Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 11 (2017) 174 – 184

Procedia MANUFACTURING

27th International Conference on Flexible Automation and Intelligent Manufacturing, FAIM2017, 27-30 June 2017, Modena, Italy

Assisted Hardware Selection for Industrial Collaborative Robots

Casper Schou[a,*] , Michael Hansson[a], Ole Madsen[a]

[a]*Department of Mechanical and Manufacturing Engineering, Aalborg University, 9220 Aalborg, Denmark*

Abstract

This paper presents a configuration framework for assisting shop floor operators in selecting a suitable hardware configuration from commercially available components. The primary focus of this work is the modeling of process, product, and equipment knowledge, and the design of a configurator tool implementing this knowledge. The configurator takes process and product information as input and derives a list of suitable components for the operator to choose from. The approach is verified through a preliminary study indicating the feasibility of the approach.

Peer-review under responsibility of the scientific committee of the 27th International Conference on Flexible Automation and Intelligent Manufacturing

Keywords: Industrial robots; collaborative robots; hardware reconfiguration; configurator; ontology

1. Introduction

Traditional, dedicated, and fully automated manufacturing systems require large batch sizes to be economically feasible. They are typically not well-suited for small and medium enterprises (SMEs) and companies with high mix, low volume production. Consequently, there is a strong need for automated manufacturing equipment suitable for smaller batch sizes with frequent changeovers [1,2]. Such equipment need to be responsive and agile with the ability to be efficiently reconfigured and reused [3].

This is not least relevant in the field of robotics. In traditional manufacturing systems, the robot is often fixed to a dedicated, fenced-in workstation doing a single repetitive task. Contrary to traditional industrial robots, collaborative

* Corresponding author. Tel.: +45-20868884.
E-mail address: cs@make.aau.dk

Peer-review under responsibility of the scientific committee of the 27th International Conference on Flexible Automation and Intelligent Manufacturing
doi:10.1016/j.promfg.2017.07.222

robots are intended to operate in the more dynamic production environment of the human operators with greater variety, diverse tasks, and more frequent changeovers.

There are two main objectives in transitioning a robot to a new task; 1) configuring the hardware of the robot, and 2) programming the robot to the new task. In the industry, the variation in tasks is often of such magnitude that they cannot be solved by a single hardware configuration [1]. Thus, the need for hardware reconfiguration is inevitable. This reconfiguration should not be an engineering task, but should be handled by the production staff working alongside the robot. However, this requires new approaches to hardware configuration and operating the collaborative robot as compared to a traditional industrial robot [3].

According to [4], the objective of hardware configuration consists of two sub objectives; 1) selecting a set of suitable modules for the given task, and 2) adding, removing and exchanging hardware modules to obtain the selected configuration. In this paper, we focus on the first of these objectives. Selecting suitable modules for a given task is not trivial as it requires knowledge on both the process, the product to be manufactured (and its components), and the equipment to be reconfigured [5]. Although shop floor operators often possess detailed knowledge on the process and the product, they seldom possess detailed knowledge on the robot equipment domain. Our ongoing research consider a configuration framework assisting the user in selecting a feasible set of modules for a given task. In this paper, we focus on the task of modeling knowledge to support the configuration and how this knowledge can be used in the design of a configurator.

2. Related Work

A key aspect towards a systematic design of reconfigurable robotic systems is that knowledge regarding the capabilities and structure of the system can be captured and utilized to support the process of making design decisions. In recent decades, ontologies have been frequently used as a knowledge modeling method [6]. A recent review of research focusing on ontologies for manufacturing purposes is presented in [6]. With offset in the reviewed literature, [6] classify current research on the topic into the following three categories: 1) development of specific applications, 2) development of domain ontologies, and 3) proposal of core ontologies. Category one represents research in which ontologies are used as a supporting technology. The second category contains research within the knowledge modeling itself, proposing ontologies with knowledge for a particular domain. The third category contains research proposing general, core ontologies applicable to a wide range of domains. In conclusion of the review, [6] emphasizes several shortcomings of the OWL format when it comes to modeling complex products or reasoning over procedural knowledge. Despite these shortcomings, [6] notes that since the OWL format has become a commonly used format in both research and practical applications of manufacturing knowledge it is desirable to adhere to this standard in future research. The shortcomings could be attended by coexistence with other logic languages.

A configurator approach using product requirement inputs given in natural language and configuration knowledge in OWL format is presented in [7]. The configuration process is divided into three steps. First, the customer requirements are mapped to product functions using function knowledge stored in a function ontology. Secondly, the product functions are mapped to product components (or modules) using product knowledge stored in a component ontology. Lastly, the obtained product configuration goes through an optimization process conducted using a Bayesian network.

OWL is also used to represent configuration knowledge used in a configurator in [8]. To extend the configuration knowledge of the OWL ontology, [8] also includes a set of rules in Semantic Web Rule Language (SWRL) to obtain a higher degree of expressiveness when modeling constraints. In implementation of their configurator, [8] use the JESS (Java Expert System Shell) library. The OWL axioms and SWRL rules of the configuration model is translated into facts and rules in JESS (Java Expert System Shell) which are then used in the configurator. An assessment of their approach is presented in [8] using a PC hardware configuration example and in [9] using a construction drilling machine as an example

A general domain ontology for assembly is proposed in [10]. The ontology includes sub-ontologies with knowledge on the three aspects of *product*, *process*, and *equipment* as originally proposed in [5]. The purpose of the modeling activities in [10] is to support reconfiguration activities; hence, the ontologies are specifically tailored for reconfigurable manufacturing equipment.