Agent-based models in robotized manufacturing cells designing

A Sekala¹, A Gwiazda¹, K Foit¹, W Banas¹, P Hryniewicz¹ and G Kost¹
¹Silesian University of Technology, The Faculty Of Mechanical Engineering, Institute Of Engineering Processes Automation And Integrated Manufacturing Systems, ul. Konarskiego 18a 44-100 Gliwice, Poland

E-mail: agnieszka.sekala@polsl.pl

Abstract. The complexity of the components, presented in robotized manufacturing workcells, causes that already at the design phase is necessary to develop models presenting various aspects of their structure and functioning. These models are simplified representation of real systems and allow to, among others, systematize knowledge about the designed manufacturing workcell. They also facilitate defining and analyzing the interrelationships between its particular components. This paper proposes the agent-based approach applied for designing robotized manufacturing cells.

1. Introduction

Industrial robots are universal technological equipment. They are used in different work scenes depending on the utilized production system (figure 1). The most often they are utilized as equipment in manufacturing workcells. In this type of a production system robots realized some specialized tasks: servicing machine tools, parts reorientation and controlling the sequence of operations. Production lines are the other work scene, in which are utilized industrial robots. In comparison to workcells, production lines are external controlled. In this case industrial robots service particular manufacturing and assembly stands locate and position elements and are used as specific production buffers.

Figure 1. Different robot work scenes [1].
Creating the robot work scenes is related with two main processes: the designing one and the selection one. During the designing process is determined the general structure of a workcell, including elements location, paths planning and area protection. During the selection process are chosen machine tools, auxiliary equipment and industrial robots. In this approach the workcell structure is the compromise between the designing and selection processes. One of the possibilities of changing this situation is to apply one of modern tools adding the heuristics elements of mentioned processes [2-4, 10-19].

2. Agent-based approach to the designing process

In the theory of artificial intelligence and automatics of the most popular tool is the concept of an agent. It is an autonomous unit which observes its environment, through sensors, and acts upon this environment using actuators [20, 21, 25]. The agent directs its activity towards achieving goals using embedded rules of rationality. Analyzing an agent, from the point of view of its construction, it could be stated that it is a system of associated elements.

An agent could be described as unit that characterizes with some properties [20-27]. Firstly it is an autonomous unit (figure 2). It means that an agent has a certain degree of control over their behavior and could operate without human or other program intervention. It could evaluate gathered facts and take proper action according to stored rules or acquired knowledge. Secondly, an agent is a communication unit. It could communicate both with others agents, and with other participants of its environment (including humans). Communication, together with autonomy and rationality allows the group of agents self-organizing. The next property of an agent is reactivity. It means that agent could respond to changes in its environment. Finally one should say that an agent is unit which is focusing on the goal. Generally speaking an agent not only reacts to changes in the environment, but it also takes the initiative to achieve determined goals. Taking into account the possibility of an agent to learn it could be described as an intelligent unit.

![General model of an agent](image)

Figure 2. General model of an agent [27].

The designing process is the process of three sub-systems designing [5-9]: the structural one, the drive one and the control one. These sub-systems create a general structure of any complex technical mean. This structure corresponds to the structure of any mechatronics device [28], which includes: a mechanical sub-system (structural), an electric one (drive) and a computer one (control).

The designing process could be presented as a process of intelligent and heuristic processing of data, received from the environment in the form of technical requirements, to obtain an action taking the form of a technical solution.

The above diagram shows that the design process, from the special point of view, could be treated as a special action of an agent of a group of agents. In this form the design process is the agent-based one. Assuming the hierarchical structure of a system (including an agent) it is possible to state that a complex agent could be a system of less complex ones, what leads to the vision of a system of primary agents in the bottom of the hierarchy. Such structure is called a multi-agent system (MAS).
3. Workcell designing using MAS

A multi-agent system is a computerized system composed of multiple interacting intelligent agents within an environment [20, 27]. Multi-agent systems can be used to solve problems that are difficult or impossible for an individual agent. They are applied particularly for solving technical problems. The very important feature of the whole MAS is the self-organization. In the system of agents operation (agents and their environment) is programmable implemented the rule of self-organization of autonomous agents according to goal common for the whole system. This approach could help to elaborate the frameworks of a system for robots work scene designing, concerning the elements of that process as agents.

The MAS is frequently organized in a form of hierarchically controlled system. This hierarchical structure is called a holarchy what means a hierarchical system of agents. Groups of agents are called holons. In the same convention it could be designed a schematic structure of a holarchy that represents the system of a robotized workcell (figure 2). It also includes the supervising levels, responsible for self-organization, and the agent’s level, representing devices in a workcell.

Taking into account presented considerations it is possible to elaborate the complex of a holarchy structure designated for designing robotized work scenes in a form of a workcell. This structure is presented in the figure 3.

![Diagram of a holarchy for workcell designing as a self-organizing process.](image)

**Figure 3.** Holarchy for workcell designing as a self-organizing process.

The presented structure includes holons representing the mentioned previously processes of selection the workcell equipment (agents of ready libraries of elements (figure 4)) and of designing the workcell equipment (agents of designed elements (figure 5)).
4. Conclusions
In the presented work was discussed the concept of a multi-agent system designed for aiding the design process of robotized work scene (particularly a workcell). The system consists of two main groups of agents, having the possibility to learn. These groups represent the supervising levels and the operational level. Agents at the supervising level are aided with databases. The design is the result of self-organizing action of agents at the operational level.

Acknowledgements
The work is realized within the project titled: “Modular automated production stand with instrumentation for non-invasive confirmation of product quality” funded by The National Centre for Research and Development, agreement No UOD-DEM-1-495/001.

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