ISSN: 2148-9173 **Vol: 6 Issue:1 April 2019**

International Journal of Environment and Geoinformatics (IJEGEO) is an international, multidisciplinary, peer reviewed, open access journal.

3D Modelling of Geometric Triangle Construction Elements in Indoor Spaces: A Case Study for Tahir and Zühre Masjid

Hakan KARABÖRK, Lütfiye KARASAKA, Bilgehan MAKİNECİ, Ahmet TANRIVERDİ, Bekir YENER, Neslişah ULUTAŞ & F. Nevriye ÖZTÜRK

Abstracting and Indexing: DOAJ, Index Copernicus, OAJI, Scientific Indexing Services, JF, Google Scholar

Dear colleagues and friends,

It is our great pleasure to invite you to attend the EURASIAN GIS Congress 2018 held in Baku on 04-07, September 2018. EURASIAN GIS Congress 2018 is a candidate of one of the most important event in the scientific schedule and tenders a possibility for researchers and academicians who researches on GIS and related disciplines. You can find a first class programme of plenary speakers, technical sessions, exhibitions and social events in this book. You will be able to catch up with the developments in Geographical Information Sciences, Information Technology, Environmental Management and Resources, Sustainable Agriculture, Surveying, Photogrammetry and Remote Sensing, meet friends and experience the traditional and fascinating culture of AZERBAIJAN. As a international congress in the field of geo-spatial information and remote sensing, EURASIAN GIS Congress 2018 is devoted to promote the advancement of knowledge, research, development, education and training in Geographical Information Sciences, Information Technology, Environmental Management and Resources, Sustainable Agriculture, Surveying, Photogrammetry and Remote Sensing, their integration and applications, as to contribute to the well-being of humanity and the sustainability of the environment. The EURASIAN GIS Congress 2018 will provide us an opportunity to examine the challenges facing us, discuss how to support Future Earth with global geo-information, and formulate the future research agenda.

150 scientists from 13 countries attended to the congress. 7 plenary speakers, 120 oral presentations and 8 poster presentations, all together with 135 in total, are presented during the congress. 135 presentations take place in 21 sessions in three days. **Karabörk, et al., (2019)** presented in the organization was selected for publication in **IJEGEO 6(1) as Short Communication.**

The Congress is carried out with the support of the organizations as the Konya Technical University, Selcuk University, Azerbaijan National Academy of Sciences Institute of Geography, Baku State University, Ministry of Agriculture of Azerbaijan Republic, General Directorate of Land Registry and Cadastre, General Directorate of Agricultural Reform of Turkey, International Federation of Surveyors (FIG), International Society for Photogrammetry and Remote Sensing (ISPRS) and Igdir University. In addition, the congress is also supported by the commercial organizations of INTEGRIS LLC, KUTLUBEY Engineering Co, RUBIKON Geosystems LLC, NETCAD, HARMIAD Surveying Engineers Businessmen Association, GEOGIS Engineering Co, MESCIOGLU Engineering Co, EMI Group Information Technology Co, PaksoyTeknik, and 4B Ölçüm.

Finally, we cheer on all of you to participate in this congress of EURASIAN GIS , and special thanks to all sponsorships and government partners for the congress. Enjoy your time and share your experiences with your friends.

Baku/Azerbaijan, September, 2018

Prof. Dr. Ferruh YILDIZ
Chair of The Organizing Committee

Prof. Dr. Ramiz Mahmudoglu MAMMADOV
Co-Chair of The Organizing Committee

International Journal of Environment and Geoinformatics 6(1): 135-138 (2019)

Short Communication

3D Modelling of Geometric Triangle Construction Elements in Indoor Spaces: A Case Study for Tahir and Zühre Masjid

Hakan Karabörk*, Lütfiye Karasaka, Bilgehan Makineci, Ahmet Tanriverdi, Bekir Yener, Neslişah Ulutaş and F Nevriye Öztürk

Selcuk University, Engineering Faculty, Department of Geomatic Engineering, 42075 Konya, TR

*Corresponding author
E-mail: hkarabork@selcuk.edu.tr

Received 04 Sept 2018
Accepted 10 Apr 2019

How to cite: Karabörk, et al., (2019). 3D Modelling of Geometric Triangle Construction Elements in Indoor Spaces: A Case Study for Tahir and Zühre Masjid, *International Journal of Environment and Geoinformatics (IJEGEO)*, 6(1): 135-138. DOI: 10.30897/ijegeo.551733

Abstract

Tahir and Zühre Masjid, which is one of the works of Konya and Anatolian Seljuk Period, serve daily from the 13th century and draw attention with its interior architecture. The Masjid is seated on a square plan and covered with a dome using triangular transitional elements. These artifacts are the most important proofs of the architectural perspectives and orientations of the past period. Demonstrating and documenting past architectural and engineering skills has become much easier with modern measurement and evaluation techniques at the present time.

In this study, interior 3D modeling study of Tahir and Zühre Masjid was made by using close range photogrammetry. Also the triangular transitional elements between the square plan and the dome of the structure were picked out. As a result, it has b een observed that the method of close range photogrammetry for documentation and restoration works is not only successful in outdoor facade but also indoor modelling.

Keywords: Close-range Photogrammetry, 3D Modelling, Indoor Space Modelling, Tahir and Zühre Masjid

Introduction

Among the most important works of Anatolian Seljuk architecture survived to the present day the structures in Konya can be shown as an example. Konya has been the capital of the Anatolian Selçuks for many years. They have built architectural structures such as madrasah, caravansary, bath, mosque and masjid in Konya and surrounding. Especially the architectural structure of the Masjids is an important problem to be solved. Because these structures are usually square plan and the transition from a square-shaped structure to an upper-circle structure is an important issue. The connection between the two different geometric structures is provided by the transition elements. The transition elements show some differences according to the period and the place they were built. The dome first emerged in Mesopotamia according to architectural sources. This element needs a carrier surface. The use of the dome as the top covering element at square and rectangular plan has been the result of the development of transition components between a circular cover and a square infrastructure (Kuban, 2015; Turan & Yaldız, 2018; Yakar & Doğan, 2018; Deniz et al., 2018). Different solutions have been developed to solve the problem of transition components to the dome such as trompe, plane triangular belt and prismatic triangle belt. It is quite difficult and time consuming to modelling and documentation of these special components with traditional measurement methods. Within the scope of the study, Tahir and Zuhre Masjid which has a square plan and plane triangular belt were evaluated close range photogrammetry technique that is combined photogrammetric and computer vision techniques. 3D models of the transition components to the dome have been successfully achieved. It has been proven that this method can be used effectively for 3D architectural solutions. With this method, the intermediate elements used for sitting the circle-based dome to the flat walls have been documented numerically.

Case Study and Methods

Tahir and Zühre Masjıd. The building is located at the Abdülaziz neighbourhood in the Meram district of Konya. The Masjid was built by Sahip Ata Fahreddin Ali. It is known to have been built by the Anatolian Seljuks in the 13th century (Fig. 1) (Konyalı 1997).

Figure 1. The Tahir and Zuhre Masjıd.

The building, which was built as a masjid, is still used as place of worship. The building with a square plan is located in a group with three place masjids as harim part, the last community place and the tomb. The masjid was covered with a vault of the last community, the harim and the tomb part covered with a dome.

In the harim section the triangular belt was used which makes the corner group as the dome transition member and the plane triangle band was used in the tomb part (Turan 2018). The most remarkable parts of the masjid are the mihrab and the tile medallion in the dome center.

Close-range photogrammetry and workflow

"Photogrammetry is the art and science of determining the position and shape of objects from photographs" (Kraus, 1994). Thanks to the computer vision the 3D shape, 3D metric information's and appearance of objects reveals from 2D images. The aim of this study is to get 3D model and to reach the correct metric information from images using close-range photogrammetry technique. Close range photogrammetry is one of the modern measurement and evaluation techniques, offers economical, practical, accurate and 3D solutions for architectural surveys.

The close-range photogrammetry workflow in general is definition as below;

i. Planning survey
ii. Calibrate camera
iii. Aquire digital images
iv. Aquire external control; referans/datum total station survey or GPS survey
v. Process images
vi. Triangulate/Orient Block
vii. Defined reference survey
viii. Deliverables
   a. Stereomodels
   b. 2D Planimetric
   c. Textures
   d. Dense point cloud
   e. Ortoimage/rectifed image
   f. Object/surface model CAD

In order to be able to carry out the photogrammetric processing steps outlined above, we preferred Photomodeler Software which has many advantage like as ease of field use, cost saving, time reduction and office safety.

Camera calibration procedure

A non-metric camera was used in the study. If a non-metric camera is used, the camera calibration is required to obtain reliable and accurate metric information from stereo image pairs. The camera calibration is related to find the real parameters of the camera such as focal length, principal point, format size, and lens distortion.
In this study, the Tahir and Zuhre Masjıd were photographed by using Finex S2980 digital cameras. The calibration paper consisting grid points was used and photographed from different angles and positions. To calibrate the Fujifilm Finex S2980 digital camera the photomodeler software was used that included the camera calibration function.

PhotoModeler calculates the camera's focal length, lens distortion, format aspect ratio, and principal point. High accuracy work requires a well calibrated camera (URL1). The parameters related to the camera are given in table 1.

Table 1. Camera calibration parameter of Finex S2980

Finex S2980	
Focal lenght	5.1227
Pirincipal point	(3.2314, 2.3662)mm
Sensor format	(6.1224, 4.5995)mm
Distortion parameter: K_1	0.002577
Distortion parameter: K_2	-0.0001528
Distortion parameter: P_1	-0.0001170
Distortion parameter: P_2	0.00136

Data Acquisition

The Tahir and Zuhre Masjıd has a architecture elements that provide transition to the circle-based dome cover. This transition is provided by the transition from a square shaped building element to a triangular element under a single-dome (Figure 3-4).

Figure 2. The transition components to the dom

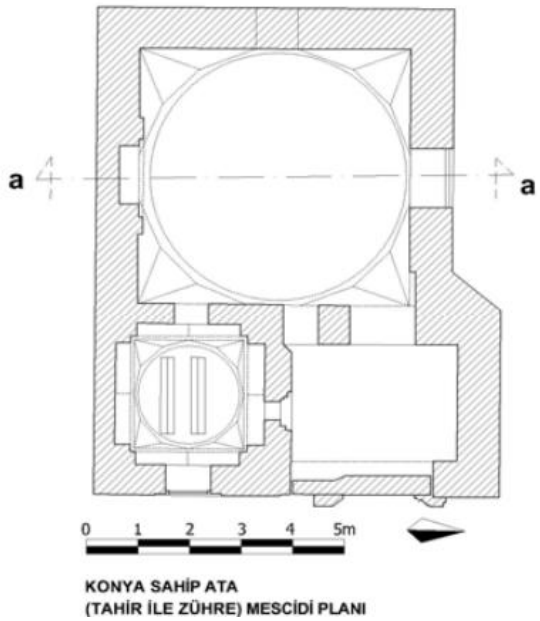

Figure 3. The plan of the masjid

After camera calibration, third photogrammetric process is the acquisition of the images. It must strong angle between photos. Due to the narrow interior space and the height of the dome of the masjid, the indoor photographs were shot with good planning. In the study the control points, for determining accuracy external information is used, Tahir ve Zühre selected on brick surfaces measured by TOPCON GPT-7003i Imaging Total Station (Figure 5). The distribution of measured points on the object surface is as shown in figure 5. It was noted that the control points on the brick surface were uniformly distributed. Also to estimate coordinates of points on any object or surface on image pairs, camera position and orientation information must be known. These are known as exterior orientation parameters which can be determined with least three control points on image. The control points defines relation between image and object coordinate system.

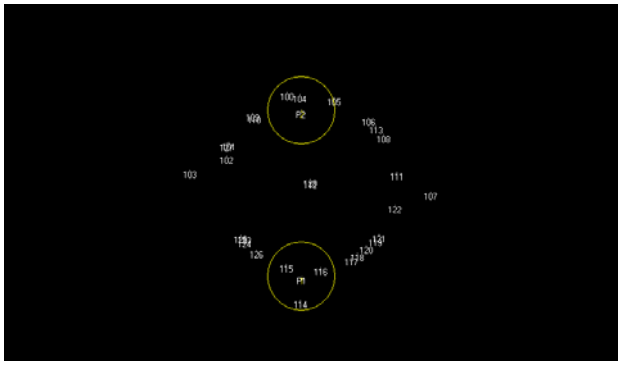

Figure 4. Distribution of the control points

3D modelling

The photogrammetric evaluation of the images of Tahir and Zuhre Masjıd were made with Photomodeler software. The all images, camera calibration parameters, and the coordinates of the control points were transferred to Photomodeler Scanner Software. This software's basic processing algorithm is a bundle adjustment. The exterior orientation parameters of the images and the 3D point coordinates are computed in the bundle adjustment process. Also, it is used calculating of the camera calibration parameters. „Bundle" word comes from the bundle of light rays from 3D points in the images. Adjustment word meaning is the process of adjusting camera positions and 3D point positions given the defined bundle of light rays. In other words to find the best 3D positions of rays the overall errors are minimized (URL1).

In order to extract 3D accurate information from 2D images, it is necessary to match all image pairs with sufficient number of tie points and control points.
After matching all images accurately and the final bundle adjustment, the root mean square error of the project was computed as 4.75 pixels. According to this result, 3D drawings of the brick surface were realized in Photomodeler software. When drawing, the surface definition was done from the Surface Draw menu. The existing brick drawings were made over the created surfaces.

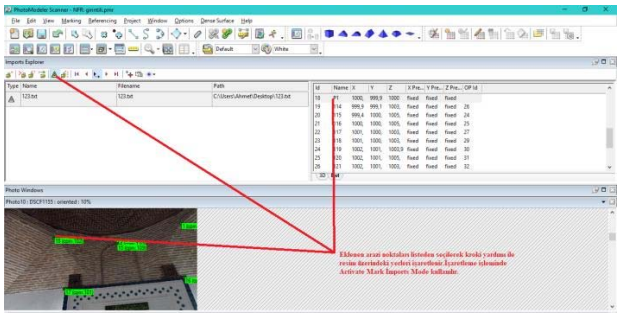

Figure 5. Identification of control points

Conclusion

The aim of this study is to reveal the transitional components to dome by measuring and evaluating it with photogrammetric methods of the Tahir ve Zuhre Masjid. The the plane triangular belt that makes a corner group as the dome transition members have been successfully achieved from terrestrial digital images. It has been determined that the dome transition elements are "the plane triangle belt" model. A strong photogrammetric project has strong angles between photos, a large number of 3D points, high precision marking, large coverage in each photo, and a good camera calibration. It has experienced problems due to the height of the building in the photo shooting stage. The angles of the photographs that were inclined due to the height make the adjustment phase difficult.

References

Deniz, A., Şeker, DZ., Alkan, M., Karakış, S., Bayık, S. & Acar, H. (2018). Development of Web-Based GIS for the Cultural Heritage of Safranbolu, Turkey, *International Journal of Environment and Geoinformatics (IJEGEO)* Vol. 5(3), 368-377.

Konyalı, İ. H. (1997). *Konya Tarihi.* Burak Matbaası, Ankara.

Kraus, K. (1994). *Photogrammetry 1,* Dümmler.

Turan, Ş.N. & Yaldız, E. (2018). XIII. Yüzyıl Konya Mahalle Mescitlerinde Kullanılan Kubbeye Geçiş Elamanları, *Türk-İslam Medeniyeti Akademik Araştırmalar Dergisi,* Cilt:13, Sayı: 26,2018-Yaz

Turan, Ş.N. (2018), Türk Mimarisinde Kullanılan Kubbeye Geçiş Elemanları; XIII. Yüzyıl Anadolu Selçuklu Dönemi Konya Mahalle Mescitleri Örneği", *NEÜ, FBE, Yayımlanmamış Yüksek Lisans Tezi*

URL 1. http://www.photomodeler.com/index.html.

Yakar, M. & Doğan, Y. (2018). GIS and threedimensional Modeling for Cultural Heritages, International Journal of Engineering and Geosciences (IJEG), Vol; 3(2): 50-55.

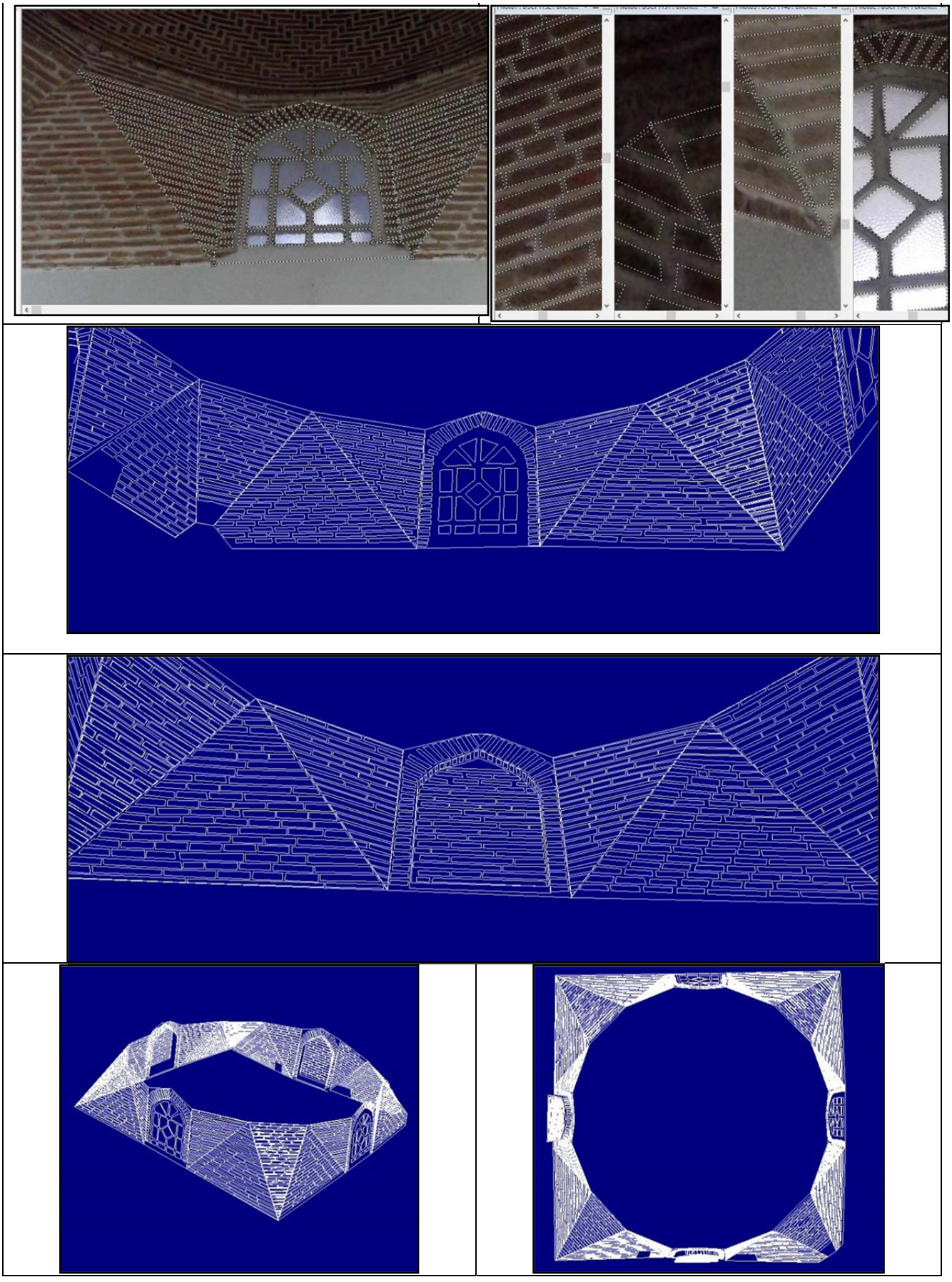

Figure 6. Three dimensional view of the dome transitional components