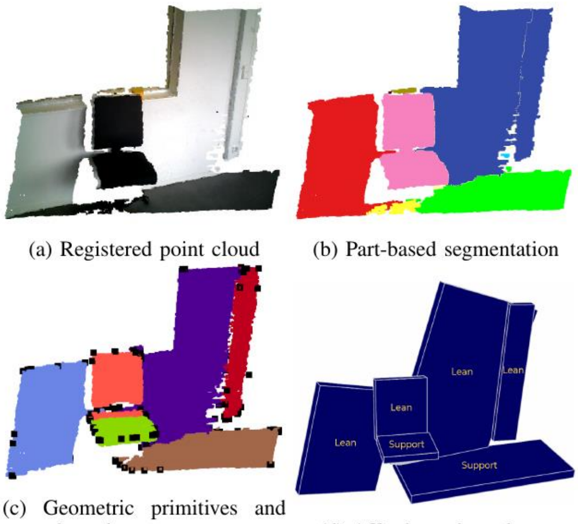
Graph-based Scene Representation for Whole-Body Humanoid Actions

The reliable detection of possible ways of interaction with environmental structures is a key capability for autonomous robots, especially when dealing with unknown environments. To tackle this problem we employ a perceptual pipeline that segments the environment into geometric primitives and assigns affordance labels, i.e. action possibilies, to these [1, 2].

This perceptual pipeline works well for affordances that refer to individual primitives, e.g. a large, vertical plane suggests the whole-body action of *leaning*. However, there are more abstract affordances that refer to more complex environmental structures, like:

- A staircase affords *climbing*
- A chair affords *sitting*
- A door affords *opening* or *closing*
- A ladder affords *climbing*
- A car affords *driving*



(a) Registered point cloud (b) Part-based segmentation (c) Geometric primitives and grasp hypotheses (d) Affordance hypotheses

These affordances refer to environmental structures, formed by specific combinations of environmental primitives. The goal of this work is to enhance the perceptual pipeline in order to identify known structures within the set of environmental primitives.

The scene will be represented in a topological graph, each node referring to an environmental primitive. This graph allows for searching geometric relationships that indicate known environmental structures, such as staircases or doors. These structures will be identified and abstract affordances will be assigned to them.

The goal of the work is the design implementation of the graph-based scene representation. This includes querying mechanisms as well as pruning strategies. The graph and the query algorithms will be evaluated using real-world examples captured by the humanoid robot ARMAR-III.

Bibliography

[1] P. Kaiser, D. Gonzalez-Aguirre, F. Schültje, J. Borràs, N. Vahrenkamp, and T. Asfour, “Extracting whole-body affordances from multimodal exploration,” in *2014 IEEE-RAS 14th International Conference on Humanoid Robots (Humanoids 2014)*, 2014.

[2] P. Kaiser, N. Vahrenkamp, F. Schültje, J. Borràs, and T. Asfour, “Extraction of Whole-Body Affordances for Loco-Manipulation Tasks,” *International Journal of Humanoid Robotics*, 2015.