

WEB-ENABLED AND EXPERIENCE-BASED COGNITIVE ROBOTS THAT  
LEARN COMPLEX EVERYDAY MANIPULATION TASKS

**ROBOHOW.COG**



**Proposal full title:** Web-enabled and Experience-based Cognitive Robots that Learn Complex Everyday Manipulation Tasks

**Proposal acronym:** ROBOHOW.COG

**Type of funding scheme:** Large-scale integrating project (IP)

**Work programme topic addressed:** ICT-2009.2.1 Cognitive Systems and Robotics

**Name of the coordinating person:** Prof. Michael Beetz

## Section 1 Scientific and/or technical quality

### 1.1 Concepts and Objectives

Future personal and service robots in human working and living environments will have to autonomously and competently perform a large and steadily expanding set of human-scale everyday manipulation tasks.

**ROBOHOW.COG: A glimpse into the future of autonomous robot manipulation** Consider a robot that has to perform a task it has not been programmed for — let's say making a pancake. To make a pancake, the robot first of all needs instructions. Such instructions can be found on webpages such as [wikihow.com](http://www.wikihow.com). These instructions are typically incomplete, vague, and ambiguous and require some interpretation because they are made for human rather than robot use. To resolve the vagueness and ambiguities the robot could then watch instructional videos demonstrating how humans make pancakes. However, acquiring procedural knowledge is not enough. The robot must also find and recognize the ingredients and necessary tools needed for making pancakes in its environment. Making pancakes requires manipulation actions with effects that go far beyond the effects of pick and place tasks. The robot must pour pancake mix on to the center of the pancake oven and monitor to forestall undesired effects such as spilling the pancake mix. The robot must also push the spatula under the baking pancake in order to flip the pancake. This requires the robot to flip the pancake with the appropriate force, to push the spatula strong enough to get it under the pancake but not too strong in order to avoid pushing off the pancake off the oven.



Figure 1: Manipulation platform TUM-Rosie making pancakes using web instructions from [wikihow.com](http://www.wikihow.com).

**The Challenges** Enabling robots to competently perform everyday manipulation activities such as household chores exceeds, in terms of task, activity, behavior and context complexity, anything that we have so far investigated or successfully implemented in motion planning, cognitive robotics, autonomous robot control and artificial intelligence at large. Robots that are to perform human-scale activities will get vague job descriptions such as clean up or fix the problem and must then decide on how to perform the task by doing the *right actions* on the *right objects* in the *right ways* in all contexts. They must also generate, debug and optimize a wide spectrum of plans that require rich specifications of how actions are to be executed, what events to wait for, which additional behavior constraints to satisfy, and which problems to watch out for. Another important challenge are task variants. Instead of a basic pancake people may rather want a flavoured one, with chocolate, berries, or chocolate chip flavors. Being able to perform novel tasks, i.e. generalize, both adequately and efficiently, is certainly another key requirement for future service robots.

**The Vision** ROBOHOW.COG aims at the realization of a programming framework that enables programmers to semiautomatically expand autonomous service robot applications to perform additional human scale manipulation tasks such as setting the table, cleaning up, and meal preparation, with little effort.

**The Approach** ROBOHOW.COG will attempt to make the realization of such easily extendable manipulation robot applications feasible, effective and efficient by representing the control programs as concurrent, percept-guided manipulation plans that are can be generated semi-automatically by extracting and processing formally represented knowledge from large existing information sources. ROBOHOW.COG will use websites, visual instructions, and haptic demonstration as the primary information sources.

**Expected Impact** We believe that these technologies will result in a new generation of autonomous manipulation robots that will be applicable to large range of application domains that require knowledge intensive and open-world robot robot systems.