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Perception and place recognition of 3D urban street environment using MLS point clouds

For navigating a self-driving car in an urban street environment, it is an essential mission to achieve the place recognition and perceptual understanding about the foreground objects and background environment, which can provide us knowledge on both dynamic vehicles and static road scenes. To accomplish this mission, traditional 2D solutions normally utilize a series of images, which cannot discern precise depth information of either objects or environment. Comparing with 2D images, 3D point clouds acquired from mobile laser scanning (MLS) systems deliver detailed 3D information of road scenes during the driving with a high measuring frequency. Moreover, geometric information acquired through MLS is invariant to drastic illumination changes, making it more robust for different weathers and times of a day. Therefore, using MLS point clouds could be a solution for place recognition and perceptual understanding tasks like object detection and shape completion.

Benefiting from widespread use of MLS systems, large-scale urban areas with accurate and detailed 3D measures can be mapped directly and effectively. A 3D mapping using MLS systems can record detailed environmental information a scene. However, these mapped data can only reflect static and constant the information of 3D scenes. They can neither provide real time sensing of the current scene nor address challenges of long-term autonomy. Thus, a practical way of using MLS data in autonomous driving should combine the given 3D mapping data (for providing information of static background environment) and the actual scans (for providing information of dynamic objects and changed scenes) to achieve full autonomy of self-driving cars.

In this work, we will conduct perception and place recognition of urban street scenes using both given 3D mapping data and real time scans, relating to three questions: (i) Where is the current location of the scanner? (ii) Which objects lies in the currently scanned scene? (iii) What is the full shape information of vehicles in the scanned scene? To achieve this goal, the following research tasks will be addressed:

- To achieve the place recognition of query scan in a given reference map. Given a query LiDAR scan of a local scene, the best match is retrieved by searching through the reference database, which tells us the exact location of the query scan with respect to the reference map. The benchmark of point cloud based retrieval for place recognition will be created, and the method for large-scale 3D point cloud retrieval will be explored to achieve place recognition in the 3D point cloud based localization.
- To recognize objects in the environment from the current LiDAR scan. Object detection of the 3D scene is one of the core tasks for perceiving the driving environment. Especially, vehicles the most concerned investigation objects and a dynamic component of the scene. Based on scanned 3D point clouds, object detection approach will be explored to detect the vehicles and other objects in the street scene.
- To acquire complete geometric information of vehicles. Acquired 3D point clouds of vehicles from MLS are inevitably incomplete due to occlusion or self-occlusion. Thus, learning-based shape completion method will be explored to generate complete and realistic structures for the sparse and partial point clouds.

The expected results are three-folds. Firstly, the location of the given 3D scan in urban areas will be estimated. Approaches and algorithms to achieve place recognition in the 3D point cloud based localization will be developed and verified. Secondly, a methodology to detect these objects in the given scan will be investigated. Lastly, the complete shape information of vehicles will be generated.