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Coupling GIS and Photogrammetry for the Development of Large-Scale Land Information System (LIS)

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Abstract GIS is now being used by Civil Engineers in every application domain and throughout every aspect of the enterprise, be it on the desktop, in the field, or in collaboration with others. Digital photogrammetry is most commonly associated with the production of topographic mapping generally from conventional aerial stereo photography. As for the GIS Photogrammetry can be seen as a system of hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data for solving complex planning and management problems. Photogrammetry-supported GIS is concerned with the accuracy of the data used in GIS offering ways of direct visualization and easier interpretation in a real-world scale. Matching the mosaic images usually implies that the radiometric intensity data from one image representing a particular feature must be matched to the intensity data from the second image, representing the same feature. After the production of mosaic for the study area, stereo pair of the final form the ArcView software was used to prepare a digital map with multi layers. The layers, which were 12 layers formed: main roads layer, Pedestrian roads layer, parks layer, Gardens layer, Service buildings layer, college of engineering layer, college of science layer, college of politics layer, architecture department layer, engineering labs layer, collection of colleges buildings layer and lectures halls layer. After the completion of the drawing layers have been producing digital map in its final form.

Keywords: *ArcView, digital mapping, GIS, LIS, mosaic, Photogrammetry, surveying*

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1. Introduction

As for the GIS Photogrammetry can be seen as a system of hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data for solving complex planning and management problems. With the recent advances in digital Photogrammetry and related disciplines, the definition of photogrammetry can be changed to the art and science of tool development for automatic generation of spatial and descriptive information from multi-sensory data and / or systems. Therefore, photogrammetry cannot be viewed as just a data acquisition mechanism for GIS. Photogrammetry and GIS are becoming closely interrelated [3].

Metric photogrammetry consists of making precise measurements from photos or other remotely sensed data to determine the relative locations of visible features and points on the earth to within a specific accuracy standard, relative to establish known ground control points. Interpretative photogrammetry deals principally in identifying features and conditions on the surface of the earth by using systematic and careful analysis to judge their significance [2].

Photogrammetrically, derived three dimensional information produced from analytical or digital stereo plotting instruments, is used to produce maps and plans and provide the source data for ground modelling packages, orthophotos and geographical information systems. Photogramrnetry is used to provide national mapping and map revision at small and medium scales. At larger scales photogrammetric data form the basis for three-dimensional modelling in a wide variety of applications including highway design, floodplain studies and pipeline routing [6].

A mosaic is an assembly of series of overlapping aerial photographs to form one continuous picture of the terrain. It may consist of a single strip of photographs, termed a *strip mosaic*, or it may be contain many overlapping strips. When photographic film has been processed, each negative of a flight strip is numbered consecutively, and each flight strip bears a number that is also assigned to each photograph of that strip. A mosaic that is constructed to give both high pictorial quality and good accuracy must be controlled by picture points. The accuracy and density of the control is, dependent on the accuracy desired in the finished mosaic. The control provided for mosaics can be obtained by ground surveys supplemented by graphically located points [7].

2. Digital Photogrammetry (Softcopy)

Since digital photogrammetry is rather new, it is easy to generate a list of problems. In some aspects, the present state can be compared with analog instruments in the thirties or with analytical stereo plotters in them seventies. Most problems arise due to the extremely large size of digital images. An aerial photograph of 23 × 23 centimeters, scanned at 20 micrometers resolution, requires over 200 megabytes of storage. Storage of such a large amount of data is no longer a problem. Hard disks with gigabytes of storage data is another problem. As an example, local transfer time of a 15-micrometers digitized aerial photo is a few minutes.

Because of these key technological advances; cost; labor; and new areas of applications (GIS and CAD), digital photogrammetric systems have been and are being designed. The main idea is to use digital images, scan the model area with a three-dimensional "floating mark" with sub-pixel accuracy. Then use a digital 4 workstation to compile the required features to form an intelligent description for an information system such as GIS and CAD systems [6].

3. Advantages of Photogrammetry-Supported GIS

Photogrammetry-supported GIS is concerned with the accuracy of the data used in GIS offering ways of direct visualization and easier interpretation in a real-world scale [8].

The GIS is a relatively new technology that joins the computer science advantages with the modern systems of capture of data, so that it allows the integration and the treatment of all type of information of a computer team, in a simple way on the part of any user that requires to work with this information [5].

With the advent of geographic information systems, a powerful method is available to store graphical and descriptive data with all their links. Digital photogrammetry and the GIS provide a group of advantages and benefits in the architectural tasks impossible to obtain with such an efficiency, velocity and economy by means of other procedure [5].

Digital photogrammetry and remote sensing data also produce a tremendous amount of information. However, these systems usually collect data not just on a single case, but also on multiple dates, allowing the analyst to inventory, and also to monitor. The ability to monitor development though times, provides valuable information about the processes at work. Furthermore, remote sensing and photogrammetry often provide valuable information about certain biophysical measurements that could be of significant value in modeling the environment. While photogrammetry has proved to be an economical method for topographic mapping, remote sensing has proved itself to be an effective tool for resource management. Conventional frame aerial photography used in photogrammetry can be characterized as low altitude, analog, and capable of providing stereoscopic viewing while satellite imagery is generally very high altitude and digital such as IKONOS and SPOT. However, photogrammetry and remote sensing are merging. As photogrammetry becomes digital, and the resolution of satellite images improves, the tools developed in each respective discipline can be applied to the other. Both technologies can be effective means to detect manmade or natural changes on the ground on a cyclic basis for map revisions basis [6].

3.1. Photo Mosaic

An aerial mosaic is an assemblage of two or more individual over lapping photographs to form a single continuous picture of an area (Figure 1). The assembly is made by cutting and piecing to gather parts of photographs, being careful to make common images coincide as closely as possible at the match lines between adjacent photos [10].

The advantages of mosaic are: [Show relative planimetric qualities, whereas objects on maps, which are shown with symbols must be limited in number. Mosaic of large areas can be prepared in much less time and at considerably lower cost than maps. It is easy to understand and interpreted by people without photogrammetry or engineering back ground [1].

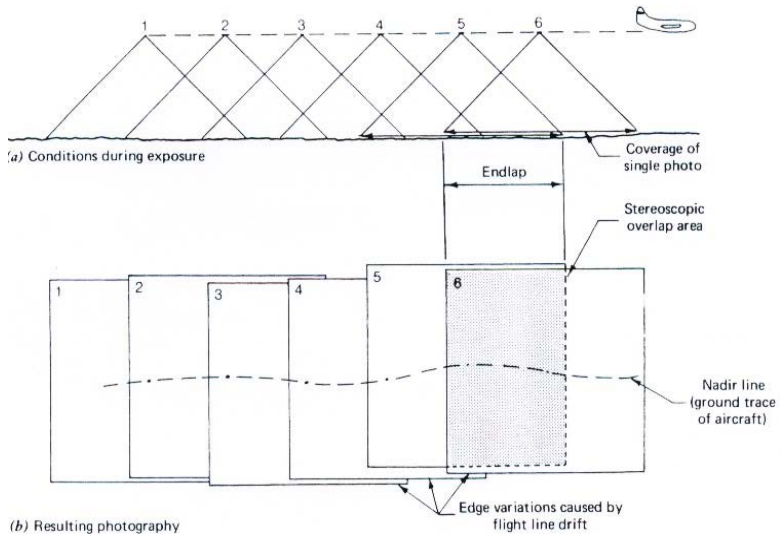

Figure 1. Photo Mosaic

Mosaic is widely used. Their value is perhaps most appreciated in the field of planning, both in land-use planning and in planning for engineering project. Also it is used to study geologic features [10].

3.1.1. Digital Photogrammetry for a Complete GIS

Integration of digital photogrammetry applications into Geographic Information System (GIS) databases offers new possibilities for the end-users. This integration allows photogrammetric data collection in a raster / vector based GIS environment. The progress is achieved in stages. These operations are carried out using digital image processing, geocoding, and monoplotting techniques. In this electronic age managing and distributing data and imagery across an enterprise is a very complex operation. With the family of products designed to eliminate the nightmare of tracking imagery and data across the network. With GIS, you have a system that manages geoimaging data (imagery, DTMs, and digitized raster graphics) from acquisition to exploitation, to storage, to distribute. Since every business is unique, a modular product line provides the tools to manage large amounts of geoimaging data throughout practically any production environment – as well as making it easy to turn a web into an imagery e-commerce site [6].

3.1.2. Computerisation of Cadastral Maps

The justification for computerizing cadastral maps includes the following [The reduction of duplication in maintaining a cadastral base for many users, As a result of converting maps from one scale to another, and To bring the cadastral map onto the same coordinate and mapping system as large scale topographic maps, thereby facilitating LIS / GIS applications].

An important issue in establishing a digital cadastral data bases (DCDB) is that computerization of the cadastral maps in general cannot be justified for land registration or land market reasons. Therefore computerization of the map requires the support of other users both financially and institutionally [9].

At the institutional level, there is an issue of who is responsible for maintaining the DCDB and distributing the updates. Obviously it is necessary for one organization to administer the DCDB although there are various models using both government and the private sector to maintain the system [9].

3.1.3. Information Systems

Large-scale geographic and land information systems (GIS and LIS) are developing rapidly in local and state governments and other organizations across the country. These systems handle critical information related to land parcels, transportation, utilities, and other infrastructure and facilities. They are changing the way organizations operate and make decisions, and therefore, they affect the daily activities and lives of the citizens and customers of these organizations [4].

As such, large-scale LISs provide great opportunities, but they also involve important challenges. Surveying and GIS professionals need to work together to ensure the integrity and reliability of the data incorporated into large-scale LISs. GLIS directly addresses the development of large-scale LISs and related professional issues.

The attributes of different types of geospatial data — such as land ownership, roads and bridges, buildings, lakes and rivers, counties, or congressional districts — can each constitute a layer or theme in GIS. (See Figure 2 for a schematic representation of data layers in GIS).

GIS has the ability to link and integrate information from several different data layers or themes over the same geographic coordinates, which is very difficult to do with any other means. For example, GIS could combine a major road from one data layer as the boundary dividing land zoned for commercial development with the location of wetlands from another data layer. Precipitation data, from a third data layer, could be combined with a fourth data layer that shows streams and rivers. GIS could then be used to calculate where and how much runoff might flow from the commercial development into the wetlands. Thus the power of GIS analysis can be used to create a new way to interpret information that would otherwise be very difficult to visualize and analyze [4].

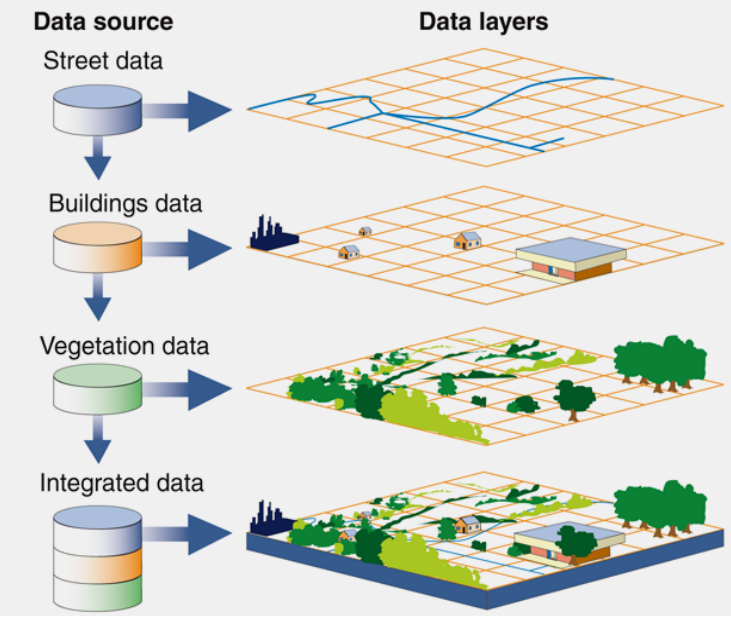

Figure 2. Example of GIS Data Layers or Themes

4. Case Study

The development of the GIS of the study area goes through several distinct stages. The first is data collection and conversion, the second is editing and final is database development as well as brows and query functions through a user interface. Emphasis is placed on the method of organization determined to maximize brows and query efficiency and friendliness, by dialogue buttons, menus scripts under ArcView (3.3).

This paper was intended to introduce a design system to manage survey datasets through the production of GIS-ready information using appropriate standard and computing application. The trial implementation does instigate sufficient results at present stage whereby the test datasets consisting of raster image and feature classes were being managed carefully through the platform of producing and delivering GIS-ready information. ArcView functionality is proved offering capabilities for geospatial data interchange, manipulation and management as well. The ArcView application has clearly shown the successes of the concept of data integration on-the-fly from multiple heterogeneous geospatial data servers.

4.1. Data Collection and Conversion

Both analogue and digital data are gathered for the study area including: A digital base map for Baghdad University site. Eight digital Arial photos provided by surveying department as shown in Figure 3. Historical data, photographs, reproduction and surveying details. Additional descriptive information was also collected.

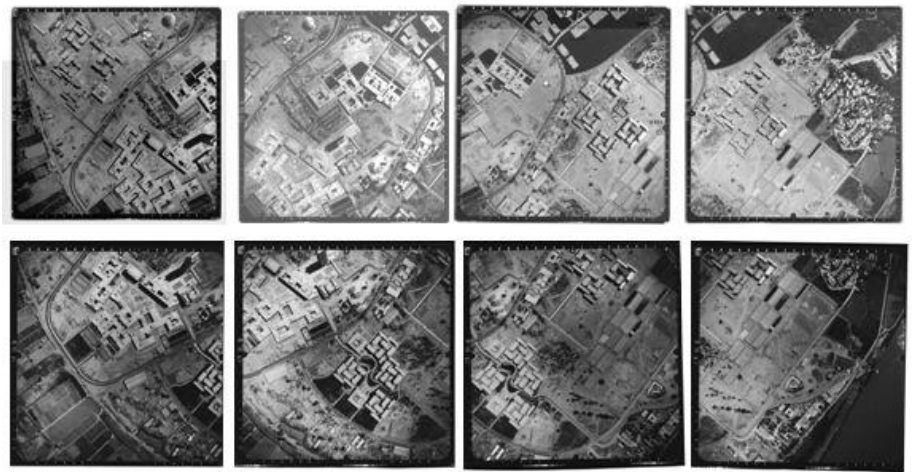

Figure 3. Eight digital Arial photos of Baghdad University site

A mosaic is an assembly of series of overlapping aerial photographs to form one continuous picture of the terrain. It may consist of a single strip of photographs, termed a *strip mosaic*, or it may be contain many overlapping strips. The images used in this study captured from space by the military in with focal length (152.16 mm), flying height (456.48 m) and scale the image (1 / 3000), which is illustrated in Figure 2. The completion of this work needs to several enough aerial photos of the area. The mosaics have been found that the University of Baghdad covered pace aviation is flight (110, 111). The entire airline has four images so that there is a common area shows each image of the photo that followed in the line of flight, one is called the forward overlap or overlap the front and the amount (60%). And also there is an overlap (side lap) or (End Lap) hereunder (30%) were converted this image to a digital format (Digital form) using (Scanner).

Matching the mosaic images usually implies that the radiometric intensity data from one image representing a particular feature must be matched to the intensity data from the second image, representing the same feature. This implies more than just matching image intensity data correlation, because the same piece feature may look considerably different radio metrically from different point of view, or at different time. Figure 4 shows the matching the mosaic of eight digital Arial photos of Baghdad University site by using ERDAS LPS (V 9.2) software.

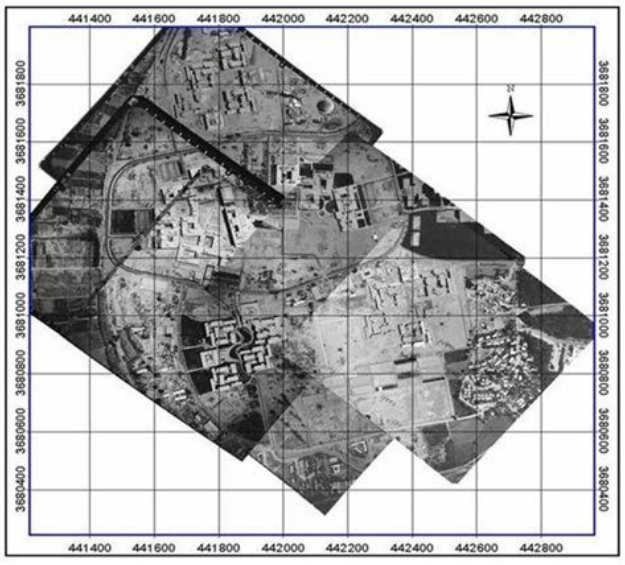

Figure 4. Matching the mosaic of eight digital Arial photos of Baghdad University site by using ERDAS software

4.2. Results and Discussion

After the production of mosaic for that study area, stereo pair of the final form the ArcView software was used to prepare a digital map with multi layers. The layers, which were formed: roads layer, colleges layer, residential

sectors layer, sport fields layer, parking layer, sub roads layer, gardens layer and urban places layer. After the completion of the drawing layers have been producing digital map in its final form with scale of 1:10,000. This scale is appropriated to the scale of digital aerial photographs that were used in the production, which in turn was to be used to produce the digital map; thirteen points were selected as check points as shown in Table 1 to compute the resulted accuracy Root Mean Square Error (RMSE) by using the following equations:

$$R_i = \sqrt{Rx_i^2 + Ry_i^2} \quad (1)$$

where

R_i: The RMSE for check point *(i)*.

Rx_i: The *X* residual for check point *(i)*, (the distance between the source and the transformed coordinates in *x* direction).

Ry_i: The *Y* residual for check point *(i)*, (the distance between the source and the transformed coordinates in y direction).

Table 1. Ground control points (GCPs) in UTM system

Remark	Y (Easting)	X (Northing)	Sta.
4U.B.	3681323.884	441 959.883	UTM Coordinate of Station 4U.B. the National Grid. 4U.B. (4) University Building.
1	81 531.108	41 509.005	
2	81 553.005	41 676.445	
3	81 591.506	41 966.536	
8	81 505.107	42 321.602	
9	81 233.677	42 354.858	
10	81 117.789	42 067.319	
11	81 071.343	41 858.940	
12	81 109.611	41 702.700	
P1	81 184.942	42 547.451	
19	80 536.217	42 093.680	
20	80 542.393	41 904.364	
21	80 706.598	41 734.572	

Depending upon the residuals, the RMSE in *X* coordinate, the RMSE in *Y* coordinate, and the total RMSE can be computed from the following equations:

$$R_x = \sqrt{\frac{1}{n}\sum_{i=1}^{n} R_{xi}^2} \quad (2)$$

$$R_y = \sqrt{\frac{1}{n}\sum_{i=1}^{n} R_{yi}^2} \quad (3)$$

$$R_T = \sqrt{R_x^2 + R_y^2} \quad (4)$$

where:

R_T: total Root Mean Square Error (RMSE).

n: number of check points.

The resulted accuracy ((Root Mean Square Error (RMSE)) computed by using a special equation (4) as described above was (55) cm.

In this paper we cut the portion of Arial photos for Nahrain University, the size of the cutting portion image is (5.5 × 13.7) cm, [491 × 205] pixels. Figure 5 shows the final corrected image of Al-Nahrain University, which we chose and worked on it to make an initial data base for this university.

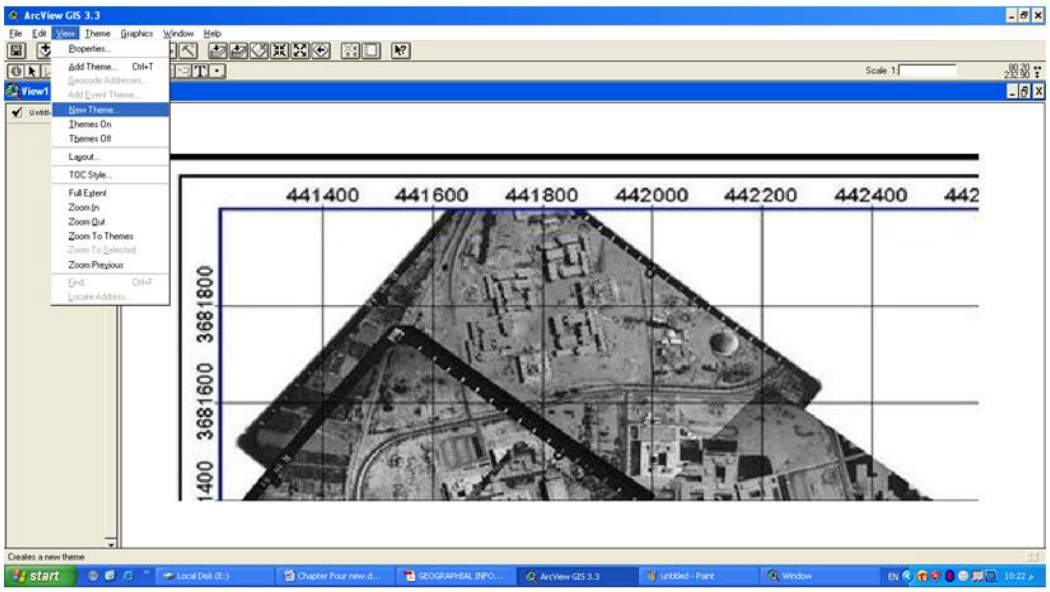

Figure 5. Image selection

By using the facilities of ArcView software, we can draw the following themes: [college of science, architecture department, college of politics, college of engineering, Engineering labs, Lectures halls, Collection of college's buildings, Service buildings, Main roads, Pedestrian roads, The parks, Gardens] as it is clear in the following sections:

1. college of science:

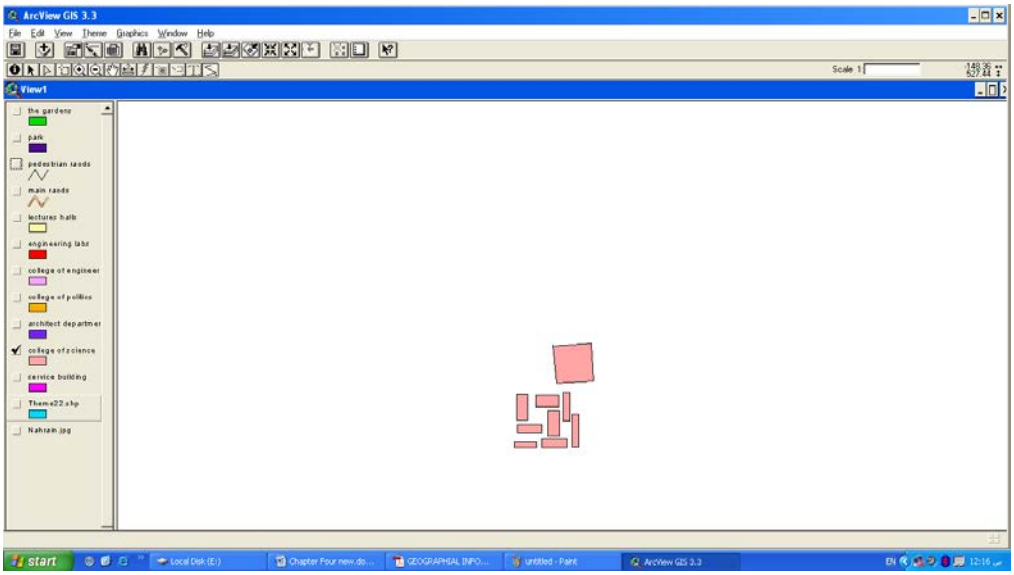

Figure 6. College of science

2. Architecture department:

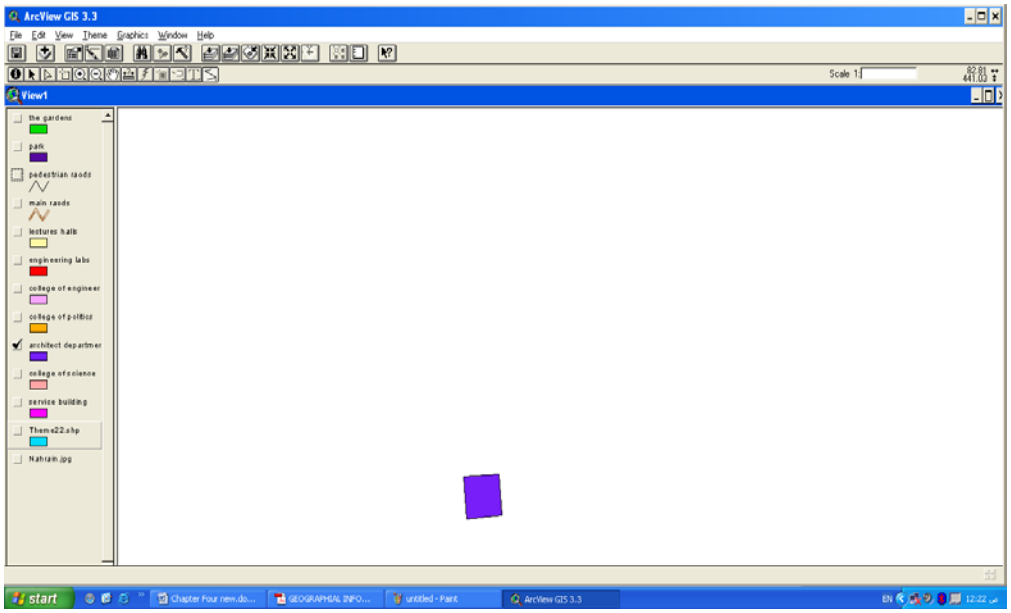

Figure 7. Architecture department

3. college of politics:

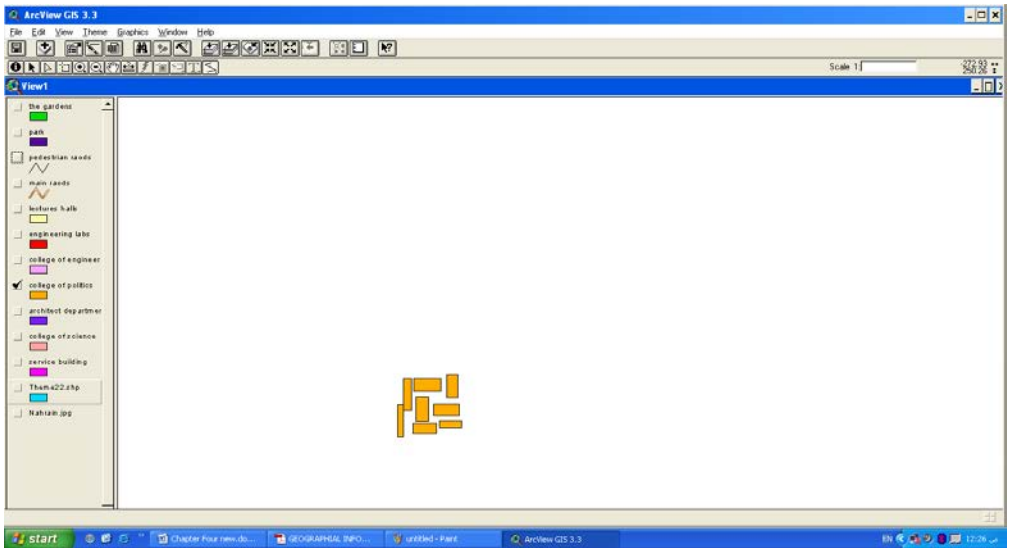

Figure 8. College of politics

4. college of engineering:

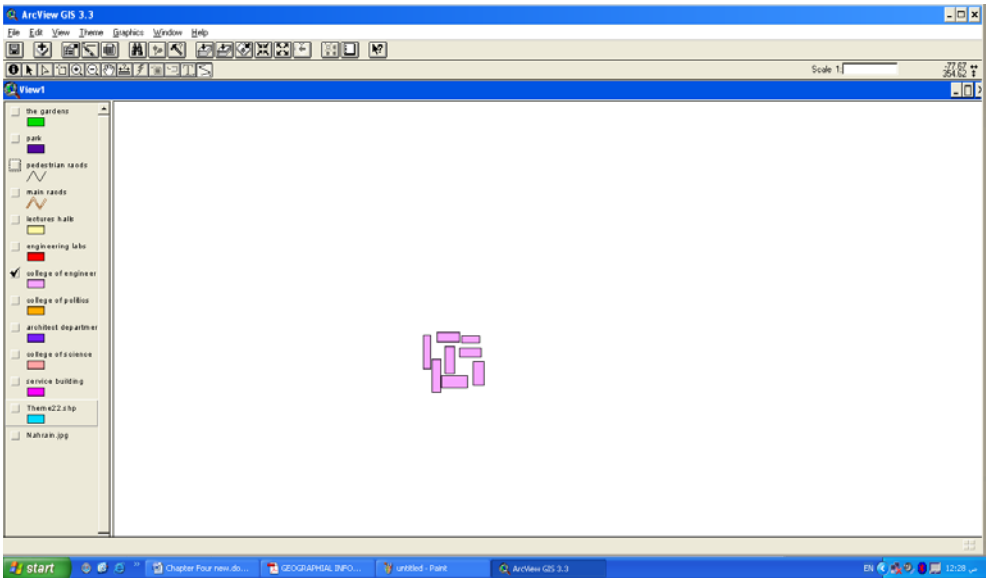

Figure 9. College of engineering

5. Engineering labs:

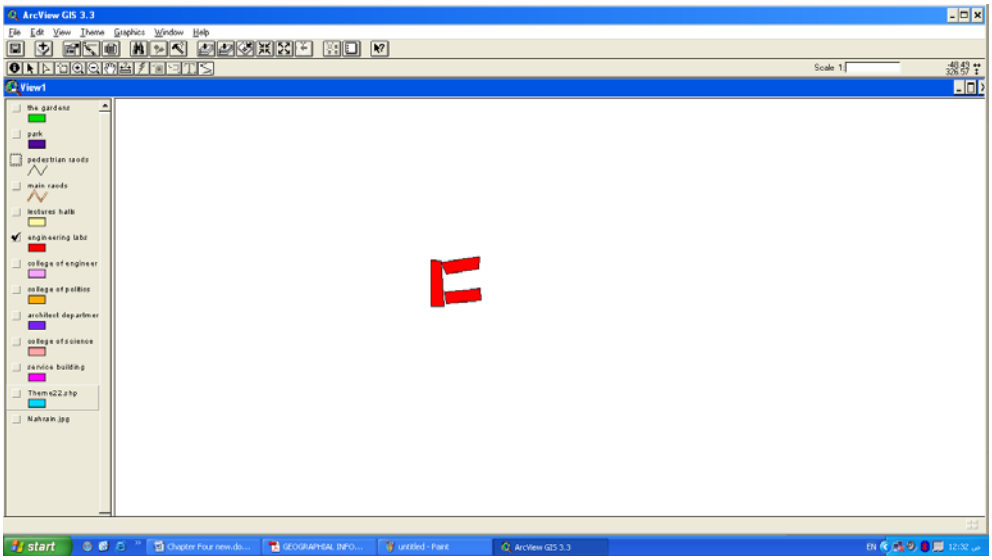

Figure 10. Engineering labs

6. Lectures halls:

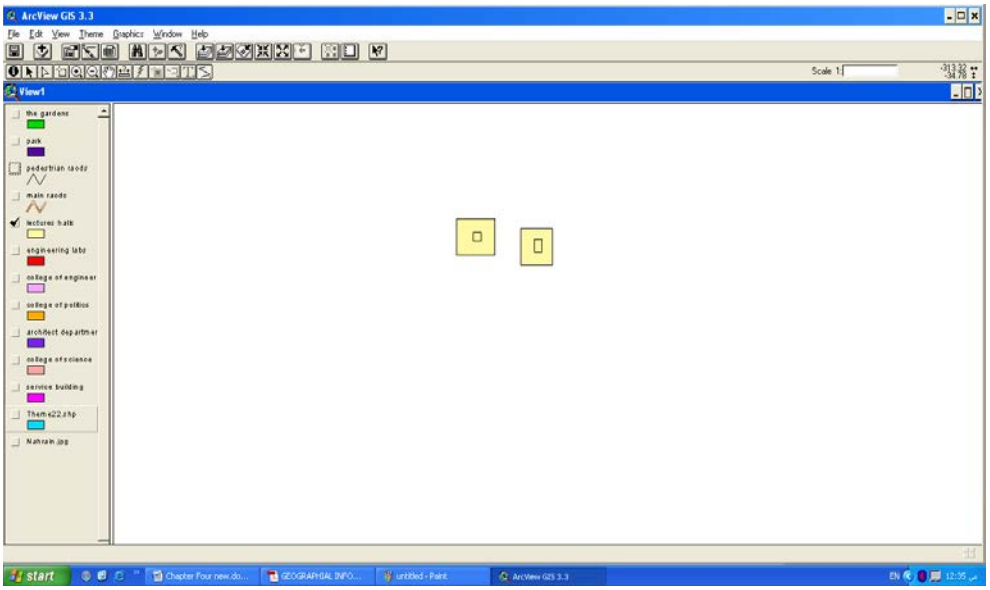

Figure 11. Lectures halls

7. Collection of colleges' buildings:

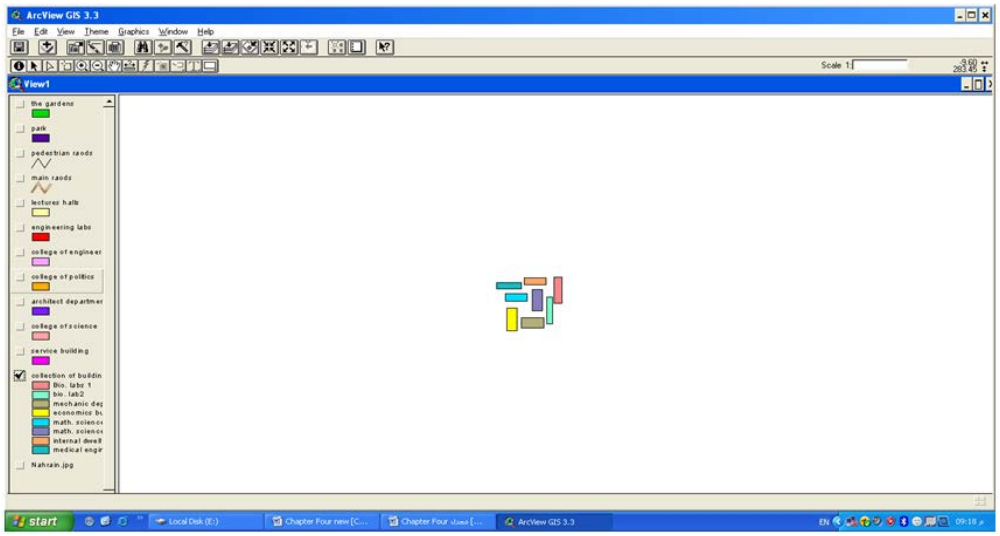

Figure 12. Collection of colleges' buildings

8. Main roads:

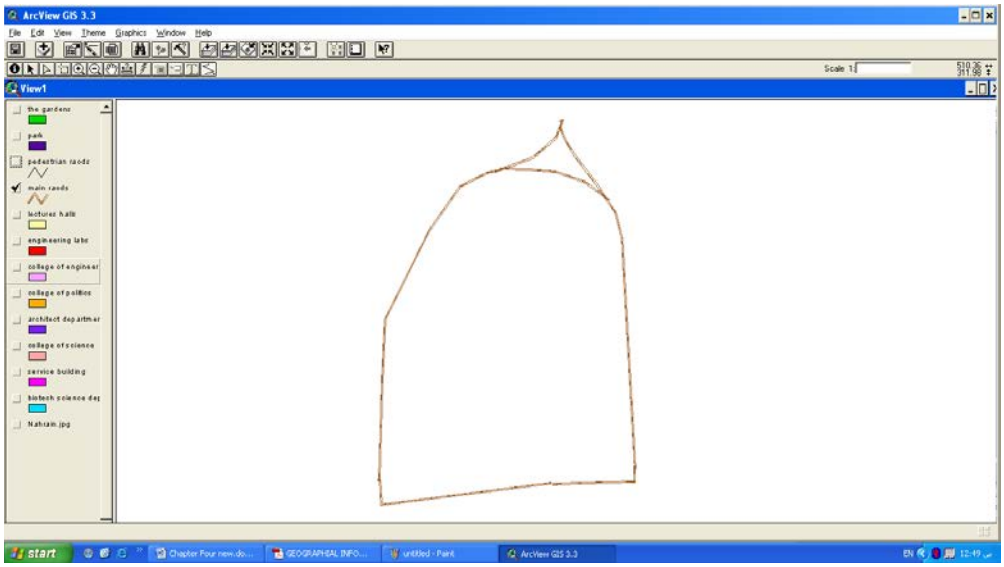

Figure 13. Main roads

9. Pedestrian roads:

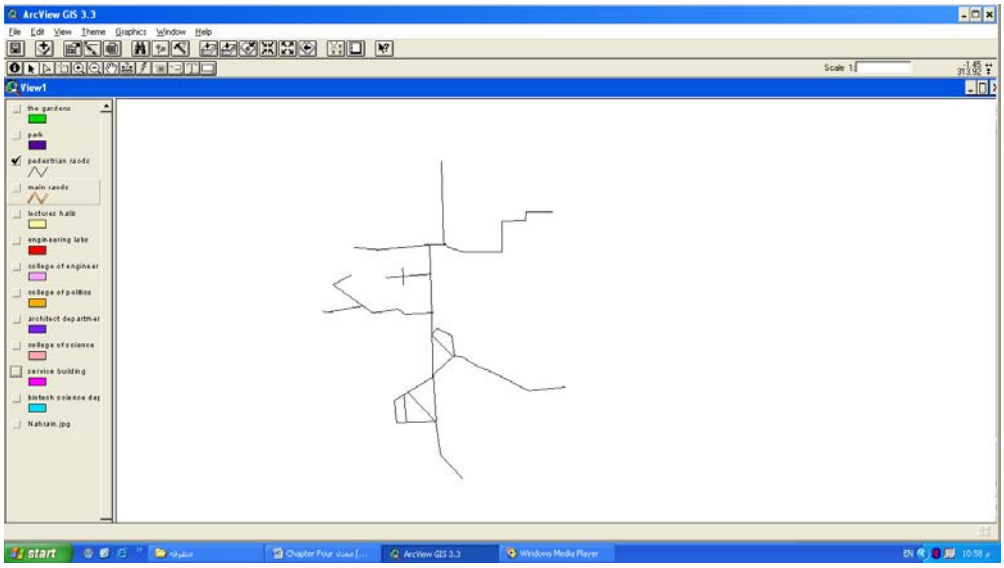

Figure 14. Pedestrian roads

10. The parks:

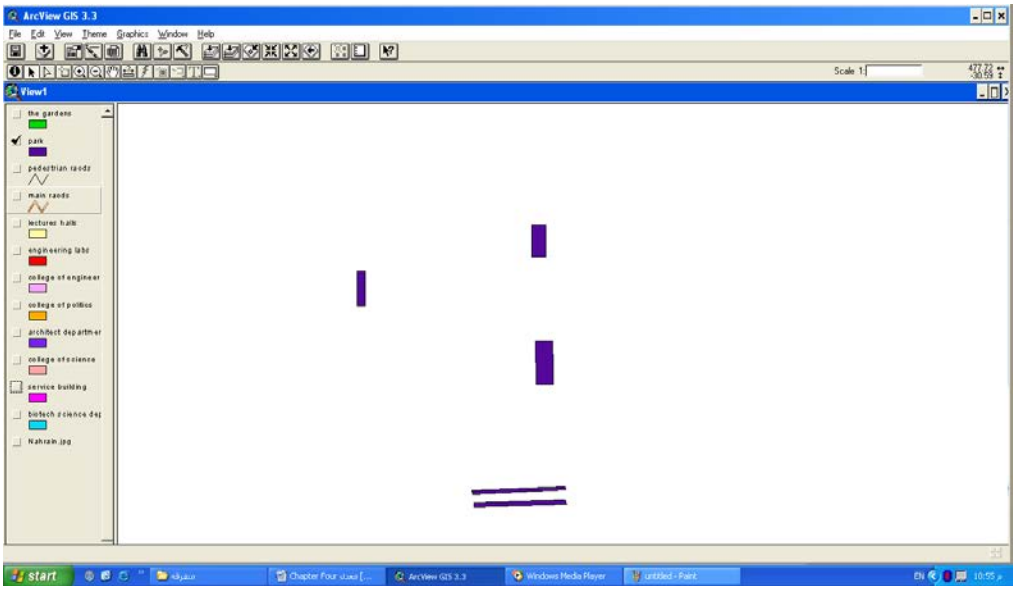

Figure 15. The parks

11. The Gardens:

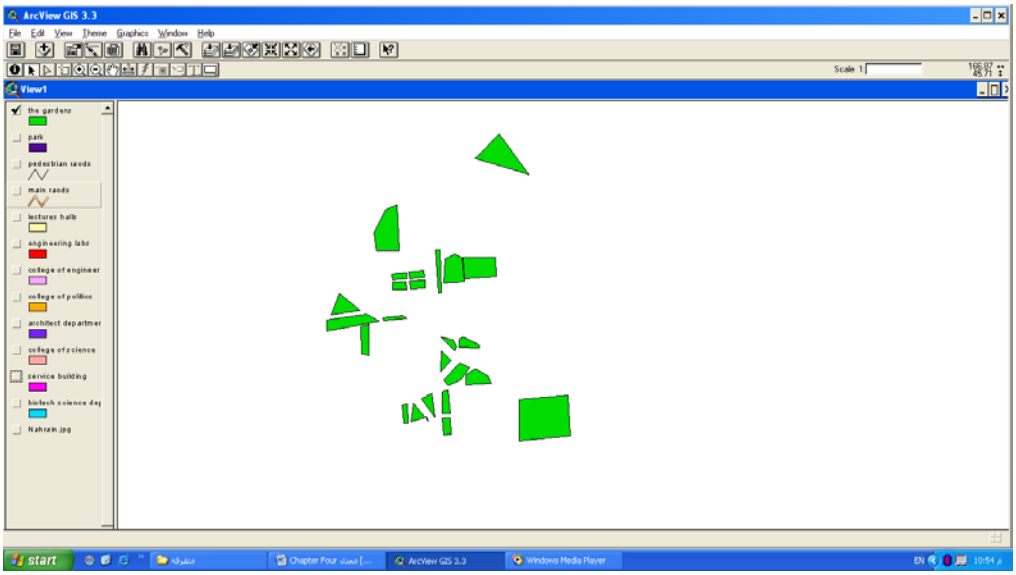

Figure 16. The Gardens

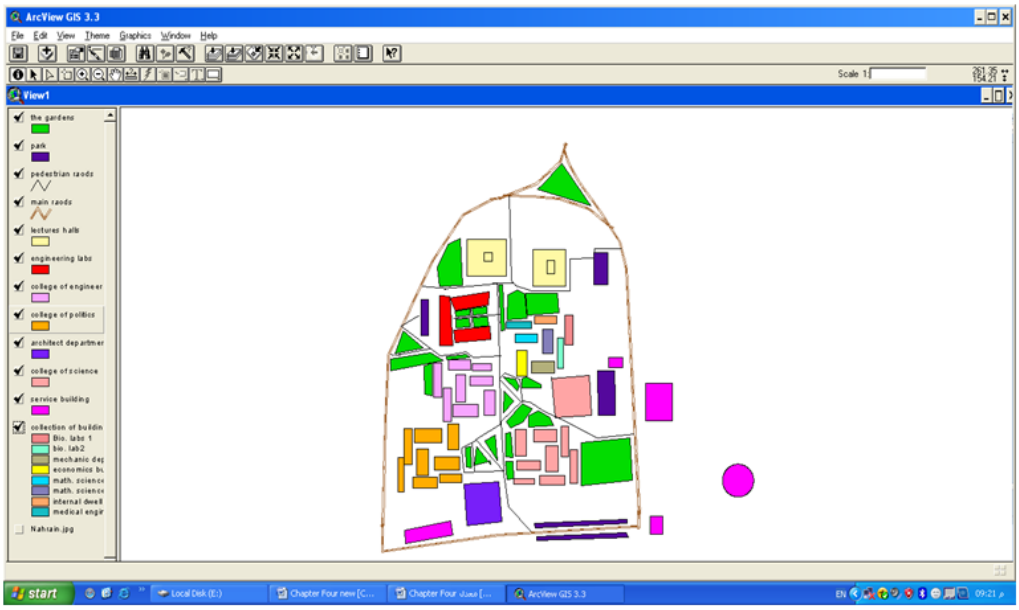

Figure 17. The Whole themes

By selecting all the above themes together, the map will be as shown in Figure 17.

5. Conclusions

Integration of digital photogrammetry applications into Geographic Information System (GIS) databases offers new possibilities for the end-users. This integration allows photogrammetric data collection in a raster / vector based GIS environment. This paper studies the production of mosaic for the study area, stereo pair and the final form the ArcView software was used to prepare a digital map with multi layers. The layers, which were 12 layers formed: main roads layer, Pedestrian roads layer, parks layer, Gardens layer, Service buildings layer, college of engineering layer, college of science layer, college of politics layer, architecture department layer, engineering labs layer, collection of colleges buildings layer and lectures halls layer. After the completion of the drawing layers, the digital map has been produced in its final form.

The resulted accuracy ((Root Mean Square Error (RMSE)) computed by using a special equation (4) as described above was (55) cm, which was suitable for the production of large scale mapping. The selected scale map is suitable and appropriate for the scale of aerial photographs that have been used in the production of the map, and the possible use of the map produced and used at any time possible and updates its data using Geographic Information System (GIS) software.

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