BesMan

Behaviors for Mobile Manipulation

The main goal of the project BesMan was the development of generic dexterous manipulation strategies which are independent of a specific robot morphology as well as the learning of new situation-specific behaviors by means of a machine learning platform.

This was done by integrating three key components: namely, trajectory planning, whole-body sensor-based reactive control, and dynamic control into a modular, robot-independent and easily-reconfigurable software framework which allows reusing components to describe a variety of complex manipulation behaviors. Furthermore, novel, situation-specific behavior should be learned by means of a highly-automated machine learning platform, which incorporates an interface to a human operator, who via demonstration will show the robot how to deal with unforeseen situations.

In order to fulfill such a generality, a software framework was developed to describe and control robot manipulation behaviors. To keep independence from particular robot hardware and an explicit statement of areas of application, an embedded Domain Specific Language (eDSL) was used to describe the particular robot and a controller network that drives the robot.

In the area of robot dynamic control, we developed a software library to obtain robot dynamic models from experimental identification by generating appropriate identification experiments and parameter estimation from the measurements.

In the area of whole-body control, we used a constraint-based Whole Body Control scheme for executing reactive robot motions, incorporating the physical constraints of a system, integrating multiple, disparate sensor-based controllers and optimally utilizing the redundant degrees of freedom in complex systems. In particular we integrated a constraint-based, multi-objective robot controller similar to iTAsC in our ROCK framework and provided the infrastructure to execute action plans based on motion constraints, as well as change the constraints online. All the active motion constraints and their parametrizations compose a subtask in our action plan that is executed by the robot.

In the area of the learning, we developed a learning platform which allows learning robotic manipulation behavior from human demonstrations. The whole procedure is highly automated and fast enough to serve as a solution to quickly learn behavior for solving unforeseen challenges and tasks, which can always occur during deployment of a robotic system. The learning platform is composed of several components, which deal with acquisition and preprocessing of human demonstrations, segmenting the demonstrated behavior into basic building blocks, learning movement primitives using imitation-learning, refining movement primitives by means of reinforcement learning, and generalizing movement primitives to related tasks.

The results of this project were developed as generic solutions which were independent of the morphology of the robot and of its application scenario. The transfer of the developed solutions between different robotic systems and between application scenarios (e.g. space and logistics) was exemplary demonstrated.

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