

Modelling of robotic work cells using agent based-approach

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Abstract. In the case of modern manufacturing systems the requirements, both according to the scope and according to characteristics of technical procedures are dynamically changing. This results in production system organization inability to keep up with changes in a market demand. Accordingly, there is a need for new design methods, characterized, on the one hand with a high efficiency and on the other with the adequate level of the generated organizational solutions. One of the tools that could be used for this purpose is the concept of agent systems. These systems are the tools of artificial intelligence. They allow assigning to agents the proper domains of procedures and knowledge so that they represent in a self-organizing system of an agent environment, components of a real system. The agent-based system for modelling a robotic work cell should be designed taking into consideration many limitations considered with the characteristic of this production unit. It is possible to distinguish some groups of structural components that constitute such a system. This confirms the structural complexity of a work cell as a specific production system. So it is necessary to develop agents depicting various aspects of the work cell structure. The main groups of agents that are used to model a robotic work cell should at least include next pattern representatives: machine tool agents, auxiliary equipment agents, robots agents, transport equipment agents, organizational agents as well as data and knowledge bases agents. In this way it is possible to create the hierarchy of the agent-based system.

1. Introduction

Most production systems, both natural and artificial, are organized in a decentralized way. The complexity of problems related with designing and supervising robotized work cells requires the search for suitable architectural solutions according to the process of informatics systems designing. The designing of robotized work cells is the process of synergistic combining the components in the group, combining these groups into specific, larger work units or dividing the large work units into small ones. Combinations or divisions are carried out in the terms of the needs of realization of the assumed objectives to be performed in these units [1-13].

In the process of complex systems designing, providing the co-processing and self-organization, the key is to create solutions with a greater autonomy, which is associated with re-configuring and context-based approach. One of the solutions that could be implemented for the computer-aided designing of robotized work cells is the approach basing on multi-agent systems (MAS). This approach facilitates easier integration of distributed knowledge resources. The reason for utilizing MAS is the possibility to divide tasks, performed in any analysed system, on smaller components (subtasks) and to perform them in parallel by many individual units - agents. The application of the agent-



based approach allows to generalize complex problems, in other words to introduce particular levels of abstraction. Robotized work cells could be modelled as an agent-based system, with generally defined objectives, whose detailed formulation might occur during the process of decomposition of the system into smaller agent-based systems that exist - in a sense – independently [14, 15].

2. Agents based system

Multi-agent systems (MAS) are the field of artificial intelligence in which the basic units is a set of agents A (agent $a \in A$) embedded in a certain environment E , as well as a set of rules R (rule $r \in R$) defining the interactions between the agents themselves and between them and their environment. Utilization these interactions by agents allows achieving the planned objective by the system as a whole. There is no single, generalized definition of an agent. According to the literature it is assumed that an agent - in other words a virtual being - is an abstract concept embedded in an environment, who could utilize certain resources and who is first of all characterized by: autonomy, reactivity, communicative, and cooperation with other agents (figure 1). The agent operates on the basis of observations including information that comes to him from the environment (reception), which one, to some extent, it could affect [16-19].

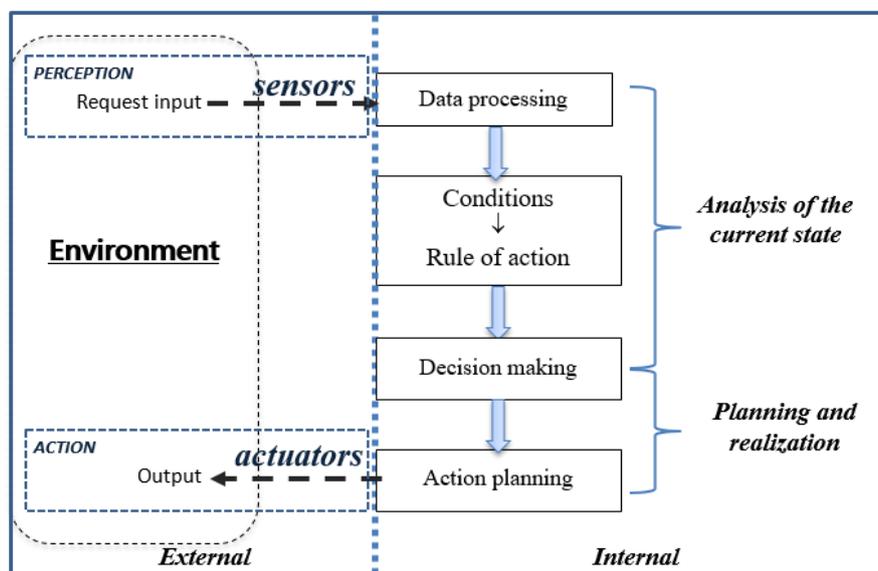


Figure 1. General structure of an agent.

The characteristic feature of MAS - with regard to their decentralized structure - is that a single agent being a part of a given MAS, does not possess and cannot obtain the full knowledge on the system. Hence the agent is no able to solve all the problems existing in the system. The possibilities, or in other words actions of a single agent are therefore very limited. They depend on many different and specific factors. Among others they depend on the changing conditions of the environment and the actions of other agents.

3. Conception of the system adding robotize work cell designing

The mentioned earlier, the ability to act autonomously in a group should be understood as the ability for cooperation. Taking into consideration this it is needed to define the term cooperation. Generally cooperation means the ability to interact with other agents in order to solve the problem, which is determined by the system. Therefore, the cooperation itself is considered to be one of the most attractive features of the multi-agent approach and, therefore, this approach creates the possibilities related with MAS implementation for design process adding.

The proposed architecture of MAS is based on the assumption that designing of robotized work cells involves selection of appropriate components of the cell and indirectly it involves selection of agents representing these components. It was assumed that in the system are previously prepared libraries of components (modules) of a work cell, such as frame objects representing: machine tools, industrial robots, inter-operational buffers, technological tooling etc. Due to the fact that the process of designing the robotized work cells is a complex one, hence the decision making procedure, for example according to the selection of the proper component, according to its location in the work cell taking into consideration the function which should be executed, requires the application of an appropriate advisory system. In the case, being under consideration, it was proposed the method of Case Base Reasoning (CBR) [20-23]. This method is based on storing and processing the knowledge and experience of a designer. It consists in searching for an analogy between the existing situation and the previous ones, which are stored as cases in the CBR database. Naturally each for case is stored information concerning [24, 26] the solution utilized in this situation. This approach makes it easier to integrate distributed resources of knowledge concerning the process of designing and functioning of the analysed work cell. The CBR is modelled, to a certain extent, on human intelligence, as well as on the human learning process because the reasoning module modifies its functioning basing on the accumulated experience. However, the major advantage of the CBR method is streamlining the process of knowledge and experience acquisition, which runs in parallel with the currently created design solution. Figure 2 presents a generalized conception of the proposed system.

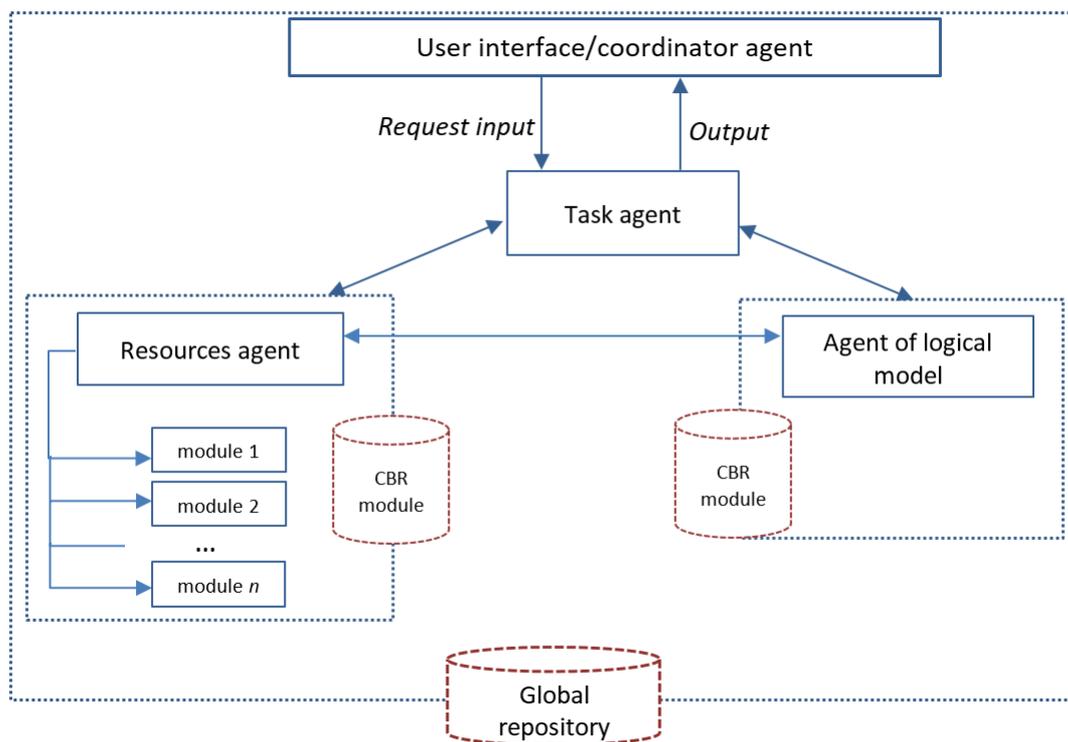


Figure 2. Proposed architecture of the system.

Particular agents, in order to achieve the required objective, should take the initiative to start a given action, to interact with other agents as well as to utilize the experience referring to the past. This is why in the described conception the special groups of agents have been determined. And hence in the presented case:

Coordinator Agent – it allows the user to communicate with the individual modules of the system, and its task is to represent the interests of the designer. His task is to send a query to the individual agents to find the appropriate services - in this case consider with the conducted project.

Task Agent(TA) - performs the tasks issued by the *Coordinator Agent*. On the basis of received information *TA* performs the algorithm of searching the operations that, according to the set of established criteria, correspond the given task.

Resources agent – is responsible for proper utilization of available resources, like technological tooling of a robot, machine tools, tools, buffers, auxiliary equipment, transport equipment and reorientation stands. Moreover, the agent controls the flow of elements that are manufactured using mentioned resources.

Coordinator Agent - represents the interests of the designer. His task is to send a query to the individual agents to find the appropriate services - in this case consider with the conducted project.

Agent of logical model - its task is presenting and monitoring, during the design process of the given work cell, its logical structure, which is understood as [25]:

$$Cell_{Logic} = (D \cup M, R, \{Group(r) \mid r \in R\})$$

where: D (machine $d \in D$) - the set of programmable machines called workstations (which may be, for example, a NC machine tools or a CNC one); M (magazine $m \in M$) - storage devices that are supported by industrial robots R (robot $r \in R$).

Moreover, in the structure of the proposed system, the common element is a global database, in which are contained all the necessary information on the designed workcell. In the database is stored information about the process state and about the resources. The agents are able to receive and analyse data. Consequently they have possibility to influence on the environment, for example, by the selection of appropriate materials, components etc. The exchange of information between the agents of the system allows dynamic decisions making and subsequent their implementation which is necessary in the design process. During the implementation of such approach, it is necessary the cooperation of all agents in order to provide information about the state of the design process in real time. Furthermore, the *Resources agent* and the *Agent of logical model* are equipped with the CBR module (figure 3), what results from the strategy of searching appropriate solutions. This strategy depends on the complexity of the problems being solved and the number of cases stored in the CBR database. The choice of an appropriate strategy of cases searching has a decisive influence on the efficiency and rate of operation of the system.

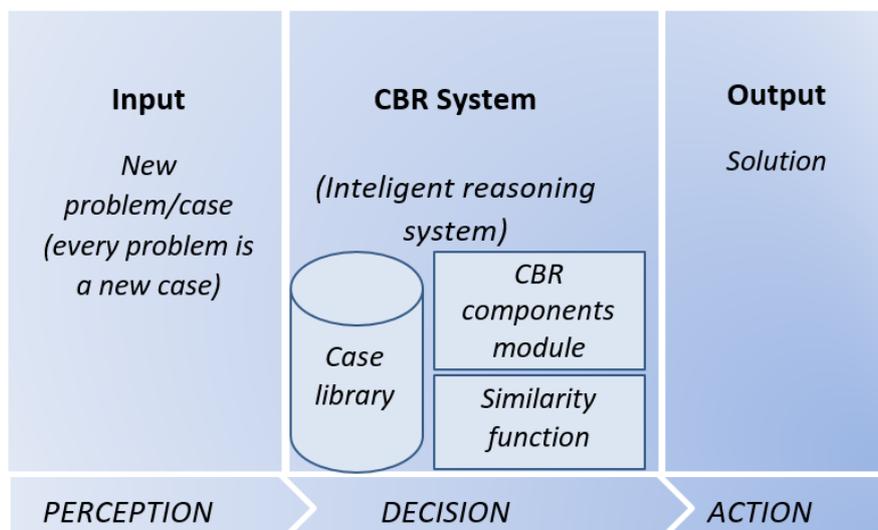


Figure 3. Proposed agent structure with the CBR module.

The concept of an agent equipped with the CBR module is presented in [26]. In current paper is described its continuation concerning the development of previously analysed approach.

4. Conclusions

The article presents the possibility of application MAS for supporting the design process concerning the manufacturing system layout design. The agents in the system should be linked according to the organizational structure of the modelled work cell. The purpose of the agent-based approach is to model robotized work cells. The objective of the presented elaboration is also to determine the architecture of such system for adding and automation the process of modelling the analysed work cells. Due to the fact that multi-agent systems could be used everywhere where one has distributed resources of knowledge, and by their ability to auto-adapt, self-organize as well as by their context-basing, in the area of processes supported by this systems, they are a convenient tool to support the task realized by the designer. Moreover, the architecture of the computer system based on MAS - in combination with the CBR approach - may allow complementing their separate activities to fulfil the requirements of the user (designer) through gathering the knowledge resources concerning the environment and the tasks that have been ordered.

These systems (MAS) could replace the man, first of all, in many operations considered with decision making. They allow making decisions faster and more accurately. The considerations, presented in the paper, are only an introduction to further works related to the development of these ideas and preparing a proper informatics environment. Obviously the paper does not cover all the problems related with the presented problem as they require recognition of many issues related with limitations of MAS, such as the issue concerning communication and interaction between different agents. Hence also arise other, not yet solved issues being the objective for future researches.

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