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Update Article

Updating "Intensity dataset acquired through laser scanning of lunar and Martian soil simulants" with additional lunar soil simulants specimens☆

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A R T I C L E I N F O

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A B S T R A C T

Updated dataset based on the laser scanning of three specimens of lunar soil simulants representing highland regions (LHS-1, AGK-2010, CHENOBI) and three specimens of lunar soil simulants representing mare regions (LMS-1, JSC-1A, OPRL2N). In previous studies, only a specimen of ilmenite was used as a lunar soil simulants. Measurements were executed using phase-shift and time-of-fly terrestrial laser scanners (Z + F IMAGER 5016, FARO Focus3D, and Leica ScanStation C10). The stored data contain radiometric information of point clouds from the measurement of lunar soil simulants. The data provide information on the effect of different types of simulants (mare and highland) on the absorption and dispersion of the laser beam. In overall, the dataset presented in this work can be used in investigation of the application of the laser technology in the measurement of lunar structures made of mare and highlands lunar regolith. Lunar highlands and mare regions are characterized by different physicochemical parameters. Therefore, both types of soil scatter the laser beam differently, what affects the range and accuracy of the laser measurements.

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Specifications Table

Subject	Civil and Structural Engineering, Space and Planetary Science
Specific subject area	Remote measurements of lunar soil simulants taken by time-of-fly and phase-shift terrestrial laser scanners.
Type of data	TLS Point cloud (*.txt format), Image
How the data were acquired	The data were captured using three different terrestrial laser scanners. Two phase-shift scanners Z + F IMAGER 5016, FARO Focus^{3D} and one a time-of-flight scanner Leica ScanStation C10 were used for the measurements.
Data format	Raw
Description of data collection	Six different lunar soil simulants representing highland and mare regions were used during the research program. A special flat targets were prepared for measurements from nine different distances (5 m, 10 m, 20 m, 30 m, 40 m, 50 m, 60 m, 80 m, 100 m). The measurements were performed one by one using three scanners. The target specimens were oriented perpendicularly to the laser beam of scanners.
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: https://doi.org/10.17632/75hphx78ck.2 Direct URL to data: https://data.mendeley.com/datasets/75hphx78ck/2
Related data article	J. Katzer, C. Suchocki, W. Błaszczak-Bąk, M. Damięcka-Suchocka, Intensity dataset acquired through laser scanning of lunar and Martian soil simulants, Data in Brief, 39 (2021), https://doi.org/10.1016/j.dib.2021.107616
Related research article	M. Damięcka-Suchocka, J. Katzer, Terrestrial Laser Scanning of Lunar Soil Simulants, Materials (Basel). 15 (2022) 1–16. https://doi.org/10.3390/MA15248773

Value of the Data

- An extended dataset provides more detailed information on the absorption and dispersion of the laser beam from the measurement of six different lunar soil simulants using three different terrestrial laser scanners.
- The new dataset update the previous one with TLS measurements of the most popular lunar soil simulants representing mare and highland regions. For previous measurements, only a specimen of ilmenite was used as a lunar soil simulants.
- The data can be used for research on the possibility of using TLS technology in the erection of building structures from highlands and mare lunar soil.
- The data can be used to analyze and compare the power of the reflected laser beam from different lunar soil simulants.

1. Objective

Currently, many countries are planning to build permanent human settlements on the Moon. The erection of lunar structures (habitats, landing pods, mining pits, storage facilities etc.) requires the use of local materials and thorough in situ resource utilization (ISRU) [1,2] approach. Accurate and remote measurement technology will be an essential tool for these construction activities. The use of lunar regolith as a building material and terrestrial laser scanning as a measurement technology seem very likely. The main aim of the research program was to obtain data from the TLS measurement for the most popular lunar soil simulants (LSS). The effects of absorption and dispersion of the laser beam from the LSS was investigated [3].

2. Data Description

The dataset is stored as the point clouds format (*.txt) and image file tested LSSs. The datasets of measurements by the Z + F IMAGER 5016, FARO Focus^{3D} and Leica ScanStation scanner were placed in separate folders, respectively. The names of the folders reflect the abbreviation names of the scanners (Z + F, Faro, Leica). The structure of the name of the files is as follows:

xx_yy_zz.txt – where *xx* stands for the name of LSS, yy abbreviation names of the scanners, zz distance in meters from TLS to target (5 m, 10 m, 20 m, 30 m, 40 m, 50 m, 60 m, 80 m, 100 m). Example file: 'OPRL2N_Z + F_10 m.txt' - measurement of the OPRL2N lunar soil simulant using Z + F IMAGER 5016 scanner from a distance of 10 m.
name.jpg – photo of the LSS, where '*name*' stands acronym of LSS

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

X Y Z Intensity – where X, Y, Z are 3D coordinates of points, unit [m] and *Intensity* is a relation between emitted and received signal power by TLS, range from 0 to 1.

3. Experimental Design, Materials and Methods

The surface of the Moon is covered with a layer of the regolith which can be used as a building material for future construction tasks. In general, the surface of the Moon is divided into mare and highland regions which are characterized by different physical and chemical properties. Therefore, three simulants representing the mare regions (LMS-1 [4], JSC-1A [5], OPRL2N [6]) and highland regions (LHS-1 [4], AGK-2010 [7], CHENOBI [8]) were used in the research. Applied LSSs are well described and widely used in many scientific studies. For the experiment, a special flat test board was prepared. The specimens of six lunar soil simulants in the form of a squares (0.15 m × 0.15 m) were glued. During measurement, the laser spot size affects the detail of the data. Keeping in mind the divergence of the laser beam, which causes the diameter of the laser spot to increase as the distance measurement increases, squares with dimensions of 0.08 m × 0.08 m were adopted for the analysis. Detailed explanations are included in the text of the main article [3]. The tested sample is presented in Fig. 1.

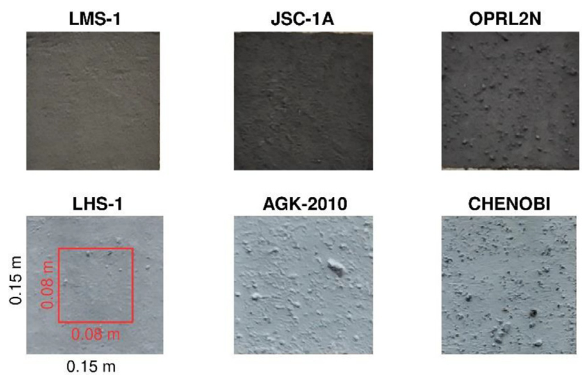

Fig. 1. Specimens used in the research.

The point clouds were captured from nine distances (5 m, 10 m, 20 m, 30 m, 40 m, 50 m, 60 m, 80 m, 100 m) using three different terrestrial laser scanners. The measurements lasted approximately two hours in unchanged weather conditions. The research deliberately harnessed scanners that use two different principles for distance measurement (time-of-flight and phase-shift). Technical specifications for the TLS that were used in the experiment are presented in Table 1.

Table 1
Technical characteristics of the tested terrestrial laser scanners (source: based on [3]).

Model of terrestrial laser scanner	Z + F IMAGER 5016	FARO Focus^{3D}	Leica ScanStation C10
Image			
Type of rangefinder	phase-shift	phase-shift	time-of-fly
Laser wavelength	1500 nm	905 nm	532 nm
Max scan rate points/second	1100,000	1000,000	up to 50,000
Measurement range	0.3 – 365 m	0.6 – 120 m	0.1 – 300 m
Scanning error	±1 mm + 10 ppm/m	±2 mm	±4 mm (1–50 m)
Beam divergence	0.3 mrad	0.19 mrad	–
Beam diameter	~3.5 mm at exit	3.0 mm at exit	0–50m: 4.5 mm*, 7 mm**

* FWHH-based.
** Gaussian-based.

The data obtained by three scanners for nine distances were pre-processed, split and grouped into files. Each file contains a point cloud from the measurement of 0.08 m × 0.08 m LSS samples. The file structure has four columns, the first three are 3D spatial coordinates, while the fourth column contains *intensity* value (see Table 2). The main interest is the fourth column, the intensity value (radiometric information).

Table 2
Sample file structure.

X [m]	Y [m]	Z [m]	*Intensity* [–]
2.633651	4.917412	0.028957	0.629639
2.634453	4.917426	0.028881	0.629639
2.635207	4.917408	0.029083	0.616367
2.636140	4.917459	0.028674	0.613098
2.636860	4.917466	0.028655	0.636454
2.637730	4.917430	0.029020	0.651406

The files can be imported in any point cloud software, is recommended open source CloudCompare software. For statistical analysis of intensity values, the data can be directly imported into a spreadsheet (e.g. Microsoft Excel, OpenOffice Calc, StatSoft Statistica). In Fig. 2 presents the distribution of the intensity values of the point cloud captured by Leica ScanStation C10 scanner at a distance of 10 m.

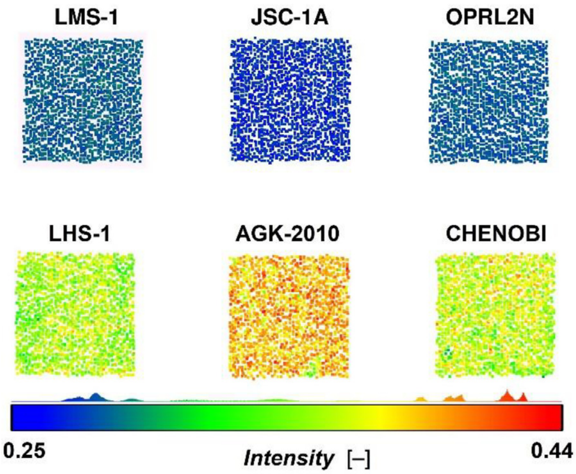

Fig. 2. Point cloud collected by Leica ScanStation C10 scanner of LSS targets at a distance of 10 m.

Data Availability

Dataset from laser scanning of lunar soil simulants (Original data) (Mendeley Data).

Ethics Statement

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

CRediT Author Statement

Marzena Damięcka-Suchocka: Conceptualization, Methodology, Investigation, Data curation, Software, Writing – original draft preparation; **Jacek Katzer:** Supervision, Conceptualization, Methodology, Investigation, Writing – review & editing.

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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.

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