DETECTION AND LOCALIZATION OF 3D TRAFFIC SIGNPOSTS USING MOBILE LASER SCANNING DATA

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ABSTRACT:

Over the past two decades, mobile laser scanning (MLS) technology has been rapidly developed. MLS systems, which are usually mounted on the roof of a vehicle and integrated with laser scanners, digital cameras, and a set of position and orientation systems (e.g. global navigation satellite system, inertial measurement unit, and distance measurement indicator), can rapidly acquire highly dense, highly accurate, and high-resolution 3D point cloud data over a large area within a short time period. The collected point cloud data have become a new data source for a variety of applications, such as smart city construction, transportation related activities, cultural heritage documentation, and basic surveying and mapping. In this paper, we propose an algorithm for automatically detecting and locating 3D traffic signposts using MLS point clouds acquired in urban areas. The main steps include voxel-based ground removal, Euclidean distance clustering, and traffic signpost detection based on 3D object matching.

Due to the scan mode of MLS systems, the collected point cloud contains a great portion of ground points. Since traffic signposts are off-ground objects, removing ground points can dramatically reduce the quantity of the point cloud to be processed, thereby reducing the computational complexity and increasing the efficiency. Considering the ground fluctuations, first, we vertically partition a raw point cloud into a set of data blocks with a certain width (e.g. 3 m) on the horizontal plane. Then, each data block is organized into an octree structure with a certain voxel size (e.g. 5 cm). In this octree structure, a voxel is connected with 26 neighbours in 3D space. To effectively remove ground points, we propose a voxel-based upward growing method. For each voxel v, it grows upward to its 9 neighbours located above this voxel. Such an upward growing process continues from its 9 neighbours to their corresponding neighbours. The upward growing process stops when no voxels can be reached. If the voxel with the highest elevation within the grown region is smaller than a pre-defined ground threshold (e.g. 30 cm), voxel v will be labelled as the ground and further removed.

After ground removal, off-ground points are further clustered into individual objects using a Euclidean distance clustering approach, which clusters discrete points based on their Euclidean distances to their neighbours. Specifically, an un-clustered point is grouped into a specific cluster if and only if its shortest Euclidean distance to the points within this cluster lies below a pre-defined clustering threshold (e.g. 10 cm). Moreover, based on prior knowledge, the clusters that are of small size and are not likely to be traffic signposts are further removed to reduce computational complexity.

Finally, we propose a 3D object matching framework, which integrates feature and geometric matching items, to detect traffic signposts. First, several traffic signpost prototypes (e.g. round-shaped, rectangular-shaped and triangular-shaped traffic signposts) are selected from the real-world point clouds. Then, a set of feature points are respectively sampled from a prototype and a clustered object and modelled using the persistent feature histogram (PFH) descriptor. Next, the proposed 3D object matching framework is carried out to compute a matching cost between the feature points on the prototype and the clustered object. Finally, based on ROC curve analysis, all the matching costs from all clustered objects are thresholded to detect traffic signposts. Figure 1 shows the processing results in each step of the proposed 3D traffic signpost detection algorithm. As seen from the detection results in Figure 1(d), we conclude that the proposed algorithm works well on detecting 3D traffic signposts from MLS point clouds.


(a) (b) (c) (d)

Figure 1. (a) A raw point cloud, (b) off-ground points after ground removal, (c) clustered off-ground objects, and (d) detected 3D traffic signposts.

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