Guest Editorial
Object-Oriented Methods for Distributed Control Architectures

OBJECT-ORIENTED approaches offer many advantages for robotics and automation (R&A). Just as the object-oriented approach helped the software discipline enter the realm of engineering, it will become the backbone of real automation and robotics system products. With the adoption of this approach, the term software architecture,"for the first time, assumed the rigorous meaning we are used to in the civil, mechanical, electronic, and other engineering disciplines. Similarly, a rigorous architectural approach is critical for the advances in R&A. Modern robotics and automation must deal with dynamics, concurrency, and distribution of large control systems. The object-oriented vision has been shown to be fundamental for modeling the behavior and coping with the complexity of such systems.

The papers presented in this Special Section offer a fairly complete view of the key aspects of the object-oriented approach. They can be divided into three groups. The first is general and describes methodology, architectures, frameworks, and tools. The second group deals with the upper layer of factory automation: planning and scheduling. The last group deals with the lower layer of factory automation: robot and machine control.

Group 1

"Distributed Computing in Robotics and Automation," by Davide Brugali and Mohamed E. Fayad, is a survey of advanced technologies for the development of distributed control systems. It describes the evolution of object-oriented techniques with specific attention given to the needs of automation and robotics applications. "Architectural Models for Global Automation Systems," by Davide Brugali and Giuseppe Menga, is an example of an object-oriented architecture for a large-scale problem. It distills reusable design practice from a long-held experience in building enterprise control systems. "SIMOO-RT—An Object-Oriented Framework for the Development of Real-Time Industrial Automation Systems," by Leandro Buss Becker and Carlos Eduardo Pereira, presents a computer-aided software engineering environment for the development of real-time control systems. It demonstrates one of the fundamental qualities of object-oriented approaches, i.e., the ability to enter system information directly to specification and design methods and tools. "DPAC: An Object-Oriented Distributed and Parallel Computing Framework for Manufacturing Applications," by N. R. Srinivasa Raghavan and T. Waghmare, describes a Java-based computing and communication infrastructure to enable large-scale distributed automation applications. It illustrates how object-oriented methods simplify the development of scalable, fault tolerant, portable, and interoperable control systems.

Group 2

"An Agent-Based Approach to Reconfiguration of Real-Time Distributed Control Systems," by Robert W. Brennan, Martyn Fletcher, and Douglas H. Norrie, introduces the concept of autonomous agents as object-oriented building blocks for the development of reconfigurable real-time distributed control systems. "An Architecture for Scheduling and Control in Flexible Manufacturing Systems Using Distributed Objects," by TsuTa Tai and Thomas O. Boucher, presents an agent-based architecture that enforces a decentralized approach to the scheduling problem in automated cellular manufacturing systems.

Group 3

"Miro—Middleware for Mobile Robot Applications," by Hans Utz *et al.*, discusses the construction and use of object-oriented robot middleware to make the development of mobile robot applications easier and faster, and to foster portability and maintainability of robot software. "Formal Verification for Analysis and Design of Logic Controllers for Reconfigurable Machining Systems," by Dhrubajyoti Kalita and Pramod P. Khargonekar, presents a hierarchical object-oriented framework for the modeling, specification, analysis, and design of manufacturing logic controllers. "Constructing Reconfigurable Software for Machine Control Systems," by Shige Wang and Kang G. Shin, proposes a software architecture based on a combination of object-oriented models and executable formal specifications. The architecture builds on software components that control manufacturing machines, and whose behaviors are described in terms of nested finite-state machines.

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