

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

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