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Implementation of H2M technology and augmented reality for operation of cyber-physical production of the Industry 4.0

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Abstract. The task is to design an instrument of interaction for an operator and a cyber and physical system in the Industry 4.0 production. There are three main technological operations defined which are necessary for the production operator interaction with the cyber and physical system. Those technological operations are: control (programming), exploitation (condition monitoring) of cyber and physical systems and its servicing (maintenance and materials and components refilling which are necessary for item manufacturing). Components and their application order with the interaction scheme are defined which are necessary for an operator to control and exploit a cyber and physical system. Those components are elements of the Humane-to-Machine technology. Cyber and physical system technical servicing technological operation is proposed to be conducted with a special machine and program device — helmets which support digital technologies of augmented reality. There is a description of a functionality principle for an augmented reality helmet.

1. Introduction

Automatic item designing production of the Industry 4.0 is based on the application of multi-operational cyber and physical systems which work without humans [1, 2]. However, humanless production is only the functioning workshop within which electronic technical documentation is circulated and product details are transported with robotized manipulators.

Production tasks completion monitoring, exploitation servicing (repair and maintenance) of a cyber and physical system (CPS) and its program control is done in production by humans [3, 4]. In this regard, to project an Industry 4.0 smart factory, it is important to use the technologies of augmented reality and Humane-to-Machine (H2M) that together realize a man-machine interface at automatic production [5, 6].

There are three different ways of the man-machine interaction interface for an operator and a cyber and physical system realization [7, 8]:

- a cyber and physical system control format when an operator controls directly or remotely CPS programming;
- a cyber and physical system exploitation format when an operator notes the parameters of the CPS work chamber technological process being conducted and the CPS condition parameters;
- a cyber and physical system servicing format when an operator makes CPS repairs, changes defective components, refills materials and components which are necessary to complete

technological operation and which were depleted when the previous item serial was manufactured, etc.

In practice, all three formats of the CPS man-machine interface require designing of special physical devices and program applications which function in production together.

2. Technological interaction of an operator and a CPS

The Industry 4.0 interaction scheme of an operator and a CPS in production is given in figure 1.

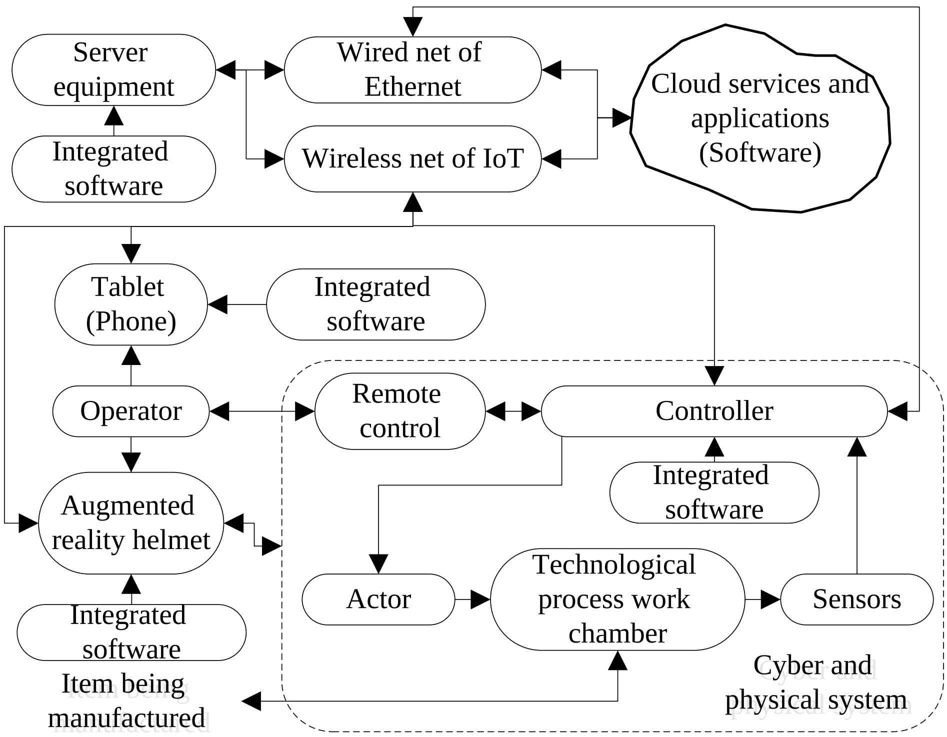

Figure 1. Operator and CPS interaction scheme in the Industry 4.0 automatic production (IoT – Internet of Things).

Cyber and physical systems control instruments in an automatic production are three types of devices [9, 10]:

- a cyber and physical system remote control with a display and some buttons with which an operator can change CPS functioning modes;
- a tablet (phone) with integrated software with which an operator can control the CPS condition and the technological processes of item manufacturing in the CPS work chamber;
- an augmented reality helmet with integrated software with which a production operator makes repairs and maintenance of a CPS.

3. H2M technology realization using a tablet

The H2M interface components for a CPS to exploit are [11, 12]:

- server equipment with integrated software to support remote access technologies for operators in the multi-agent mode;

- a tablet (phone) with integrated software to interact informatively with the wireless Internet of Things net with the server equipment.

Server equipment for an operator is a set of cloud services and applications which are necessary for the CPS control function. The CPS controller has formats of data exchange with the server equipment by the IoT channels and the channels of the wireless Ethernet net. The IoT wireless net is used in a CPS to transmit to the server the CPS condition data and the technological operation completion condition data. The Ethernet wired net is used in a CPS to download the data and applications from the cloud storage.

The tablet integrated software receives the diagnosis information (production data) from the server through the IoT channel and indicate it to an operator in an integrated screen in the interactive mode. Cloud services components help the operator to monitor in the tablet screen the item manufacturing charts (themes and production plans), CPS technological operations loading charts and other information which the operator requires to evaluate company production division.

4. H2M technology realization using a CPS remote control

A CPS remote control is a man-machine interface component which helps the production operator choose modes and set parameters of CPS functioning. The CPS remote control is connected to the CPS controller which has the integrated software for the CPS. The software is the CPS functioning algorithm which is necessary to complete production technological operations [13, 14].

Technological operations are done in the CPS work chamber which has different instruments and a set of sensors. The chamber instruments complete the necessary technological operations of the item manufacturing. The work chamber sensors transmit to the controller the diagnosis parameters.

The CPS remote control helps the operator to regulate the CPS dynamic properties (quick reaction, accuracy, some resistivity and other) which directly influence the CPS exploitation properties as a part of the production company.

5. Augmented reality technology to service the CPS

The CPS maintenance is done by the production operator periodically or once (according to the necessity). The CPS periodical maintenance is done to maintain the cyber and physical working conditions. CPS maintenance operative forms are done in the production if one or several components failed. An instrument for the both forms of CPS maintenance is an augmented reality helmet.

An augmented reality helmet is a result of the innovative project completion to create the product infrastructure which functions with the informative digital technologies. An augmented reality helmet includes:

- server equipment components (physical devices);
- special software components placed in the company server and in the smart factory cloud environment.

An augmented reality helmet is an intellectual system of optical and electronic headdress with the components of server infrastructure. The headdress system (wore on a head) is installed in the standard helmet of a production worker and is a device like standard glasses which lenses project a technological image which an operator percepts.

The frame indicative image contains the following graphical elements of the augmented reality:

- additional information (technical schemes, instructions and descriptions, user manuals, caution measures while a particular work is being conducted, etc.) which is necessary for the production operator to complete the diagnosis and repairs of a defective cyber and physical system;
- control commands (item replacement, order how to dismount the protective panels, how to switch off the CPS from the currents, etc.) which is taken from the computerized control system of the digital company (server part);
- recommended instruments (screwdrivers, spanners and other) to complete maintenance by changing the failed CPS component with a new one and other.

Graphical elements of the augmented reality are applied visually (mingled) on the object that the operator sees through the semi-transparent glasses of the cyber and physical system physical part. The augmented reality helmet glasses have wide range of the wavelength. This enables the operator to see the CPS elements in the visible range and provides the reflection from the inner surface at the wavelength (in the range of green colors) which color projects the description of the operator indicative image.

The augmented reality helmet headdress has an autonomous power source like an accumulator which contains a mini-video camera and cell connection receiver and transmitter which functions with the technology of the industrial Internet of Things to interact in the radio channel (mobile connection) with the server part.

The augmented reality helmet server part is a program-machine division done with the standard office equipment to register in the savable format on the digital server the video stream of production operator actions and the objects that the operator can see in a cyber and digital production.

A stationary server has a special room for it in the Industry 4.0 smart factory which has the Internet connection using the quick response wired channels of the Ethernet. Video content from the augmented reality headdress with digital radio channels which cover all objects of the smart factory production infrastructure, is transmitted by the industrial Internet of Things to the server part to be registered (saved on a disc) and for its analysis with the cloud application.

6. Conclusion

Component designing for the digital production of the Industry 4.0 within which all main technological operations are completed without humans is an actual [15, 16] development way for the world industry. The main interest is the science and research project oriented to create control elements for the digital company industrial infrastructure based on the advanced informative technologies.

The augmented reality technology with the cyber and physical system exploitation in the Industry 4.0 production can be studied as a variation of the Humane-to-Machine technology to define formats and interaction interfaces between operators and the CPS. The proposed way of CPS maintenance using an augmented reality helmet is an innovative one, also aggregating the technologies of the industrial Internet of Things and cloud technologies.

In practice, the proposed way of CPS maintenance has no obstacles because the technologies being used are combined with the informative technologies which are the base for creation and functioning of the Industry 4.0 smart factories.

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