Interpretation of Urban Scenes based on Geometric Features

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***Abstract*— In this paper we investigate the acquisition of 3D functional object maps for outdoor urban scenes from point cloud data, using techniques which worked reliably for indoor household environments in our previous work[1]. By employing 3D geometry reasoning methods, our approach can successfully segment the important parts of the environment and give semantic annotations to the underlying data points which represent them.**

I. Introduction

With a few exceptions (see [1] for related work discussions), the majority of 3D mapping systems today provide just information necessary for safe navigation, and only very rarely for finer-grained operations such as robot manipulation. In contrast, household robotic assistants operating in indoor environments require a deeper understanding of the map and rely on higher level semantics to operate properly. In this paper, we are presenting our experiences on applying our mapping framework from its initial usage for indoor environments [1] to outdoor urban scenes, by merely modifying and adapting the set of commonsense knowledge rules used in our functional mapping approach.

II. Geometric Mapping

The input to our mapping system is a set of unorganized 3D points representing urban scenes, obtained for example from laser sensors. Each scan is processed through a pipeline of steps which include: i) sparse outlier removal; ii) normal and curvature estimation; iii) feature persistence analysis; and iv) feature histogram computation [1]. To consistently align separate views into a global consistent model, we make no assumption about the acquisition viewpoint and perform registration directly in the persistent feature histogram space [2]. Depending on the dimensionality of the complete model, we employ space decomposition techniques (e.g. octrees) to analyze and parallelize the subsequent geometric operations. Furthermore, to simplify segmentation and model fitting, our approach makes use of resampling techniques which transform the model into a homogeneous point distribution and attempt to fill holes caused by occlusions [1].

III. Functional Mapping

Through Functional Mapping we segment and classify those parts of the map which could represent potential objects of interest for a robot, through the use of commonsense rules, like: a) a signpost is always posted on a pole, within some predefined distances from the ground; or b) a building has its walls perpendicular to the ground. These rules are independent of each other most of the time and are ran in parallel to speed up the segmentation process. At the end, if a subset of points corresponds to more than one object class, a weighting scheme is employed and the most probable surface for the partial model so far is voted as the winner. This has the advantage that parts of the model can be modified later on, once new data is acquired. Due to the particularity of our urban datasets, for each point we defined and semantically annotated one the following classes of labels: i) street; ii) sidewalk; iii) vertical wall; iv) building; v) window; vi) door; vii) tree or vegetation; viii) signpost; and ix) stairs.

Figure 1 presents partial results segmented using our method.

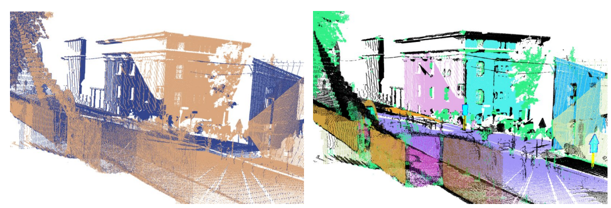

Fig. 1. Left: original registered point cloud data; right: interpreted dataset with semantic annotations.

IV. Conclusions

We have presented our experiences on semantically interpreting outdoor urban scenes based on geometric features. Our approach decouples the pure geometric part of the mapping from the functional one, and thus simplifies the inclusion of commonsense knowledge in the segmentation process. This has also been validated in our indoor household environment maps [1], which have proven to be accurate for performing robot manipulation.

References

[1] Radu Bogdan Rusu and Zoltan Csaba Marton and Nico Blodow and Mihai Dolha and Michael Beetz, Towards 3D Point Cloud Based Object Maps for Household Environments, in Robotics and Autonomous Systems Journal (Special Issue on Semantic Knowledge), 2008.

[2] Radu Bogdan Rusu and Nico Blodow and Zoltan Csaba Marton and Michael Beetz, Aligning Point Cloud Views using Persistent Feature Histograms, in Proceedings of the 21st IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Nice, France, September 22-26, 2008.

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