

## CHANGE DETECTION VIA TERRESTRIAL LASER SCANNING

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### ABSTRACT:

We present in this paper an algorithm for the detection of changes based on terrestrial laser scanning data. Detection of changes has been a subject for research for many years, seeing applications such as motion tracking, inventory-like comparison and deformation analysis as only a few examples. One of the more difficult tasks in the detection of changes is performing informed comparison when the datasets feature cluttered scenes and are acquired from different locations, where problems as occlusion and spatial sampling resolution become a major concern to overcome. While repeating the same pose parameters is an advisable strategy, such demand cannot always be met, thus calling for a more general solution that can be efficient and perform without imposing any additional constraints. In this paper, we propose a general detection strategy based on terrestrial laser scanning data. We analyze the different sources of complexity involved in the detection of changes and study their implication for terrestrial laser scans. Based on this analysis we propose a detection model, which is both aware of these hurdles and is efficient. We show that by finding an adequate representation of the data, efficient solutions can be derived. We then demonstrate the application of the model on several natural scenes and analyze the results.

### 1. INTRODUCTION

Differing from conventional mapping techniques like photogrammetry, laser scanners provide rapid and direct description of 3D geometry independent of lighting conditions, and without the need for a manual collection of the data. Furthermore, the point-cloud provided by high-resolution laser scanners is both dense and accurate, thereby allowing a detailed description of objects irrespective of their shape complexity. It is therefore, not surprising that laser-scanning technology is rapidly becoming the popular alternative for modeling 3D scenes, for site characterization, cultural heritage documentation and reverse engineering, as only a few examples.

A key application where terrestrial laser scanning technology offers great use is monitoring of changes that occur over time. One example is the need to update geographic information by comparing the existing information with current state; another, which is more extreme, follows disastrous events where comparison of pre- and post- events is required, preferably in an efficient manner. Change detection should not necessarily be related to large-scale events. Behavior of small size natural phenomena or changes of specific objects are of great importance for analyzing deformations or objects evolution, and require a more subtle analysis of the measured scene. We point that the detection of changes can find its use in the elimination of moving objects within a static scene; such application can find use when reconstructing static landmarks, while avoiding irrelevant objects in the scene.

To date, detecting changes is mainly performed via images, usually by using object to background separation or a simple subtraction between images. Such models are limited and usually impose rigid constraints like static mounting of the camera, recognizable (usually artificial) landmarks, and are sensitive to shadows and local illumination problems. With 3D data arriving from airborne laser platforms, change detection is mainly applied in the form of a Digital Surface Models (DSMs) subtraction, where the DSMs are created from the raw laser point cloud (e.g., Vu et al., 2004). Murakami et al. (1999) also add to this intensity images as an additional information layer to help revising GIS databases. Vogtle and Snelde (2004) propose

a methodology for detecting changes in urban areas following disastrous events. Instead of solely computing the difference between the laser-based DSMs, a region growing segmentation procedure is used to separate the objects and detect the buildings; only then, an object-based comparison is applied. Hofton and Blair (2001) propose waveforms correlation of coincident footprints between different epochs to study vertical or elevation changes in LIDAR data.

As for change detection via terrestrial laser scans, most works focus on deformation analysis for designated objects. Comparison can be performed by the subtraction of a resampled set of the data (Schäfer et al. 2004), or adjustment to surface models like cylinders (Gosliga et al., 2006) or planes (Lindenbergh and Pfeifer, 2005). For the comparison of a complete scene, Hsiao et al. (2004), propose an approach that combines terrestrial laser scanning and conventional surveying devices such as total station and GPS, in order to acquire and register topographic data. The dataset is then transformed into a 2D grid and is compared with information obtained by digitization of existing topographic maps. Such approach has very appealing use in practical applications, but is very limited in scope and cannot be generalized into a change detection scheme for 3D data. Girardeau-Montaut et al. (2005) discuss the detection of changes in 3D Cartesian world, and point to the possibility of scans comparison in point-to-point, point-to-model, or model-to-model manners. The authors then use point-to-point comparison with some adaptations and make use of an octree as a data structure for accessing the 3D point cloud. Comparison is carried out by using the Hausdorff distance as a measure for changes.

The review demonstrates the great potential of change detection via laser scanning data that allow assessing variations within the physical scene without resorting to interpretation of radiometric content, as is the case with images. It also shows that in most cases where terrestrial laser scanning is being applied, some constraints on the studied objects or on the scanner pose are being imposed. Since, the assessment of the actual change, and the ability to quantify and measure it (e.g., size, volume), offer great assets, we study in this paper the detection of changes without the imposition of external constraints (other than having

# Change Detection Via Terrestrial Laser Scanning Isprs

**Lucian Dinca, Miglena  
Zhiyanski, Hongxu Wei**



### **Change Detection Via Terrestrial Laser Scanning Isprs:**

Laser Scanning Belén Riveiro, Roderik Lindenbergh, 2019-10-18 This book provides an overview on the evolution of laser scanning technology and its noticeable impact in the structural engineering domain. It provides an up-to-date synthesis of the state of the art of the technology for the reverse engineering of built constructions including terrestrial mobile and different portable solutions for laser scanning. Data processing of large point clouds has experienced an important advance in the last years and thus an intense activity in the development of automated data processing algorithms has been noticed. Thus, this book aims to provide an overview of state-of-the-art algorithms, different best practices, and most recent processing tools in connection to particular applications. Readers will find this a comprehensive book that updates the practice of laser scanning for researchers and professionals not only from the geomatic domain but also other fields such as structural and construction engineering. A set of successful applications to structural engineering are illustrated, including also synergies with other technologies that can inspire professionals to adopt laser scanning in their day-to-day activity. This cutting-edge edited volume will be a valuable resource for students, researchers, and professional engineers with an interest in laser scanning and its applications in the structural engineering domain.

**Landslides and Engineered Slopes. Experience, Theory and Practice** Stefano Aversa, Leonardo Cascini, Luciano Picarelli, Claudio Scavia, 2018-04-17 Landslides and Engineered Slopes Experience Theory and Practice contains the invited lectures and all papers presented at the 12th International Symposium on Landslides, Naples, Italy, 12-19 June 2016. The book aims to emphasize the relationship between landslides and other natural hazards. Hence, three of the main sessions focus on Volcanic induced landslides, Earthquake induced landslides, and Weather induced landslides, respectively, while the fourth main session deals with Human induced landslides. Some papers presented in a special session devoted to Subareal and submarine landslide processes and hazard, and in a Young Session, complete the book. Landslides and Engineered Slopes Experience Theory and Practice underlines the importance of the classic approach of modern science which moves from experience to theory as the basic instrument to study landslides. Experience is the key to understand the natural phenomena, focusing on all the factors that play a major role. Theory is the instrument to manage the data provided by experience, following a mathematical approach; this allows not only to clarify the nature and the deep causes of phenomena but mostly to predict future and, if required, manage similar events. Practical benefits from the results of theory to protect people and man-made works. Landslides and Engineered Slopes Experience Theory and Practice is useful to scientists and practitioners working in the areas of rock and soil mechanics, geotechnical engineering, engineering geology, and geology.

**Forest Ecosystems in Mountain Regions: Conditions, Risks and Impacts** Lucian Dinca, Miglena Zhiyanski, Hongxu Wei, 2025-04-10 Forest ecosystems from mountain regions (FEMR) provide a wide range of ecosystem services and are a hub of biodiversity. Information about their condition under the action of diverse actors is essential in facing current global and climatic challenges. As ecosystems in mountain regions are vulnerable to

changing environmental conditions and other factors the assessment of their condition with respect to diverse impacts and risks will provide essential and significant knowledge for their further management and adaptation strategies Ecosystem services provisioning is dependent on the ecosystems condition in mountain areas and the information in the socio ecological context supports outlining the pathways for sustainable regional development Considering the wide diversity of driving factors and the variety of complex mountainous ecosystems across biomes new knowledge on interrelations in socio ecological systems in mountain regions across the world is of special interest [Big data and artificial intelligence technologies for smart forestry](#) Weipeng Jing,Rafał Scherer,Marcin Woźniak,Zhufang Kuang,2023-03-30 *Achieving Sustainability in Ukraine through Military Brownfields Redevelopment* Cezar Morar,Laurel Berman,Serap Erdal,Liudmyla Niemets,2024-12-30 This book is written by international experts who are brownfields practitioners from over 15 countries Blighted and contaminated properties including military industrial commercial and multi residential properties globally referred to as brownfields are a shared phenomenon among NATO and NATO partner countries They provide practical solutions to addressing evaluating and cleaning up brownfields including multiple case studies Topics include reuse of military brownfields sustainable site reuse community engagement risk assessment impacts of the war in Ukraine related to military brownfields development and redevelopment a free training to improve capacity to evaluate environmental and health risks of brownfields and shared best practices [Guidelines for the Use of Mobile LIDAR in Transportation Applications](#) Michael James Olsen,2013 TRB s National Cooperative Highway Research Program NCHRP Report 748 *Guidelines for the Use of Mobile LIDAR in Transportation Applications* presents guidelines for the application of mobile 3D light detection and ranging LIDAR technology to the operations of state departments of transportation Mobile LIDAR uses laser scanning equipment mounted on vehicles in combination with global positioning systems GPS and inertial measurement units IMU to rapidly and safely capture large datasets necessary to create highly accurate high resolution digital representations of roadways and their surroundings Publisher s description [Comprehensive Remote Sensing](#) Shunlin Liang,2017-11-08 *Comprehensive Remote Sensing* Nine Volume Set covers all aspects of the topic with each volume edited by well known scientists and contributed to by frontier researchers It is a comprehensive resource that will benefit both students and researchers who want to further their understanding in this discipline The field of remote sensing has quadrupled in size in the past two decades and increasingly draws in individuals working in a diverse set of disciplines ranging from geographers oceanographers and meteorologists to physicists and computer scientists Researchers from a variety of backgrounds are now accessing remote sensing data creating an urgent need for a one stop reference work that can comprehensively document the development of remote sensing from the basic principles modeling and practical algorithms to various applications Fully comprehensive coverage of this rapidly growing discipline giving readers a detailed overview of all aspects of Remote Sensing principles and applications Contains Layered content with each article beginning

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