Mixed Reality in the Context of a Smart Mobile System

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RACE

SEVENTH FRAMEWORK PROGRAMME

Outline

1. The RACE Project
2. State of the Art
3. Scientific Achievements
4. Outlook

1 The RACE Project
- Introduction
- Demo Domain
- Architecture
- Concepts and Instances

2 State of the Art

3 Scientific Achievements

4 Outlook

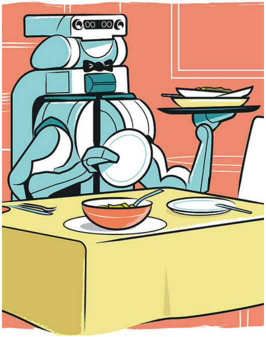
The RACE Project

RACE

Robustness by **A**utonomous **C**ompetence **E**nhancement

Focus:

- framework and methods for learning from experiences
- conceptualizing stored experiences
- adapt plans and behavior



The RACE Project

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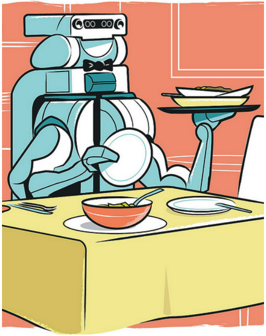


Experiences: execution traces that...

- integrate sub-symbolic and symbolic representations
- provide a detailed account of success/failure

Demo Domain

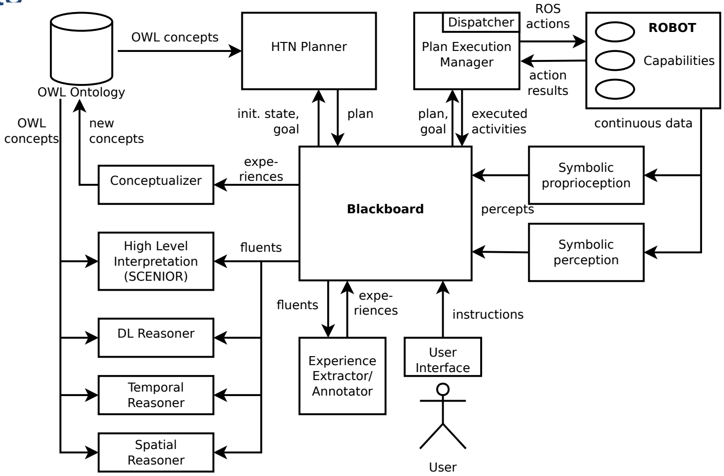
PR2 as Waiter in a Restaurant Environment

Demo: ServeACoffee

http://youtu.be/uqoBXbBtm2E

Comparative Evaluation of competence-enhanced Robots

Objectives



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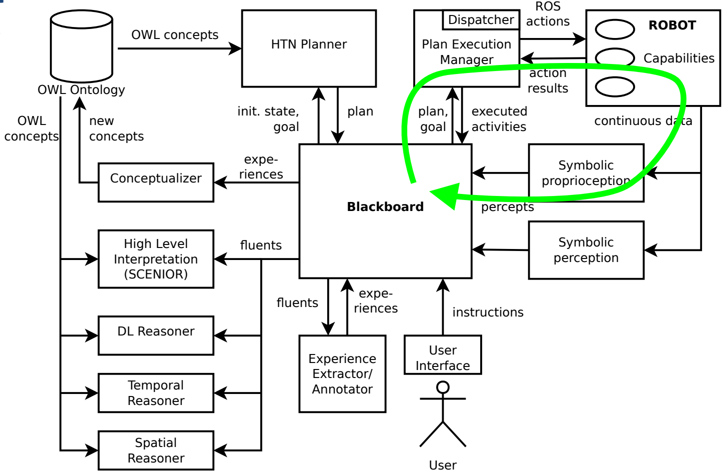

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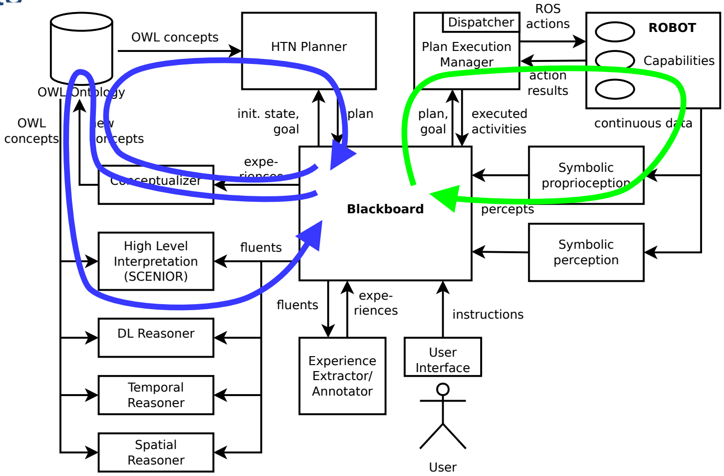

Representing Concepts and Instances

OWL-DL Ontology (T-Box):

```
Class: MoveObjectFromTo
EquivalentTo:
RobotActivity
AND (hasObject EXACTLY 1 PhysicalEntity)
...
AND (hasGetObjectFrom EXACTLY 1 GetObjectFrom)
AND (hasMoveObjectTo EXACTLY 1 MoveObjectTo)
AND (hasOverlap SOME Overlaps)
AND (hasBefore SOME Before)
```

Representing Concepts and Instances II

Blackboard (A-Box) instances:

- basic data type: Fluent
- exchanged through ROS messages
- all fluents are instances of concepts in the ontology

```
!Fluent
   Class_Instance: [MoveArmToSide, moveArmToSide1]
   StartTime: [61.142, 61.142]
   FinishTime: [66.306, 66.306]
   Properties:
      - [hasArm, RobotArm, leftArm]
      - [hasResult, ActivityResult, succeeded]
```

1 The RACE Project

2 State of the Art
- Planning
- Evaluation
- Reasoning
- Learning

3 Scientific Achievements

4 Outlook

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- Conditional planning widely employed (RACE, currently)
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  1. what information to look for
  2. how to acquire necessary information

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  - computationally hard, limited to smaller domains
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  1. what information to look for
  2. how to acquire necessary information
- example:
  - *Tidyup-Robot Project*, Freiburg (Dornhege, Hertle 2013)
  - ACogPlan, Hamburg (Off. et all. 2011)

Evaluation of a planning System

- generally not a trivial task (Brenner and Nebel, 2009)
- example: *ACogSim (Off et all. 2012)*
  - evaluate overall system behavior for several domains
  - focus on continual planning
  - metrics:
    - is the planner (always) able to perform the given task?
    - how often switch between planning and acting?
    - how much time is necessary for the whole planning and reasoning process
    - how long is the average planning phase?
    - how does the performance change with a decreasing amount of initial knowledge?

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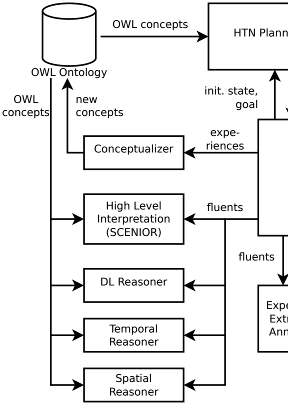
- another example: *RACE Deliverable 5.1 – Evaluation Infrastructure*

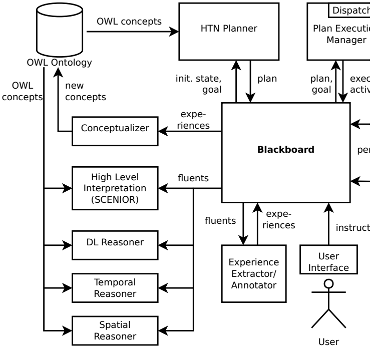
Reasoning

- RACE:
  - hybrid-reasoning: spatial, temporal, causal
  - dedicated reasoner feed the blackboard (finally the planner)
  - dependent on initial knowledge and perception (during execution)



Learning

- RACE:
  - supervised
  - (human) instructor gives tasks and "teaches" concepts
  - (Experience Extractor and Conceptualizer planned)



1 The RACE Project

2 State of the Art

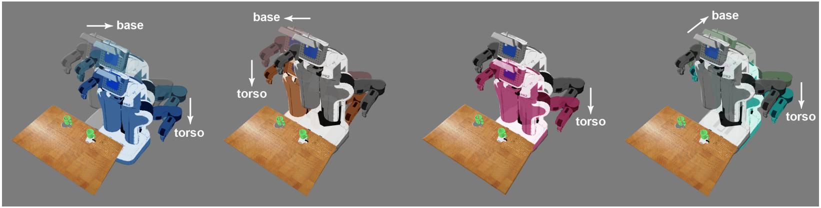
3 Scientific Achievements
- MR for Evaluation
- MR as Reasoner
- MR for Learning
- First Evaluation Results

4 Outlook

Evaluation

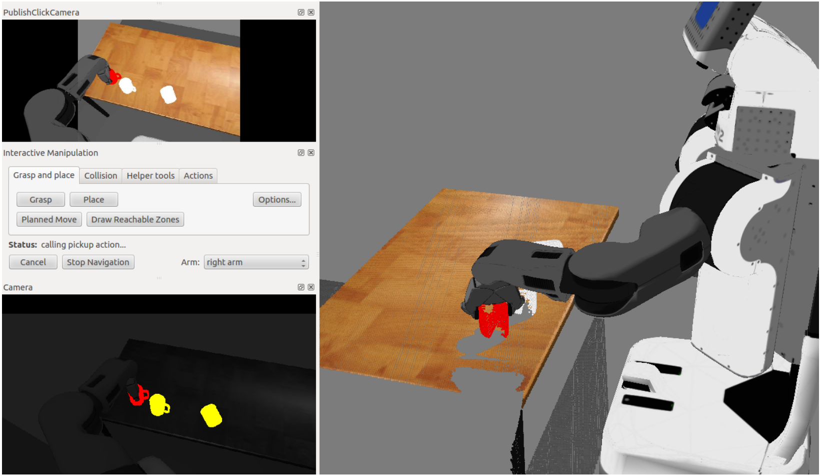
Mixed Reality (Rockel et al. 2013)

- improving object recognition and grasping quality of the robot



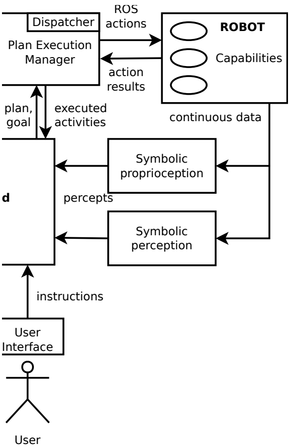
Evaluation II

Thermal Camera

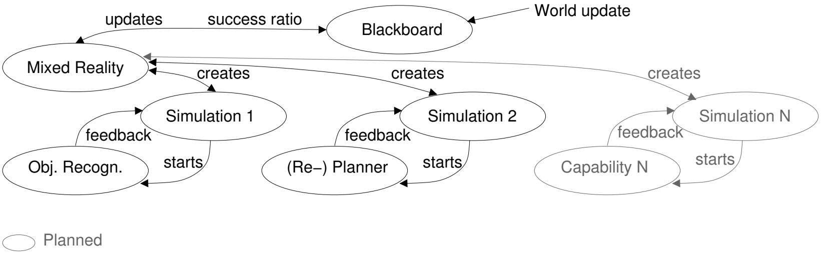


Evaluation III

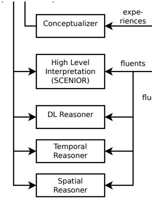
- evaluates
    - parts of the system (manipulation, perception, navigation etc.)
    - the complete system (time, distance, efficiency, failure, accuracy etc.)



Mixed Reality as Modality for Reasoning

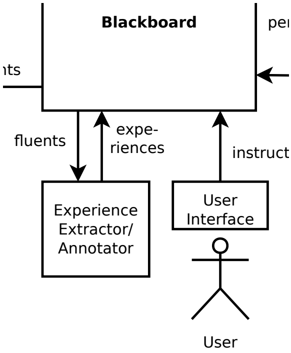


- Mixed Reality gives recommendation about actions the robot should take to improve robot capabilities
- can be considered as reasoner
- feeds the blackboard (eventually the planner)



Learning

- enables unsupervised learning
  - creates different scenarios and executes the system
  - automatic recognition of failure or success cases
  - creates experiences



First Results and Summary

Mixed Reality

- benefits
  - automatic change in simulation
  - without sensor noise (ideal sensors)
  - new sensors objects (not yet in reality available)

First Results and Summary

Mixed Reality

- benefits
  - automatic change in simulation
  - without sensor noise (ideal sensors)
  - new sensors objects (not yet in reality available)
- first results
  - object recognition in torso down pose improved by 10 %
  - grasping in torso up pose improved by 32.5 %

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4 Outlook
- Open Points
- Questions

Open Points

- unsupervised learning by automated scenario execution
- MR as Reasoner
- MR for Evaluation (of the whole system)

Any Questions?

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UNIVERSITÄT OSNABRÜCK

universidade de aveiro

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Thank You!

Further Reading I

- D. Klimentjew, S. Rockel, L. Einig, J. Zhang. ***Mixed Reality to Evaluate and Optimize Complex Mobile Systems for Improved Robustness Examplified by Object Recognition, Re-planning and Parallelization***. IROS2013, November 3-7, 2013, Tokyo Big Sight, Japan (submitted)
- D. Klimentjew, S. Rockel, J. Zhang. ***Towards Scene Analysis based on Multi-Sensor Fusion, Active Perception and Mixed Reality in Mobile Robotics***, In Proceedings of the IEEE First International Conference on Cognitive Systems and Information Processing (CSIP2012), 15-17 December, Beijing, China, 2012.
- S. Rockel, D. Klimentjew, J. Zhang. ***A Multi-Robot Platform for Mobile Robots – A Novel Evaluation and Development Approach with Multi-Agent Technology***, In Proceedings of the IEEE International Conference on Multisensor Fusion and Integration for Intelligent Systems (MFI), University of Hamburg, Hamburg, Germany, 2012.
- S. Rockel, B. Neumann, J. Zhang, K. S. R. Dubba, A. G. Cohn, Š. Konečný, M. Mansouri, F. Pecora, A. Saffiotti, M. Günther, S. Stock, J. Hertzberg, A. M. Tomé, A. J. Pinho, L. S. Lopes, S. v. Riegen and L. Hotz. ***An Ontology-based Multi-level Robot Architecture for Learning from Experiences***. In: Proc. Designing Intelligent Robots: Reintegrating AI II, AAAI Spring Symposium, March 25-27, Stanford (USA), 2013.
- L. Zhang, S. Rockel, F. Pecora, L. Hotz, Z. Lu, J. Zhang***. Evaluation Metrics for an Experience Based Mobile Artificial Cognitive System.*** IROS2013, November 3-7, 2013, Tokyo Big Sight, Japan (submitted)
- D. Off, J. Zhang***. Continual HTN Robot Task Planning in Open-Ended Domains: A Case Study.*** In Proc. AAAI-11 Workshop, San Francisco, USA, August, 2011
- D. Off, J. Zhang***. Continual HTN Planning and Acting in Open-Ended Domains.*** In Proc. ICAART 2012, Vilamoura, Portugal, February, 2012

Further Reading II

C. Dornhege, A. Hertle. ***Integrated Symbolic Planning in the Tidyup_robot Project.*** In: Proc. Designing Intelligent Robots: Reintegrating AI II, AAAI Spring Symposium, March 25-27, Stanford (USA), 2013.