3D MODELLING AND DETAIL DRAWING OF INCEMINARE MEDRESSEH BY DIGITAL PHOTOGRAMMETRY AND LASER SCANNING METHOD

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ABSTRACT:

It should be a holy duty to preserve the historical and cultural heritage left by our ancestor. In recent years, the documentation of cultural heritage with digital close range photogrammetry and terrestrial laser scanning has become one of the most popular methods. These methods can be applied to different disciplines. Especially, digital close range photogrammetry and laser scanning are used more and more as technique of architectural structures e.g. facades of complex building.
Architectural photogrammetry has a great importance to preserve and to record the historical heritage as well as documenting them. Photogrammetry has long been used as a tool for getting 3D information of cultural heritage objects. Compared to other techniques, photogrammetry shows distinct advantages like large amount of data, very accurate, three dimensional, textura, high resolution and detailed data and geo-referanced data.
In this study, façade of Inceminare Medresseh, which is today used as a museum of stone and wooden art works of Seljuk Period, built in between the years of 1258-1279 by the Vizier Sahip Ata Fahrettin Ali, which was purpose of teaching and learning of Hadis for Muslims, was scanned with laser scanner and modeled 3D. In addition, photogrammetric surveying based on detailed drawing is prepared for Konya Inceminare Medresseh.
Scanning was performed with Optech ILRIS 3D Intelligent Laser Ranging and Imaging System. Object is obtained as the point cloud which has the reflective intensity data. The evaluation of point cloud of object is performed by the Polyworks commercial software. For photogrammetric survey, photographs are taken by Sony F828 digital camera. Additionally, the ground control points were measured by Topcon GPT 3007 Reflectorless Total Station. Photomodeller software was used in detail drawing of these.

1. INTRODUCTION

The architectural heritage is continuously at risk due to threat of multiple catastrophes caused by human and/or natural interference. The importance of architectural archives is to help preserving the historical monuments thus obvious and urgent. Architectural archives of monuments and historic buildings, complemented with geographical information of the surroundings, are a valuable source of information to preserve, reconstruct and rehabilitate the architectural patrimony. (Pereira, Z.2004)
Precise documentation of cultural heritage status is essential for its protection and scientific studies carried out during the restoration and renovation process. The close range photogrammetry has been used successfully for documentation of cultural heritage. With recent developments in computer and information technologies, this well-known traditional method has been replaced with digital close-range photogrammetry. This new method offers us new opportunities such as automatic orientation and measurement procedures, generation of 3D vector data, digital ortho-image and digital surface model. Terrestrial laser scanning is another technology that in recent years has become increasingly popular for documentation which provides very dense 3D points on an object surface with high accuracy. In addition, the 3D model and digital ortho-image can be easily generated using generated 3D point cloud and recorded digital images. (Yastikli, N., 2007)
In this study, the usage of digital photogrammetry and terrestrial laser scanning is investigated for cultural heritage documentation with respect to data collection, data processing, and final products.

2. MATERIAL AND METHOD

2.1 The Inceminare Medresseh

The Inceminare Medresseh is in the west of the Alaaddin Hill, Seljuk District of Konya. During the reign of Izzeddin Keykavus II, the sultan of the Seljuk, the vezire Sahip Ata Fahrettin Ali founded this institution (1264) as Dar'ul Hadis. The architect was Keluk who is a son of Abdullah. Dar'ül Hadis is of the domed atrium type of Medresseh of the Seljuk period. It has one extra. The Taç Kapı (Crown Port) in the east is one of the finest examples of the stonework at the age. The Taç Kapı, beginning from the frames and the pointed are of the port, the verses of Fetih and Yasin surahs of Koran are engraved is sülüs (large-text writing) relief along the lines crosswise.
In this museum, one can see the best examples of the marble reliefs of winged angels and the eagle with two heads, which was the symbol of the Seljuk, the capital of which was Konya. The Inceminare Medresseh was active until late XIX century. It is known that it was repaired in 1876-1899. After many repairs in the Republic period, beginning in 1936, it was made into the Museum of Wooden and Stonework in 1965). (Konya City Guide) (Figure2)

Figure 1. View of Inceminare Medresseh

Figure 2. Detail of verses, geometrical figures and plant motifs

2.2 Photogrammetric Procedure

3D model generation and visualization of cultural heritage can be prepared easily by using digital close range photogrammetry products (Yastikli, N.2003).
Dimensions of Inceminare Medresseh which decorated verses of Fetih and Yasin surahs of Quran with geometrical and plant motifs are 2 meter depth, 6.40 meter width, 9.20 meter height.
The ground control points are measured by Topcon GPT 3007 Reflectorless Total Station for every work of arts. About 14 control point measured façade of Inceminare Medresseh. Inceminare Medresseh is evaluated by photogrammetric methods. Drawing of work of arts details have been made by Photomodeller 4.0 software. Photographs façade of Medresseh has been taken with Sony F828 digital camera.
This camera was calibrated in Selcuk University Photogammetry laboratory by using EOS systems Inc. Photomodeler software. In this project we used JPEG picture formats. The calibration parameters are as follows;

f= 7.8010 mm
W= 9.3267 mm
H= 6.9959 mm
x_0 = 4.6992mm
y_0= 3.5384 mm
K_1=3.140e-003, K_2=-2.832e-005
$P_{1=}$ -1.590e-004, P_2=- 2.983e-005

Where;

f= focal length
W, H= sensor area
$x_{0,}$ y_0=coordinates of principal points
K_1, K_2, P_1, P_2 =distortion parameters

Photomodeller software package is well-known as being low cost 3D measurement tool for architectural and archeological applications.
The first photogrammetric process is the acquisition of the images with digital camera. The stereo photographs of Inceminare Medresseh were taken by the digital photogrammetric methods using by Sony F828 digital camera. All photographs were transferred photogrammetric software. Four images were used for the evaluation of Inceminare Medresseh. The images size is 3264*2448 pixels. The control points were marked by sufficient number for bundle adjustment and covering all side. After this process, adjustment procedure was accomplished. Its drawing was made using by surface drawing methods. Surface drawing gives us the ability to draw in only one photograph and on a plane defined by surface to produce 3D data. Surface drawing is useful for drawing/modeling detailed patterns that lie on one plane (such as brick or stone work on the facade of a building). Surface drawing requires no referencing so detailed patterns and curves are much easier to mark.
Surface drawing requires surfaces. These surfaces must appear on a photograph with a solved camera station and the 3D coordinates of the surfaces points must be known (i.e. have been solved already or are control points).
The line drawing mode was used non-planer of façade because of the surface drawing hasn't been made. Results were transferred to dxf format for the restorer studies. (Karasaka, L., et al, 2006)

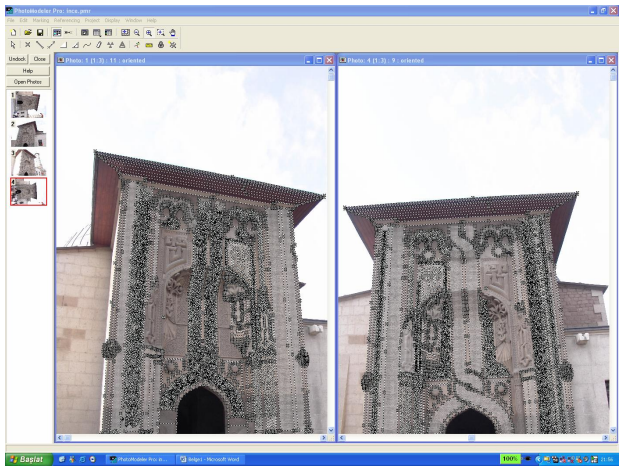

Figure 3. Evaluation of Inceminare Medresseh

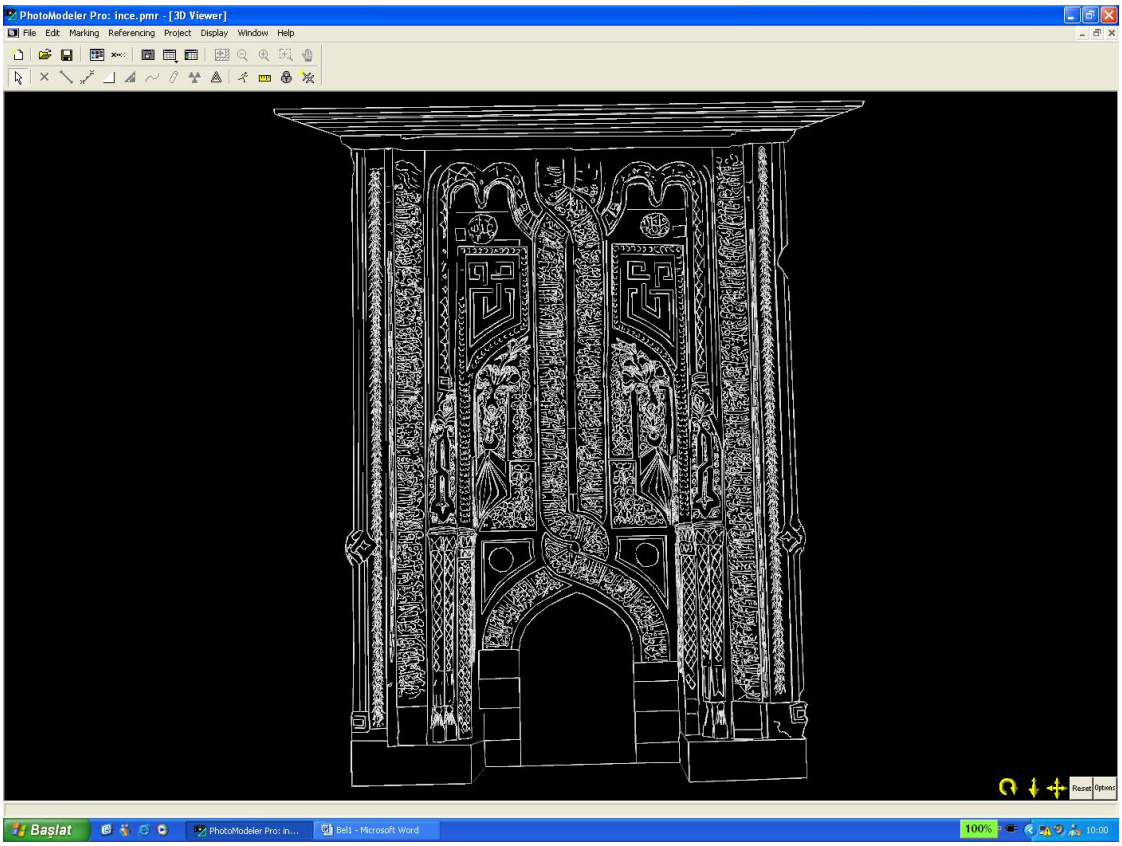

Figure 4. General view of Inceminare Medresseh

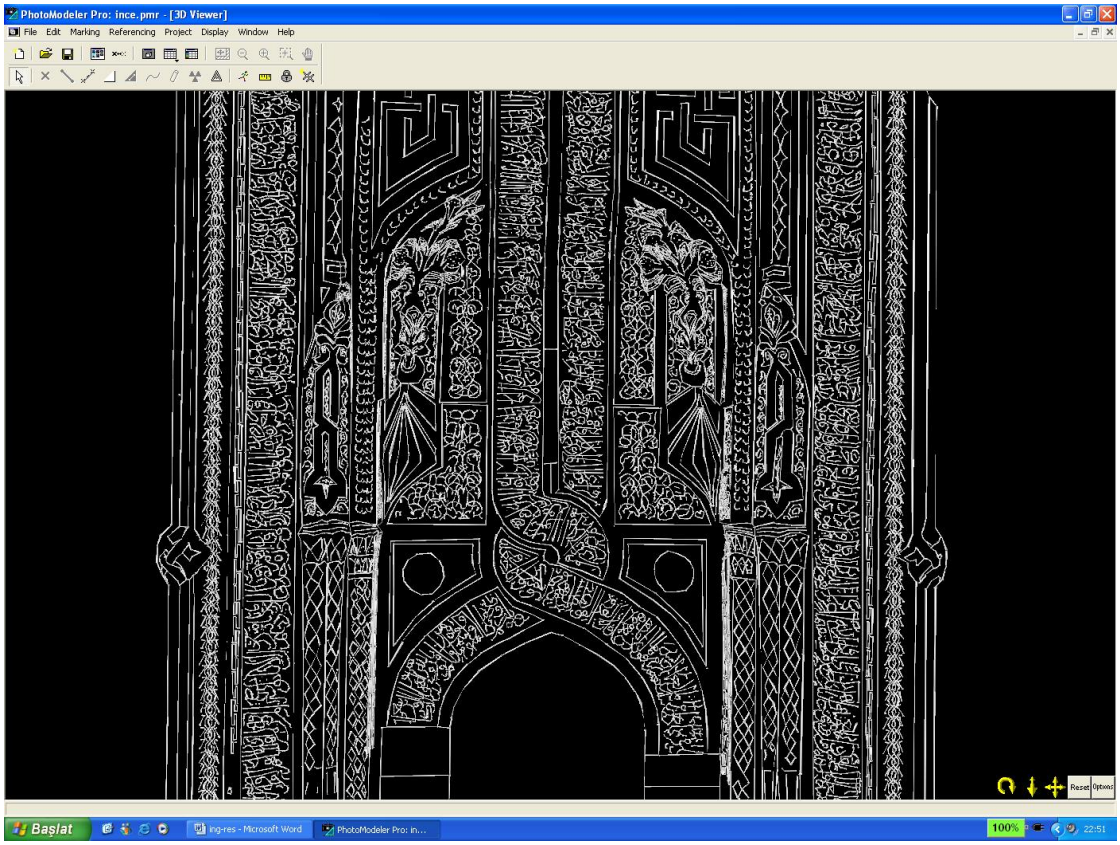

Figure 5. Detail drawing of verses of Fetih And Yasin surahs, geometrical figures and plant motifs

2.3 Laser Scanning Procedure

Laser scanning has already shown its outstanding advantages in acquiring 3D information on an object's surface in many different applications within the past years. For laser scanning a highly collimated laser beam is scanned over o predefined solid angle in a regular pattern. While scanning the distance to the object is measured by measuring the time of flight of the laser signal with high precision.(Balletti, C. et all, 2004)
Laser scanners can automatically digitize the 3D coordinates of the complex shape of an object. This makes it easy to create a detailed 3D model of the object from a 3D point cloud. (Kadobayashi, R. et al)
Using traditional methods, structural surveying is a time-intensive and costly undertaking. Recent advances in terrestrial laser scanning technology allow us fast and efficient collection of 3D coordinates of cultural heritage object automatically. Laser scanners can measure millions of points with a laser beam within a short period of time.
The scanning was executed by a Optech's ILRIS-3D terrestrial laser scanner. Optech's ILRIS-3D laser imaging system provides the means to reduce the time and cost significantly.

Features:

- High resolution and high accuracy
- Highest dynamic range available on the market: from 3 m to beyond 1 km
- Class 1 laser rating: completely eye safe
- On-board 6-megapixel digital camera and large-format LCD viewfinder
- Ruggedly designed for demanding field applications
- Battery operated
- No leveling, retro-reflectors, or mirrors required
- Compact and easy to use
- Easily hand-carried and deployed by a single operator.

ILRIS-3D Specifications

Performance	
Dynamic scanning range	3 m - 1,500 m to an 80% target 3 m - 800 m to an 20% target 3 m - 350 m to an 4% target
Data sampling rate (actual measurement rate)	2,500 points per second
Beam divergence	0.00974°
Minimum spot step (X and Y axis)	0.00115°
Raw range accuracy*	7 mm @ 100 m
Raw positional accuracy*	8 mm @ 100 m
Laser wavelength	1,500 nm
Laser class (IEC 600825-1)	Class 1 **
Digital camera	Integrated digital camera (CMOS sensor) optional external camera
Scanner field of view (ILRIS-3D)	40° x 40°

Table 1. ILRIS-3D specifications

Figure 6. ILRIS-3D and measurement of Inceminare Medresseh

The location of Inceminare Medresseh is in city centre. The scanning was made in the morning at 5:00 am because of the front of object is crowd pathway. The object was scanned from six stations. The number of measured points was approximately 3 million and the total data amounted to about 60 MB.
Space resolution is important factor evaluating point cloud quality. It presents an ability to distinguish the minimum interval on objects. Space resolution was usually affected by the radius of laser beam and the angle resolution ability of laser scanner in the same distance condition. Higher space resolution, the more detailed characteristics of objects can be captured by laser scanner. (Zhou, K., et al, 2008)
In this study, three stations was scanned to object to approximately 25-30 minutes in form spot space 1cm (x and y direction). Other three stations was scanned to object to approximately 45-50 minutes in form spot space 5mm (x and y direction).
To obtain 3D images to 3D polygonal model, PolyWorks Version 10.0 InnovMetric software was used. Firstly, the binary data provided by Optech ILRIS-3D were parsed using Optech Parser 4.2.7.2 to obtain a point cloud in IXF format processed by Innovmetric PolyWorks 10.0. Secondly the translated images were imported into PolyWorks InnovMetric software.and then merged into one polygonal model.

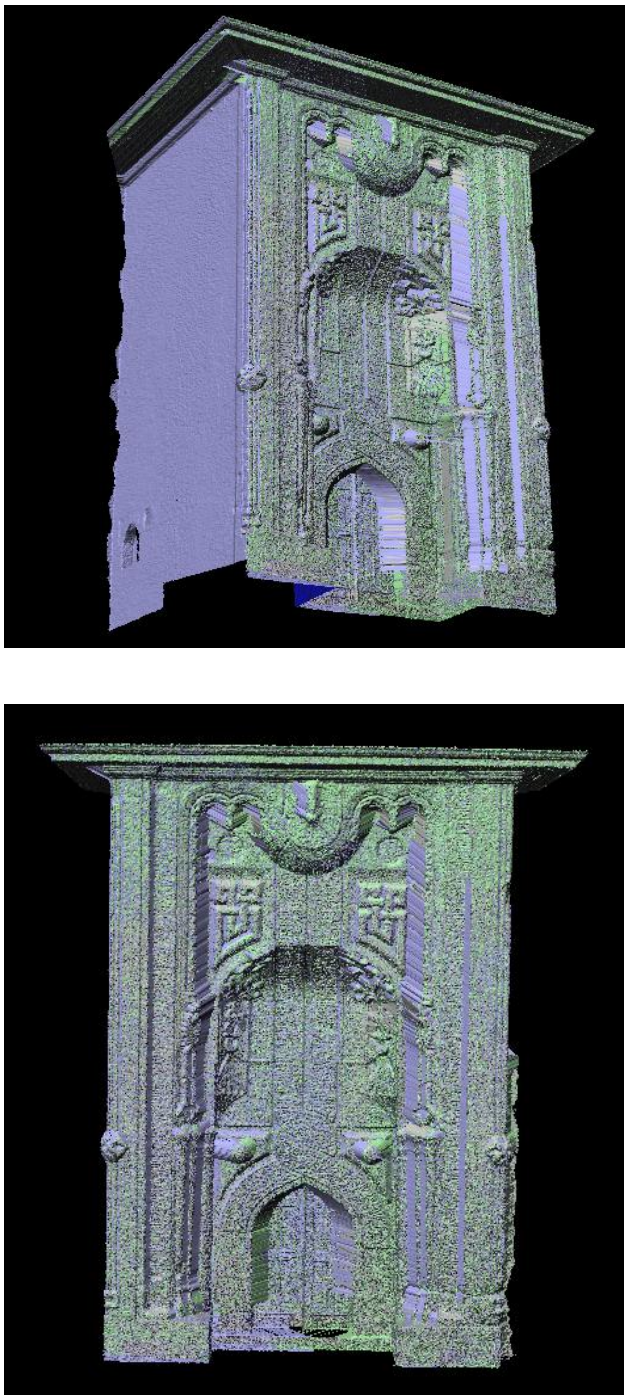

Figure 7. 3D model of Inceminare Medresseh

3. CONCLUSION

In this study, methods in digital photogrammetry and terrestrial laser scanning are investigated for documentation of cultural heritage.

Laser scanners are facilitated documentation of historical and cultural heritage. The results of this study demonstrated that digital photogrammetry and terrestrial laser scanning can be used successfully for cultural heritage documentation, which has very complex geometry and irregular shape.

Surveying of historical heritage based on laser scanning technology has not only reduced the time for field work but also has provided 3D models visualization. When compared with the evaluations, the digital photogrammetric procedure is much more appropriate than laser scanning procedure for drawing purpose. 3D point cloud doesn't appropriate for detail drawing in complex and irregular object surface because of million of 3D point cloud data by laser scanners. However, it becomes feasible to combine terrestrial laser scanning method and digital photogrammetric method for documentation of cultural heritage.

REFERENCES

Bakirci, N., 2006, Konya City Guide, Istanbul, pp.118-121

Balletti, C., Guerra, F., Vernier, P., Studnicka, N., Riegl, J., Orlandini, S., 2004, Practical Comparative Evaluation of An İntegrated Hybrid Sensor Based on Photogrammetry and Laser Scanning for Architectural Representation, in the International Archives of Photogrammetry and Remote Sensing, Commission V,ISPRS XX Congress, Istanbul, Turkey, 12-23 July 2004.

Kadobayashi, R., Kochi, N., Otani, H., Furukawwa R., Comparıson and Evaluatıon of Laser Scannıng andPhotogrammetry and Theır Combıned Use for Dıgıtal Recordıng of Cultural Herıtage

Karasaka, L., Yildiz, F., Yakar, M., Karabork, H., Altuntas, C., Yilmaz, H.M., 2006 Photogrammetric Methods for Documentation Based on Detailed Drawing of Historical and Cultural Heritage Fifth International Symposium" Turkish – German Joint Geodetic Days", March 29-31, Berlin, Germany

Pereira, Z., Morgado, A., Pereira, G.L. Comparison of Different Approaches to Create Architectural Archives, Geo-Imagery Bridging Continents, XXth ISPRS Congress, Istanbul, Turkey

Photomodeller manual

Yastikli, N., 2007, Documentation of cultural heritage using digital photogrammetry and laser scanning, Journal of Cultural Heritage, 8 (2007), pp.423-427

Yastikli, N., Alkis, Z., Emem, O. 3D Model Generation and Visualization of Cultural Heritage. CIPA 2003 XIXth International Symposium Proceedings, Antalya, Turkey

Zhou, K. , Zhao X., Zhou, J. , W ang F, , Hu S., 2008, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B5. Beijing-China

Url1: http://www.optech.ca

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