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Editorial

Preface of Special Issue on Laser Scanning

Francesco Pirotti [1,*], Xinlian Liang [2] and Qi Chen [3]

[1] Interdepartmental Research Center of Geomatics (CIRGEO), TESAF Department, University of Padova, via dell'Università 16, 35020 Legnaro (PD), Italy
[2] Finnish Geospatial Research Institute, National Land Survey of Finland, Geodeetinrinne 2, 02431 Masala, Finland
[3] Department of Geography, University of Hawai'i at Mānoa, Honolulu, HI 96822, USA
* Correspondence: francesco.pirotti@unipd.it; Tel.: +39-392-395-2067

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1. Introduction

A laser is a spatially coherent light that can travel through space with very little diffraction. This distinctive feature makes lasers an ideal signal carrier for measuring distances. The special issue of "Laser Scanning" (also known as LiDAR—Light Detection and Ranging) provides several interesting reports on the wide range of applications that this technology supports. Laser scanning is so defined because it uses laser technology to detect objects and calculate distances between the sensor and the reflective surfaces. Reflected laser pulses provide a means for measuring time-of-flight, phase differences, and other properties of the reflected pulse and of the surface that causes a full or partial reflection. A strong added value of laser scanning is that it can provide multiple returns from a single emitted pulse, because of the partial obstruction of the laser beam. For several decades, accurate distance measures have been done with laser scanners as described above, and the technology is ever actively being improved. Recent developments include multi-wavelength scanners, solid-state LiDAR, single-photon LiDAR, and scanners with increased pulse frequency, thanks to solutions related to concurrent pulses in the air (multiple time around—MTA). Also the decreased weight of components allows sensors to be assembled into unmanned vehicles (e.g., Unmanned Aerial Vehicles—UAVs) [1,2].

Laser scanning applications covered in this special issue can be divided into the following categories: multi-wavelength LiDAR [3,4], mobile mapping support for indoor [5–7], outdoor, and other applications [8], object tracking and navigation [9–11], deformation monitoring [12,13], modelling and detection [14–16], geometric accuracy assessment [17–19], and hybrid technologies like LiDARgrammetry [20], which are summarized in more detail in the following section.

2. Featured Papers

Multi-wavelength LiDAR is a technology that expands the typical single-wavelength LiDAR, usually having a wavelength in the near infrared range (e.g., 1064 nm [2]). It provides important information on the reflective properties of targets by using more channels, such as green, near-infrared, and mid-infrared channels, and using them for the improved classification of land cover [3] and for accurate land/water discrimination [21].Unmanned, as well as manned, aerial systems, equipped with laser scanners are topics of active investigation. Precise system calibration improves point position accuracy, which is a matter of foremost importance for accurate models. Authors in [17] proposed an outdoor calibration procedure for UAVs using linear and planar features scanned from different flight lines, allowing them to accurately estimate bias between the components of the sensors (i.e., boresight and lever-arm angles).

LiDARgrammetry is the reverse engineering of aerial laser scanning products to extract infrared stereo pairs (i.e., greyscale imagery). The stereopairs are used in the typical photogrammetric procedure.

This allows using well-known photogrammetric workflow and software; operators can align stereo pairs and digitize 3D points, extract breaklines, etc., which adds value to the LiDAR product [20].

Moving the focus from the air to the ground, laser scanners can and are used for indoor and outdoor navigation and modelling. A backpack laser scanner with simultaneous localization and mapping (SLAM) can provide accurate models without information from Global Navigation Satellite System (GNSS) [6]. Lower-cost solutions based on photogrammetry and ultra-wide band (UWB) for relative positioning can be interesting alternatives [5]. Indoor reconstruction can be a complex process when the laser's line of sight is occluded by objects. Authors in [15] proposed the indoor completion of walls with an energy minimization problem using graph cuts, doors, and windows to be detected from occlusions by a ray-tracing algorithm. Authors in [7] provided a full framework for the reconstruction of buildings' indoor environments with added information on converting objects into the Industry Foundation Classes(IFC) model for inclusion in building information modelling (BIM) software.

Laser scanning is not only applied to urban and regional scales, but is also common in the accurate modelling of small- and medium-sized objects. In many sorts of manufacturing, precise models like computer-aided design (CAD) are required in the processing stages. Two particular examples are reported in this special issue. One is related to car doors in the automotive industry, where the accuracy of a handheld scanner was tested in [13]. The second application is in oral medicine, where intraoral scanners were tested for accuracy (deviations of intermolar width), providing information on clinical validity [19].

Detecting object position and movement is important for mobile applications, especially in the realm of robotics, where laser scanning can provide this information at a very fast rate. Robot position and moving direction is a key information that can be provided as described in [8]. Elevation maps extracted from laser scanning can also support robot navigation as shown in [11]. Monitoring movement during and after the aircraft landing phase is another application that can be done with laser scanners, allowing the improvement of airport safety thanks to knowledge of accurate position and speed (accuracy of 17 cm and 0.17 m/s, respectively) [9]. Also, human detection and monitoring takes advantage from laser scanning information, together with infrared imagery, leveraging the two technologies to complement one another [14]. A particular application of movement detection is shown in [12], where the vibration of fan blades was monitored through a laser scanner vibrometry (LSV) technology, providing the means for determining harmonics.

The above examples, extracted from the laser scanning special issue, are just some of the possible applications of laser scanning, but well represent the wide range of possible uses. The goal of this collection is also to demonstrate that the application of this technology is progressing towards multiple areas and is an ongoing development. The future will surely see laser scanning technology incorporated in crucial fields such as robotics, automatic navigation, and 3D surveying, from planetary to micro-scale, and this is a small contribution fostering further engagement.

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