NEW SURVEY TECHNOLOGIES FOR PRODUCTION OF GIS MODEL OF THE ANCIENT ROMAN JERASH CITY IN JORDAN

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KEY WORDS: GPS, GIS, DTM, ORTHOPHOTO and 3D MODEL

ABSTRACT

Jordan is a very rich country in containing famous and important archaeological sites, some of these sites are unique as Petra, others are very important such as Jerash. The Department of Geomatics engineering at Al Balqa applied University had started to use modern survey technologies such as GPS, satellite images, photogremmetry and classical instrumentation to build a GIS and precise base maps for these archaeological sites. Initial measurements using GPS and satellite images have been started in Jerash city site.
Jerash is an ancient Roman city inhibits important and numbered monuments. Due to the population growth and the expansion of the modern city, many important monuments are lost and disappeared. Therefore the monitoring and the digital documentation of the site, including both the built and the natural environment, are essential for the conservation and protection of the cultural heritage of the ancient city. Our interest in this work is to produce a modern base map and orthophoto of Jerash city to be used in GIS modelling. This orthophoto will include the residential areas around the archaeological site. The procedure of using High resolution satellite images to produce the DTM and the orthophoto will be explained. GPS measurement is also used for precise measurements in the area. Finally, GIS and 3D model of the residential area will be produced to analyse the expansion effect of the modern city on the ancient Roman site.

1. INTRODUCTION

Jordan is one of the most important countries in the Middle East rich in archeological sites. In the recent years there is an increase interest in the documentation and reservation of these sites for cultural and economic reasons. Archaeological researchers these days are aware of the capabilities and the importance of modern technologies such as satellite images, remote sensing, Photogrammetry and GIS (Grosman, 2000) to their work. New survey technologies play an important role in the mapping and the management of the archeological data (Kvamme, 1999; Bewley and Raczkowski, 2002).
The objective of this work is the production and the development of a base map for the old and new Jerash city. This base map could be used in the archeological GIS map at different levels:
At the first level (national level) it allows the user to zoom into different sites in the country and select sites based on different criteria. This includes basic information on the site, old and new images and information about related objects in the whole city.
At the second level displays a detailed map of the site and its general components.
At the third level it portrays an in-depth data of selected monuments and displays a plan of the structure which contains the monument as well as an overview image.
And at the last level is the creation of 3-D model to be displayed with the possibility of a walk through visit.
To achieve these levels we have produced the DEM and orthophoto using some satellite images, by means of digital photogremmetry software. The DTM produced is used to create a 3D model of Jerash City (Baltsavias, 2001). PCI Geomatica is used to create the DEM from SPOT image, terrascan and terramodel are used for DEM editing and classification to obtain the DTM, and finally ArcScene is used for merging of DTM with building to create the final surface model. a validation of generated DTM is done by direct comparison with Rapid static and kinematic GPS measurement performed at the interested area.
The High Resolution Stereoscopy (HRS) instrument on SPOT 5 is dedicated to simultaneous stereopair acquisition (Vadon, 2003). The generated DEM from source data is performed in three basic steps: setting up sensor mathematical model to reflect the relationship between points on the ground and pixels on the image, performing image matching to get a disparity map, and finally computing each point's altitude.
The most important step in DEM extraction is the image matching. For a given pixel on an image, its corresponding point on the other image is generally searched within a window by image matching (Baudoin, 2003).
SPOT data is highly used because of its geometric resolution and secured availability, and the stereo capability of the sensor. This data can supply substantial topographic and thematic information to GIS. In this work we are not interested in discussing the photogremmetric aspects but in using the software to get reliable results and also to use the capabilities of our Digital photogremmetry lab in modern techniques in documentation and 3D modeling.
The produced digital map by means of satellite images, digital photogremmetry and GIS, could be used for classifying and analyzing spatially distributed archaeological, geomorphological, and ecological data, for historic and prehistoric studies.

1.1 Site Description and Historical Back Ground

The ancient city of Jerash (Gerasa or Jarash) is located in Jordan (Figure.1), and has a remarkable record of human settlement since Neolithic times. The archeological area of Jerash is about (1.5km*1.0km), and has important archeological details. Few ancient cities are as complete as Jerash, a city complex that once was a thriving commercial zone and part of the Decapolis. Built in the 2nd century BC, the city was conquered in 63 BC by the Roman General Pompey. Jerash is a high-profile archaeological site with theatres, public squares, baths and temples, the great majority of the monuments are unrecorded and unprotected and are daily eroded by development projects.
The monitoring, preservation, management and the digital documentation of the site, including both the built and the natural environment, are essential for the conservation and protection of the cultural heritage of the ancient city. Important monuments in the site begun to disappear, due to the wide acceleration of urbanization around the archeological sites, Moreover the environmental hazards are adding another dimension to the problem.
Using GIS, DBMS, and WAN technologies, the geomatics engineering department at Al-Balqa applied university with

collaboration of another institution seek to develop a more powerful planning tool, to reduce damage to cultural properties throughout the state, to allow faster and more informed cultural resource consultations among government agencies, and to lower the costs for developers in complying with cultural resource regulations.

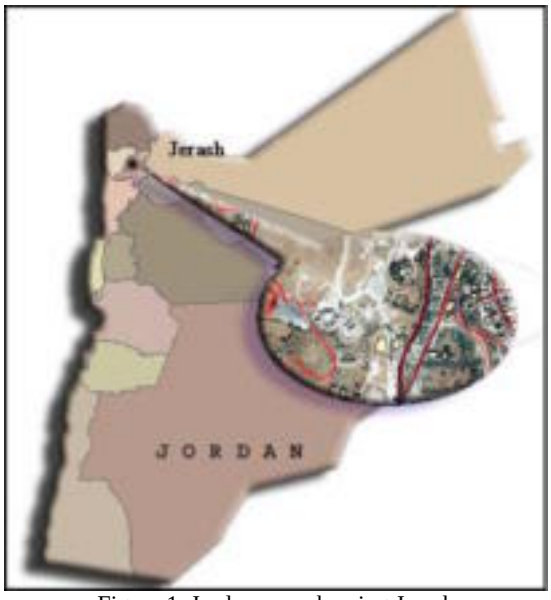

Figure 1. Jordan map showing Jerash

The GIS capabilities will also enable land managers to develop predictive capabilities regarding archeological site density and visibility, and use that information to advise developers on project locations throughout the department of antiquities in Jordan.

2. GIS AND ARCHEOLOGY

The infrastructure will bolster ground breaking research into using GIS to assess the environmental and social risk to classical archeological sites (Niknami, 2002). The Department of Antiquities of Jordan use JADIS (Jordan Antiquities Database & Information System) program for archeological database. However, the data collected for JADIS database is fairly general, Meanwhile in our project we intend to produce a real, precise and detailed geospatial database for the ancient Roman settlement of Jerash. Completion of the Jerash geospatial database and its regional setting is the most import goal. Then database could be delivered to JADIS to be used and managed by the Department of Antiquities.
Subsequent web-based mapping (e.g., ArcIMS) will enable data access and visualization by non-expert GIS archeologists involved in the larger excavation team. In the second stage, spatial data from the larger geographic context will be used to assess the impact and risk to the site.
Applications of GIS within classical archeology are completely new and will be enhanced by the proposed GIS data model. The research will develop new but widely applicable methodologies for site risk assessment, the results of which will contribute to developing policies for the preservation of sensitive archeological sites.
GIS technology will show the exact coordinates of the geographic location of the archeological site and all the monuments and their distribution within the site. We will offer virtual reality visits (using virtual reality technology) to allow people to visit some of the most important monuments in the site, hoping to offer complete virtual reality visits in the near future for every part of the site. Finally, we intend to allow access to our data to everybody through a website.
The GIS data model and the base map will help greatly the government officials working in the field of archeological heritage management in addition to all scientists interested in the field as well as tourism in the country. The archeological map offers a valuable device for better managing, monitoring and updating the sites as it will never become a static map (Harrower, 2002). It will always allow the updating and feeding of data according to the changing conditions of the site. It will also enhance the capability of those working on actual conservation and restoration of the sites and their monuments. As soon as, the data integrated in the GIS, a map can give a global view of the status of the sites as whole and detailed information on a specific monument as well. The updated map will always better aid the researchers, professionals and students as it disseminates information on our archeological heritage especially in an accessible web site.

3. METHODOLOGY OF BASE MAP GENERATION

3.1 DEM generation in PCI Geomatica

PCI Geomatica has a special module for DEM generation from SPOT 5 (PCI Geomatics, 2001), the procedure of using PCI orthoengine is as follows: First, an initial setting of the project is done by the definition of the coordinate system and reading the orbital parameters from the raw SPOT data. Second, is to define the GCP points (at least 6 GCP), then adding tie points in automatic or manual. Third, is creating epipolar image. Finally, is the automatic extraction of the DEM. Spot images used were 5m resolution and the 10 GCP's used were surveyed by rapid static GPS measurement, with good precision and good identification of the pixel on the two images.
The PCI give good possibilities to select the pixel, and it was a good idea to select the joint small roads in the images. Tie point in manual or automatic mod is used to improve the image matching between the two stereo images. The residual of bundle adjustment was less than 2.5 m in all the 10 GCP's and for 30 tie points was less than 1m.
The final errors as reported in the software were: the RMS error report on epipolar DEM file was 2.1 m, and the RMS error report on geocoded DEM file was 3.3 m.

3.2 DEM editing and Validation

The generated DEM is edited initially using PCI geomatica software (see Figure 2), then the interested area is exported into Terrascan format). Classification techniques are used in Terrascan program to eliminate the error points and to obtain the ground points. Terramodel program is then used to create the contour lines using just ground points.
DEM validation is done by direct comparison between GPS measurements (Rapid static and kinematic), and the generated DEM (see figure 3). The differences were ranging between 2 4 meters.

3.3 Orthophoto generation

The DTM and the Ikonos satellite images, were used to produce the orthophoto in PCI geomatica, the procedure of the ortho generation was simple and the results are shown in Figure 4. The produced orthophoto was used to digitize all the details in the map and to be the base map of our GIS of Jerash city. Field surveys were done to collect data about all the landmarks in the

area and the building heights as well.

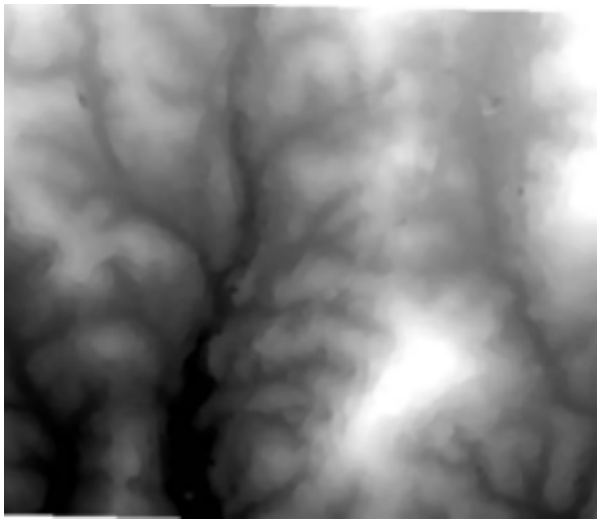

Figure 2. DEM of Jerash area, PCI Geomatica

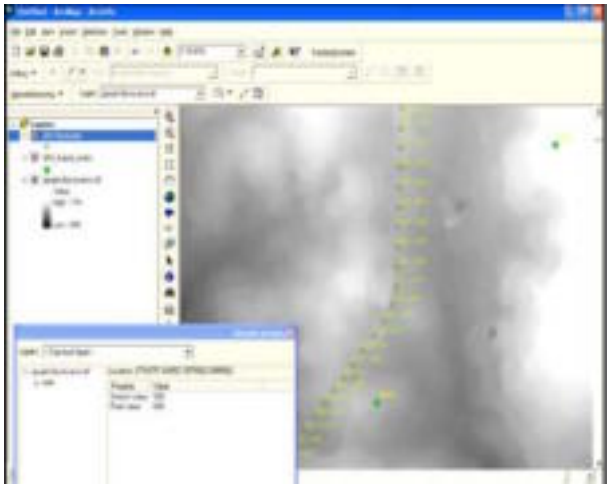

Figure 3. DEM validation, by comparison with kinematic GPS trajectory

Figure 4. Orthophoto base map of Jerash city

3.4 3-D model of the city

Using the DTM, the digitized buildings and the attribute of their heights, we have created 3D model of Jerash City in Arcscene (see Figure 5). This model could be used in the analysis and archeological studies, such as line of sight between the ancient and the new city. This First 3D model of the area will help the Department of antiquities to perform spatial analysis of the whole city (ancient and modern).

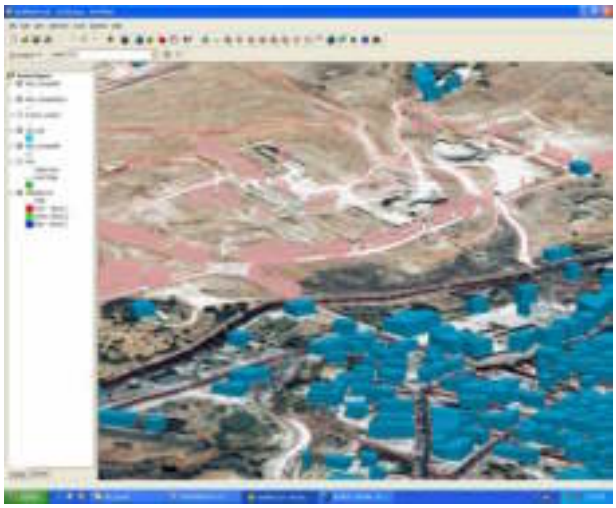

Figure 5. 3 D model of Jerash city with some created layers

4. GIS DATA MODEL

The department of antiquities in Jordan use the stand alone program JADIS for data base management of the archeological sites (see Figure 6). JADIS Data Entry Program is a stand alone MS Access program, that is designed by Dr. Gaetano Palumbo, (http://archaeology.asu.edu/Jordan/JADISGIS.htm#MainJadis). The program is not enough to be used as GIS. And also most of maps used by the Department of Antiquities of Jordan are not precise, and they have general information, and need to be updated to satisfy the archeological studies.

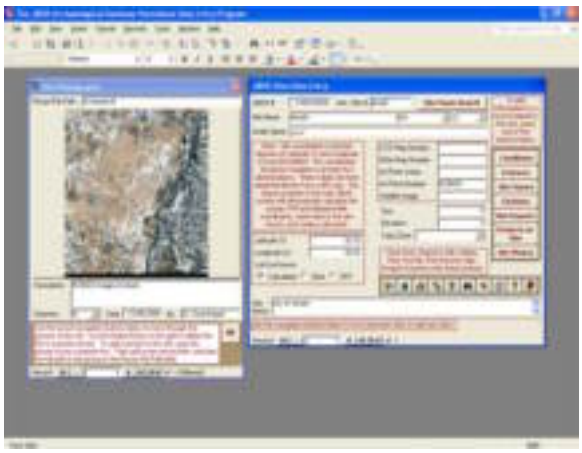

Figure 6 – JADIS data entry program

As the interest of Archaeology is in the tempo-spatial matter, many of the techniques and idea of Geo-Informatics are quite effective (Lertlum, 2003). Advantage of using these tools and techniques are in: 1.data integration, 2.quantitative analysis,

3.tempo-spatial analysis, 4.presentation, 5.sharing information. Advantages of Geo-Informatics techniques are parallelized with the work flow of archaeological study (see Figure. 7).

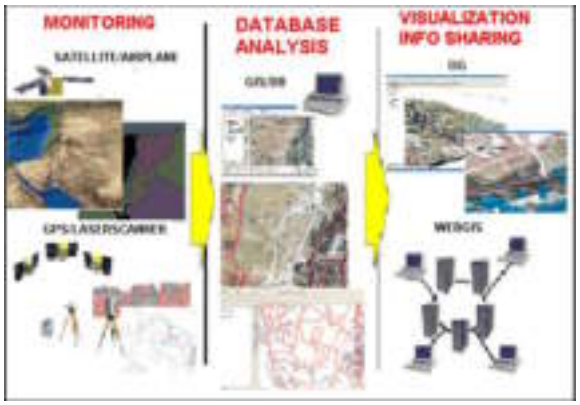

Figure 7. Work flow and the Geo-Informatics techniques, (Lertlum, 2003)

4.1 Monitoring

Monitoring, namely measurement, mapping are frequently required in archaeological survey. Different techniques should be applied for different scaled matter. The archeological maps in Jordan are not precise enough to show all the archeological details and most archeological maps are not published in satisfying scale. Satellite images and aerial photographs can be of great help in this case. These images contain not only the distribution of the ruins but also many important information of geographical features.

Precise monitoring and taking record of the site structure is a time-consuming work to be done in archaeological excavation, especially when the structure is three dimensional. In such case, photogremmetry and laser scan equipments would be quite effective in obtaining three dimensional data of the site structure and in monitoring small objects.

4.2 Database and Analysis

Archaeological study requires many types of data, such as geographical maps, topographical maps, archaeological maps, not only spatial data, but also attribute data such as types of archaeological founds. Applying GIS in archaeological database enables integration of the data and support unified data management. Another advantage of constructing Archaeological GIS is that GIS contains both aspects of database and analysis tool. Furthermore, Info-Sharing will be more effective using WEBGIS technologies. Interoperation of data will encourage the interdisciplinary study and mutual understandings.

4.3 Visualization and prototype model

Computer graphics can present results of analysis and reconstructed ancient-environments comprehensibly. Computer aided visualization in archaeology is called "Virtual Archaeology". 3D model of each archeological object give the possibility to construct prototype model of each monuments (Grün, 2002). .

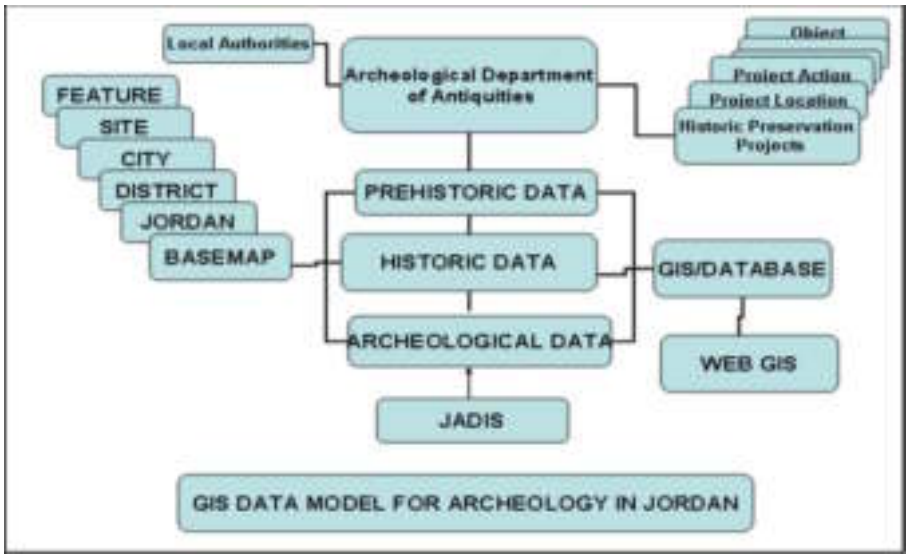

Figure 8. The proposed GIS data model

Based on Geo-Informatics techniques and the integration between Geomatics and IT technologies, we propose the GIS data model (see Figure 8), for the archeological site of Jerash. Such models should be adopted by the Department of Antiquities of Jordan. JADIS data entry program should be considered as data resource, when ever archeological attributes are needed for research, planning or education purposes

5. SPATIAL ANALYSIS

GIS systems allow the overlaying of spatial data from different sources, using different structures and resolutions, thus providing a tool for modeling spatial data.

The first analysis we were able to perform was the evaluation of the urban expansion of the modern city around the ancient city. Using GIS Technologies the study was done by overlying the layers created from the aerial photo in 1981 and the satellite images in 2004 (see Figure 9). As you see in Figure 8 the expansion of the city is in the North West direction meanwhile, there are many archeological sites still not excavated in that area. The department of antiquities is aware of this expansion, but the prevention of this expansion requires the cooperation between several authorities. Using GIS model and the periodic

satellite images is the best way for monitoring and analyzing the modern city expansion over the archeological site. Continuous monitoring of these phenomena is possible using our database through our university or in collaboration with other interested international institutions.

The archeological site entrances are poorly designed to serve the tourists. The created GIS with 3D model and the landscape will help in planning better entries, rest areas, and may be an audio visual theatre and library to talk about the site.

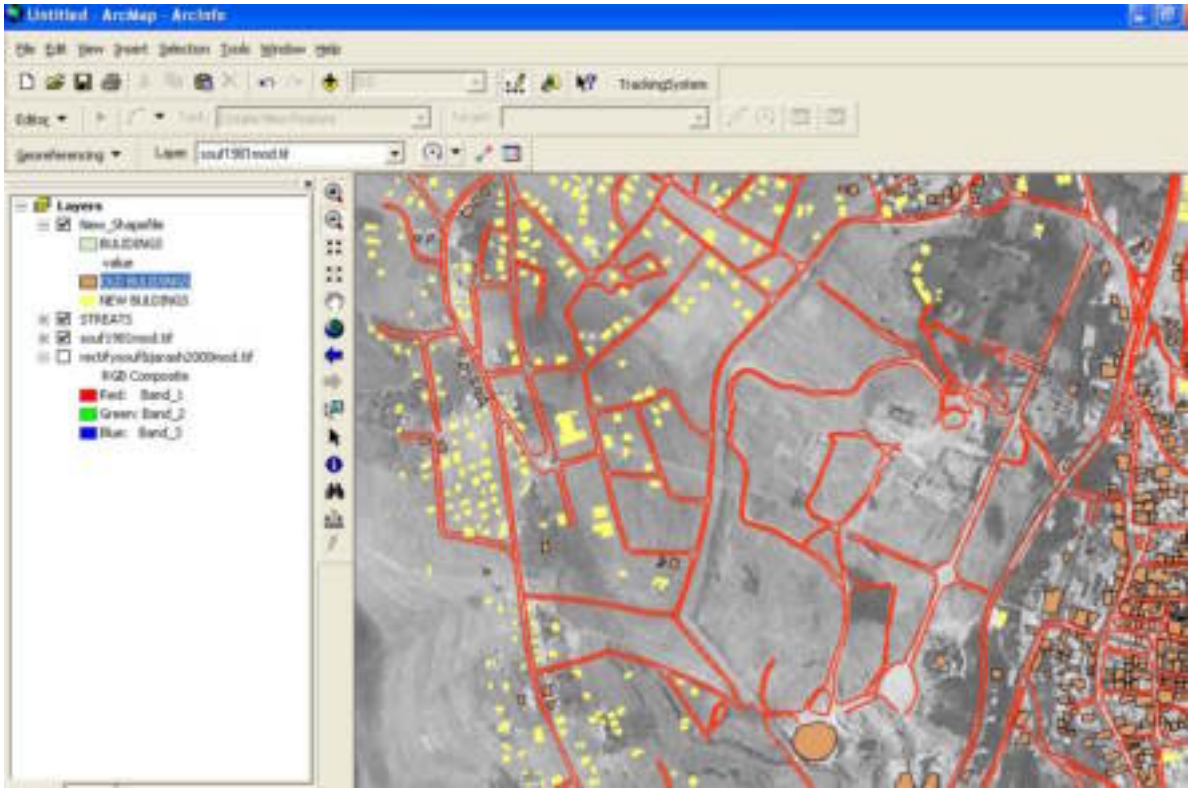

Figure 9. The Expansion of the modern city around the archeological site of Jerash during the period 1981 to 2004

6. CONCLUSIONS

The archeological site of Jerash city is important and has a great deal of archeological details which deserve the efforts and the work for its database collection and management. GIS is already proven to be extremely helpful and effective in the field of archaeology. It allows archaeologists and technicians to analyze all the existing data and to look for patterns amongst the different layers of spatial data. The produced digital base map by means of satellite images and digital photogremmetry is new and fast technique, which allows the updating and the production of all the needed archeological maps. This base-map could be used for classifying and analyzing spatially distributed archaeological, geomorphologic, and ecological data, for historic and prehistoric studies. The area of Jerash needs more attention and collaboration between different authorities for controlling and planning the protection and the conservation of the archeological site. The produced base-map and the 3-D model well help more in performing more advanced analysis and studies.

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ACKNOWLEDGEMENTS

The author gratefully acknowledge Dr. B. Sadoun and Eng. S. Aqel for their support during this work.