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A CASE STUDY OF TERRESTRIAL LASER SCANNING FOR URBAN CONSERVATION STUDIO AT ÇARŞAMBA NEIGHBOURHOOD IN ISTANBUL

3D LASER SKENIRANJE ZA POTREBE URBANE KONZERVACIJE NA PRIMJERU NASELJA ÇARŞAMBA U ISTANBULU

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ABSTRACT

The proper approach of heritage preservation starts with understanding its values and respecting its authenticity and integrity. This requests detailed records and analyses which in principally can be conducted using traditional methods with classical tools or using advanced technological tools.

Currently, advantages of using new technologies have been welcomed by the heritage preservation courses at universities. This paper aims to present the implementation of the 3D laser scanning in a graduate studio in urban conservation at FSMVU (Fatih Sultan Mehmet Vakıf University) in Istanbul, with all potentials and limitations. In particular, the process of creating a point cloud by 3D laser scanner Faro Focus 150 S and producing orthographic figures for documentation, for selected streets in the historic neighborhood of Çarşamba at Fener-Balat in Istanbul will be explained. The use of the 3D laser scanning was especially beneficial where the classical tools for documentation couldn't bring satisfing results.

This paper by comparing classical tools and 3D laser scanning techniques tries to identify all the advantages and disadvantages of the new technology and the difference in the quality of the obtained results.

Keywords: *historic preservation, point cloud, 3D laser scanning, education, Istanbul*

SAŽETAK

Pravilan pristup očuvanju naslijeđa najprije podrazuimijeva razumijevanje definiranih vrijednosti i poštivanje autentilnosti i integriteta. Iz toga proizilazi i potreba za detaljnim snimanjem i analiziranjem graditeljskog naslijeđa, kako upotrebom tradicionalnih metoda i klasičnih alata tako i upotrebom alata savremene tehnologije.

Danas, prednost upotrebe nove tehnologije je dobro prihvaćena na univerzitetima u okviru nastavnih procesa. Ovaj članak prezentira implementaciju 3D laserskog skeniranja, na post-diplomskom studiju urbane konzervacije na FSMVU (Fatih Sultan Mehmet Vakif Univrzitetu) u Istanbulu, sa svim potencijalima i ograničenjima. Osobito će biti objašnjeni procesi kreiranja oblaka točki (point cloud) pomoću korištenja skenera Faro Focus 150 S, kao i produciranja orto foto snimka za dokumentiranje odobranih ulica u historijskom dijelu grada Fener-Balat, u naselju Çarşamba u Istanbulu. Prednosti korištenje 3D laser skenera posebno su istaknute tamo gdje klasični alati za dokumentirnje nisu mogli dati zadovoljavajuće rezultate. Kompariranjem upotrebe klasičnih alata i tehnika 3D laserskog snimanja moguće je razumjeti sve prednosti upotrene nove tehnologije i kvaliteta dobijenih rezultata.

Ključne riječi: *historijska zaštita, point cloud, 3D lasersko skeniranje, edukacija, Istambul*

1. INTRODUCTION
1. UVOD

In dealing with the heritage preservation, an initial phase is necessary before any decision is made and any intervention is implemented, which can be described as preparation of detailed survey and inventory on site. This would provide a full comprehension of historic structures and their level of integrity and authenticity. Precise record is an important step to understand not just the structure itself but the historical and cultural context. This is important for both architectural and urban conservation. The basic traditional tools supported with different software can provide an orthographical record. Nevertheless, the results are spotted to have still some inaccuracy. In the last few years, 3D laser scanning has opened a new stage in dealing with heritage documentation. The application of this technology has shown multiple benefits in recording hardly approachable areas and sites affected by different constraints. In addition to saving time, this technology requires few people to work on site and produces precise records. This indicates that the use of new software and technologies is inevitable and helpful in providing the most precise results. However, it requires solid knowledge in using specialized technologies based on terrestrial scanning equipment and software based processes [1]. Therefore, at urban conservation studios at universities knowledge of traditional tools is obligatory while having possibilities to integrate both traditional along with contemporary tools is beneficial as much as challenging. The experience of using terrestrial laser scanning at urban conservation studio will be explained through the following case of FSMVU where students worked at the historic area of Fener in Istanbul.

2. INTRODUCTION TO THE CONSERVATION STUDIO AT FSMVU
2. UVOD U STUDIO URBANE KONZERVACIJE NA FSMVU

As a part of the curriculum of Architectural Preservation and Restoration Master program at FSMVU the conservation studios are arranged in two semesters, focusing on single structures and urban contexts. The studio related to the urban contexts is arranged in 14 weeks, during which students are expected to conduct a thorough survey of a selected historic site. For this historic site they are expected to analyze conservation problems and propose compatible solutions while preserving its integrity and authenticity and at the same time enhancing defined values. Also, the teaching approaches at proposing solutions for revitalization aims at the integration of different possible interventions from restoration to contemporary infills without compromising the historic urban context.

SWOT analysis	Traditional	3d Laser scanning
Strength	Close work with local inhabitants; Better understanding of the historic context and structures.	Detailed record; Short working time.
Weakness	Less detailed record; Long on site work. No quality assurance for record in preparation phase. The record accuracy is not guaranteed. Incapability of taking measurements for high elevation.	Depends on whether condition and day time of work. Dependence on software post production.
Opportunity	To work without availability of technology products.	High quality of record for high or complex structures.
Threat	Mismatch of proportions; Risks on site accidents; Lack of measurements and record for high elevations.	Less points; Low quality of model.

Table 1. *SWOT analysis. Source: Authors*

Tablica 1. *SWOT analiza Izvor: Autori*

Expected outputs of the initial phase of the urban conservation course are to collect information about the current state of conservation of the selected site as a result of on-site inventory.
All the relevant information about the current condition of buildings (solid-void, floor elevation, function, state of conservation etc.) and the percentages of open spaces (green area, car parks, traffic scheme etc.) are collected and presented on maps. Special attention is given to the historic buildings and monuments for which inventory templates are prepared with detailed descriptions. Additionally, in order to comprehend the area better, it is required to define the types of historic buildings, their architectural elements and decorative features. In the second phase the facade drawings of the selected streets are prepared, which present the current condition of these structures and indicating proposals for future improvement. In a final phase a report about the whole survey, analyses and proposals is expected to be prepared. It includes brief information about the history of the selected site, explanation about changes of the urban fabric over time.
During the spring semester of urban conservation studio in 2017/18 students were divided into 4 groups. In this paper in order to present the process of the application of terrestrial scanning technology in the graduate studio at urban conservation the results of one group will be used.

2.1. DIGITAL DOCUMENTATION TECHNIQUES IN THE CONSERVATION STUDIO

2.1. TEHNIKE DIGITALNOG DOKUMENTIRANJA U OKVIRU STUDIJA URBANE KONZERVACIJE

After the preliminary analyses of the study area one street was selected to be a case study for each student group. The streets were determined according to the high level of integrity and authenticity. The silhouette drawing for both sides of each street was expected to be drawn. Only after the preparation of the survey drawings, the students were able to prepare proposals for the required interventions that vary from infills, removal of unsuitable additions, change in colours etc. The starting point was to prepare a record of the current condition. For this purpose the traditional methods are usually applied such as use of simple measuring tools for distances and levels and photo apparat. With these basic tools, students are able to understand urban fabric and its codes as they are spending more time on site. However, the constraints of some sites can cause poor record and therefore result in lack of information. In such cases, the use of the terrestrial laser scanning is more beneficial, as it is shown by the SWOT analyses (table 1).
The scanning technology shortens the working time that is needed to produce a detailed and highly qualified record of the scanned buildings, including complex structures, as well as tall and richly decorated ones. It is also beneficial as it decreases the risk of an accident since fewer people are needed on-site during scanning.
Still, the scanning process depends on weather conditions and suitable time for work, as it is important to avoid any intensive movement around the scanned area that can cause low quality in modelling. On the other side, the final results of the scanning record are related to the availability of the scanning equipment and the software for post-production. The traditional techniques can be applied while working under more primitive conditions. In the usage of traditional techniques, there is a risk of accident and lack of precise measurements for high elevations. Moreover, the results of traditional techniques can be checked only after finalizing the survey drawings.

3. FENER BALATAREA: BRIEF HISTORIC OVERVIEW

3. PODRUČJE FENER BALAT: KRATKI HISTORIJSKI PREGLED

During spring semester in the 2017-2018 academic year, the historic area Fener-Balat[1] was selected, which is located in the Historical Peninsula of Istanbul in the district of Fatih.

[1]The Fener neighbourhood takes its name from Phanariots, were members of prominent Greek families in Phanar (Φανάρι, modern Fener), the chief Greek quarter of Istanbul, who traditionally occupied four important positions in the Ottoman Empire as administrators in the civil bureaucracy, exercised great influence in the Ottoman Empire in the 18th century. From 1669 until 1821 Phanariotes served as dragomans (interpreters who also acted as foreign-affairs advisers) to the Sublime Porte (the Ottoman government) and to foreign embassies. They have also appointed hospodars (rulers) of the Danubian principalities, Moldavia and Walachia, vassal states of the Ottoman Empire during the period 1711–1821 [4].

The area stretches from the southern shores of the Golden Horn to the inland neighbourhood of Çarşamba and characterized with hilly topography (Figure 1). The area is very rich in Byzantine and Ottoman monuments and remarkable examples of 19th century civil architecture.

By chronological order, for the built heritage of the area, one can start with Golden Horn Walls of the city which date back to Theodosian Era (401-450 CE). [2] The walls are today partly lost and partly imperceptible due to the structures standing above them and using them as foundations. As for other important monuments of Byzantine Era, Fethiye Camii and Panagia Muhliotissa Church can be taken as two important religious structures from the Mid and Late Byzantine Era. Fethiye Camii after the conquest of Istanbul was the first Greek Patriarchate which was re-established by the initiative of Mehmed II. The small masjids which date back to the reign of Mehmed II and Bayezid II, imply the regeneration of the neighbourhoods after the conquest [3]. This is an important feature of the historical area, although these masjids are all reconstructions on the same plot. Some examples of these masjids can be given as Mismarcı Sücaattin, Abdi Subaşı, Tevkii Cafer, Tahta Minare, and Hızır Çavuş. Yavuz Selim Camii is an important example of 16th century Ottoman Classical architecture.

As for 18th structures of the area, Ismail Ağa Camii and Murat Molla Library should be mentioned. The presence of the Patriarchate in the area since 1614, also makes the area special for Greek and Orthodox culture. Besides the Patriarchate, the area is full of examples of residential architecture and important Greek Schools such as the Fener Rum Lisesi (Megali tou Genous Sholi), Ioakimion Greek School for girls, Maraşlı Greek School and 19th century Greek Churches such as Metrology, Hagios Georgios Potiras Churches. As for the 20th century, some houses from the beginning of the century and Architect Kemalettin's madrasah building as an example of First National Architecture Movement, facing Fethiye Camii in the neighbourhood of Çarşamba is worth mentioning.

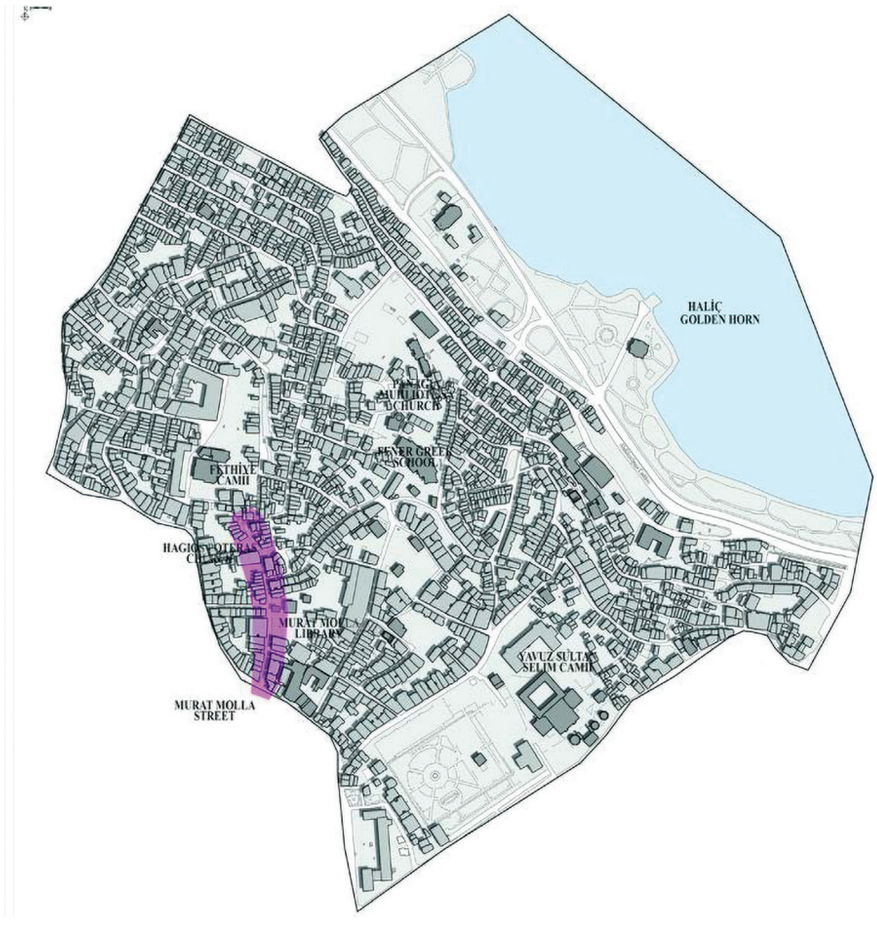

Figure 1 *Historic area of Fener Balat in Istanbul*
Source: Authors

Slika 1 *Historijsko područje Fener Balat u Istanbulu*
Izvor: Autori

The selected street for the case study was Murat Molla Street, containing authentic historic buildings: 2 monuments and residential structures which should be preserved. The monuments are a 19th century church, namely Hagios Poteras and an Ottoman Era library, Murat Molla, dating back to 18th century. According to the construction techniques and used materials, it can be concluded that historic residential buildings are dating back to the late Ottoman period, precisely 19th century. The residential structures of the neighbourhood have as most definite characteristic projections with bay windows. The floors are separated by cornices of dogtooth. Rectangular and arched windows are seen. The silhouette of the street is enriched with historic building of Hagios Georgios Potiras Church and Murat Molla Library. The organic fabric of the streets, narrow plots, the courtyard-urban space relationships of the houses can also be spelled for the additional characteristics of the selected area. [5].

Figure 2 *Aerial photo of Murat Molla Street at Çarşamba neighbourhood in Istanbul*
Source: Conservation studio FSMVU

Slika 2 *Slika iz vazduka obuhvata Murat Molla ulice u Çarşamba naselju u Istanbulu*
Izvor: Conservation studio FSMVU

2.3. LASER SCANNING PROCESS
2.3. PROCES LASERSKOG SKENIRANJA

The scanning process included usage of a new generation terrestrial laser scanner. These scanners are quite small in size and practical to be used on site.

For this purpose, FARO's portable FocusS 150S Laser Scanner was used to scan the streets in the selected historic neighbourhood. This type of portable laser is suitable for architectural surveys that can capture mid-range measurements up to 150m. It is equipped with a built-in 8 megapixel HDR-camera that can provide detailed record and images with natural colour overlay to the scan data even under extreme lighting conditions [6].

Steps of a terrestrial laser scanning survey are distinguished into three phases: preparation, record and post-production. In the preparation phase, the site was visited to understand all possible obstacles during record. Size and topography of the streets, frequency of movements, most crowded time of the day, accessibility are some of the factors that were assured before on-site record. Also, hand drawn sketches of the scanned area were prepared in order to schedule scanning order and to check the process manually.

The first step in the scanning process, is to prepare paper checkerboards and to place them on the facades to be used as targets for scanning. The checkerboards were placed on vertical surfaces at different levels and on different planes. This is used to assure the ordering of the scanned data. There should be at least three of the paper targets intersecting with the previous scan for the registration of the scans into clusters and/ or a point cloud. In this scanning process, 36 checkerboards were used and 11 scans were accomplished. Problems with processing orthographic-figures can be faced due to extremely huge data of terrestrial scanning. Therefore, all parameters such as resolution, scan quality, colour, and exposure should be set for scanning according to the complexity of the scanned area and needed level of the survey [5]. Scanning should be done carefully in order to collect enough points to assure best results [1].

Post-production is a final phase which refers to the uploading of collected scanned data to obtain cloud points using software, which in this case was Faro Scene software. This program also was used to obtain orthographic-photographs which in post-phase are inserted in Autocad for preparing final drawings needed for the course.

Figure 3 *FARO 150 S 3D laser scanner (left) and paper checkerboard (right)*

Slika 3 *FARO 150 S 3D laser skener (lijevo) i papirne oznake (desno)*

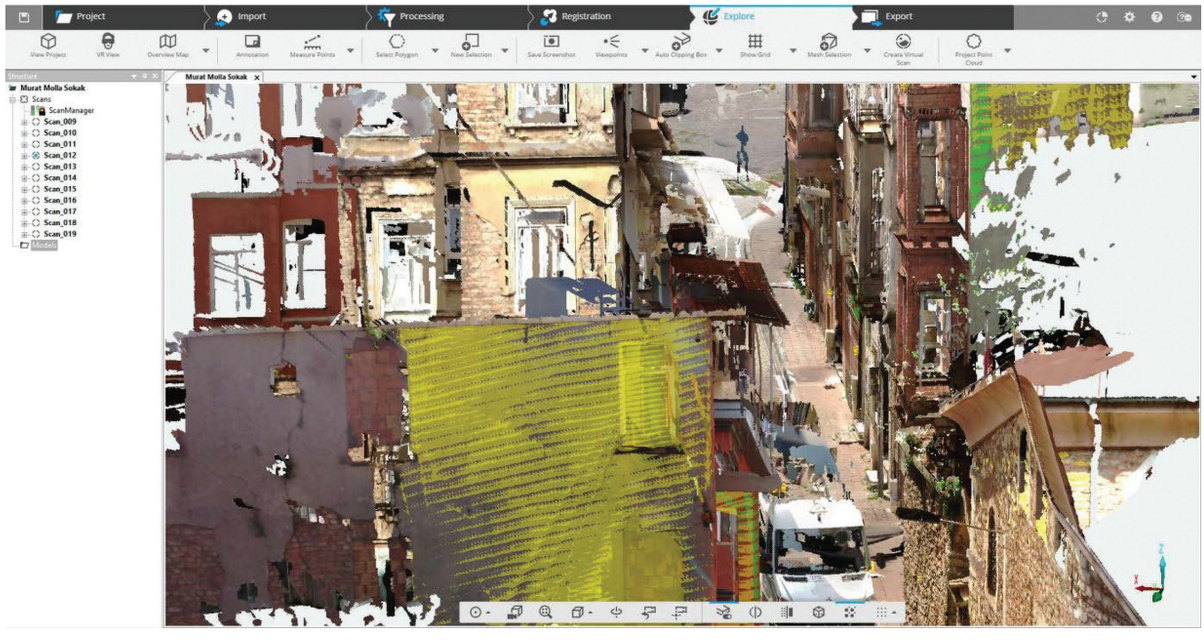

Figure 4 *Working interface in Faro Scene software*

Slika 4 *Radno sučelje software Faro Scene*

Source/Izvor: Conservation studio FSMVU

Figure 5 *Post production orthographic-photograph and Autocad drawings for the west facade of Murat Molla Street.*

Slika 5 *Post produkcija ortog-fotografije I Autocad crtez zapadnne fasade Murat Molla ulice*

Source/Izvor: Conservation studio FSMVU

3. CONCLUSION
3. ZAKLJUČAK

In conservation practice, it is widely accepted that new technologies have brought more efficiency to site-work. Therefore having the possibility to use benefits of terrestrial scanning is an advantage while it requires knowledge of the trained staff to be constantly updated following technological developments and using growing possibilities of different software packages.

In this paper, experience of students of one graduate studio in urban conservation using possibilities of FARO's portable FocusS Laser Scanner was presented. During the semester the students used laser technology products such as the panoramic and orthographic photographs and the traditional measuring, and photogrammetric methods for preparing the survey drawings. The results have shown that modern technology is suitable to be used for both single structure records as well as for urban level records.

The application of the new technology was welcomed by the students as they had the chance to extend their knowledge beyond traditional techniques and obtain better results for their documentation.

Compared to the traditional techniques the good quality results can be obtained in a much shorter time. The advantages have been seen in using the laser for more complex structures and high elevation. In conclusion, available digital tools of our time provide faster and precise surveys of the cultural heritage.

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4. REFERENCE

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