Integrated Computer-Aided Engineering 25 (2018) 97–98
DOI 10.3233/ICA-180570
IOS Press

Introduction

Today's state-of-the-art robots are capable of submillimeter movement accuracy when performing highly repeatable tasks. They perform extremely well in highly structured environments, where objects are in well-known, predictable locations. However, robots are not known for "thinking on the fly" to cope with unexpected events or changing situations. They are best when they can be programmed to perform a specific activity, which requires a specific set of motions, and that activity can be performed in the exact same way many hundreds or thousands of times. Not surprisingly, robots have been adopted much more in high volume, repeatable operations such as painting and welding rather than in smaller job shop type operations where only a handful of similar products are being made at a given time. Another way to describe this is that robots are not considered agile. Robot systems of the future 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 in order for them to be useful to small manufacturers and to also allow larger manufacturers to offer more automated customization of high volume parts. Many computer-aided engineering approaches are beginning to show promise in helping robots become more agile, including techniques such as machine learning, cognitive modeling, artificial intelligence, knowledge representation and ontologies, dynamic and real-time planning, and real-time intelligent control. This special issue focuses on both theoretical and practical contributions of applying these techniques to improving the agility of robotic systems from an engineering and computer science perspective.

The selection of papers for this special issue was extremely rigorous, with only six papers being published out of the many that were submitted. Each paper included in the special issue was reviewed by at least two rounds of reviews by three to eight reviewers. In addition, robot autonomy is multi-facetted, and we attempted to include a cross section of papers that address multiple relevant aspects.

The first two papers present algorithmic approaches to enable robot autonomy. "Robot Grasp Preimages Under Unknown Mass and Friction Distributions" describes an algorithm for computing robust grasp preimages, which are the space of initial poses from which an object will converge into the desired grasp. This is a game-theoretic technique for estimating worst-case scenarios for difficult to observe properties like pressure and friction distributions. "Identifying Optimal Trajectory Parameters in Robotic Finishing Operations Using Minimum Number of Physical Experiments" as the title states, presents a method to identify optimal trajectory parameters in process applications like robotic finishing, while minimizing the required number of physical experiments. The method intelligently samples the parameter space to select a point for evaluation from the sampled set by determining its probability to be optimum among the set. The iterative method rapidly converges to the optimal point with a small number of experiments.

The next three papers explore knowledge representation-based approaches to enable robot autonomy. "An Integrated Semantic Framework for Designing Context-Aware Internet of Robotic Things Systems" presents a semantic framework for context-aware robotic systems to support the development of applications for monitoring and managing robotic systems. Included in this paper is a knowledge representation framework called SmartRules for context modeling and an operational platform centered on the notion of manageable objects to abstract the access to any physical or virtual device which can communicate through the Internet. "A Self-Adaptation Framework based on Functional Knowledge for Augmented Autonomy in Robots" describes a knowledge-based strategy where a robot exploits a white-box runtime model of itself to adapt to operational changes. The knowledge base is a deep model grounded on an ontology that correlates the robot's mission with the robot's architecture. It is generated during the robot's development from its engineering models. The robot uses self-knowledge to adapt its architecture to the mission's situation. "Ontology Based Design, Control, and Programming of Modular Robots" describes an approach for agile design, control, and programming of modular robots. More

ISSN 1069-2509/18/$35.00

specifically, the robot design and its controller are generated automatically from user requirements. To accomplish this, a new ontology, based on the IEEE Standard Ontology for Robotics and Automation, was developed. The system infers abstract and dimensionless robot designs from this ontology by relating robot actions to necessary structural parts.

The last paper in this special issue explores how multiple components can be put together in an overall architecture to enable robot agility. “Enabling Robot Agility in Manufacturing Kitting Applications” describes various technologies that are being developed at the National Institute of Standards and Technology (NIST) which can be used to enhance the agility of manufacturing robot systems. These technologies are validated using two industrially-relevant use cases. The first deals with task failure identification and recovery and the second deals with robot dynamic re-tasking. These use cases were successfully performed using a formal knowledge representation, a graph database, a perception system, and a task and motion planning system, as well as an overall architecture which brought all of the components together.

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