Automation objects: enabling embedded intelligence in real-time mechatronic systems

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Abstract: Recent research in automation and control systems has focused on enabling flexibility, open integration and easy (re)configuration of embedded intelligence in real-time mechatronic systems. This paper introduces recent research contributions in this area that have been collected in a special issue of the International Journal of Manufacturing Research devoted to automation objects.

Keywords: agent-based systems; IEC 61499; industrial automation and control; object-oriented systems.

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Luca Ferrarini is a Professor in the Department of Electrical and Computer Engineering, Politecnico di Milano. His research interests include modelling and control of manufacturing plants, discrete event systems, hybrid control systems and object-oriented modelling and design techniques. Professor Ferrarini is the President of ANIPLA and a Senior Member of the IEEE.

Jose L. Martinez Lastra is a Full Professor of factory automation at the Tampere University of Technology, Tampere, Finland. His main research interest is in the application of information and communication technologies in the field of factory automation. Prof. Lastra is a member of a number of scholar societies and since 2003, he has been a member of the Board of Directors of OOONEIDA, Inc. (Canada). In 2006, Prof. Lastra was awarded with a patent in the field of (re)configurable material handling systems deploying agent-based control.

Valeriy Vyatkin is a Senior Lecturer at the University of Auckland, New Zealand. Vyatkin graduated in 1988 from Taganrog State University of Radio Engineering (TSURE), Taganrog, Russia, with excellence in applied mathematics. He received the PhD and the Dr. Sci. degrees from TSURE in 1992 and 1998, respectively, and the Dr. Eng. Degree from the Nagoya Institute of Technology, Nagoya, Japan, in 1999. His previous faculty positions were with University of Halle in Germany (2000–2005), and with TSURE (1989–1994, 1998–2002). In 1994–1999, he was with Nagoya Institute of Technology for post-doctoral research. His research interests are in the area of industrial informatics, including software engineering for industrial automation systems, distributed software architectures, methods of formal validation of industrial automation systems and theoretical algorithms since 2004.

1 Introduction

Recent research in automation and control systems has focused on enabling flexibility, open integration and easy (re)configuration of embedded intelligence in real-time mechatronic systems. To help bring this research community together, the Open Object-Oriented Knowledge Economy for Intelligent Industrial Automation (O3neida[1]) was formed in 2004 with the goal of fostering the technological infrastructure for a new, open knowledge economy for automation objects, products and systems (Auinger et al., 2005; O3neida, 2006).

The intention of this special issue of the *Int. J. Manufacturing Research* (IJMR) is to summarise this recent research on intelligent automation and control systems. In particular, this special issue focuses on the notion of 'automation objects', or reuseable, portable software components that encapsulate intellectual property (IP) for deployment into mechatornic devices, machines, systems and automated factories. The research in this area has spanned design, testing and standardisation.

For example, engineering methodologies for automation objects have focused on the use of IEC 61499 function blocks (IEC, 2005) and techniques from object-oriented (Booch, 1994) and agent system design (Weiss, 1999). Formal verification techniques have been developed as well as simulation and run-time environments to test these software designs. In order to promote consistency among developers, vendors and users,

and to ultimately enable the wide-scale adoption of these new intelligent systems, work is also underway on the development of standards for software, compliance and automation object definition.

The papers selected for this special issue are very representative of the recent work on automation objects. The issue starts with a survey of relevant research in the area of intelligent automation. Vyatkin et al. provide an overview of the technologies used by the researchers in this issue to realise distributed intelligent control: i.e. component-distributed architectures (IEC 61499), mechatronic ontologies, object-oriented design methods (UML) and formal verification.

The next four papers present specific frameworks for distributed intelligent industrial automation. In Sünder et al., a new modular control architecture is proposed, which is intended to meet the requirements of future production systems. The basic idea behind their work is to match the control hardware and control software with the modular nature of modern industrial systems. Next, Bonfe et al. present a formal framework for object-oriented modelling of mechatronic systems. Their paper highlights the connection between the behavioural approach for modelling dynamical systems and the object-oriented approach for software modelling and design. Ferrarini and Verber also use an object-oriented framework for distributed intelligent automation and control with the addition of service-oriented functionalities, Plug-and-Participate capabilities, the Java Virtual Machine and IEC 61499. Finally, Albadawi et al. use intelligent agent technologies to provide a flexible platform for the implementation of model-based control.

The final two papers of this special issue focus on the important area of communication in distributed automation systems. Lopez and Martinez Lastra tackle the high-level problem of semantics. In their paper, it is shown that software components can be described according to an Automation Object Reference Model that involves the creation of an ontology to define mechatronic devices. Scarlett and Brennan view communication at a lower level in the final paper. They tackle the problem of timeliness in real-time distributed systems and, more specifically, propose a new event-triggered protocol that is intended to more closely match the event-based IEC 61499 model than traditional time-triggered protocols used for real-time communication.

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Note

[1]www.oooneida.org