Data in Brief 39 (2021) 107616

Contents lists available at ScienceDirect

Data in Brief

journal homepage: www.elsevier.com/locate/dib

Data Article

Intensity dataset acquired through laser scanning of lunar and Martian soil simulants

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A R T I C L E   I N F O

Article history:
Received 19 October 2021
Revised 16 November 2021
Accepted 17 November 2021
Available online 20 November 2021

Keywords:
Lunar soil simulant
LSS
Martian soil simulant
MSS
Terrestrial laser scanner
TLS
The Moon
Mars

A B S T R A C T

The future construction effort on the Moon and Mars is increasingly discussed by the scientific community. In authors' opinion quick, precise and remote measuring technique will be essential for successful development of lunar and Martian construction projects. One of such techniques is terrestrial laser scanning (TLS). The dataset consists of results obtained using two different, commercially available, laser scanners. The measurements were conducted on Earth using lunar and Martian soil simulants. As a reference (Earth soil simulant) a standardized sand used for cement tests was utilized. Scans were performed from different distances. The acquired point clouds can be used for thorough analysis of a laser beam dispersion and absorption. The comparison with other results is enabled. One should also keep in mind that some of the characteristics of Earth, the Moon and Mars which will influence TLS technique and measurements (e.g. local atmosphere or lack of it, temperatures, radiation, light, distances and colours).

DOI of original article: 10.1016/j.autcon.2021.103979

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https://doi.org/10.1016/j.dib.2021.107616

Specifications Table

Subject	Civil and Structural Engineering
Specific subject area	Remote Sensing, Non-Destructive-testing (NDT),
Type of data	LiDAR Point cloud (*.pts format), Image
How the data were acquired	The data were acquired using two different types of terrestrial laser scanners. The first was a time-of-flight scanner Leica ScanStation C10, the second was a phase-shift scanner Z + F IMAGER 5016.
Data format	Raw
Description of data collection	Lunar, Martian and Earth soil specimens were scanned from seven different distances (15 m, 30 m, 60 m, 90 m, 120 m, 150 m, 200 m). Lunar Soil Simulant (LSS), Martian Soil Simulant (MSS) and Earth Soil Simulant (ESS) were used to prepare target specimens for scanning. The incidence angle was ranging between 0° and 1.5°, thus target specimens were oriented perpendicular to the laser beam.
Data source location	Institution: Koszalin University of Technology City/Town/Region: Koszalin Country: Poland Latitude and longitude (GPS coordinates) for collected samples/data: latitude: 54.200383, longitude: 16.19721
Data accessibility	Repository name: Mendeley data Data identification number: DOI: 10.17632/z76tb72r4w.1 Direct URL to data: https://data.mendeley.com/datasets/z76tb72r4w/1
Related research article	J. Katzer, C. Suchocki, W. Błaszczak-Bąk, P.K. Zarzycki, M. Damięcka-Suchocka, Reliability and effectiveness of laser scanners in future construction efforts on the Moon and Mars, Automtion Constr. xx (2021) 1–8. https://doi.org/10.1016/j.autcon.2021.103979.

Value of the Data

- The data provide radiometric information of the laser beam for two different types of TLS from the measurement of Lunar Soil Simulant (LSS), Martian Soil Simulant (MSS) and Earth Soil Simulant (ESS). The point clouds can be useful for planning future construction effort on the Moon and Mars.
- The data can be used by researchers to analyse possible application of TLS technology for extra-terrestrial construction tasks.
- Data can be exploited for analysis and comparison of the absorption and dispersion of the laser beam reflected from LSS, MSS and ESS.

1. Data Description

The data set in question consists of two families of results. Results obtained using Leica ScanStation C10 and results obtained using Z+F IMAGER 5016. The names of the folders containing the results reflect the names of the scanners. The structure of the name of the files is as follows:

xxm.pts	- where xx stands for the distance in meters from TLS to scanned specimens (15, 30, 60, 90, 120, 150 and 200 m).
YY_xxm.pts	- where YY stands for name of a specimen (ESS, LSS, MSS), xx stands for a distance in meters from TLS to scanned specimens (15, 30, 60, 90, 120 and 150 m).

The structure of the files (*.pts format) is as follows:

For Leica ScanStation C10:	*X Y Z Intensity* (range from −2048 to +2048).
For Z+F IMAGER 5016:	*X Y Z Intensity* (range from 0 to 1).

Where:

X, Y, Z are 3D coordinates of points, unit [m]
Intensity is a relation between emitted and received signal power by TLS (radiometric information of point cloud)

2. Experimental Design, Materials and Methods

LSS and MSS developed by Zarzycki and Katzer [1] were used for scanning. The simulants were chosen due to the fact that they are dedicated for civil engineering tests. Used LSS is based on ilmenite sourced from the Baltic Sea. It was thoroughly described in a publication describing its application for creation of lunar concrete-like composites [2]. Used MSS is based on iron-rich sludge from drinking-water treatment plant. The sludge is a by-product of water purification. Water sourced from deep soil layers is characterized by very high content of manganese and iron ions. These ions are oxidized during water purification and precipitate as hydroxides that form the main volume of iron-rich sludge. The sludge and its potential applications were described by Świderska-Dąbrowska et al. [3]. Both simulants of extra-terrestrial soils are affordable and characterized by satisfactory quality in comparison to other available simulants [4]. As a reference point, globally available and standardized (EN 196-1 [5]) sand was used. The sand play a role of a Earth soil simulant (ESS). The sand in question is dedicated for cement testing. The specimens were in a form of square flat area 14 cm • 14 cm (see Fig. 1). The thickness of the glued simulants was from 1 to 3 mm covering evenly the whole area of each square. The influence of both used board and the glue are negligible. Basic metal clamps were used to keep the board with glued targets stable. Scanners were used subsequently in the same testing sequence of distances from scanned surfaces.

Terrestrial Laser Scanning (TLS) collects numerous points on an object in short time by emitting laser pulses toward the object and measuring the distance between the device and the target. A scheme of geometric data collected by TLS is presented in Fig. 2. Apart from geometric data (D, φ, θ) TLS registers also the power of the laser beam backscattered from the targets, which is called intensity.

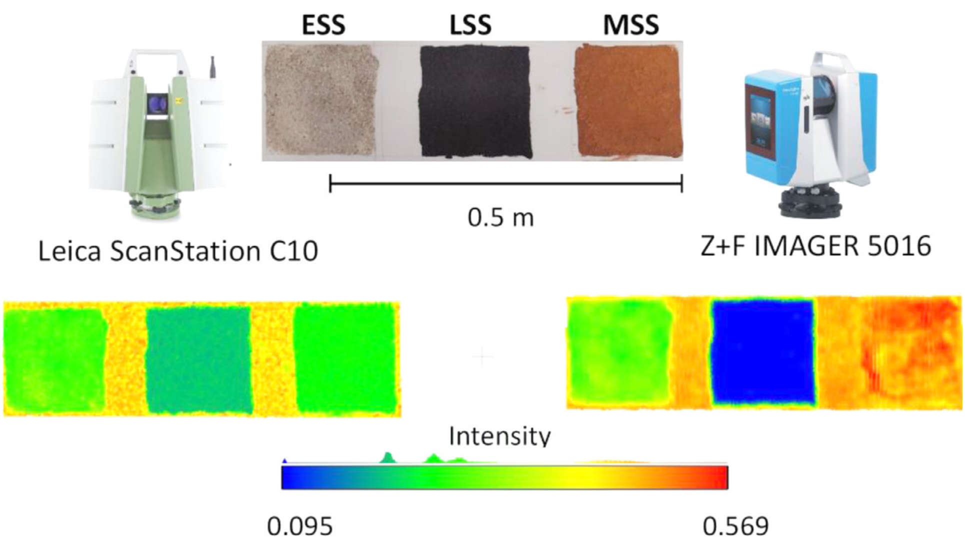

Fig. 1. Used scanners and specimens (modified from [6]).

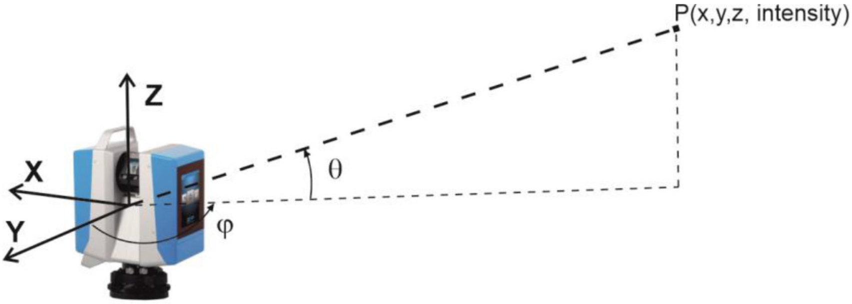

Fig. 2. Geometric data collected during the measurement by TLS.

Table 1
Technical characteristics of used scanners.

	Z + F IMAGER 5016	Leica ScanStation C10
Type of Rangefinder	phase-shift	time-of-flight
Wavelength	1500 nm	532 nm
Scan Rate Points/sec	1,100,000	Up to 50,000
Range	365 m	300 m @ 90%
Beam Diameter	3.5 mm at exit	From 0 to 50 m: 4.5 mm (FWHH-based), 7 mm (Gaussian-based)
Ranging Error	±1 mm + 10 ppm/m	±4 mm within a 1–50 m range
Accuracy of Vertical and Horizontal Angle	14.4”	12”
Beam Divergence	0.3 mrad	–
Maximum Vertical / Horizontal Angular Resolution	0.00026° / 0.00018°	–

Based on the measurement data, the scanner software calculates the spatial coordinates of the each points in real time.

$$\begin{cases} x_P = \mathrm{D} \cdot \cos\theta \cdot \cos\varphi \\ y_P = \mathrm{D} \cdot \cos\theta \cdot \sin\varphi \\ z_P = \mathrm{D} \cdot \sin\theta \end{cases} \tag{1}$$

Where: D - distance between the TLS and target, φ- horizontal angle, θ - vertical angle

Finally, the scanner stores the spatial coordinates (xyz) and the intensity value in a file. The spatial accuracy of the each point mainly depends on the relative precision of the measurement range, horizontal and vertical angle. Technical specifications for the scanners that were used in the measurements are presented in Table 1. The maximum resolution of point clouds of tested samples depends on technical parameter of the scanner (see Table 1) and distance between target and TLS, the resolution decreases with increasing distance. Specimens were remotely scanned by TLS from seven different distances therefore, the spatial resolution of the point clouds was ranging from 1 to 10 mm.

Ethics Statements

This work didn't involve human subjects, animal experiments and data collected from social media platforms.

CRediT Author Statement

Jacek Katzer: Conceptualization, Methodology, Validation, Investigation, Resources, Writing – original draft, Writing – review & editing, Supervision, Project administration; **Czesław Suchocki:** Conceptualization, Methodology, Software, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization; **Wioleta Błaszczak-Bąk:** Formal analysis, Investigation, Data curation, Writing – review & editing; **Marzena Damięcka-Suchocka:** Formal analysis, Investigation, Data curation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Authors would like to acknowledge prof. Paweł K. Zarzycki from Koszalin University of Technology (Poland) whose help in acquisition of lunar and Martian soil simulants was essential.

Funding: This research was partially supported by the National Science Centre (Poland) through grant number DEC-2020/38/E/ST8/00527 and partially by the National Science Centre (Poland) and Ministry of Science and Higher Education (Poland) through project number IA/SP/0017/2019.

Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2021.107616.

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