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Deliverable Title:	Fourth Demonstration on Scenario 2: Tightly coupled cooperative task execution.
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Contents

Executive Summary

Deliverable 5.3.4 deals with the demonstrations in the context of WP5.3. The main contribution of this deliverable is the demonstration of our implementation of the link between natural language, planning, plan recognition, and sensorimotor experience in robotics. In the context of the task ”set the table” performed by the humanoid robot ARMAR, several aspects of structural bootstrapping are demonstrated. In the video **Xperience-Scenario-2-Y4.mp4**, we show how natural language interface can be used for setting tasks for the planner as well as for describing the state of the world and human actions. We also demonstrate how high level domain descriptions can be generated from the robot's memory and how new plans are generated based on the current state of the world.

The demonstration integrates contributions from WP1 (the ArmarX architecture with its MemoryX), WP2 (motion primitives for grasping, placing and pushing), WP3 (Planning) and WP4: tightly coupled interaction (WP4.1) as well language understanding pipeline and plan recognition (WP4.2). The entire demonstration was performed at KIT on the humanoid robot ARMAR-III.

Linking language, planning, and plan recognition to sensorimotor experience in robotics

As shown in the video, the human agent asks the robot to help him to set the table for two people. The execution of the uttered command requires generation of the multi-step plan. The robot is supposed to generate a plan resulting in putting two cups on the table, while the human agent puts forks, knifes, and plates on the table, which is performed as follows (see Fig. 1). The task description is provided by the Language understanding component. The domain description is generated from working memory of the robot (MemoryX). The task and domain descriptions constitute the input for the PKS symbolic planner, which generates a plan, see Fig. 2. The execution of the plan is monitored by the Statechart framework of ArmarX. The grasping and pushing skills depend on object models and grasp definitions in the robot's memory (MemoryX).

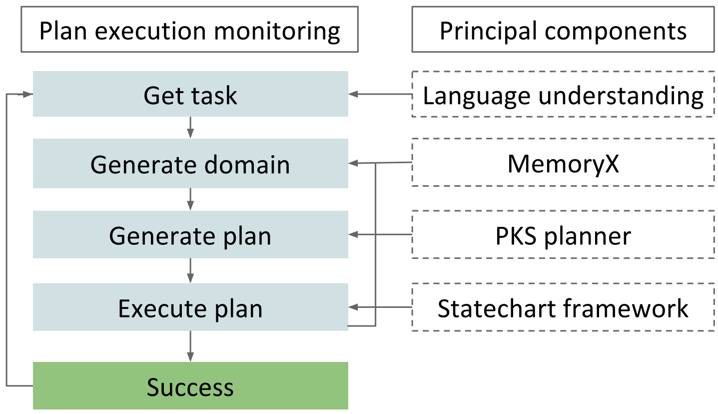

Figure 1: Planning and execution monitoring.

The same set of actions can be triggered using plan recognition. The human agent starts setting the table and comments his actions. The robot recognizes the plan of the human agent and generates its own plan to help setting the table.

Figure 2: Plan visualization.

When the table is set, the human agent continues with the scenario. He asks the robot to arrange one chair. The robot pushes one chair to the table. Based on the reachability maps, the robot estimates a feasible position for approaching the chair. Using the whole body pushing, the chair is pushed to the target location. When executing pushing, the robot is avoiding occurring obstacles.

Finally, the human agent asks the robot to put the multivitamin juice on the table. The robot generates a plan for executing this command, but the juice cannot be found at the assumed location. The robot assumes another location derived in the location database, and re-plans, after which the juice is located and put on the table.