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Comparison of Traditional Methods and 3D Laser Scanners in Architectural Structures: The Case of Kuruçeşme in Mersin

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Abstract: Laser scanners create three-dimensional models of surrounding objects and are used as a basis or reference in fields such as architecture, engineering, archaeology, and others. Three-dimensional modeling, area scanning, monitoring the progress of large projects, and other related topics provide significant advantages. These techniques and tools, which are used in various applications such as distance measurement, object detection, and remote sensing, have a wide range of applications. 3D laser scanning technologies offer benefits in many areas, from detailed documentation of existing buildings to the design of new projects and the management of construction processes. With their ability to perform fast, precise, and efficient measurements, laser scanners greatly facilitate architectural applications. In the future, it is expected that this technology will be used more widely in architectural processes. This study examines the measurement of the Kuruçeşme structure using traditional measurement techniques and 3D laser scanners, and compares these two methods. It focuses on identifying the advantages and disadvantages of these two methods and their compliance with acceptable error values.

Key Words: Laser scanners, Architectural structures, Traditional measurement methods, Kuruçeşme

1. Introduction

Laser scanners operate fundamentally by sending laser light to a specific surface and detecting the light reflected from that surface. The reflected light is detected by the scanner and converted into point cloud data containing distance and position information. These scanners are generally more commonly used in fields such as architecture, construction, engineering, and geographic information systems (GIS). They are also known as 3D scanners and are used to create precise digital models or images of objects. Laser scanners can capture the details of surfaces in high resolution.

With the advancing technology, laser scanners are leading to significant transformations in the world of architecture and construction. One example of these

transformations is the widespread use of laser scanners instead of traditional measurement and surveying techniques. Thanks to laser scanners, architects, engineers, and other professionals are increasingly choosing this technology daily due to the advantages it offers, such as three-dimensional modeling, area scanning, monitoring large projects, tracking project progress, and performing detailed measurements

2. Literature Review

Laser scanners are based on two fundamental systems: mechanical deflection and laser radar. The mechanical deflection system tracks the horizontal and vertical angles of the laser signal, while the laser radar system calculates the time taken for the laser light sent from the scanner to return after hitting a surface of an object[1]. These two systems combine to create a global and three-dimensional coordinate grid. The laser scanning technique is also used in various fields such as underwater scanning and aerial laser scanning[2].

Aerial laser scanning is performed using a laser scanning device mounted on an aircraft, equipped with systems like GNSS and IMU. When objects and surfaces are scanned from the air with these systems, a point cloud is obtained that includes (X, Y, Z) coordinates and elevation values[3]. This method enables the rapid, accurate, and efficient scanning of large areas and is particularly ideal for obtaining three-dimensional data of cultural heritage and natural site areas[4].

Terrestrial laser scanning includes four different scanning systems: handheld, wearable, mobile, and stationary Handheld laser scanning can be used both stationary and mobile, and thus is considered a combination of mobile and terrestrial laser scanning systems[5]. Wearable laser scanning is designed to be carried on a person's back, allowing for real-time scanning and location determination in narrow, enclosed, and open environments[6]. It can be transported in a vehicle trunk and is suitable for use anywhere a person can walk. It has been integrated with SLAM technology to be comfortably used indoors, outdoors, in underground mines and tunnels, in cultural heritage sites, and in urban areas[7].

[1] H. Yılmaz ve M. Yakar, "Yerel Lazer Tarama Teknolojisi," *Yapı Teknolojileri Dergisi*, 2, 2 (2011): 43.
[2] H. Yılmaz ve M. Yakar, "Lidar (Light Detection And Ranging) Tarama Sistemi," *Yapı Teknolojileri Elektronik Dergisi* 2, 2 (2006): 23-33.
[3] A. Alptekin and M. Yakar, "3D modeling of Mersin Akyar Cliffs," *Turkish Journal of LiDAR* 2, 1 (2020): 5–9.
[4] D. Balcı, "The use of laser scanners in documenting cultural heritage," *Turkish Journal of LiDAR* 4, 1 (2022): 27–36. ; M. Ebrahim, "Overview of 3D Laser Scanners Techniques," *International Journal of Scientific Research* 4, 10 (2015): 323–331.
[5] E. Kanun et al., "Obtaining 3D Point Cloud of Ağzıkara Han Using Terrestrial Laser Scanning Technique," *Turkish Journal of LiDAR* 3, 2 (2021): 58–64.
[6] A. Karabacak and M. Yakar, "3D Modeling of Mersin Akyar Cliffs with Wearable Mobile Lidar," *Advanced Engineering Days* 6, (2023): 86–89. ; A. Karabacak and M. Yakar, "3D Modeling of Mersin Sarisih Caravanserai with Wearable Mobile Lidar," *Advanced Engineering Days (AED)* 6, (2023): 90 – 93.
[7] A. Karabacak and M. Yakar, "Application Areas of Wearable Mobile Lidar and 3D Modeling of Cambazlı Church," *Turkish Journal of LiDAR* 4, 2 (2022): 37–52. ; A. Karabacak and M. Yakar, "3D Modeling of Mufti Abdullah Sıddık Mosque Using Wearable Mobile Lidar," *Advanced LiDAR* 3, 1 (2023): 1–9.

Mobile laser scanning is supported by location and status sensors such as laser scanners, GPS, and IMU to record scanning data obtained from moving platforms. Stationary laser scanning is a technique frequently preferred in archaeology and engineering due to cost and time considerations, and it can be used to produce various outputs[8].

Photogrammetry is a branch of science used to determine the location, shape, and size of objects on the earth's surface through overlapping photographs[9]. With the advancement of technology, photogrammetry has started to provide more accurate and faster results compared to classical terrestrial measurements[10]. The 3D models created using the photogrammetry method emerge in real measurements and images. Photogrammetric measurement systems allow for modeling the geographic reference of the object as well as determining the geometry of the actual object[11]. These technologies enable 3D models that possess real images, especially since they are processed with the actual image of the object[12].

Terrestrial photogrammetry is frequently used in three-dimensional documentation studies; however, there are shortcomings, such as the inability to photograph the upper facades of certain structures[13]. The use of UAV carrier forms provides significant advantages in addressing these shortcomings. Although photogrammetry is preferred in many applications, it may not achieve the expected efficiency in highly developed areas and places where human access is restricted[14]. Therefore, unmanned aerial vehicles may be preferred. This way, scanning and visualizing large areas, collecting

[8] A. Alptekin ve M. Yakar, "Kaya Bloklarının 3B Nokta Bulutunun Yersel Lazer Tarayıcı Kullanarak Elde Edilmesi," *Türkiye LİDAR Dergisi* 2, 1 (2020): 1-4.

[9] H. M. Yılmaz et al., "Digital Photogrammetry in Obtaining of 3D Model Data of Irregular Small Objects," *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* 37, (2008): 125-130. ; M. Yakar and H. M. Yılmaz, "Using in Volume Computing of Digital Close Range Photogrammetry," *The International Archives of The Photogrammetry, Remote Sensing and Spatial Information Sciences*, 37, (2008): B3b.

[10] O. Mohammed and M. Yakar, "Yersel fotogrametrik yöntem ile ibadethanelerin modellenmesi," *Selcuk University Journal of Engineering Sciences* 15, 2 (2016): 85-95. ; M. Yakar vd., "Silifke-Mersin Bölgesinde Roma Dönemi Eserlerinin 3 Boyutlu Modelleme Çalışması ve Animasyonu," *Jeodezi ve Jeoinformasyon Dergisi*, 101, (2010).

[11] C. Alyılmaz et al., "Measurement of Petroglyhps (Rock of Arts) of Qobustan with Close Range Photogrammetry," *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* 38, Part 5 (2010): 29-32. ; F. Pulat vd., "Yersel Fotogrametrik Yöntem Kullanılarak Fotogrametrik Yazılımların Karşılaştırılması: Hüsrev Paşa Camii Örneği," *Türkiye Fotogrametri Dergisi* 4, 1 (2022): 30-40.

[12] F. Pulat et al., "Three-Dimensional Modeling of the Kubbe-i Hasiye Shrine with Terrestrial Photogrammetric Method," *Cultural Heritage and Science* 3, 1 (2022): 6-11. ; F. Yıldız vd., "Yersel Fotogrametride Kullanılan Metrik Olmayan Dijital Kameraların Kalibrasyonunda Kullanılan Yazılımların İncelenmesi Üzerine Bir Çalışma," *Harita Dergisi*, 134, (2005): 61-70.

[13] H. Karabörk et al., "Investigation of Accuracy For Digital Elevation Models Generated with Different Methods in Photogrammetry," *In International Society for Photogrammetry and Remote Sensing*, 35, (2004): B3. ; M. Yakar vd., "Photogrammetric Study for Sircali Medrese Door," *9-th International Multidisciplinary Scientific GeoConference SGEM 2009*, (2009): 879-884. ; M. Yakar vd., "Sahip Ata Külliyesi Rölöve Örneği," *TMMOB Harita ve Kadastro Mühendisleri Odası*, 10, (2015).

[14] A. Şasi and M. Yakar, "Photogrammetric Modelling of Sakahane Masjid Using an Unmanned Aerial Vehicle," *Turkish Journal of Engineering* 1, 2 (2017): 82-87. ; E. Kanun et al., The Use of UAV Photogrammetry in Modeling Ancient Structures: A Case Study Of "Kanytellis"," *Advanced UAV* 2, 2 (2022): 41-50.

precise data, and offering different flight modes provide significant advantages compared to terrestrial photogrammetry[15].

With the widespread use of UAVs, it becomes possible to develop applications for quickly showcasing artifacts on online platforms and to enhance the documentation and visualization capabilities of cultural heritage areas[16]. 3D models created with a photogrammetric approach using UAV technology are a cost-effective and fast technique compared to other modern methods for preserving such cultural heritage areas[17].

Environmental factors and the characteristics of the object can affect the results of measurements made with terrestrial laser scanners. Therefore, many studies have been conducted regarding the accuracy of measurements taken with terrestrial laser scanners, and various methods have been developed. According to these studies, laser scanners have been found to possess a certain measurement accuracy at both long and short distances[18]. Research conducted on the accuracy of laser scanners and the methods developed have been published scientifically. According to these publications, laser scanners have a measurement accuracy of approximately 10 cm at long distances of 1000 m and above, and around 1 cm at short distances of 300 m and below Traditional techniques and technological/modern techniques can be used in the documentation of cultural heritage (Figure 1).

[15] F. B. Ünel vd., "Kıyı Çizgisinin Belirlenerek Mülkiyet Durumunun İncelenmesi," *Türkiye Arazi Yönetimi Dergisi* 2, 1 (2020): 33-40. ; L. Karataş et al., "Detection and Documentation of Stone Material Deterioration in Historical Masonry Buildings Using UAV Photogrammetry: A Case Study of Mersin Sarisih Inn," *Mersin Photogrammetry Journal* 4, 2 (2022): 53-61.

[16] H. M. Yılmaz vd., "İnsansız Hava Aracı İle Ortofoto Üretimi ve Aksaray Üniversitesi Kampüsü Örneği," *Geomatik* 3, 2 (2018): 129-136. ; M. Yakar ve Y. Doğan, "Mersin Silifke Mezgit Kale Anıt Mezarı Fotogrametrik Rölöve Alımı ve Üç Boyutlu Modelleme Çalışması," *Geomatik* 2, 1 (2017): 11-17. ; O. Villi ve M. Yakar, "İnsansız Hava Araçlarının Kullanım Alanları ve Sensör Tipleri," *Türkiye İnsansız Hava Araçları Dergisi* 4, 2 (2022): 73-100.

[17] M. Yakar et al., "The Effect of Grid Resolution in Defining Terrain Surface," *Experimental Techniques* 34, 6 (2010): 23-29. ; M. Yakar et al., "Photogrammetric Measurement of The Meke Lake and Its Environment with Kite Photographs to Monitoring of Water Level to Climate Change," *In ISPRS Commission V Mid-Term Symposium*, (2010): 613-616. ; M. Kahveci ve N. Can, "İnsansız Hava Araçları: Tarihçesi, Tanımı, Dünyada ve Türkiye'deki Yasal Durumu," *Selçuk Üniversitesi Mühendislik, Bilim ve Teknoloji Dergisi* 5, 4 (2017): 511-535. ; F. Tükenmez and M. Yakar, "Production of Road Maps in Highway Projects By Unmanned Aerial Vehicle (UAV)," *Advanced Engineering Days (AED)*, 6 (2023): 94-96. ; O. Villi ve M. Yakar, "İnsansız Hava Araçları ve Coğrafi Bilgi Sistemleri Uygulamaları," *Türkiye Coğrafi Bilgi Sistemleri Dergisi* 5, 1 (2023): 20-33. ; A. Erdoğan et al., "3D Modeling of Cultural Heritage By Photogrammetric Method: The Case of Karabıyık Bridge," *Turkish Journal of Unmanned Aerial Vehicles* 3, 1 (2021): 23. ; A. Güleç Korumaz et al., "Digital Approaches in The Documentation of Cultural Heritage," *Selcuk University Journal of Engineering, Science and Technology* 26, 3 (2011): 67–83. ; E. Kanun et al., "Cultural Heritage Modeling Using UAV Photogrammetric Methods: A Case Study of Kanlidivane Archaeological Site," *Advanced UAV* 1, 1 (2021): 24–33.

[18] S. W. Nazari et al., "Analysis of 3D laser Scanning Data of Farabi Mosque Using Various Software," *Advanced LiDAR* 3, 1 (2023): 22–34. ; M. E. Oruç and G. Baş, "Use of Terrestrial Laser Scanning Technology in Complex Structures and Areas," *Turkish Journal of LiDAR* 3, 2 (2023): 39–47.

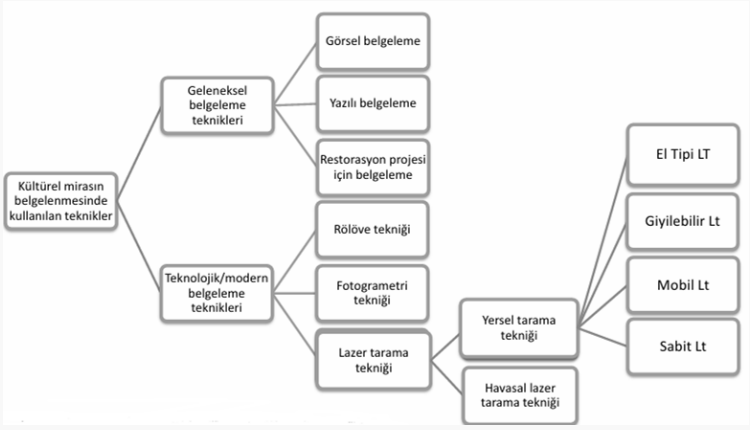


Figure 1: Techniques Used in the Documentation of Cultural Heritage

3. Traditional Measurement Techniques in Architecture

One of the traditional measurement techniques in architecture is the survey method, which involves taking measurements of an existing structure (such as a mosque, bathhouse, madrasah, school, hospital, bridge, etc.) using measuring tools such as measuring tapes, laser distance meters, levels, plumb bobs, water levels, and markers[19]. The survey process aims to reveal the aspects of a structure that are deteriorating, aging, unusable, or in need of renovation/repair, or it serves simply to document its current condition.

3.1. Advantages and Disadvantages of Traditional Measurement Techniques

When measuring a structure using traditional measurement techniques, it is necessary to take photographs of the structure, draw all its details individually, and transfer the drawn measurements into a computer environment. Due to these and many other stages involved, this measurement technique requires more manpower and time. Since different teams are involved at each stage, the process tends to be prolonged when measurements are taken using this technique.

The advantage of this method compared to 3D laser scanners is that it does not require a technical staff member who knows how to use 3D laser scanners and can convert the resulting data on the computer.

4. Working Principles of Laser Scanners

Laser scanners use laser light to create a three-dimensional model of the objects in their environment. Fundamentally, laser scanners rely on two main working principles: time of flight (ToF) and phase difference. With the Time of Flight Principle, distance is measured using the time it takes for

[19] A. Yaman and K. Muhammed, "Investigation of The Use of Geoslam Terrestrial Laser Scanner for Documentation and 3D Modeling of Historical and Cultural Heritage: Example of Ulucami in Aksaray Province," *Turkish Journal of LiDAR* 1, 1 (2019): 5–9.

laser light to hit an object and return. The scanner sends laser light to the object, and this light returns to the scanner after striking the object's surface[20]. By measuring this return time, the scanner calculates the round-trip time of the laser light to determine the distance to the object. In this way, a three-dimensional model of the object is created using the flight time of the laser light striking from different angles.

Aerial laser scanning systems use laser scanners mounted on airborne vehicles, such as airplanes or unmanned aerial vehicles (UAVs). They typically utilize the ToF principle to collect elevation data from the ground. Ultrasonic sensors measure the distance to objects using the ToF principle by calculating the time between sending an ultrasonic wave to an object and detecting the reflected wave.

In the phase difference principle, distance is measured by using changes in the wavelength of laser light. The scanner sends laser light to the object, and this light returns after striking the object's surface. The returning laser light has a phase difference compared to the original light. This phase difference is used to determine the distance to the object. The phase difference principle provides more accurate distance measurements compared to the time of flight principle. Some optical sensors measure distance using the phase shift principle, calculating distance by sending light to an object and measuring the phase shift of the returning light.

Laser scanners create three-dimensional models of the objects around them using these principles. These models can then serve as a basis or reference for work in architecture, engineering, archaeology, and other fields. These techniques and tools are used in many applications, such as distance measurement, object detection and remote sensing.

4.1. Use of Laser Scanners in Architecture

Laser scanners are used to digitally document existing structures. This process is referred to as reverse engineering and documentation. This scanning and documentation create a three-dimensional model of an existing structure or area (site), serving as a basis for redesign or restoration projects.

Laser scanners play a significant role in managing construction projects, monitoring progress, and ensuring quality control. They can accurately document the real condition of the construction site, allowing for comparisons with the project and helping to identify any discrepancies or irregularities.

The restoration and preservation of historical buildings have been significantly facilitated by the use of laser scanners. They bridge the gap in many areas where traditional techniques fall short, resulting in savings in both time and labor. 3D laser scanners aim to digitally document fine details and architectural features of the structure, providing convenience for the restoration and preservation

[20] M. E. Atik et al., "Classification of Photogrammetric Point Cloud Data Using Machine Learning," *Journal of Geodesy and Geoinformation* 9, 2 (2022): 137–149.

process. Laser scanners can be used to detect structural weaknesses or safety hazards, helping to mitigate potential risks.

The accuracy of a survey should align with the scale of the project and include a specific margin of error (English Heritage, 2003).

SCALE	Acceptable Margin of Error
1:10	+/- 5 mm
1:20	+/- 6 mm
1:50	+/- 15 mm
1:100	+/- 30 mm
1:200	+/- 60 mm
1:500	+/- 150 mm

Figure 2: Acceptable Margin of Error (English Heritage, 2003) Traditional Measurement Techniques in Architecture

The data obtained from scanning an existing area can serve as a starting point for design projects and allow architects to test their ideas in a digital environment. For instance, by creating a digital model of a structure using a laser scanner, it provides the opportunity to see how design decisions would look in a virtual/computer environment and how they would appear in reality, while also allowing for the exploration of different options. On the other hand, it offers the possibility of providing real-time information about the progress of a project.

The point clouds produced by 3D scanners can be used directly for measurement and visualization in architecture and construction. The renewal and transformation of cities from the industrial age (unsustainable) to the information age (sustainable) can significantly benefit from the implementation of digital applications aimed at enhancing planning, development, operation, reuse, and renovation, as well as solutions for the built and human environments during urban renewal and transformation.

A new framework has been proposed for three-dimensional change detection on construction sites using photogrammetric point clouds. Using UAV-based photogrammetric point clouds, three-dimensional change detection can be performed on construction sites to identify filled and empty areas.

4.2. Advantages and Disadvantages of Traditional Measurement Techniques

Laser scanners are used to document existing buildings or structures in detail, scan the interior and exterior surfaces of buildings, take precise measurements, and create three-dimensional models. This documentation process is seen as a crucial step for restoration projects or architectural design analysis. Laser scanners can also be used to monitor the construction process and track progress, with measurements taken at large construction sites being used to verify the compatibility of the design determined during the planning phase with real-world conditions. Compared to other industrial sectors, architecture and engineering are disciplines with high safety risks, low efficiency, and intensive labor

requirements. Using laser scanners not only increases efficiency in architecture but also facilitates the early detection of potential errors, allowing for corrections.

Laser scanners contribute to the documentation of large-scale cultural heritage structures and the improvement of design phases during reconstruction. In these sectors, three-dimensional laser scanning and similar techniques are widely used for building documentation and construction management. In recent years, the capabilities provided by laser scanners have been utilized more frequently with the development of scanning techniques aimed at monitoring the strengthening and expansion of existing structures.

Central databases play a significant role in the design, coordination, and information exchange throughout a building's entire life cycle. Three-dimensional point cloud technology is utilized in the architectural, engineering, and construction sectors, particularly in areas such as reconfiguration, geometry quality management, construction progress tracking, performance analysis, and safety management.

In documenting cultural heritage, the use of modern and traditional methods is common. However, shortcomings of traditional methods are observed, particularly in areas such as façade acquisition of narrow spaces, measurement of roofs, and detection of details in tall buildings. This situation necessitates the integration of different documentation techniques and the adoption of more precise data collection methods.

Creating digital models of large and complex structures is a challenging process using traditional methods. However, advancements in computer technology and software have enabled the development of three-dimensional modeling and analysis techniques. In this context, modeling done with three-dimensional scanners, surface analyses, and volume calculations are also used in disciplines like archaeology.

The disadvantages of laser scanners include limited access to small-scale projects due to high initial costs. Effective use of scanners requires technical expertise. Finding trained personnel in this field is an important factor.

5. Work Area

The Kuruçeşme structure is located in the province of Mersin, in the southern part of Turkey.



Figure 3: Representation of Mersin Province on the map of Turkey

Kuruçeşme is located in the İhsaniye neighborhood of the Akdeniz district in Mersin Province and has remained a meeting point in the marketplace for many years. Situated to the north of the metropolitan structure, this building is located on Hospital Street within a small park area.



Figure 4: Visual Relationship of Kuruçeşme with the Metropolitan Building

The fountain features faucets and decorations on three facades (east, south, and west), while one of its facades (the north) is a blind facade. Currently, a commercial establishment is located in front of this facade.



a. b. c.

Figure 5: Kuruçeşme Facades - South Facade (a), East Facade (b), West Facade (c)

5.1. Measurement of Kuruçeşme Using Traditional Measurement Techniques

Firstly, the measurements of the Kuruçeşme structure were taken using a measuring tape and markers (jalon), and drawings of all its facades were created. Subsequently, these measurements were digitized using AutoCAD drawing software. The AutoCAD drawing (dwg) was then transferred to SketchUp, where a three-dimensional representation of the structure was developed (skp).

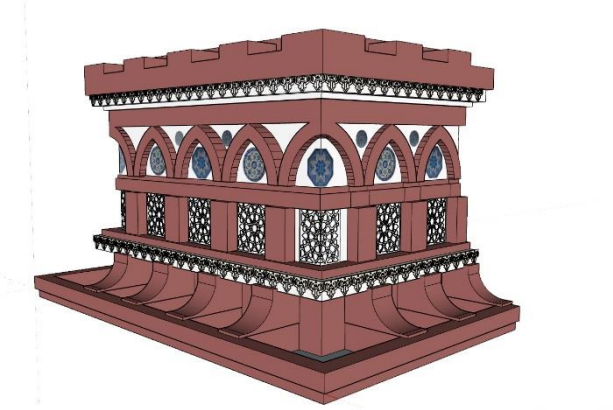


Figure 6: Southeast view of the Kuruçeşme model in the SketchUp program.

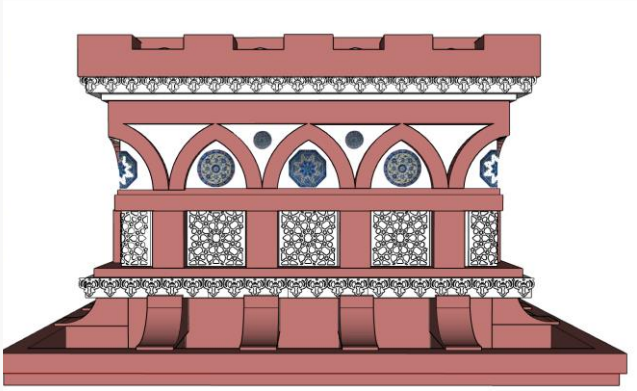


Figure 7: South view of the Kuruçeşme model in the SketchUp program.

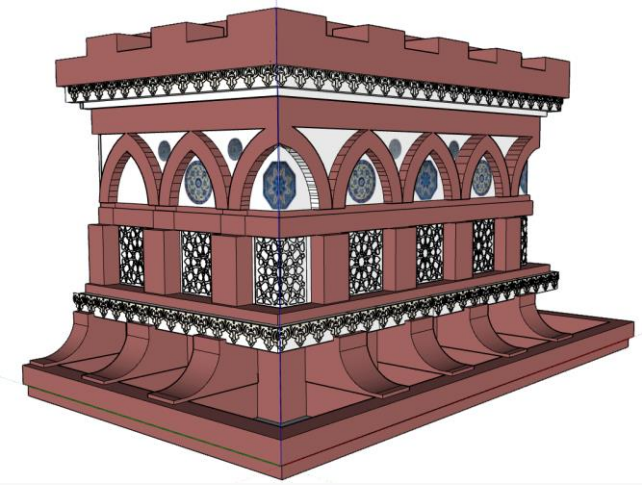


Figure 8: Southwest view of the Kuruçeşme model in the SketchUp program.

5.2. Measuring Kuruçeşme with Laser Scanners

Five ground control points were established in the field. This work, conducted using mobile LiDAR, took approximately 3 minutes.

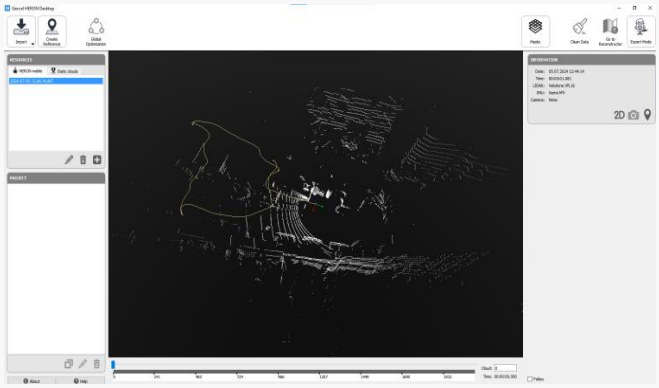


Figure 9: Autodamper phase

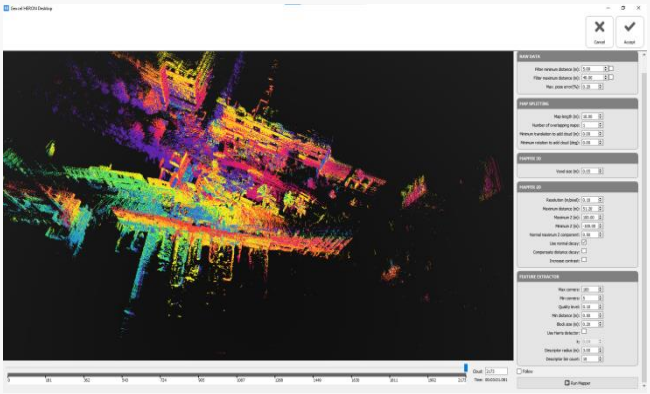


Figure 10: Createmaps is being created

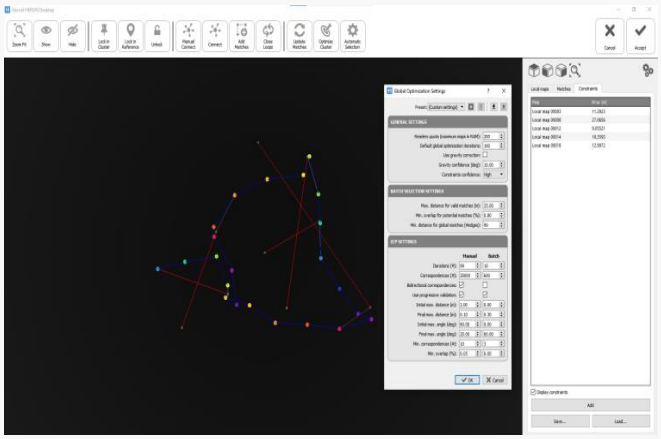


Figure 11: New connections were established

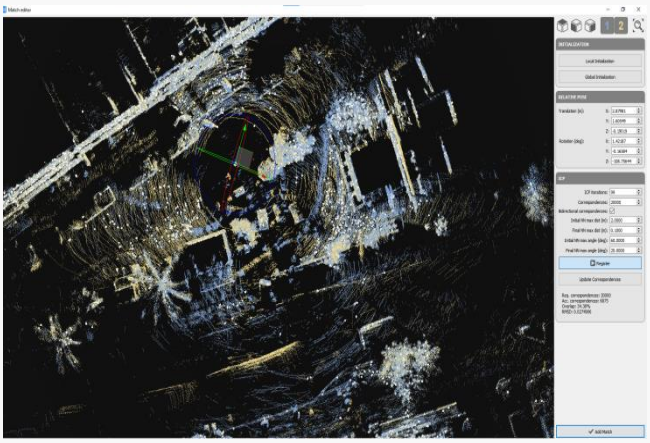


Figure 12. The process is being processed

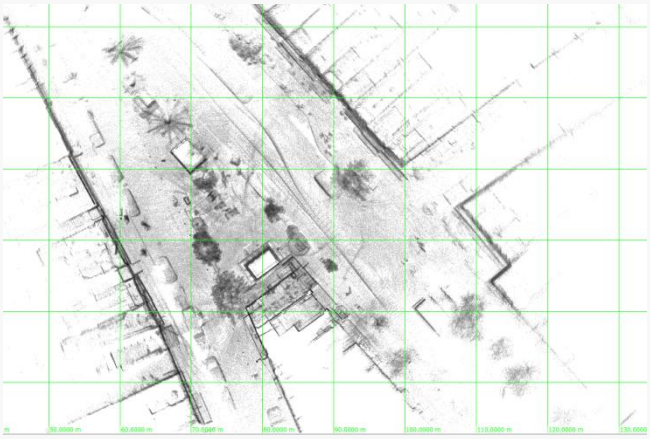


Figure 13: Orthoimage of Kuruçeşme

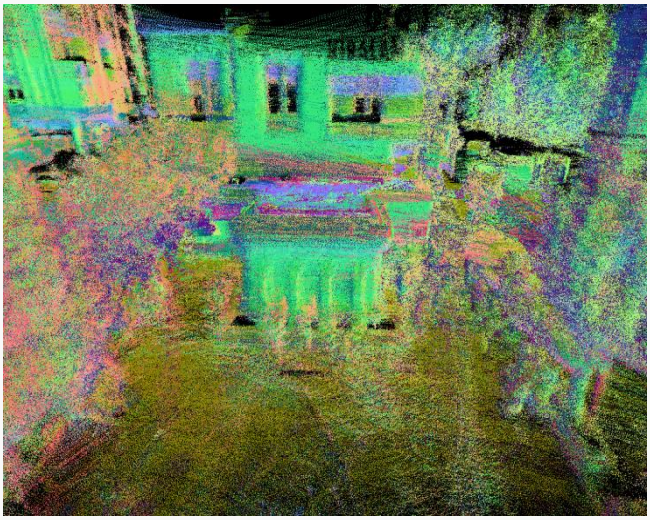


Figure 14: South facade of the Kuruçeşme

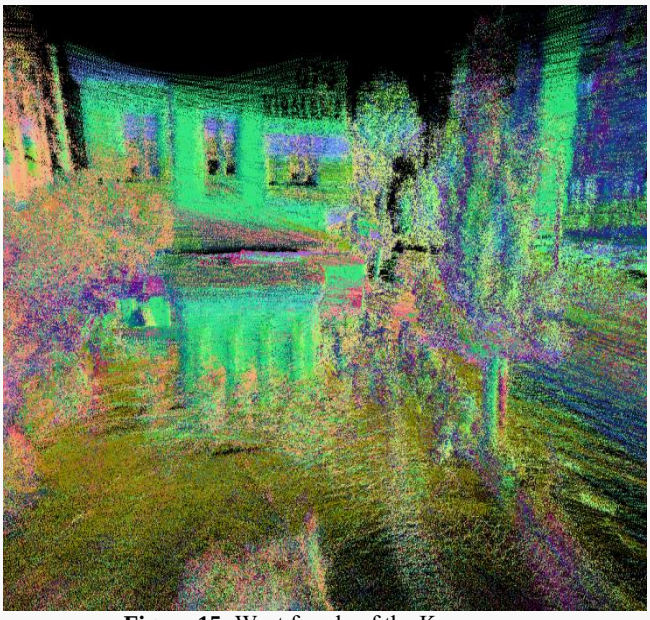


Figure 15: West facade of the Kuruçeşme

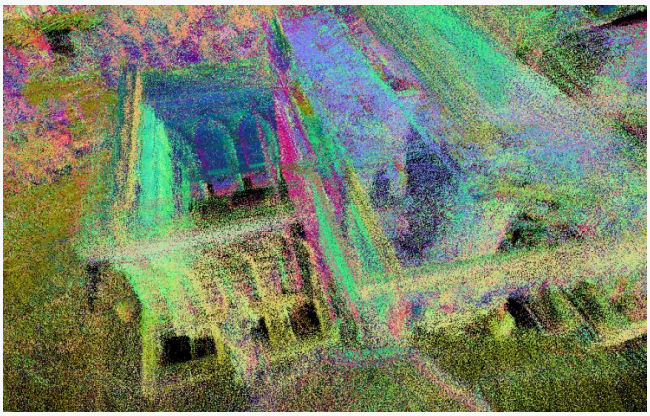


Figure 16: East facade of the Kuruçeşme



Figure 17: Photo from the fieldwork

6. Findings and Discussion

There are several advantages and disadvantages to the use of laser scanners in architecture. Examples of advantages include the ability to perform fast and precise measurements, which accelerates the design process for architects and engineers, thereby increasing accuracy. The documentation of existing structures has become easier thanks to laser scanners. They can serve as a basis for restoration and repurposing projects for cultural heritage buildings. While they provide significant gains in efficiency and cost, they also save labor and time, thus reducing costs throughout the project duration. Data obtained from 3D laser scanners can be used for 3D modeling and visualizations.

However, there are also some disadvantages that can complicate the use of laser scanners in architecture. For example, the high initial cost of laser scanners and their hardware makes them less accessible for small businesses and projects with limited budgets.

Using and maintaining laser scanners requires technical knowledge and experience. Additionally, regular maintenance and calibration of the devices are necessary. Laser scanners generally produce large amounts of data, which require time for processing and analysis. The storage and security of this generated data are also important. Especially in large projects, data processing can take days, prolonging the project completion time. The accuracy and precision of these devices can vary depending on various factors. Particularly, accuracy may decrease as the distance increases and in adverse environmental conditions.

During the use of laser scanners, human movement, vehicle traffic, and the presence of certain trees and plants in the work area can cause some deviations in the scanner's readings. It is recommended to conduct measurements during times when human and vehicle movement is minimal.

With the advancement of laser scanner technology, more innovative applications are expected to emerge in architecture, preservation, and construction fields. For instance, integration with areas such as artificial intelligence and automation may be considered.

In the future, it is anticipated that the scope of laser scanners in architecture will further expand. There may be increased demand for topics such as smart cities, green buildings, and sustainable architecture. The significance of this technology in architectural practice is gradually increasing, and it is expected to be used more widely in the future.

When comparing the measurement results obtained from traditional architectural measurement techniques with the 3D models produced by 3D laser scanners, it has been determined that many measurements of the Kuruçeşme structure fall within acceptable value ranges, while some measurements do not fall within acceptable values (the acceptable margin of error for plans at a scale of 1:100 is ±30 mm, see Figure 2. Acceptable Margin of Error English Heritage, 2003).

7. Conclusion and Recommendations

The limitations of traditional documentation methods in the documentation of cultural heritage, such as slow processing, high costs, and low accuracy, are leading to their abandonment in favor of advanced technology documentation techniques[21]. One of these advanced technologies, laser scanning, has become a widely used measurement technique in recent years. The laser scanning technique offers advantages such as minimal equipment requirements and the ability to process quickly[22].

While traditional methods can measure the facade and detail of objects, it can be challenging to take plan measurements of very large objects or structures. Terrestrial laser scanners stand out due to their ability to collect large amounts of data in a short time. Accuracy studies have shown that the distance of the scan and the density have a significant impact on accuracy[23].

The equipment and software required for the application of terrestrial laser scanning techniques are expensive. However, these costs can quickly be offset by factors such as accuracy, ease of use, labor savings, and time savings[24].

Since laser scanners are affected by environmental conditions (such as vehicle and human movements, and clusters of plants and trees near the structure), it is possible to achieve fewer deviations and more accurate results in simpler, standalone structures or in areas with less human and vehicle activity.

The use of laser scanners in architecture is very important for architects and engineers. Thanks to these 3D laser scanning technologies, they provide benefits in many areas such as the detailed documentation of existing buildings, the design of new projects, and the management of construction processes. Laser scanners are distinguished by their ability to perform fast, accurate, and efficient measurements, providing great convenience in architectural applications. In the future, it is expected that this technology will further develop and be used more widely in architectural processes. Therefore, the importance and impact of laser scanners in the field of architecture are steadily increasing.

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[23] Ibid.
[24] Ibid.

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