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Archaeological Documentation Based on Geomatics Techniques for Jerash Historical Site

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Abstract: The archaeological heritage constitutes the basic record of the past human activities; the documentation and management of archaeological heritage and historical sites become very important issues. The uses of new efficient and accurate techniques are very important for achieving the previous goals. In this paper, orthophoto, field surveying and Geographic Information System (GIS) were integrated for documenting the historical and archeological sites in Jerash city. A very precise two dimensions (2D) and three dimensions (3D) Digital models were built using aerial photographs, GIS and a precise Laser Distomate. This leads to a 3D representation of the studied site for each part of the historical site. This will allow the restoration in case of slow deterioration caused by environmental factors or sudden destruction caused by earth quakes or other natural disaster or war or vandalism. After validation, the obtained results showed all details with high accuracy.

Keywords: Archaeology documentation; 3D model; orthophoto; field surveying; GIS; laser distomat TLM200; AutoCAD.

1. Introduction

In the past, the main task of preserving and documenting archaeological sites were based on the specialist in archaeology, but now, this is based upon effective collaboration between professionals from many disciplines in particularly the geomatics discipline. Geomatics techniques play an important role to preserve archaeological sites which is considered the basic record of past human activities (Rzouq et al, 2006).

Architectural monuments are widely used and endangered by long term influences like traffic or air pollution or destructive events causing heavy damage like earthquakes damaged, or completely destroyed, the amount and quality of any surviving documentation becomes highly important (Toz, 2000). Therefore, it is necessary to document the actual state of architectural monuments in a manner which opens the opportunity to restore the monuments in case of heavy damage.

The establishment and visualization of large, reality-based 3D landscape and city models has received significant attention over the last two decades both in the scientific and the commercial community. Reality-based 3D models are being acquired in a variety of application domains ranging from archaeology, urban planning and simulation to computer games. Each of these domains has its specific requirements which led to the development of application specific

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solutions focusing on the primary needs of each specific domain. In some domains the primary focus is placed on 3D objects with a maximum level of detail and a high degree of realism (Nebicker, 2004). Al Rzouq et al (2007) studied archaeological site of baptism using the integration between many disciplines: photogrammetry, GIS and geophysics. They built a three model of baptism site along Jordan River in Jordan. They emphasize on the identification of existing archaeological sites and they generate map for tourism purposes where complete listing of all historical sites was conducted.

Many studies were conducted by Nebicker (1997, 2001, 2002, 2003) concerning the application of geomatics in building three models in particularly for urban purposes. The reconstruction of 3D objects has reached a semi-automated level with reasonable production rates. Their works were focusing on the integration of multiple sensors, namely aerial imagery and laser scanning in order to further increase the robustness and productivity of the 3D data acquisition process. The most important field nowadays is the efficient acquisition, correction and assignment of object textures (Haala and Brenner, 2001), (Grün et al., 2002).

3D Data Modeling and Management-Over the last few years we have seen an increasing amount of work in the field of modeling and managing geospatial 3D objects. A number of projects were focusing on the modeling and management of complex 3D objects in a primarily relational Data Base Management System (DBMS) environment, e.g. (Pfund, 2001), (Wang, 2000). Some ongoing projects employ object-relational concepts to address the issues of topology (Oosterom et al., 2002) and integrated 3D geo-data management within a 3D GIS framework (Zlatanova et al., 2002; Kraak 2003). The main objective of this paper is to build a real 3D with high accuracy for documentation purposes in international system of projection. Hendrickx et al (2011) used stereo-scopic images taken from a macrodome for heritage documenting the site of Tuekta burial mounds in the Russian Altay using photogrammetery techniques and other geomatics techniques such as GPS and Total station.

Al-kheder et al in 2008 used 3D laser scanning and digital photogrammetry for developing a documentation system for desert palaces in Jordan reporting all spatial information for each palace. Their approach was demonstrated by generating high 3D textured Digital models for Amra and Kharanah palaces. Alexakis et al (2011) used the integration of geomatics and DEM analysis for the reconstruction of the landscape habitation of Thessaly in central Greece during the Neolithic period. In their study, field survey, statistical analysis of coring data, spatial analysis of environmental parameters in GIS and image processing techniques of satellite images and DEMs were carried out to contribute to the detection of the Neolithic settlements and the reconstruction of Neolithic landscape.

The 3D reconstruction of building has been an active research topic in computer vision as well in digital photogrammetry and other geomatics techniques nowadays. 3D model are increasingly necessary for urban planning and archeology documentation (Eurvey and Vosselman, 2000). Dorffiner and Forkert (1998) present 3D object model in which the shape of the object surface is stored adjoining surfaces paths approximates the object itself. The second part is the photo-texture which is transferred. Close range photogrammetry techniques have long been used as a tool for collecting 3D model information of cultural heritage (Yastikli, 2007). Lerna et al (2008) outlined the feasibility and completeness of architectural project management with GIS related technology.

They found that there is no doubt of the benefits of linking the graphical database with the alphanumeric information. Karsli et al (2003) integrated digital photogrammetric techniques and GIS to constitute 3D Digital model of historical building to conserve it as a simple architectural information system.

Active Remote Sensing was also used in this type of researches; the combinations of intensity and range sensors provide efficient and flexible solution if the collection of textures 3D models for heritage sites is aspired Halla and Al Shwabkeh (2003). Halla and Brenner (2001) have built a three realistic model using Lidar technology.

The main objective of this paper is to build 2D and 3D digital models for Jerash site with very precise coordinates using photogrammetry, GIS and field surveying techniques. This will document these heritage sites.

2. Description of the study area

Jerash is a very old Jordanian city, located at 48 km north of Amman and nestled in a quiet valley among the mountains of Gilead, It is the grandeur of Imperial Rome being one of the largest and most well preserved sites of Roman architecture in the World outside Italy. To this day, its paved and colonnaded streets, soaring hilltop temples, handsome theaters, spacious public squares and plazas, baths, fountains and city walls pierced by towers and gates remain in exceptional condition. A series of earthquakes in 749 AD did serious damage to the city and hastened its decline (Atlas Travel & Tourist Agency, 2008).

3. Materials and method

Software

The following software's were used in this work:

a) LPS photogrammetric software to build the orthophoto.
b) Liscad Software to process and to view the field surveying works.
c) GIS to digitize all features in the study area.
d) AutoCAD civil engineering to build two dimensional data and three dimensional data.

Data collection

Different types of data were used for this research:

a) Two aerial photographs scale 1:10000 from Royal Jordanian Geographical Center (RJGC) acquired on 2002.
b) A large number of GCPs points collected by earliest Total Station.
c) A large number of elevation heights collected by Laser Distomat TLM200.

4. Methodology

The followed method consists of:

i) building an orthophoto for the study area,
ii) building a digital terrain model for the site of the study area using aerial photographs,
iii) building a network of points defined in x, y and z using A total station,
iv) building a database using GIS software for the study area after that,
v) building a 2D using auto CAD civil engineering software for each part of the site,
vi) installing the obtained 3D model of each part into the study area site using GIS software.

The following flow chart describes the followed method (Figure 1).

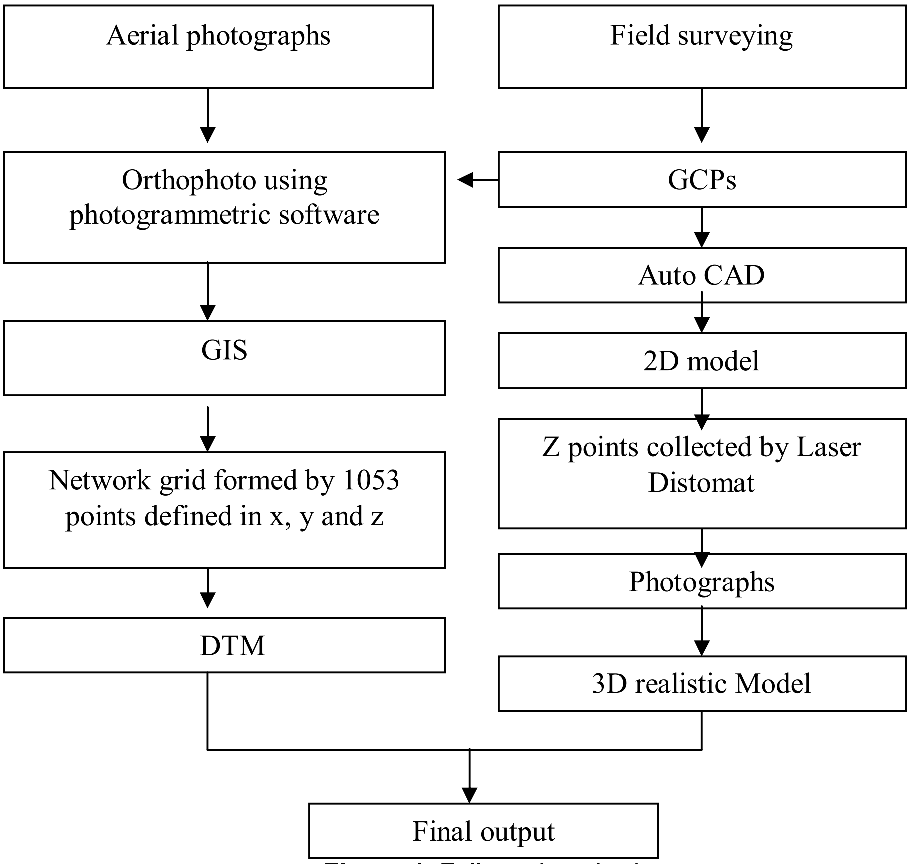

Figure 1. Followed method

5. Results and discussion

Photogrammetry is an important tool to eliminate the parallax in aerial photographs and to build an orthophoto and 3D digital mode.

In this work, an orthophoto was built for the study area site using two aerial photographs images scale 1:10000. The Route Mean Square (RMS) error is inferior to 0.30 meters. Contour lines for the study area were built using LPS software. A lot of GCPs in the overlap area of the two aerial photographs obtained from Royal Jordanian Geographic Center (RJGC) were necessary to eliminate the parallax and to provide a system of projection (UTM WGS84) and a system of coordinate.

Figure 2 presents the obtained orthophoto for the site of study area.

A land surveying using a very sophisticated total station was used to collect very precise points defined in x, y and z for the site. A network grid with 1053 points defined in x, y and z were created (Figure 3). This allows the creation of Digital Terrain Model (DTM) for the site of study area using GIS software. The laser Distomate TLM200 is laser-measuring tool. It is a step up for the professional. It is easier and quicker to use than traditional tape measurers and more accurate than sonic style measuring devices. It has a large LCD screen and ergonomic rubberized grip for comfort and impact resistance. Just aim, push the button, and measure. The TLM200 is able to calculate distance, area, volume, and 2-point Pythagorean. It is accurate to ±1/8-inch per 100 feet. It's more versatile than other methods; able to measure indoors, outdoors and hard to reach spots such as vertical distances. It's safer than other methods; avoid hazardous measuring procedures and measure safely with the TLM Measurer.

Figure 2. Orthophoto built from two aerial photographs

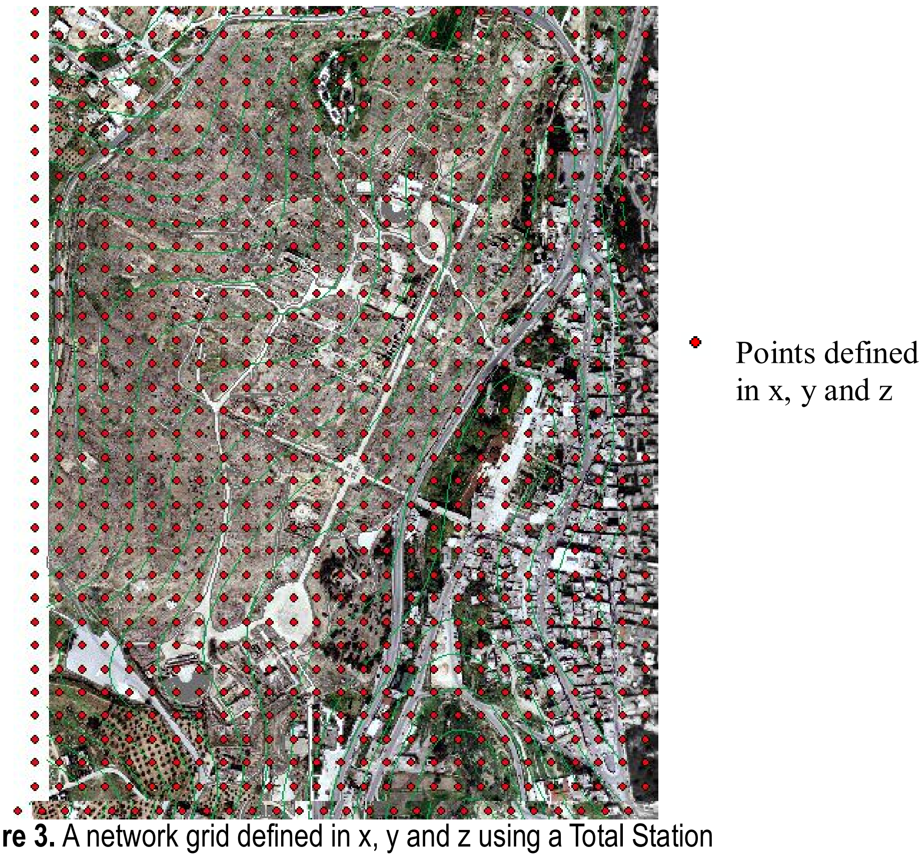

Figure 3. A network grid defined in x, y and z using a Total Station

The important monuments were drawn using AutoCAD 3D civil engineering software. The bottoms and the top of each detail were measured by the Laser Distomat which is an instrument for measuring the heights without needing to a reflector.

These measurements were necessary for the AutoCAD Civil engineering to raise the z elevations with high accuracy. Thus, we obtained a 3D digital model without texture.

GIS is an important tool for planning and management of historical sites. It includes a group of very feasible procedures and tools facilitate the encoding, analysis, edition, modeling and the exit of spatial referenced and semantic data. It plays a role to facilitate the inventory, evaluation, preservation and documentation of archeological sites.

The previous orthophoto enables the digitizing of all important spatial plani-metric information as layers for the site of study area. The attributes of features were created and linked to their spatial information. A Triangulation Irregular Network (TIN) was created which enables the creation of DTM for the site.

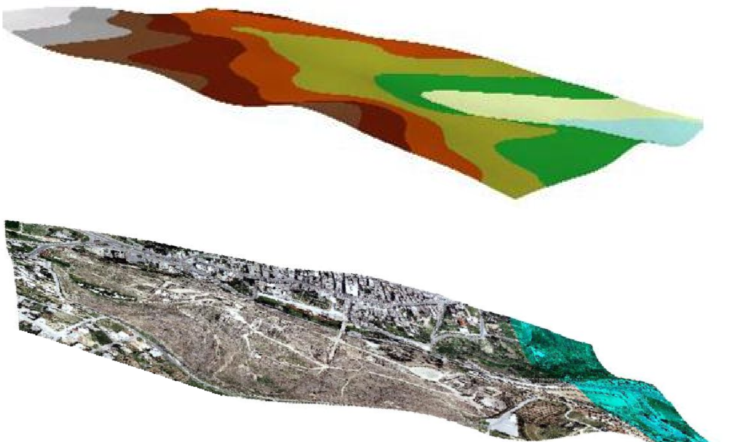

Figure 4. TIN and DTM for the study area

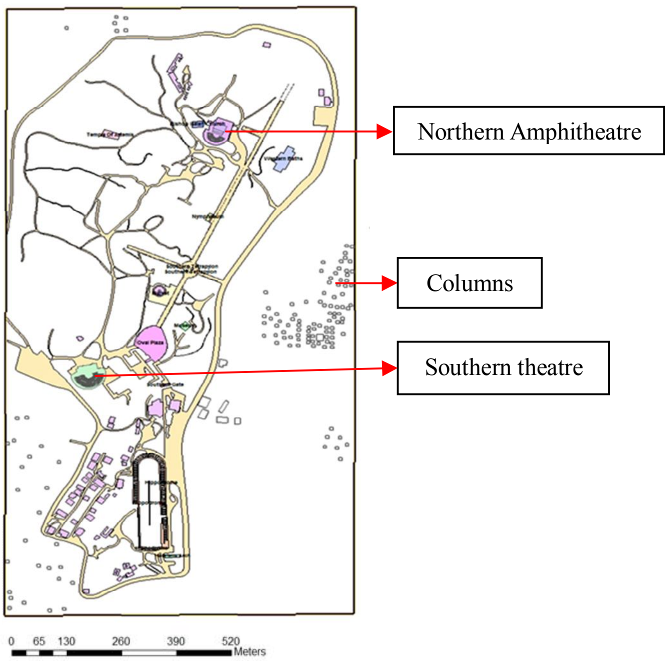

Figure 5. GIS layers

For the two amphitheatres: Colonnade Streets and other elements of the historical site, a lot of Z points were collected using Laser Distomat to compute the elevations of all the archaeological details. These points were used to build 3D model for the important monuments in the site as shown in Figure 6.

Figure 7 shows the obtained 3D model installed in the site of study area. These results shows that these 3D model take exactly their positions due to the high accuracy in x, y and z, in one hand, on the other hand, because they are all built at the same system of projection**.**

This study has a great benefit in documenting historical sites with high accuracy. This helps the restoration of these monuments in case of any deterioration due to environmental factors or to rebuild them in case of sudden damage caused by natural disaster.

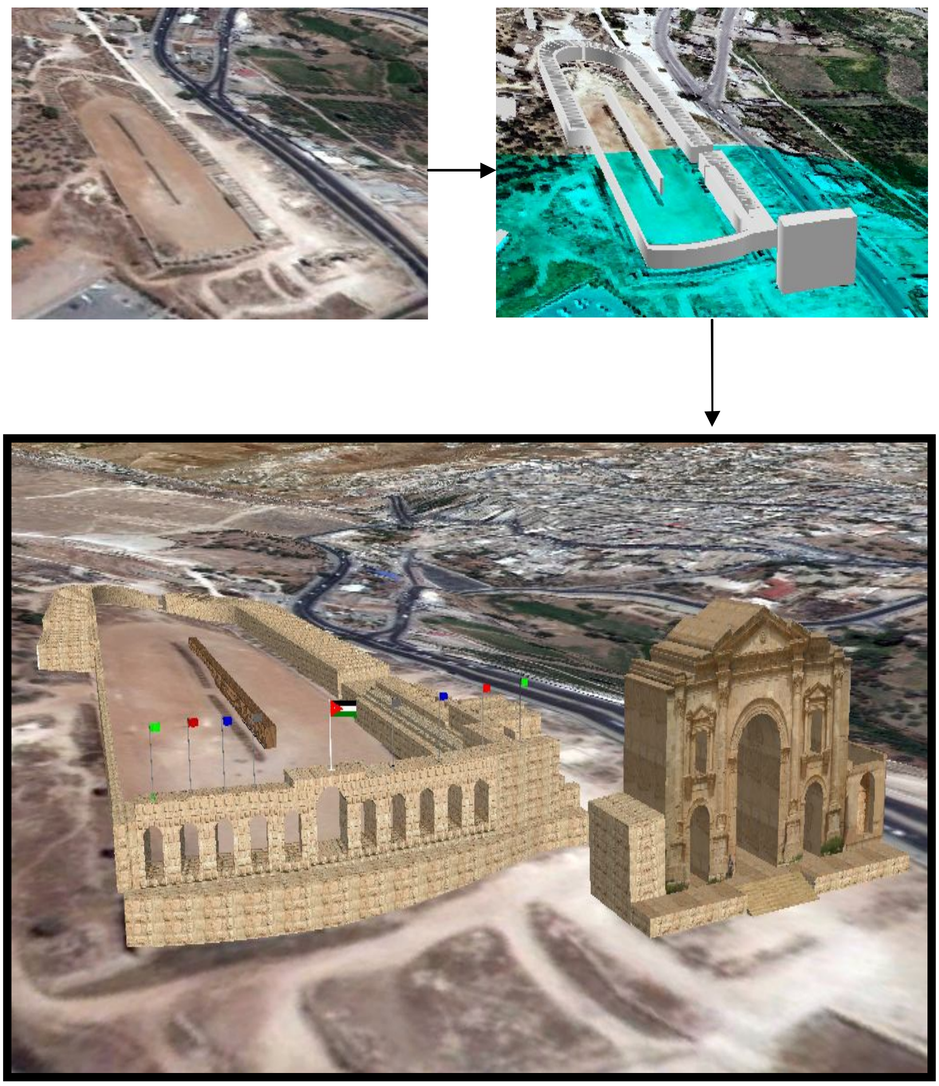

Figure 6. 3D realistic digital models of some features in the study area

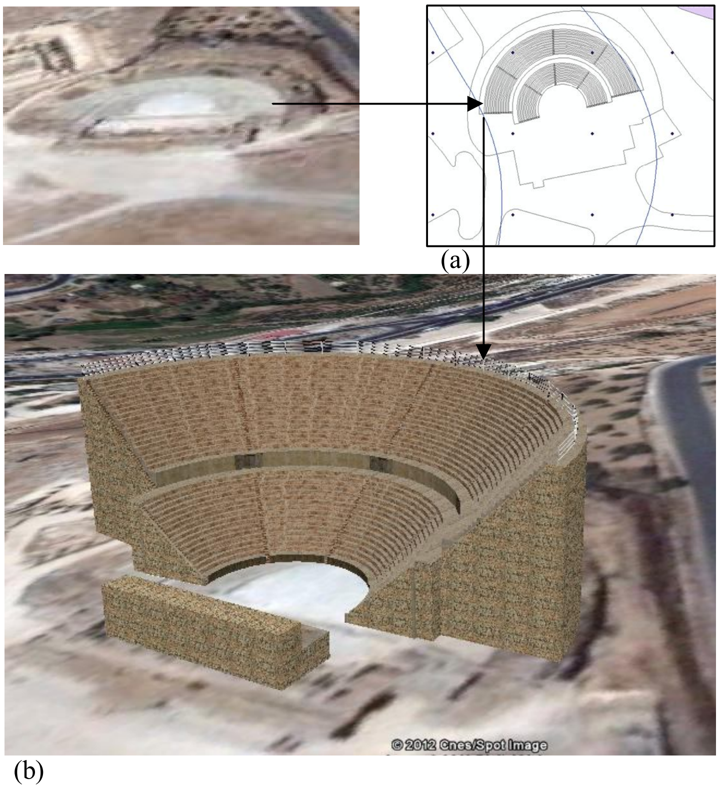

Figure 7. One from the two amphitheatres in the study area (a) presented a 2 D built by using AutoCAD software; (b) a 3 D digital model of the amphitheatre

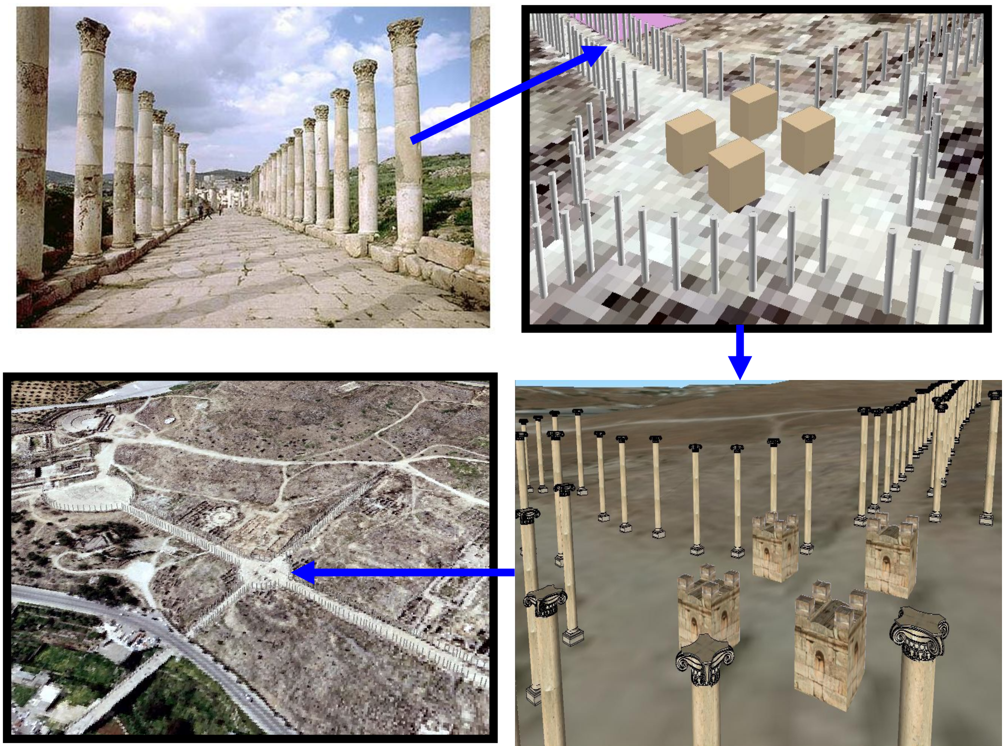

Figure 8. Colonnade streets built using photogrammetry orthophoto range laser distomat, and AutoCAD 3D civil engineering

6. Conclusion

In this paper, an orthophoto was built from two aerial photographs using photogrammetric software for the site of the study area. Field surveying works provided a network grid defined in x, y and z. A GIS works were conducted to build a database and a DTM for the site of study area in addition of building contour lines with high accuracy and respecting a Universal Transverse Mercator-WGS84 using the previous points defined in x, y and z. Furthermore, AutoCAD civil engineering software and Laser Distomate were used to build a 3D digital model for the important monuments in this site.

This paper proved the high efficiency of the integration of photogrammetric works and field surveying in the field of documenting and preserving historical sites.

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