Robustness by Autonomous Competence Enhancement

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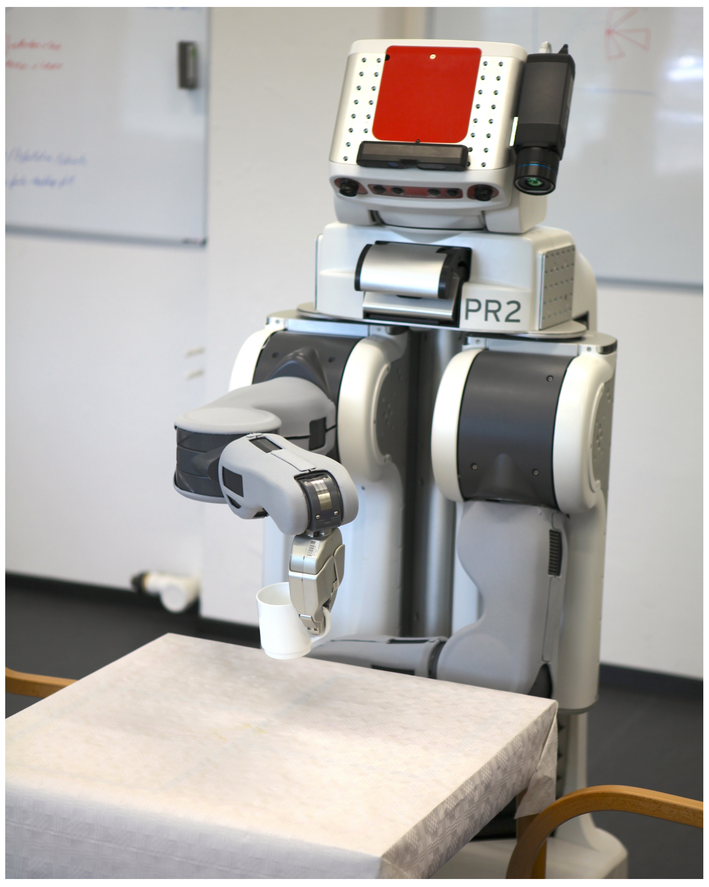

Figure 1: *PR2 placing a mug on the table*

1. Introduction

The RACE project aims to develop an artificial cognitive system, realized by a service robot capable of building a high-level understanding of the world by which it is surrounded. This is achieved by storing and exploiting its experiences. Experiences will be recorded internally at multiple levels: as high-level descriptions in terms of goals, tasks and behaviours, connected to constituting subtasks, and finally to sensory and actuator skills at the lowest level. In this way, experiences provide a detailed account of how the robot has achieved past goals or how it has failed, and what sensory events have accompanied the activities.
The project aims to produce the following key results:

- Robots capable of storing experiences in their memory in terms of multi-level representations connecting actuator and sensory experiences with meaningful high-level structures.
- Methods for learning and generalizing from experiences obtained from behaviour in realistically scaled real-world environments.
- Robots demonstrating superior robustness and effectiveness in new situations and unknown environments using experience-based planning and behaviour adaptation.

In order to reach these ambitious goals, a common conceptual framework for representing robot experiences, planning and learning has been established. It shall be demonstrated how a robot can evolve its understanding of the world as a result of novel experiences, and that understanding allows a robot to better cope with new situations and to perform at a level or robustness and effectiveness not previously achieved.

2. Architecture and Framework

The central piece of the RACE architecture is the *Blackboard*, the contents of which are similar to what can be found in an ABox in Description Logics. Its main goal is, like in traditional blackboard architectures, to keep track of updates of other system components. Through the user interface a planning goal is entered into the blackboard which triggers the `HTN` (Hierarchical Task Network) Planner. The Planner creates then its initial planning state and writes a generated plan back to the Blackboard.

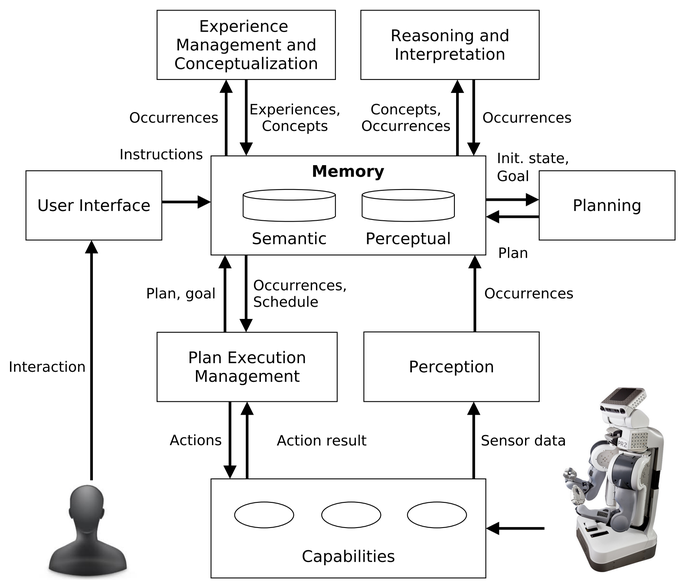

Figure 2: *Architecture of RACE*

3. Evaluation Approach

To measure success for a given task in a given scenario, we use an approach inspired by model-based validation techniques; namely, we measure the compliance of the actual robot's behavior to the intended ideal behavior for that task in that scenario. Fig. 3 graphically illustrates this principle: the trace of a given execution of the RACE system is compared against a specification of what the ideal behavior should be, resulting in a "Fitness to Ideal Model" (FIM) measure. These specifications will be formulated in a way that facilitates the task of automatically computing the FIM measure.

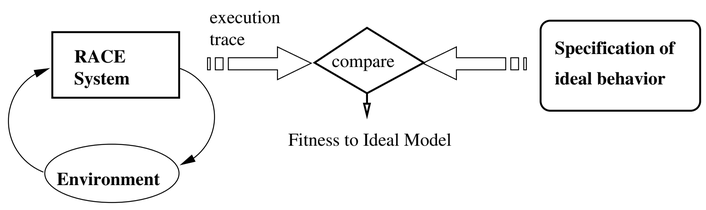

Figure 3: *Evaluation of RACE*

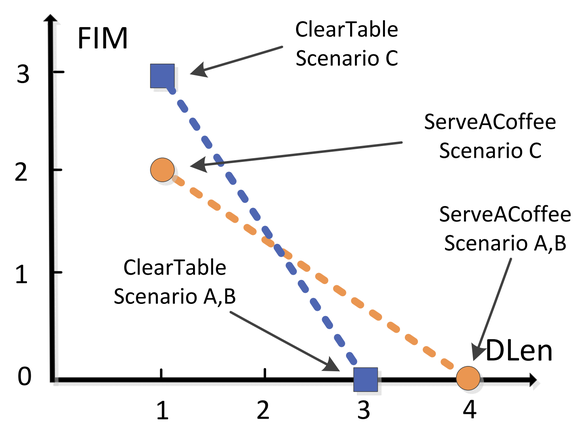

Figure 4: *Evaluation Results*

4. Scenario Setup and Experiments

The system has been tested and evaluated in an experimental restaurant domain. To collect experiences, the robot will carry out tasks of a waiter, for example serve a coffee and clearing tables, etc. Demonstrations "Serve-a-coffee", "Clear-table", "Deal-with-obstacles" and "Clear-table-intelligently" have been defined and performed on the physical PR2 platform in a restaurant environment. The results are presented with respect to the metrics defined in Section 3.

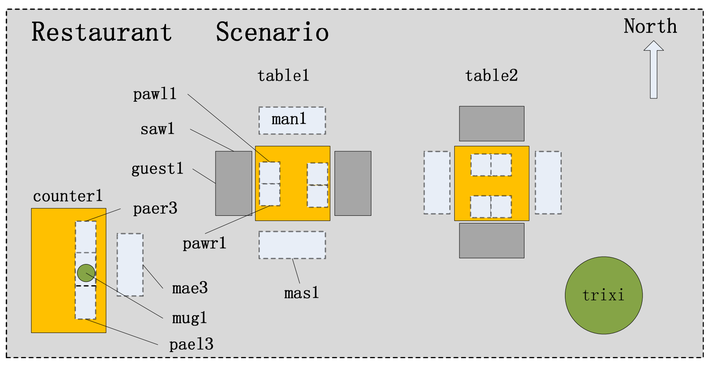

Figure 5: *Floorplan of RACE*

Figure 6: *Environment of RACE*

5. Partners

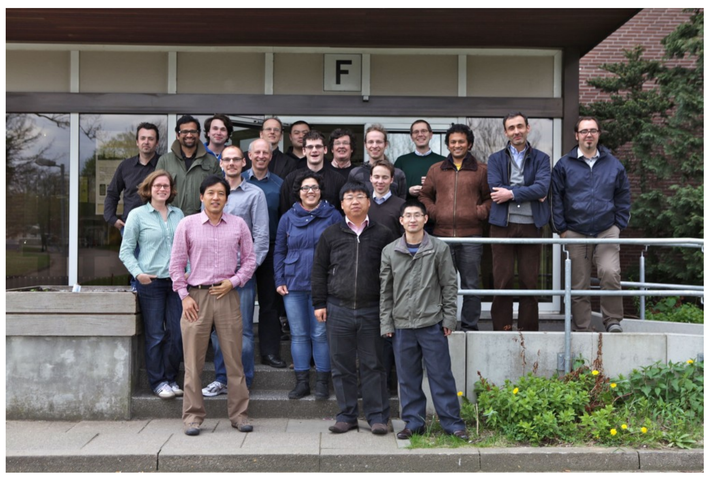

Figure 7: *Partner of RACE*

Acknowledgements

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