

Domain Ontologies for Reasoning Machines in Factory Automation

Jose L. Martinez Lastra, Ivan M. Delamer,
and Fernando Ubis



1 Introduction

Background and Motivation

Over the last thirty years, the demands of manufactured goods customers have changed dramatically. From an era when mass production techniques enabling cheaper production costs for standardized goods predominated, we are now in a new era often called *mass customization*. The driving force behind this change is the customer who eagerly demands more tailored products which distinguish the end user from those using “all alike” serial products. As product lifecycles shrink, rapid and agile responses from manufacturers to demand shifts are more and more essential. Although factory automation was an ideal solution for the problems presented by mass production with long product lifecycles, it has several limitations when it comes to producing tailored products in the agile and adaptive environment required by ever shorter product lifecycles.

Production techniques have evolved over time, taking advantage of the latest technological developments. The introduction

of new research areas such as Information and Communication Technologies (ICT) has promoted this evolution. The application of artificial intelligence (AI) techniques, in particular, opened up a new area for this development and yielded further new improvements.

Applied research in the AI field is commonly divided into seven main areas: knowledge representation, understanding natural language, learning, planning and problem solving, inference, search, and vision.

Some of the aforementioned areas become essential when applying these techniques to other fields. Knowledge representation, inference, and understanding natural language are examples of AI applications used in other technological domains.

Problem Definition

Mass customization and shorter product lifecycles have led to the requirements of adaptive and agile behavior for manufacturers. In the real world, this often translates into an urgent need to accommodate new products by rapidly establishing new factories or by retrofitting existing ones. To achieve these new goals, many engineering tasks which are currently performed manually need to be automated.

Research Objective

Since the early 1990s, ontologies have occupied an important place in the manufacturing domain of the AI community, and their use has evolved over the last ten years. This process started with the development of the Process Specification Language (PSL) by the National Institute of Standards and Technology (NIST) [1]. Although PSL never obtained long-term support, it would become an important influence on several later approaches, especially those based on Semantic Web Services. Ontologies gradually began to find a place in manufacturing automation architectures as part of a bigger effort, where people were focusing on multi-agent systems for manufacturing control. The use of ontologies was much influenced by developments from the manufacturing field, most notably the emergence of Web-based solutions and the Semantic Web.

Currently, in many cases, the technical specifications of products, the processes required to manufacture them, and the devices and machines used are all written in natural language, often aided by visual diagrams. These specifications are combined with the pre-existing know-how and experience of engineers to develop, systematically, the layout of the factory and the automatic control programs which coordinate and supervise the processes. Whenever changes are needed to accommodate a new product or process, engineers are brought in to

match the natural language specifications established by the product design and the natural language system configuration. The use of ontologies in the (re)configuration process is more efficient since ontologies provide a solution for knowledge representation and inference, and present a single language that can be understood and interpreted by both humans and machines.

This book introduces ontologies as a formal representation of knowledge, focusing mainly on the application of OWL (Ontology Web Language) to the factory automation domain. In this scenario, ontologies emerge as a sound solution for representing knowledge about manufacturing processes, equipment, and products in a machine-interpretable way. This knowledge can then be used with automated problem-solving methods to (re)configure the control software that coordinates and supervises manufacturing systems.

OWL provides a formal representation framework, which confers machine interpretability more than human understandability. OWL stands over the web standards, which provide the semantics, interpretability, and interoperability. OWL has three different sub-languages that confer different levels of expressivity and automatic reasonability.

The rest of this book is organized into three chapters that introduce an ontology theoretical framework, followed by ten additional chapters offering the practical application of ontologies for knowledge modeling in the factory automation domain.

Chapter 2 **Ontology** introduces the reader to the ontology framework through a review of ontology theory.

Chapter 3 **Tools for Ontology Building** presents the various tools available for ontology modeling.

Chapter 4 **Ontology Building** describes the methodology required for a reliable ontology setup and lifetime maintenance.