Towards Reliable Object Anchoring in Highly Dynamic Traffic Scenes

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Symbol grounding is the problem of how the meaning of a symbol is to be grounded in something other than just more meaningless symbols [3]. This open problem in robotics and artificial intelligence is most challenging. The object anchoring problem is the lightweight version of symbol grounding, as it restricts the symbols to refer to objects, thus avoiding abstract concepts or attributes [2].

This demonstration presents work in progress, a novel approach for mapping highly dynamic environments, i.e., we design a system capable for mapping road traffic scenarios like given in Figure 1. Given 3D laser scans acquired at a high frame rate and no other sensor input, a 3D map is built by removing dynamic parts of the scene and estimating the ego-motion of the vehicle precisely at the same time. To achieve this, we have combined reliable and fast 3D scan matching in an ICP-like fashion with semantic perception, object tracking and recognition.

We extend the well-known ICP algorithm, available in "3DTK – The 3D Toolkit" [1] for HDL-64 laser scan data and build a system for solving the simultaneous localization and mapping problem in urban road scenarios. As the pose of the car is unknown, the geometric structure of overlapping 3D scans has to be considered for registration. However, this structure is changing, due to change of position of the other moving objects. Therefore, moving objects need firstly to be identified and be removed. We use a semantic-driven approach for solving this task of identifying dynamic objects in 3D scans. The overall system is called dynamic VeloSLAM. To be more precise, we execute the following steps:

1) First, we segment the 3D point cloud. Here a problem arises with all objects standing on the ground. For example, the feet of a human have roughly the same height value as the ground at the point he is standing on. The feet and the floor form only a crease edge, no jump edge. Thus, we use a special ground removal method and then the objects are nicely separated.
2) After the ground segmentation, one scan of point cloud was divided into many separated objects. In a typical urban environment, there is a wide variety of objects such as vehicles, pedestrians, buildings, etc. We use low-level geometric features, i.e., PCA features, for classification of the objects.
3) The interpreted objects are tracked using a Kalman filter. Each cluster is tracked separately, and the tracking is used to improve the classification described above. The multi-hypothesis approach in combination with either nearest-neighbor data association or global optimization give the algorithm its stability.
4) Dynamic VeloSLAM considers clusters, which are not matched as possible new targets, and a new tracker is initialized. If a cluster cannot be matched, we keep the hypothesis for a certain number of 3D scans, thus ensuring the possibility for reacquisition. After exceeding the threshold, the tracker is deleted.
5) If the motion detected of a cluster exceeds a threshold, we consider the object as dynamic. All dynamic objects are removed for recovering the vehicle motion and to build a map.
6) Finally, we use our 6D SLAM method as described in [4]. Its basis is a fast and reliable scan matching algorithm for ICP, a heuristic for closing loops efficiently, and a Lu/Milios-style relaxation.

To validate our approach, we collected a data set on the road from Wuhan to Huangshi. We select a roundabout in the road as main experimental scene 1. The demonstration show the results on the mentioned data set.

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Fig. 1. Typical scenario, where we aim at precise 3D mapping. See also http://youtu.be/bHaZpQ_5wg8