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COGNITIVE ROBOTICS

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For the past decade, robotics has mostly focused on low-level sensing and control tasks such as sensor fusion, path planning, and manipulator design and control. At the same time the field of Cognitive Robotics made significant progress in equipping robots and software agents with high-level cognitive functions such as reasoning over actions, goals, and environments, as well as behaviour planning. Cognitive robots must, for example, be able to reason about goals, space, events, actions, time, when to perceive and what to look for, the cognitive states of other agents, explain observations, perform (collaborative) task execution, etc.

The special issue was conceived with the aim to emphasize and solicit research papers concerned with foundational research questions on cognitive robotics, as well as robotic system design and robotic applications that utilise and integrate artificial intelligence (AI) methods. We have particularly focussed on papers that make a direct connection between robotics and AI and show added value for at least one of the fields and ideally for both. The special issue showcases the state-of-the-art and the growing body of work uniting AI, in particular knowledge representation and reasoning (KRR), and robotics.

Schwering et al. consider the challenge of robot sensor readings that are often dealt with in a hard-coded, heuristic fashion. They propose a logic, namely epistemic situation calculus, to address this problem from a KRR perspective. In this logic, the epistemic effect of sensing actions is deferred to so-called fusion actions, which may resolve discrepancies and inconsistencies of recent sensing results. Moreover, a local closed world assumption can be applied dynamically. When needed, this assumption can be revoked and fusions can be undone using a form of forgetting.

Mast et al. present an approach for referential human-robot communication that deals with perceptual deviation using the Probabilistic Reference And GRounding mechanism PRAGR and vague feature models based on prototypes. The system handles descriptions of arbitrary complexity for generation and resolution of Natural Language. The focus is

in particular on phrases that include spatial relations. Authors propose a flexible concept assignment mechanism for referential robot-robot or human-robot interaction. The paper discusses the impact of vague as compared to crisp properties on referential success and robustness towards spatial perspective alignment errors.

Plaku et al. report on an interactive search algorithm that effectively solves combined task and motion-planning problems. The system computes collision-free and dynamically-feasible trajectories that enable a robot to complete tasks specified in the planning-domain definition language (PDDL). Action and motion planning are combined through a partitioning of feasible motions into equivalence classes based on task predicates. Action plans guide the selection of equivalence classes in the search expansion. Authors provide evaluation through simulation of a pick-and-place task and show that their algorithms performs better than previous work.

Santos et al. propose a probabilistic system for self-localization based on a qualitative representations derived from Qualitative Spatial Reasoning about object occlusion. The system successfully combines numerical (probabilistic) reasoning with qualitative techniques. Authors have evaluated their system using a mobile robot equipped with a RGB-D sensor. Results show that the algorithm allows the robot to successfully locate itself within qualitatively distinct regions.

Skočaj et al. presents an integrated robot system capable of interactive learning in dialogue with a human. They describe a collection of mechanisms that enable integration of heterogeneous competencies in a principled way. Central to the approach is the creation of beliefs from visual and linguistic information, and the use of these beliefs for planning system behaviour to satisfy internal drives. The system is able to detect gaps in its knowledge and to plan and execute actions that provide information needed to fill these gaps. A hierarchy of mechanisms is proposed which are capable of engaging in different kinds of learning interactions, e.g. those initiated by a tutor or by the system itself. The operation of the system is demonstrated through an integrated robot system in the case of learning conceptual models of objects and their visual properties.

Mansouri and Pecora investigate the use of a meta-CSP based technique to interleave reasoning in diverse knowledge types. The approach is made clear through a robotic waiter case study, for which a particular selection of spatial, temporal, resource and action KR formalisms are integrated. Based on the case study, they discuss general principles related to the selection of appropriate KR formalisms and jointly reasoning about them. The resulting integration is evaluated both formally and experimentally on real and simulated robotic platforms.

The special issue had an advisory committee consisting of Wolfram Burgard (University of Freiburg, Germany), Anthony Cohn (University of Leeds, United Kingdom), Hector J. Levesque (University of Toronto, Canada), Gerhard Lakemeyer (RWTH Aachen University, Germany), Bernhard Nebel (University of Freiburg, Germany) and Luc Steels (Vrije Universiteit Brussels, Belgium). We would like to thank them for their useful suggestions, support and encouragement.

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