of any Satellite Imagery or Aerial Photography it is usually necessary to orient the image into it's correct geographic space. This is done by collecting GCP's by GPS receiver to assign geographic coordinates to identifiable features in the image. This process can be perform by using ArcViewGIS/Image Analysis extension. This extension allows the user to leverage a broad range of readily available image data types (including popular satellite imagery, aerial photography, and other remotely sensed data) supplementing a wide variety of GIS applications (ref.8). Arc View's Image Analysis extension also provides an Align tool to perform image rectification georeference imagery to GPS points or reference images.

In this study, rectification of the registered aerial photography was involved the establishment of GCP's which were measured by GPS receiver. This points have been previously selected at a specific locations

in the study area by using a topographic map of scale (1:100000). The map was covered the same area of the of the adopted aerial photography and serves as the base map.

Figure(3) shows the topographic map of the study aerial photography. The rectification process have been applied on this map by selecting a control point at each corner of the reference map, then projected the GPS measured data points .

The purpose of the rectification process for the base map is to determine the Universal Transverse Mercator (UTM) coordinate shift between the GPS measured control points and the real coordinate of the map. The first step of the procedure is to download the base map to the Arc View's Image Analysis window as shown in figure (3a), then adjusted the projection of the map to UTM-Clarke1880 coordinate system. The second step is to rectify the image by using Align tool order from the tool bar, in this step , four GCPs were selected from the base map and projected in the corners of the map (one point at each image corner) as a green circles in the figure (3b). At the last control point, the rectification was satisfy by matching the corresponding image and the map coordinate points. That's mean , the image coordinate system was transforming into a map coordinate system (ref.7). The measured GPS control points were also projected on the rectify map (red circles) as shown in the figure (3b) to illustrate the geographical distribution of these points as well the coincidence degree between the points and the map coordinates.

Finally, the rectify map and the related links of the control points coverage were saved to keep the new version of the topographic base map with its new coordinate system. The accuracy level of the final results obtained from this study on the establish coordinate system for registered image shown in figure (2) will be depend on the rectify map obtained in this section.
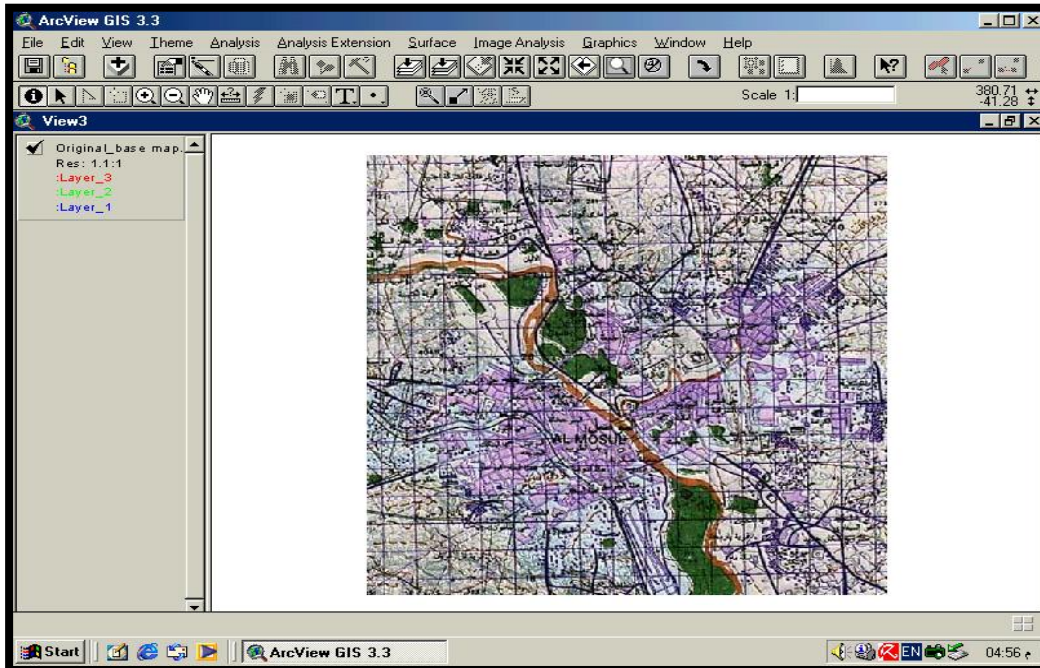
Figure(3a): before rectification process
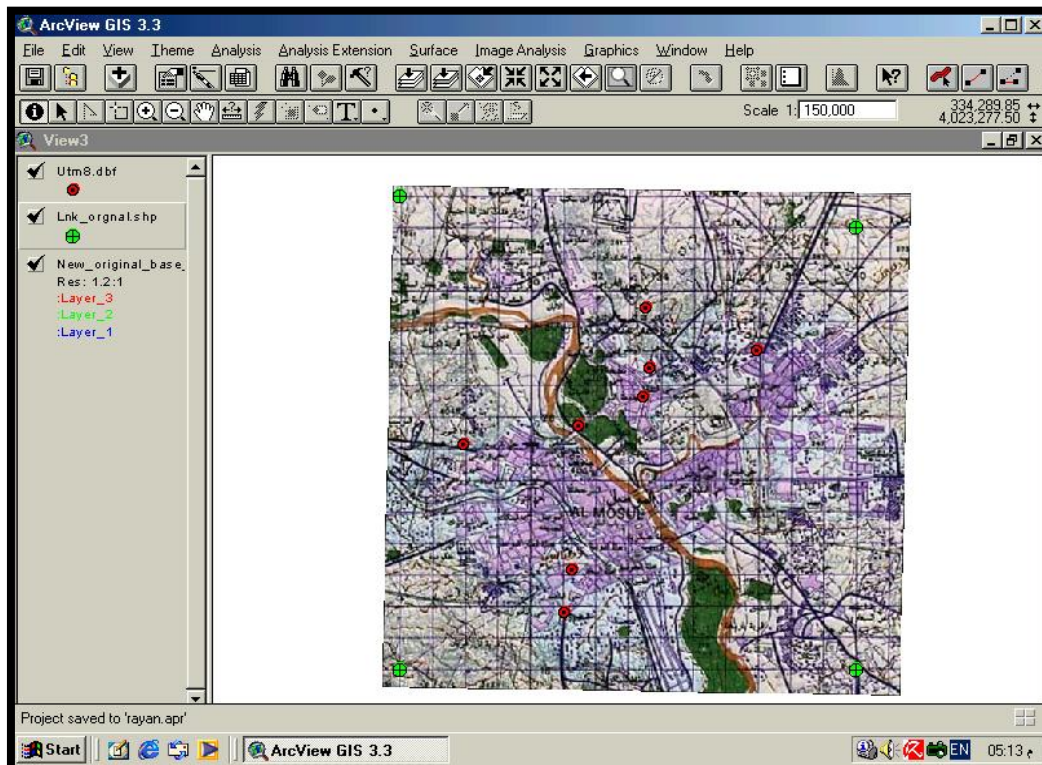
Figure(3b): after rectification process
**Figure(3): The base map of the study aerial photography**

Result and Discussion

Remotely sensed data (satellite imagery and aerial photography) is inherently in need of geometric correction to maximize its usefulness within a GIS for subsequent analysis procedures (like an image rectification) for the integration of remote sensing and GIS. Image rectification is often more complicated, recognizable features on a map are not always found on an image or may be difficult to recognize and vice-versa. GPS technique was became an important tool for trying to solve this problem by measuring a well-know geographical locations for a features included in the study image to be as a GCP's as done by this study. Then, the selected points have been projected on the rectified-registered image according to the reference ellipsoid of the base map of the same area.

Figure(4) shows the superimposed image between the registered image and the base map. This figure ensure the high accuracy level of the image registration. In figure (4) the image were rectified with the same procedures applied in figure(3b). Figure(4) indicates the high level matching between the GCP of the geographical locations (measured by GPS receiver) for both image and base map. The total root mean square error (Total_rms) of the links points shown as a green circle in the corners is (0.1718). This minimum value of (Total_rms) error refers to a high quality result of image rectification. The lower the Total_rms error , the more accurate the rectification (ref.8). These results lead to high accuracy level of establishing the coordinate system of the final registered aerial photography as shown in figure (5). This figure shows the registered image with a coordinate system based on UTM-Clarke1880. Figure (5) demonstrates the good agreement between the new scaled coordinate system and the geographical locations of the points measured by the GPS receiver and listed in table(1).

Figure (6) shows the final new form of the aerial photography adopted in this study with a UTM coordinate system (Easting-axis and Northing-axis). This image cab used as a tool for the remote sensing and geographical application. The final accuracy obtained from figure (5 and 6) is equal to (31m) depending on a base map of scale (1/100000). This result is relatively agreement with (ref.9) which is get accuracy less than (25m) in the rectification process between Landsat TM image and a map of scale (1/50000).

Finally, if the GCP's could be placed with 100 percent accuracy, we can expected some errors will appears due to several causes like; positional inaccuracies (i.e. selection of GCP's in the registration process), poor quality of the image and base map, image resolution, and map scale . All of these errors could be a reasons for the expected coordinate shift between the image and the base map .
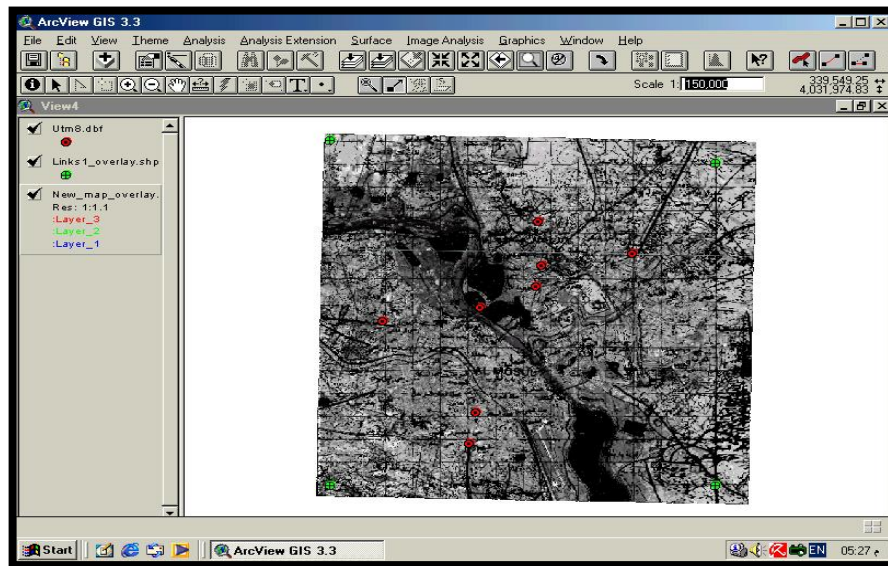
Figure(4): The GPS data points distribution on the rectified superimposed image between aerial photography and base map
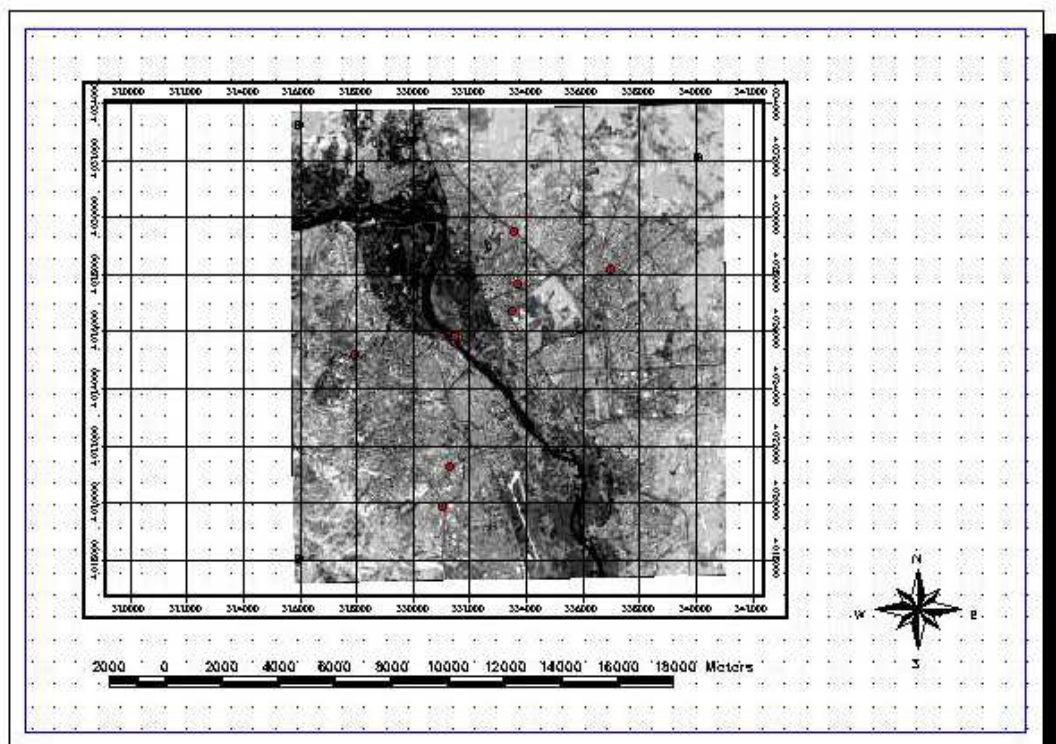
Figure(5): The geographical distribution of the measured GCP's on the final version of the aerial photography
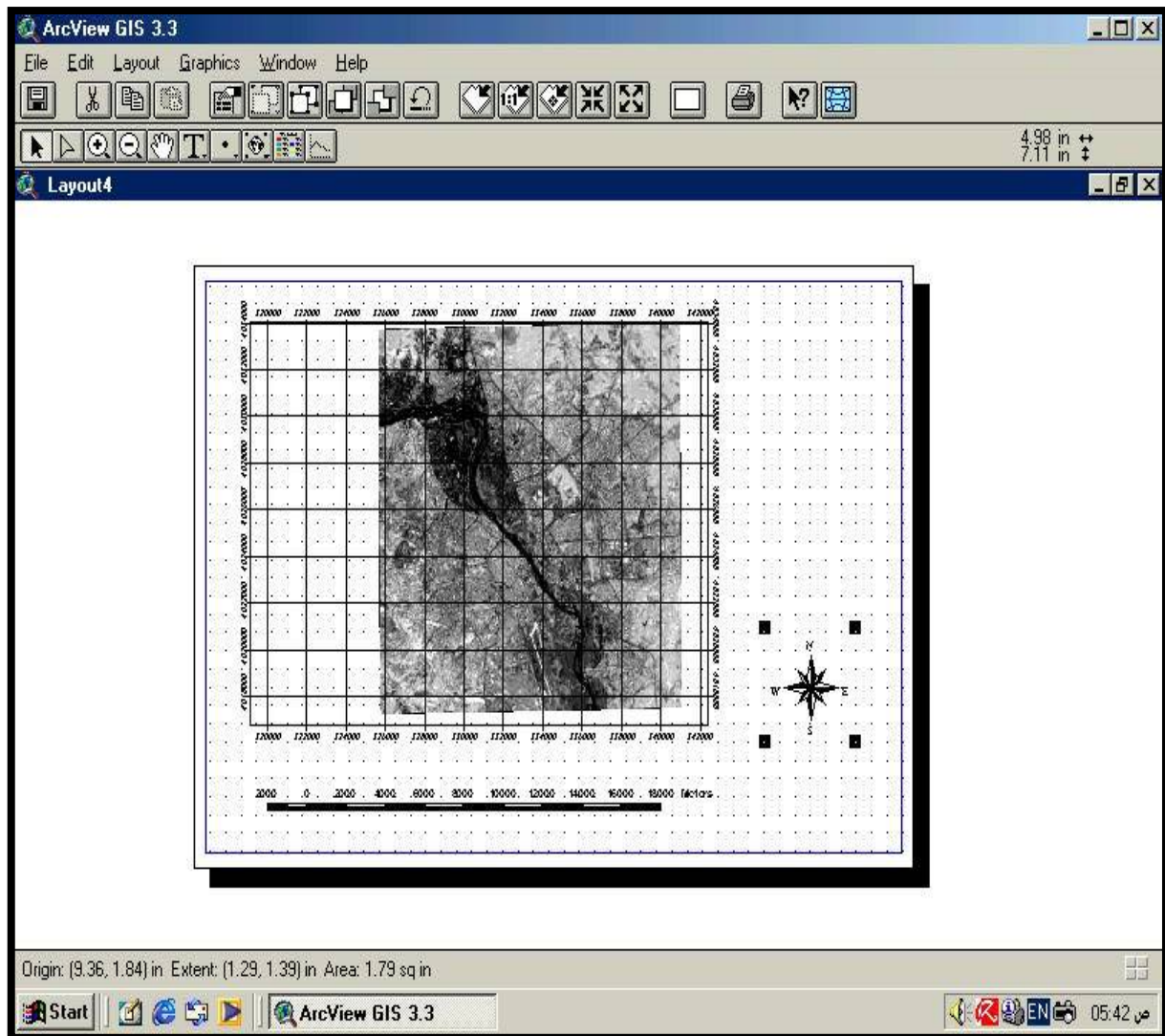
Figure(6): The final version of the aerial photography with a UTM

Conclusion

In this study, rectification is a accomplished by matching corresponding geographical location measured by GPS receiver and previously selected from a base map of scale (1/100000), with an aerial photography as a sample of remote sensing data.

From the results of the applied procedures adopted in this study, we can conclude that, the selected of the links corner points from the base map is not enough to get a best rectification of the corresponding image. To ensured the high level accuracy of the established coordinate system (e.g. geographical lat/long., UTM) of the image, It is prefer to use GPS control points rather than the links points of the base map to improve the accuracy of the rectification process. That's lead to lower Total-rms errors.

The lower Total-rms errors, the more accurate the rectification, then the more accurate establish coordinate system of the remote sensing data (satellite imagery and aerial photography).

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