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Editorial

Preface: Special issue on knowledge driven robotics and manufacturing

1. Introduction

State-of-the-art robots are capable of sub-millimeter movement accuracy. However, they are often programmed by an operator using crude positional controls from a teach pendent. Reprogramming these robots when their task is altered requires that the robot cell often be taken offline for a human-led teaching period. In an industrial setting, for small batch processes or when frequent line configuration changes are needed, this down time may be unacceptable.

The robotic systems of tomorrow need to be capable, flexible, and agile. These systems need to perform their duties at least as well as human counterparts, be quickly re-tasked to other operations, and cope with a wide variety of unexpected environmental and operational changes. To be successful, these systems need to combine domain expertise, knowledge of their own skills and limitations, and both semantic and geometric information.

This subject has recently received significant attention, as evidenced by the numerous special sessions and workshops around the world. In 2013, the guest editors organized a special session entitled “Knowledge Representation for Robotics and Automation” at the IEEE International Conference on Robot Intelligence Technology and Application (IEEE RITA). This session had several interesting presentations that discussed various approaches to using knowledge representations and artificial intelligence to enable agility in industrial and medical robotics. Based on the interest level and success of this session, the guest editors proposed this special issue and invited the authors of the best papers to submit. In addition, other researchers in the field who did not attend our special session were invited to share their recent advancements and best practices. This resulted in this special issue, which presents eleven papers that examine various aspects of knowledge representation and planning for industrial systems, as well as use cases that comprise both the assembly and medical domains.

2. Issue synopsis

This special issue includes eleven papers, as listed below:

1 Extensions to the Core Ontology for Robotics and Automation.
2 Exploring the IEEE Ontology for Robotics and Automation for Heterogeneous Agent Interaction.
3 Ontology Based Action Planning and Verification for Agile Manufacturing.
4 Intention Recognition in Manufacturing Applications.
5 Towards Robust Assembly with Knowledge Representation for Planning Domain Definition Language (PDDL).
6 Knowledge-Based Instruction of Manipulation Tasks for Industrial Robotics.
7 Design, Programming and Orchestration of Heterogeneous Manufacturing Systems Through VR-powered Remote Collaboration.
8 On-line Knowledge Acquisition and Enhancement in Robotic Assembly Tasks.
9 Knowledge Representation applied to Robotic Orthopedic Surgery.
10 RehabRobo-Onto: Design, Development and Maintenance of a Rehabilitation Robotics Ontology on the Cloud.
11 Table-Top Scene Analysis Using Knowledge-Supervised MCMC.

This special issue opens with two papers that examine various aspects of the IEEE Robotics and Automation Society's Ontologies for Robotics and Automation (ORA) Working Group's ontology. The first paper presents an updated version of the Core Ontology for Robotics and Automation (CORA) and discusses a set of new ontologies that complement CORA and make some of its concepts more ontologically sound. The second paper presents an ontology for positioning, called POS, that is designed for sharing spatial concepts in the Robotics and Automation domain. It also discusses the implementation of POS in a simple human–robot cooperation scenario.

The next three papers describe efforts that are leveraging the standards coming from the ORA Working Group. All three of these papers focus on the manufacturing kitting domain. The third paper examines a novel knowledge-driven system that provides added agility by removing the programming burden for new activities from the robot and placing it in the knowledge representation. The fourth paper explores the area of collaborative human–robot activities, with a focus on enhancing the robot's ability to recognize the intention of the human. The fifth paper explores the measurement science aspects of robot agility in the form of an integrated agility framework enabling agile planning and replanning via auto generation of planning domain definition language (PDDL) files.

The following three papers also look at the manufacturing domain, but explore knowledge representations outside of the ORA Working Group. The sixth paper focuses on the knowledge embedded in ontologies that are created for robotic devices and manufacturing tasks, and presents examples of AI-related services that use the semantic descriptions of skills to help users instruct the robot adequately. The seventh paper provides a survey of the knowledge representation needs of high-fidelity virtual collaboration environments from an industrial perspective. The eighth paper presents a Multimodal Assembly Controller (MAC) approach

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to embed and enhance knowledge into industrial robots working in multimodal manufacturing assembly scenarios to enhance learning.

The final three papers explore the application of knowledge representations outside of the manufacturing domain. The ninth paper proposes a probabilistic approach for generating abstract scene graphs from 6D pose estimation in order to understand table-top scenes. The last two papers explore knowledge representation approaches in the medical field. The tenth paper proposes a rehabilitation robotics ontology, called RehabRobo-Onto, which provides open access on the cloud and is interoperable with other knowledge resources, like disease ontologies. The eleventh paper presents and discusses an ontology for robotic orthopedic surgery. This ontology is based on task definition and reasoning applied to a hip surgery procedure.

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