Application of imitation modelling means to create digital twins of the Industry 4.0 company technological equipment

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Abstract. The task is being studied how to project digital twins of technological equipment in the example of remote control model computer model software realization. Digital twins of technological equipment are infrastructure components of production companies of the Industry 4.0 functioning in the level of cloud services. Technological equipment access to cloud services is done with protocols of the Internet of Things with guaranteed delivery of packages. The production technological equipment interacts in the level of physical devices and the level of virtual models (digital twins) which is a cyber and physical system. The results are given after a practical experience of designing an and a research of a digital twin of the remote control which supports the internet protocol of TCP/IP made with LabView software.

1. Introduction

Designing process of cyber and physical systems include the application of CAD (Computer-Aided Design) means by computer specialists. The most popular in practice are the CAD systems which can create a model imitation and visual form of generated solutions [1, 2]. An example of such a CAD system is LabView software developed in company National Instruments.

LabView software can create easily comprehended interfaces between machine and human using the calculus means which function in interactive form of discreet events. So as a part of automatic work place a designer could create virtual devices on the screen of its personal computer (PC) which are similar to the being projected physical machine which has a particular control program. The control program is defined with known physical processes and described with mathematical equations in discreet and non-interrupted time. In this case virtual equipment function on the PC and has absolute information similarity to the physical device being projected in reality [3, 4].

Designing of such virtual machines is necessary for some project stages where it is necessary to check that the equipment functions properly as a complicated technical system (production divisions) where there are no such physical machines. In this case the missing equipment which is being delivered for now can be changed with its digital twins (imitation mathematical models) functioning in instrument PCs. The advantage of such designing way for mechanical assembly production is a possibility for a designer to analyze the machine functionality done with checking of mathematical model of machine behavior which is a part of software.

Such mathematical models in future could be used as digital twins of technological equipment in the
Industry 4.0 (digital factory, smart factory, virtual factory) to organize cyber and physical non-human item designing components production [5, 6]. Smart factory production operator could make quality monitoring of technological operations completion and correctness monitoring of cyber and physical technological equipment.

In this article practical experience of application of LabView software to automatize the creation of human-machine interface which is a part of complicated technical system of production purpose in particular for digital production in smart factory.

2. Interaction scheme between operator and cyber and physical system
The scheme of interaction between operator and cyber and physical system in production is given in figure 1. Cyber and physical system is some components realized as physical devices and some realized in the cyber level.

Figure 1. Interaction scheme of operator and cyber and physical system in a production company of the Industry 4.0.

As a physical device cyber and physical system provides completion of technological operations in work chamber which are necessary to automatically produce item designing component. In cyber level cyber and physical system is a virtual model which is informatively similar to the physical devices (digital twins). Information connection among components of physical and cyber levels is done with the technology of the industrial Internet of Things (IoT). In figure 1 as a channel of information exchange is given an internet channel functioning with protocol TCP/IP (Transmission Control Protocol/Internet Protocol). Unlike UDP (User Datagram Protocol) protocol the protocol of TCP there is a notation of installation and break-down of connection which may guarantee the delivery of packages.

When the information is lost in transition through the channel a re-asking is done and second attempt to deliver a package. Protocol TCP may guarantee the integrity of received data in order in which it was sent.

Physical device level in cyber and physical system is done with [7, 8]:

- control signals receiver which constantly register commands of control which are sent through radio environment with protocol of TCP/IP;
- control commands decoder which detects the commands coded in message which are sent through radio environment with protocol of TCP/IP;
- work chamber to complete technological operations automatically (each technological operation is done in work chamber with standard algorithm or technical algorithm which is precise one of the commands);
- controller, actor and sensors of equipment correctness and quality of technological operation.
completion which together create an automatic information and measurement control system of physical equipment;

- equipment correctness state former and quality of technological process completion which is a valuable information for analysis (state command) in coded form;
- control signal formers which stably transits the command codes of state which is sent through radio environment with protocol of TCP/IP.

Cyber level (cloud service) of cyber and physical system is virtual models of the following components [9, 10]:

- remote control with visualized organs for PC operator and means of light indications;
- control commands former which can process and decode numbers of technical processes algorithms which must be completed in work chamber of physical device (the control commands must be formed by operator with visualized organ means of control);
- control signals former which may stably transit control command codes which are sent through radio environment with protocol of TCP/IP;
- control signals receiver which stably register commands of state which are transmitted through radio environment with protocol of TCP/IP (state commands activate light indicators of remote control which are available to monitor by the operator where light indicators correspond to the technological processes completion state and the state of non-correctness of physical device components).

3. Model of components of the cyber and physical system cloud service

Cloud service model components of a cyber and physical system are imitation models which are made with LabView software on the level of functional blocks.

Human and machine interface supports virtual control organs (keypad panels) and light indicators of state. An example of remote control face panel of cyber and physical system controlling which are indicated to operator in interactive mode given in figure 2.

![Figure 2. The face panel of cyber and physical system remote control made with LabView software.](image)

Remote control face panel includes the following components of control: button to disengage remote control; remote control work state indicator; panels to input the codes of control commands (CC); panel indicator of inputting the codes of control commands; indicator of successful (erroneous) recognition of command codes; button start to send the command codes; command transition button; operator actions record button (register in a text file); reset button of command indicators; range selection button (sections) transmitting frequency of commands; number regulator of additive noise level in a connection.
radio channel.

To complete the control function of cyber and physical systems (support type selection of technological operation and the selection of library algorithm of technological operations) for operator it is necessary to arrange with the virtual control panel the corresponding control command code and send the command to be executed. In LabView software the operator choice transforms into program code being transmitted with protocol TCP/IP in physical level of cyber and physical system. A piece of software model of inputting panel for the control command codes is given in figure 3.

![Figure 3](image3.png)

**Figure 3.** A piece of software for code entry control commands panel model.

In virtual level the chosen algorithm of technological process of item manufacturing corresponds a set of mathematical expressions given as some recurrent equations. The recurrent equations describe the production process of technological operations completion in the equipment work chamber in the terms of process description in the looped digital system of automatic control with random delay. The delay parameter is inputted in the control channel keeping in mind that the signal distribution could be affected with additive disturbances.

So the received control signal commands could not always be detected from the first time. Using this mechanism in LabView software is done the internet protocol of the information transmitting with guaranteed delivery of packages. In case if in work chamber of physical device, the technological operation has been completed successfully in the remote control face panel the light indicator of corresponding command is lit with green, if not it is lit with red.

![Figure 4](image4.png)

**Figure 4.** Command codes former unit configurator made with LabView software.

User interface of command codes formation configuration block which is made in LabView software is given in figure 4. Like models of the figure 3 and figure 4 were used different functional components
of cloud service remote control for a cyber and physical system.

4. Conclusion
LabView software is a software of CAD designing which is applicable for science and production where it is necessary to make the designing stages and subsequent tests (researches) of projection objects which contains information and measurement control components described with discreet mathematical models. Such projection objects (mechanical assembly production) are widely known to create complicated digital production complexes equipped with cyber and physical systems.

Digital models of LabView software blocks is a possible option to describe the process with discreet events of production processes done with cyber and physical systems in the level of cloud services the access to which is granted with the industrial Internet of Things. The received and proved models of cyber and physical systems components are elements to create digital twins of technological equipment of the Industry 4.0 item designing company.

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