*2nd Intercontinental Geoinformation Days (IGD) – 5-6 May 2021 – Mersin, Turkey*

**Intercontinental Geoinformation Days**

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# Documentation of cultural heritage with backpack lidar usage on photogrammetric purpose

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**Keywords**
Backpack Lidar
Cultural Heritage
Documentation
GNSS/IMU Integration
3D Model

**ABSTRACT**

Modelling historical artefacts' external and internal structures together is a task that can be done with many sessions with classical terrestrial laser scanners. Backpack Lidar Systems are a proper newly applied alternative method in large areas of use and historical buildings where many sessions should be held with terrestrial laser scanner systems. These systems quickly acquire coordinate data and omega, kappa and phi angles differences with internal GNSS / IMU components and save time and cost following photogrammetric mentality. In this research, using Backpack Lidar System; The exterior and interior structure of the village mosque, which is an Ottoman artefact built in 1899 at the Dumanoluğu Village in the Şiran District of Gümüşhane City, was modelled in 3D. With its integrated camera, the point data has been coloured and made suitable for architectural survey studies. The village mosque's exterior scan was completed within seven minutes, and the interior scan within five minutes. 2.041.971 points were obtained in the external scanning, and 821.306 points in the internal scanning. Four GCPs were used for the mosque's exterior screening. The point clouds obtained were combined and modelled.

## 1. INTRODUCTION

For centuries, human beings have built important structures for protection, shelter and meeting their basic needs. These structures have suffered partial or total deterioration due to wars, natural conditions and people throughout history. Every society has an absolute duty to transfer the cultural heritage of humanity to future generations and protect it in the best way. Living in a geography that has hosted the most important civilisations of human histories, such as Anatolian lands, imposes a much more important responsibility.

It is a great necessity to use sufficient technological infrastructure and human resources to protect and transfer all cultural artefacts in the borders of our country to future generations. For this purpose, developing and increasing the use of photogrammetric methods can be seen as a duty. All methods such as photogrammetric techniques, Unmanned Aerial Vehicles (UAV), terrestrial, mobile and air-assisted lidar systems, and satellite data can be used to preserve and document cultural heritage (Kaya et al., 2021; Ulvi et al., 2019; Makineci 2016; Yaman and Kurt 2019).

All photogrammetric methods have advantages and weaknesses according to the area of use and purpose. According to the literature, it is possible to talk about the success of terrestrial laser scanning systems, which have been widely used in recent years in cultural heritage documentation. However, the problems that develop to the loss of time and the increase in the number of sessions lead to new alternatives (Zeybek 2019). Backpack Lidar systems carried by human assistance are also an essential alternative issue of recent times. In this study, the success of these systems was demonstrated by documenting a mosque's internal and external architectural features in a short time using Backpack Lidar.

## 2. MATERIALS AND METHOD

### 2.1. Study Area

The historical village mosque belonging to the Dumanoluğu Quarter of Gümüşhane Province, Şiran District, located in the east of the Black Sea Region, Turkiye, was chosen as the study area.

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**Cite this study**
Erdal K & Makineci H B (2021). Documentation of cultural heritage with backpack lidar usage on photogrammetric purpose. 2nd Intercontinental Geoinformation Days (IGD), 245-248, Mersin, Turkey

## 2.2. Backpack Lidar System

In this study, the Greenvalley Libackpack DGC50 backpack LIDAR system was used. When the backpack LIDAR models are analysed, it is seen that they generally have a single laser sensor and a panoramic camera. Unlike the general, the Libackpack DGC50 model has two laser sensors (one horizontal and one vertical), with a panoramic camera and GNSS/IMU receiver. With the GNSS receiver in the LIDAR system, point data is obtained in coordinates during the sessions held in outdoor dimensions (Fig 1).

The GNSS receiver in the laser scanner works with the PPK method. While providing access to the satellite data required for the PPK, the ground station operating with the static method is used simultaneously. In this way, the horizontal position of the obtained point data can be obtained up to ±7 cm. In addition, the properties of the Lidar used in the study are shown in Table 1 (greenvalleyintl.com 2021).

**Table 1.** Greenvalley Libackpack DGC50 specs

| | |
|---|---|
| **Dimension (mm)** | 1010 X 344 X 252 |
| **Battery** | 5700 mAh |
| **Weight** | 10.3 kg |
| **Working hours** | ~2 h |
| **Laser Sensor** | VLP16 × 2 |
| **Accuracy** | ±3 cm |
| **Vertical FOV** | -90°~90° |
| **Horizontal FOV** | 0°~360° |
| **Measuring range** | 100 m |

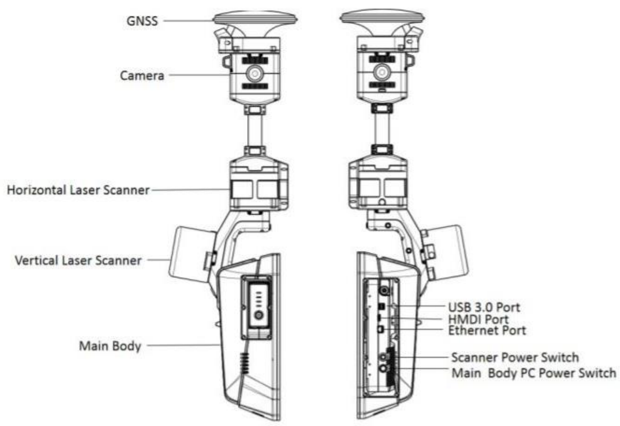


**Figure 1.** Greenvalley Libackpack DGC50 Profile

## 2.3. Workflow of Study

The general workflow of the study is divided into fieldwork and office work. There are Ground Control Points (GCPs) used in fieldwork and operations for generating lidar data. Office work includes adjustment of GCPs and analysis of point cloud (fig 2).

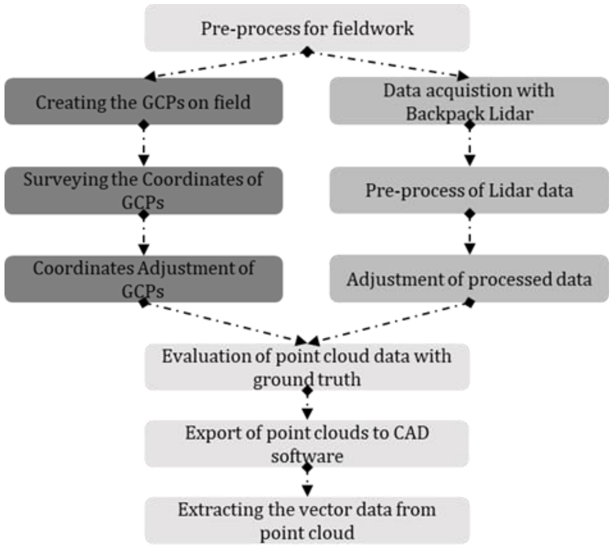


**Figure 2.** Workflow of fieldwork and office work

Lidar system is started around the historical monument to be scanned outdoors. Since the Greenvalley Libackpack DGC50 consists of a laser scanner + panoramic camera + GNSS components, some issues need to be considered before starting data collection. Check that the camera is ready and make sure that the recording process has begun. It is checked that the GNSS receiver is connected to a sufficient number of satellites and that it is ready. It is necessary to wait at least 3 minutes before starting data collection; It is expected to obtain the satellite data required for an accurate coordinating process of the point cloud. After waiting, data is created to be collected after the "8" mark is made slowly on the ground to perform GNSS calibration.

## 3. RESULTS AND DISCUSSIONS

In the research, external and internal scanning was carried out to obtain and document the point cloud of the mosque. The external scan of the mosque was completed within 6 minutes (fig 3), and the internal scan within 4 minutes (fig 4). 2.041.971 points were obtained in the external scanning, and 821.306 points were obtained in the internal scanning.

Today, terrestrial laser scanners are used for historical artefacts, archaeological excavations, etc. It is frequently used in many modelling studies. Terrestrial laser scanners are installed at many points in the area to be scanned, so fieldwork takes a long time. The increase in the number of processes in office work takes a long time due to the efforts to combine the point clouds obtained from different points (Ulvi et al., 2019). When we examine other models of handheld laser scanners, it can be obtained from the laser scanner we use in our work for a long time due to hand-held and single laser scanner fatigue. Less point cloud is obtained from the obtained point cloud (Yaman and Kurt 2019).

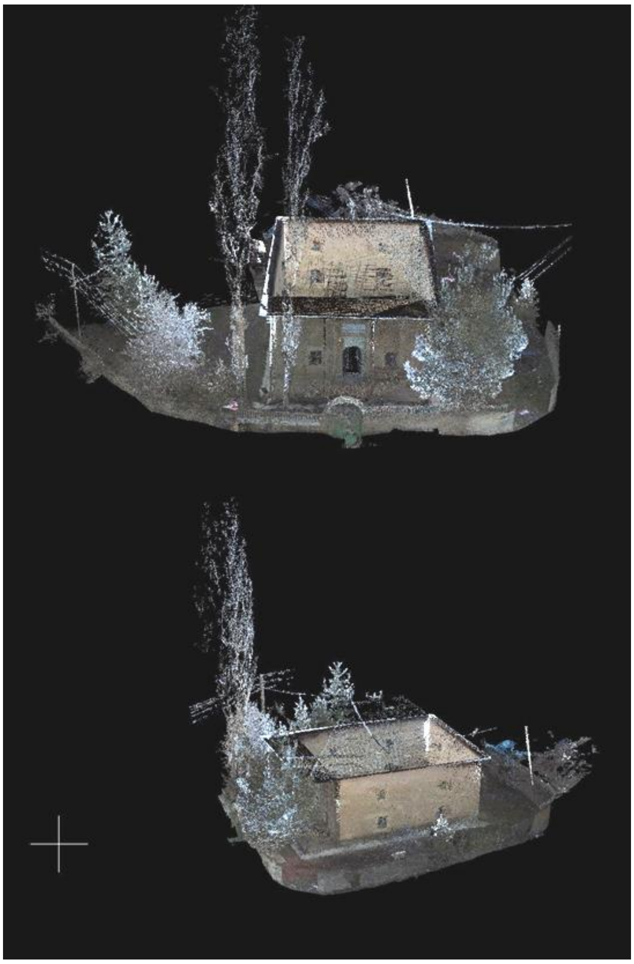

**Figure 3.** The external scan of the mosque

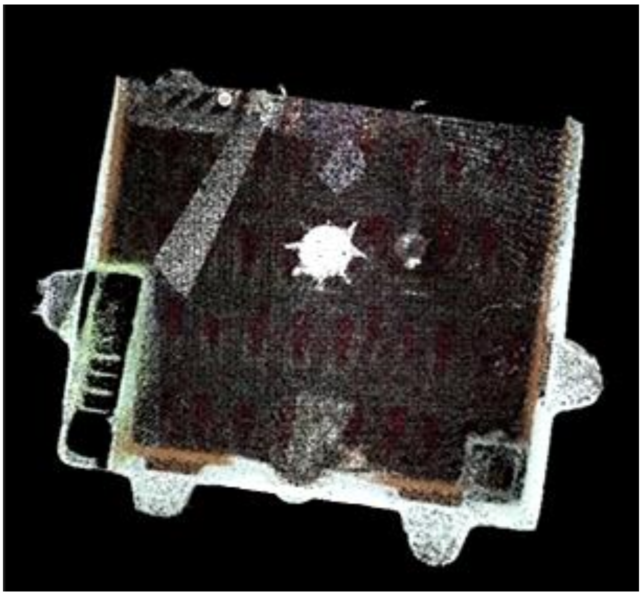

**Figure 4.** The internal scan of the mosque

Using photogrammetric studies according to the National Large Scale Map Production Regulation (BÖHHBÜY 2018); It is necessary to use a minimum of 4 checkpoints, up to 30% of the GCP number. Since the point cloud data collected with the GVI Libackpack DGC50 is coordinated, adjustment is not performed in this study. Considering the minimum number of GCPs, 4 GCPs were measured in the exterior scanning of the historic mosque. Error-values of the determined GCPs is given in Table 2.

**Table 2.** Minimum, Maximum, Mean Errors of GCPs

| | Horizontal (X, Y) (cm) | Vertical (Z) (cm) |
|---|---|---|
| Min Error | 0.020 | 0.004 |
| Max Error | 0.082 | 0.077 |
| Mean Error | 0.047 | 0.041 |

The coordinated point cloud is transferred to CAD software. The drawing process (vectorisation of structure) is performed in CAD. In this way, vector data is obtained. The walls of the historical mosque can be obtained in vector form, as in Figure 5.

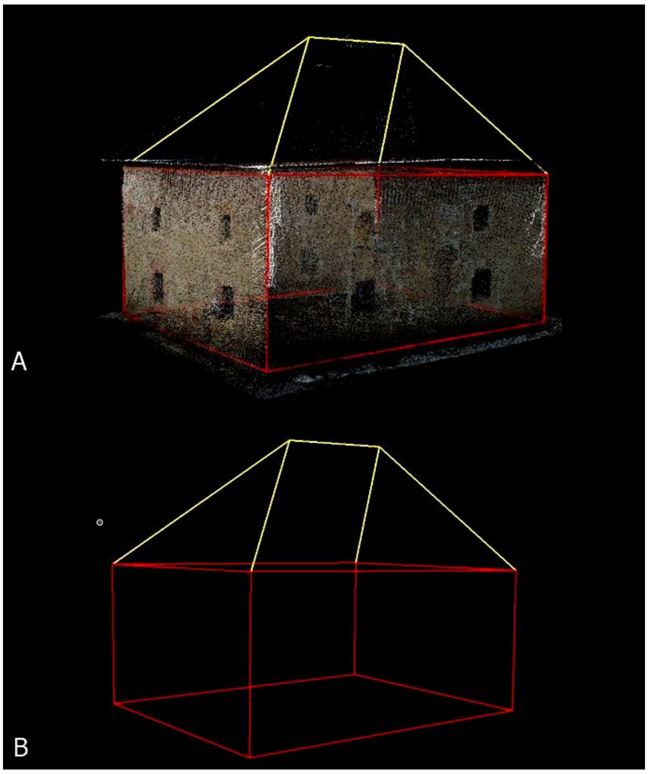


**Figure 5.** Vectorisation of Structure A: Vectors with point cloud and B: Only vectors

## 4. CONCLUSION

This study aimed to determine that the documentation and modelling of historical buildings can be carried out quickly and effectively with Backpack Lidar. Well-to-do results have been demonstrated with the fieldwork and office work carried out for this purpose.

**ACKNOWLEDGEMENT**

The authors declare their appreciation to Küre Engineering, which made an essential contribution to obtaining the data.

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