Robotic facilities resources of the future mechatronic factories

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Abstract. The practical problem is to project robotic facilities resources, which are used in the future mechatronic factories. Mechatronic factory robotic facilities resources are software and hardware components of dynamic self-organization factories placed in the intelligent robotic systems (IRS). A structural scheme, which describes the IRS components interaction, which is the base for together unified image of robotic facilities resources in the physical IRS (cloud IRS) is shown. A cyclic diagram of the IRS physical and cloud components interaction is shown. A structural scheme, which describes multi-functional convergence of physical IRS and cloud IRS is shown. Obviously, that robotic facilities resources as a cloud service is the most universal form of the future mechatronic factory in the industrial. Robotic facilities infrastructure primary components are defined, which are necessary to project future mechatronic factory, which specialty in engineering.

1. Introduction

The construction of a future mechatronic factory is based on the application and organization of the interaction of a significant number of components that have their own robotic facility resources [1, 2]. In contrast to the functioning enterprises, where the robotic facility resources were concentrated in the instrumental computers and in numerically controlled machines, the robotic facility resources of the future enterprises have a distributed structure [3, 4].

Controllers, data storage servers, peripheral data exchange devices in the communication system are located as part of all industrial intelligent robotic systems (IRS), as part of an warehouse storage system for future mechatronic factory, as component of the resources of the cloud, etc. [5, 6]. In this case, when designing future mechatronic factories, it is necessary to develop solutions aimed at organizing the interaction (at the physical IRS and cloud IRS) of all components of the mechatronic resource that are involved in the manufacturing [7, 8].

Multi-robot collaboration physical IRS interaction is provided with software and hardware of transport IRS and is done mechanically. Cloud interaction of IRS is based on the information exchanges, which are used in the future mechatronic factory [9, 10].

Cloud future mechatronic factory is based [11, 12] on a remote server of cloud function within, which different types of services could be deployed. IRS uses cloud resource [13, 14]:

- a software IRS as a cloud resource;
Nomenclature of cloud resources [15, 16] and its different functionality for IRS provides actuality the project problems of production technologies selection and their distribution among robotic facilities resources to organize innovative manufacturing [17, 18].

2. Collaboration of physical and cloud IRS

IRS is the future mechatronic infrastructure component. IRS is used to complete a limited number of production operations. An intelligent robotic system has two functional components, using IoT (Internet-of-Thing) technology.

Collaboration of physical and cloud IRS components scheme is shown in figure 1.

Intelligent robotic system physical components are:

- a controller to make calculation function of control commands;
- a multi-sensors system to measure production parameters;
- a mechatronic actuator, which provides products manufacturing;
- a chamber, inside which the multi-material processing is done.

Intelligent robotic system cloud components are:

- a virtual computer deployed in the future mechatronic factory cloud server, and which makes functions product manufacturing modelling (evaluate production parameters and forming control commands);
- a virtual application, which provides the imitation modelling software for the virtual machine;
- a virtual storage, which contains a detailed representation of the manufacturing algorithm as a digital twin (mathematical model) of production process.
Representation of IRS in the physical and cloud components is a base to design the uml (unified modeling language)-diagram of the IRS-objects and the mechatronic facilities. The IRS physical and cloud components interaction cyclic diagram is shown in figure 2.

In figure 2 IRS functional junctions are represented as rectangular with corresponding descriptions. Oriented arrows show the tides of commands and data, which characterize:

- a production processes in the physical IRS;
- a imitation modelling in the cloud IRS.

![Figure 2. Collaboration of physical and cloud IRS components cyclic diagram.](image)

The interrupted line shows the data being circulated among physical and cloud IRSs in the mechatronic robotic facilities. The physical and cloud IRS interaction cyclic diagram is a representation form for one of IRS behavior diagram accepted in uml-modelling. IRS behavior is studied separately for the physical IRS and cloud IRS, each of which defines the uml-diagram of the operations sequence being manufactured in the mechatronic robotic facilities. Processes of data exchange and manufactured product exchange among neighboring IRSs can be represented as a corresponding uml-diagram.

3. Physical and cloud components of future mechatronic factory

Mechatronic robotic complex is a technological base of the future mechatronic factory, which functions automatically. All manufacturing processes in a mechatronic robotic complex have a together similar representation in the physical IRS and the cloud IRS.

Mechatronic physical IRS represented as a family of multi-robot cyber-physical systems. Mechatronic cloud IRS represented as a part of the cloud factory resources. Interaction scheme of future mechatronic factory physical and cloud components is shown in figure 3.

Physical component (workshop) of the mechatronic facilities is some stationary installed multi-operational IRSs. Among stationary IRS chambers the mobile IRS transports the detail according to the manufacturing algorithm.

Mechatronic robotic facilities components are:

- a set of cloud computers;
• a set of cloud applications;
• a set of cloud storage.

Mechatronic facility component cloud computers can be deployed on the base of a highly-productive server or with several servers, which support the Ethernet channels. A set of cloud computers for manufacturing processes calculation function is a calculation platform as cloud service for the future mechatronic factory.

A calculation platform, which interacts with cloud applications and data storages in the future mechatronic factory cloud, is form infrastructure as a cloud service for IRS. Cloud infrastructure is a mechatronic robotic facilities twin and is the most complete option of the facility representation in the cloud.

Cloud infrastructure allow a simultaneous and multi-mode imitation modelling with cloud computers for all manufacturing processes. Intelligent cloud component of future mechatronic factory includes software, cloud computers, platforms and infrastructures as a cloud service for the IRS.

Figure 3. Interaction scheme of future mechatronic factory physical and cloud components.

4. Conclusion
The main property of the mechatronic robotic facility is a deep automatizing of the production. Production automatizing means in the modern stage are intelligent robotic systems and software the primary, come component of which is placed in the cloud.

Mechatronic robotic factory software configuration helps to create different types of cloud resources from which the most functional is the computer infrastructure. With the computer infrastructure as a cloud resource can be done factories digital twins, oriented to manufacture the wide range of products. Computer infrastructure specialty from the requirements of a particular production (a particular type item manufacturing) is done with a software.

Imitation modelling environment made with a software of infrastructure creates the necessary conditions to design and research artificial intelligence methods, which are for the mechatronic robotic control. Artificial intelligence methods made in the computer infrastructure define the most complicated
way of IRS automatic interaction — IRS self-organization, which permits to implement the emerging technologies.

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