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Façade Rehabilitation by Using Close-Range Photogrammetry in Historical Menguc Street in Konya/Turkey

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Abstract:

The method of the close-range photogrammetry can be used not only in one monument, but also in monumental groups and façades in streets. By using this method, the façade rehabilitation of streets can be documented accurately and reliably and also the whole façades of streets can be analysed completely. In this paper, the façade rehabilitation of Historical Menguc Street in Konya by using close-range photogrammetry is studied and according to acquired results, the advantages and disadvantages of this method will be explained.

In architecture, an accurate documentation for preserving cultural heritage can be obtained by using developing techniques. Nowadays there have been many developments in documentation of cultural heritage by developing technology. Modern methods including modern materials, new software and measurement techniques are generally preferred to the methods of conventional documentation in architecture. Among these modern methods, one of the most important is using the methods of close-range photogrammetry together with digital measurement tools. In recent years, photogrammetry techniques have also been used commonly in surveying historical buildings and their deformations, and providing data for conservation projects in architecture.

The 3D-vectoral data of the object digitized with the close-range photogrammetry, its surface images, its animation and 2D-orthophoto images could be taken in a scaled form. This technique also helps to produce documentation and preservation of historical heritage, and also provides an opportunity for its comparable evaluation between the present and future conditions. The advantages of the close-range photogrammetry are to provide a accurate documentation of historic materials and preservation of cultural heritage by three-dimensional (3D) digitization, and also making the required measurements on surveyed elements continually.

Keywords:

Close-range photogrammetry, façade rehabilitation, documentation.

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1. Introduction:

The main component forming societies and isolating them from the others is certainly "civilization" constructed by societies which includes the cultural heritage as a part of it. Therefore, the conservation of cultural riches, keeping them alive and bequeathing them to future generations is the most significant responsibility of all societies. The Venice Charter accepted in this context in 1964 begins with the following expressions;
"The concept of an historic monument embraces not only the single architectural work but also the urban or rural setting in which is found the evidence of a particular civilization, a significant development or an historic event. This applies not only to great works of art but also to more modest works of the past which have acquired cultural significance with the passing of time.
The conservation and restoration of monuments must have recourse to all the sciences and techniques which can contribute to the study and safeguarding of the architectural heritage" begins with these definitions.
As a result of cultural differences disappearing in the globalized world, the consciousness of conserving cultural heritage became a necessity on which people were densely endeavoring and is possible by documentation and restoration when needed. In order to form the documentation and conservation projects, an accurate and reliable preliminary study should be performed, because the restoration of the cultural heritage appropriate to its original which has been destroyed or exterminated naturally or by humans will be possible after a good documentation process.
The detailed investigation of a construction, city texture or an archeological ruin and their documentation, evaluation in terms of architecture and restoration projects can be made after describing the current condition of the structure with scaled drawings belonging to its interior and exterior architecture, distinctive decoration, load-bearing system and construction materials. Today, a reliable documentation and restoration process becomes possible by using the developed techniques and technologies

efficiently, since the documentation with modern tools and devices, new softwares and measuring techniques superseded the conventional documentation methods. Measuring with digital devices and the local photogrammetry methods generally used for the determination of the historical buildings, detecting deformations and forming the base for the conservation projects are the major components of modernization in recent years.

2. Photogrammetry in Architecture:

Photogrammetry, as a word, has been formed with the words photos + grama + metron (light + drawing + measuring) in old Greek language which has the meaning of "measuring by drawing with light". Comprehensively, photogrammetry consists of the determination of photographic views, their evaluations and measurements and the determination of reliable information related to every kind of objects and their surroundings (Wolf and Dewitt, 2000).

After the invention of photograph by Niecepe in 1813 and Daguerre & Arago in 1838, Aime Laussedat used photograph in forming maps for the first time in 1849 who has developed the first tools and methods for this purpose (Anay, 2007; Gulec, 2007). Then, the German architect Meydenbauer used the "photogrammetry" term in architecture for the first time in 1858 in accordance with his strong belief in documenting cultural heritage for restoration when necessary, and he has founded the Royal Prussian Photogrammetric Institute, the first institute on this subject (Burtch, 2004). Beginning with the invention of stero-comparator in the early 1900s and developing first numerical machines in 1940s, as a result of the studies by Howard Aiken in Harvard University, John Von Neumann in Princeton University and the other researchers in America and Germany, photogrammetry recorded large scale improvements. After experiencing the periods of table photogrammetry (1850-1900) and analog photogrammetry (1900-1960), the analytical photogrammetry period began (Burtch, 2004) in which the computers were used only for calculation purposes. Eventually, the digital photogrammetry softwares were produced after developing the first personal computers in 1980s and today's level of photogrammetry was achieved by the help of the digital photography began to be used in the late 1990s.

The photogrammetric studies can be classified according to their utilization areas, photographing positions, evaluation of photographs, number of photographs and used equipments (Gulec, 2007).

According to photogrammetry evaluation methods;_Analog photogrammetry, analytical photogrammetry, digital photogrammetry.

According to photographing positions; Aerial photogrammetry, remote sensing, close-range photogrammetry.

Close-range photogrammetry:

Close-range photogrammetry is the 3D digitalization process of the site measurements and the close-view photographs taken with a calibrated camera in high resolutions by using computer softwares in the digital medium.
The local photogrammetry technique has been used for years in archeological measurements and for the documentation of the historical monuments. The developments in digital techniques caused the photogrammetry to become more efficient and economic method in documenting and conserving the architectural monuments (Duran and Toz 2002).
The improvements performed on the methods used for documentation and observation processes of the cultural heritage is so much important in terms of architectural conservation applications, urban and regional planning, industrial architecture, art history, architectural history and archaeological researches. Architectural photogrammetry is a "documentation" method that deals with producing accurate and reliable measured drawings in a short period of time which are indispensable components of architectural conservation projects and related to the current condition of the monument. Additionally, this method can also be used for analytical documentation (structural properties, deformations, changes, etc.). The studies made on this branch increased the importance and the application areas of the local photogrammetry, i.e. 3D modeling of constructions, architecture, city planning, tourism, etc. (Suveg and Vosselman, 2000; Turan, 2004; Yakar et al., 2005).
3D views and animation, 3D vectorial data and 2D orthophoto views of an object digitalized with local photogrammetry can be obtained in any required scale. Besides its aids in documenting and conserving the historical heritage, it also provides the comparable evaluation between the cultural heritage's present and future conditions by performing clear understanding and easy presentation about the monument.
The architectural photogrammetry not only includes the studies related to the drawings of the buildings but the renovations of the buildings after several damages, the amount of deformations and the measurements related to the restoration studies as well (Dallas, 2001). In architecture, the local photogrammetry is used for;

- The current condition of a construction,
- The determination, restoration and documentation of the historical and cultural heritage,
- Body and surface modeling,
- Interior area modeling,
- 3D modeling for the reassembling and reconstruction projects of an historical monument,
- The design and application of the public works conservation plans,
- The determination of the flexural, torsional, shearing and failure deformations of the

constructions,

- The acoustic measurements and calculations,
- The urban and regional planning studies,
- The production of scale modeling, busts and industry models,
- Drawing and modeling the details in required scales,
- The measuring processes of buildings after construction,
- Area planning including new buildings,
- The formation of animations produced with 3D models whose inside and outside can be examined,
- Transforming data as they can be used in CAD and engineering software programs (Asri et al., 2007).

3. Case Study:

Documentation is a result of a very complex and sensitive working period formed by data-acquisition, information gathering, discussion and production stages that should be performed before all the conservation and renovation studies. It covers the current information about the monument and its surroundings which is composed of photographs, historical records, documents and drawings, historical archives, stamps, travel notes, etc. (Yilmaz et al., 2008).

Today, the cultural heritage should be conserved and documented due to rapid deterioration or destruction of cultural monuments as a result of weather conditions, wars, floods, earthquakes and fires, inappropriateness and inapplicability of the legal and managerial laws, and because of constructing buildings in touristic regions without any permission and not comprehending the conservation and restoration consciousness.

In this study, the façade rehabilitation of Historical Menguc Street in Konya is studied by using close-range photogrammetry. Menguc Street is situated in the conservation (sit) area where there is ancient city centre (Türbeönü). This street composed of traditional houses and new settlements is very significant in terms of urban history and tourism potency. Menguc Street is also close to the tomb of Mevlana Celaleddin, a Sufi is known in the world. With the construction of new house settlements and transportation of city centre from Türbeönü to the different place of city, families having traditional houses in Menguc Street had abandoned these places. After the death of houseowners settling in the new city centre, historical houses staying uninterested and neglected because of the lots of inheritors, etc., are either occupied by poor families or stayed vacant in a long time. This situation has brought about destruction and even demolition of many houses. Moreover, up to before twenty years, because of not having registration of many houses has speed up the demolition process of houses. Konya Metropolitan Municipality has decided to get rehabilitation project of Menguc Street done with the aim of straightening this situation, revitalizing of the historical area and street and regaining them to tourism

and city. Department of Architecture in Selcuk University has undertaken the studies of documentation for rehabilitation project of these constructions.

In this section of study, examples of various applications made by using digital fotogrammetry have given; the stages of these applications have explained in detail, and after discussing the material and the method used in the applications, the obtained experiences have put forward.

During the studies, Photomodeler Pro v5.2.3, the photogrammetry software produced by EOS System Inc., was used to obtain 3D models from 2D photographs. This product allows you to create accurate, high quality 3D models and measurements from photographs. It is widely used by professionals in the fields of accident reconstruction, architecture, archaeology, engineering, forensics, web page design, and 3D graphics. The photographs were taken in 3072×2048 pixel resolution (6.3 megapixels) by Canon EOS 300D digital SLR camera with 18 mm objective previously calibrated with Photomodeler Pro's calibration module (***figure-1***). The in-situ coordinates of the points on the photographs and the sketchs were obtained by using Topcon GPT 3005 Total Station and transformed into text files and CAD files with dxf extension by the Toplink computer program.

figure (1): *Canon EOS 300D Digital SLR*

figure (2): *Topcon Laser Total Station*

The first stage was the planning and application processes of the site investigation. In order to make the documentation study, the monuments were completely observed and a preliminary analysis was performed to determine the documentation technique appropriate for the monument. Then, in the next stage, the photographic documentation process was carried out at the site. The measured drawings for the monument were prepared by using AUTOCAD 2007, a practical and flexible technical drawing and solid modeling software widely used on the world.

***figure (3):** Coded Targets in Façade.*

The sketchs were primarily prepared to obtain the measured measured drawings of the monument; the check points on the monument were fixed with labels (***figure-3***) and the site points obtained by the help of the total station were marked on the sketchs. Afterwards, the photographs related to the monument were taken by a calibrated camera in a particular order allowing to be imbricated (***figure-4***), and the data obtained at the site was entered to the Photomodeler software at the office to produce 3D real views (***figures-5,6***). The orthophotos from the corrected 3D views were transferred to Autocad 2007 by exporting as the raster image (***figures-7,8,9***). After this stage, new drawings were formed from these views by using Autocad 2007 and the unmeasured or unmodelled sections of the existing drawings were completed by the help of the measurements provided from the traditional techniques (***figures-10***).

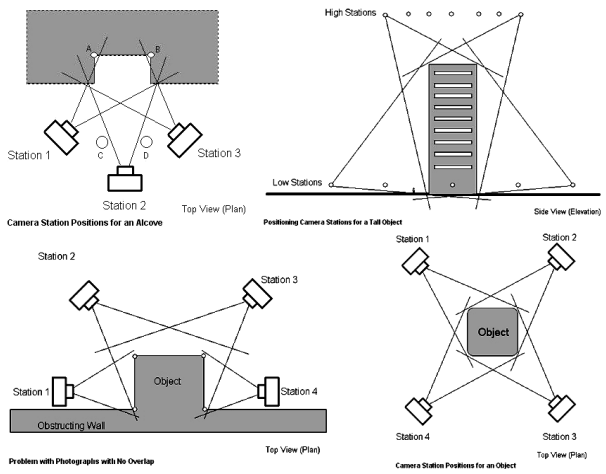

figure (4): *Camera Positions.*

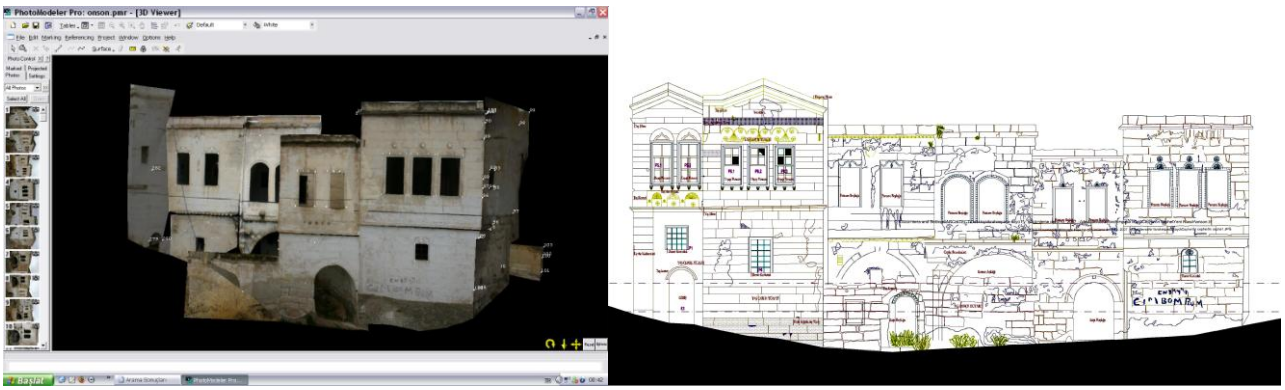

figure (5): *A house in Ibrahim Pasa Village.*

figure (7): *2D Orthophoto.*

figure (8): *Drawing and Raster (Orthophoto) in AutoCAD.*

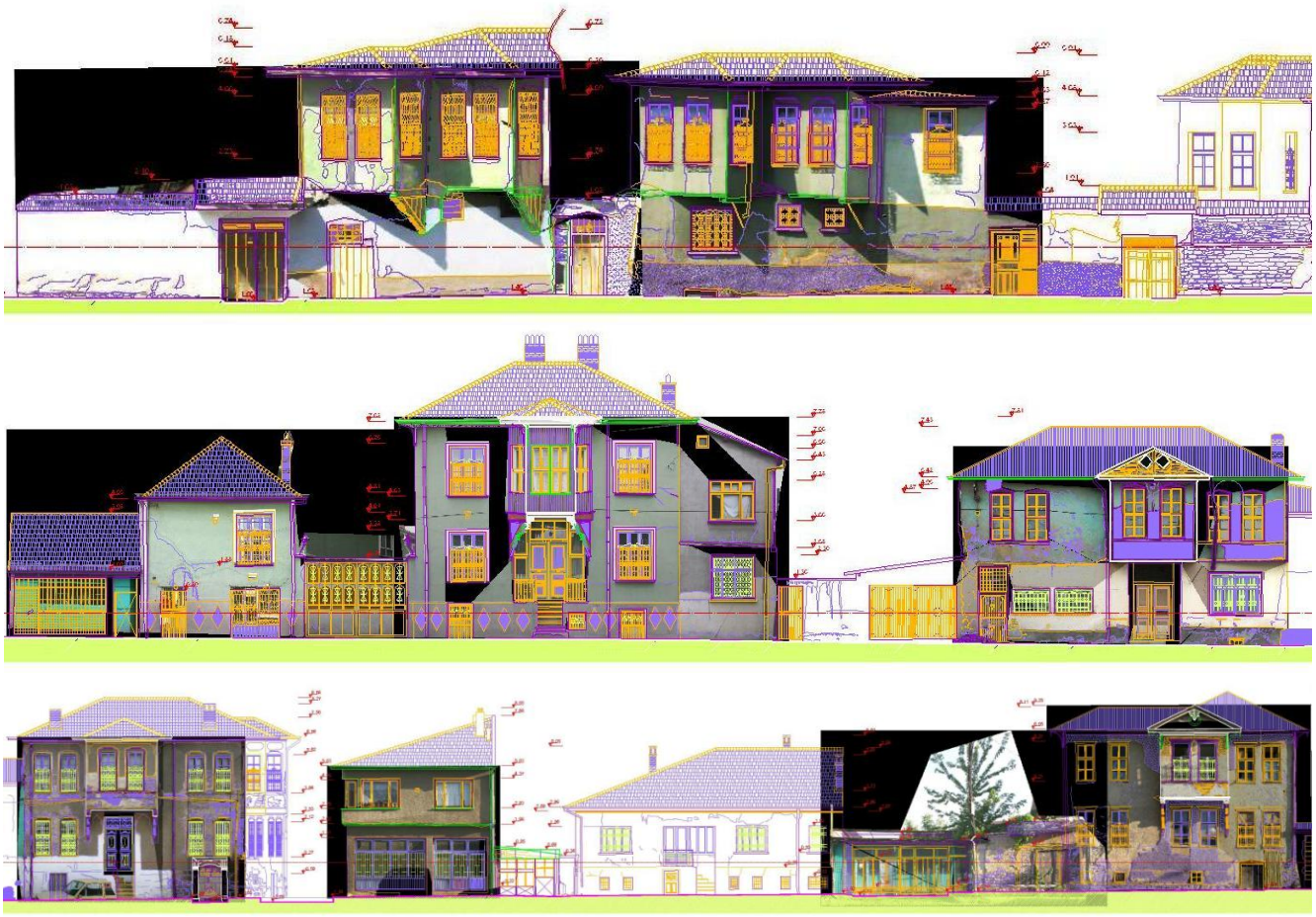

figure (9): *Drawings of Façade Rehabilitation Project in Konya.*

figure (10): *2D Drawing in AutoCAD.*

4. Advantages and Disadvantages:

The advantages of local photogrammetry can be listed as providing historical inventories more sensitive, conserving cultural heritage in digital medium by digitalization, the ability of continuous measuring on required documented components. Additionally, using local photogrammetry presents conveniences in determining the areas difficult to be measured, drawing details, comparing deformations possible to occur on the structure in the course of time, achieving the required accuracy and working on damaged and dangerous structures.

This method can be used safely in dangerous places when distance is favorable. The limited distance for facades looking at narrow streets allows taking only wide-angled photographs, thus modeling quality decreases during image correction due to the distortion increasing from the center to the sides of the photographs and consequently the documentation accuracy decreases. Under these circumstances, taking more photos and a good calibration can be a solution; however it may take too much time to study on and imbricate many photos (Anay, 2007).

The main & auxiliary memories and a fast processor are required to study with high resolution photographs. Since the digital cameras save the photographs in digital medium, the photographs are not subjected to bathing process and directly transferred to the computer.

The costs reduce, since the site activities can be completed with a small group of researchers and all the information related to the monument can be obtained by the model formed after the site activities.

All the studies after site investigations can be performed at the office.

Taking the photographs once and making necessary measurements, a permanent documentation is provided which includes digital data ready to be used when needed.

The detail accuracy on the prepared model can be adjusted and the surface of the model can be covered with texture.

It gives the opportunity to work easily and safely in dangerous buildings, unreached sections.
The working period is insignificantly affected from the weather conditions.
The accuracy of the model is a little influenced from the workers, weather conditions and equipments but it provides the opportunity to control and correct the problems.
The modeling can be made during the office stage after completing the photographing and measuring processes.
The last product can be studied in safe and accuracy by transferring it into the CAD medium.
It provides to have faster results for the further studies. When compared to the studies performed by hand, the wide range data can be obtained faster.
It is an ideal method in transferring the obtained data into CAD systems directly.
It provides to get 3D data directly, which increases its importance in terms of CAD programs.

Disadvantages

There can be faced with problems during the formation of the model if the photographs were not in required amount or quality.
The texture quality depends on the quality and the distance of the photograph. The results obtained by using low resolution or close-range photographs may not be satisfactory.
The places with insufficient number of points and having no check points have problems during the evaluation stage, and the obtained orthophotos get through deterioration.
Necessary softwares, measuring devices and computer equipments are all so expensive.
The education of the program and the measuring devices is not given in architecture departments.
Insufficient domination to the monument and not comprehending the related information is due to short period of site investigations.
Inadequate drawing ability of the photogrammetry softwares causes to transfer the drawings into other CAD programs.
Drawing muqarnas, dome, vault like members is a difficult and time-wasting process.
The cross-section and plan like drawings cannot be performed.
When the environmental conditions are not suitable, i.e. if an obstacle exists in front of the monument preventing to take the measured drawings or not having sufficient distance, the photographing process becomes difficult and causes to have errors in the drawings.
For the places at which no check points occur –e.g. roofs– the evaluations are faced with deteriorations and problems.
During the transformation of 3D modeling into 2D expression, there occur deteriorations

and need some corrections in order to become appropriate for the architectural expression.
It is a complex technique requiring special data and not favorable for the small applications.
The easy and accurate preparation of three dimensional and detailed visual products became possible in the digital medium, besides the solution, evaluation and synthesis periods of the architectural conservation area.
In order to obtain a 3D view at the end of the digital photogrammetry study, imbricatable consecutive photographs with pre-planned number and quality should be taken. The geodesic measurements required for this modeling should be performed with great accuracy. At least 3 common points should exist on the imbricated sections which are not on the same line of action. Each detail point should be photographed at least in 2 (or preferred 4) views in order to form the model. For exterior orientation, 4 check points not lying on the same line of action should be included in the photograph. If the modeling process is performed without any check point, a well-known distance (the long one is preferred) should be used. In modeling, the details on the object can be used as the target point and certain or automatic signals can be used to increase the accuracy (Asri et al, 2007).

5. Conclusion:

The usage of photogrammetry in architectural measured drawings became almost indispensable. In conventional methods, each corner of the historical monument is measured over the scaffolding and then its measured drawing is prepared. The conventional measuring technique is not preferred due to time-waste, accuracy and practicality.
The conventional and the photogrammetric methods should be used together for the documentation of the historical monuments, archaeological sites and cultural heritage when necessary. High level of technology should be used in plan and cross-section measurements to produce accurate drawings. The contribution of the architectural photogrammetry to the conservation and documentation studies can be seen clearly. The site investigation period and the labor power are minimized with the photogrammetry method and so much time remains for the other studies. The information obtained by the model can be used in many branches like tourism, civil engineering, architecture, visual arts, etc.

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