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Subject-Information Environment Deployment of Heat Press Operation Hardware Emulation

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***Abstract*—The architectural diagram and deployment stages the laboratory learning bench of heat press operation hardware emulation as a component of production line in operational printing are given. The analytical apparatus of project on Arduino Uno computing platform basis receives the parameters of printing order and determine the control signal for actuators, mimicing of system general behavior.**

Keywords*—*laboratory bench, computing platform, learning experiment environment, operative printing, JDF, Industry 4.0.

I. Introduction

Training of engineering profile personnel is focused on professional skills formation with permanent use of topical industry content. The applying of technological resources of branch enterprise has a positive effect on the development of necessary critical competencies of engineering students. The introduction of the practice of organizing learning experiments as close as possible to the production conditions plays a key role in the apprehension of engineering-oriented disciplines and the amplification of sustainable professional acquirements.

Gaining experience in working with subject area equipment and regular experimental consolidation of acquired theoretical knowledge improve the competitiveness of graduates in market conditions and guarantee the productivity of placemented engineers. Appropriateness the requirements of modern production environment contribute to furtherance of successful professional career.

The transition to remote learning mode, caused first by coronavirus pandemic and widespread leading in quarantine restrictions, and later by the open full-scale russian invasion and the mass appearance needy for academic refuge, led to the search to alternative pedagogical solutions in the educational process. Computer-mediated learning provides advanced technological toolkit for acquiring knowledge and competencies in asynchronous environment using mobile and stationary devices.

Previous experience the institutions of higher engineering education in information technology use and cognitive flexibility development was formed in determining strategies improve the effectiveness qualified professionals training, including sustainability trends in automation and exchange of target data of production situations. Therefore, the implementation of the principles of Industrie 4.0 in the educational process of teaching engineers is inextricably rearrangement with goaled restructuring of academic courses in the direction focused on modern information and communication technologies. Consequently, it is important to study the ways of deploying computerized media platforms of learning experiment, which on production data analytics basis are able to emulate typical processes behavior by profile industry.

II. Problematics in Deployment of Cyber Physical Systems for Experimental Researches

According to Fourth Industrial Revolution's leading strategy for cyber-physical systems (CPS), computerized full-scale and analytical components work closely together, representing a virtually perfect network combination. At the same time, means provided by the CPS allow to combine research efforts related to the subject areas of different engineering disciplines. High functionality and adaptability of such systems provides increased efficiency in the comprehensive appliance of information technology.

A. Expanding the application areas of industrial data

Integration of disparate cyber-physical modules into a unified hardware and software complex guarantees the expansion of computing resources through third-party servers, expert agents, knowledge bases, cloud storage and more. However, for a long time, the spread of the CPS concept has been hampered by insufficient activity in the introduction of corporate channels between branch enterprises and higher engineering education institutions. Meanwhile, unexpected synergistic effects can be achieved by analyzing the indication of industrial sensors in generating scenarios for academic laboratory cyber-physical systems.

The productive technique of fault prediction [1], which provides input data for forecast maintenance of industrial equipment, will also increase the influence of pedagogical models in the formation of professional skills of applicants of higher engineering degree. In general, by accelerating production processes, a large amount of industrial data can also be used in an alternative way. For example, such multiple-choiced targeted application of enterprise resources is proposed to be used in the deployment of virtual learning experiment environments. As organic instrumental means of the academic space, they are suitable for studying the features of branch machines fleet configuration and the situational solution of number typical production problems [2].

B. Categorization of learning experiment environments

Within the engineering specialties context, one of main way of the subject area cognition is the ability to operate with the research means of typical for the industry transitional processes. In nowadays realities of remote learning, *infocommunicative environments* have become especially widespread in the organization of distance engineering education, offering toolkit of virtual space with adequate implementation of simulation fragments and surrogate models of the subject area [3]. Although in general the given decision saved the practical component of educational process and provided an understanding the learning experiment based stages, but acquisition of skills in working with professional equipment here focuses only on interaction with a computer manipulator. Being physically absent from the higher education institution campus, the student cannot directly operate with the material components of the laboratory bench, measuring devices, hardware base of the model-object, etc. Thus, due to the lack of classroom *natural-spatial environment* of experimental research, the practical and cognitive activity of the applicant is generally deprived of the possibility of enlargement [4].

A certain compromise in this state of affairs is the *subject-information environment* of the learning experiment, which includes cyber-physical systems with a constructive interface for telemetry inconnecting. One of the means of implementing such solution is passive monitoring of remote mechanisms via webcams and obtaining individual experimental results in the form of graphs, tabular data and the like [5]. The obvious disadvantage the following remote laboratory organization is the need for costly industrial equipment that not all engineering institution can afford. Also, the lack of feedback has nihilistic consequences, giving the student only the role of an observer. The presence of a campus operator-instructor [6] does not particularly save the situation, although it can bring the negative impact of the human factor.

Thus, there is a need to deploy an automated *subject-information environment* of a remote laboratory, which would not require constantly present service personnel and provide emulation of industrial equipment based on information the parameters of the job task and about the current course of the technological process in real time. The effectiveness of such a cyber-physical media platform of the learning experiment is determined primarily by the adequacy of the conceptual model of the subject area. Therefore, when implementing remote laboratory workshops, special attention should be paid to the formalization of the structural components of the platform and relationships between them.

III. Design Stages the Laboratory Bench for Emulation of Heat Press Operation

The presented research shows the stages of designing the cyber-physical environment of the learning experiment for the study of technological processes of operational printing, in particular the hardware emulation of the automated control system of the heat press when performing a printing order. Modern heat presses are used for personalized decor of clothing, utensils, stationery, textiles, trinkets, etc. under the action of pressure and elevated temperature for a clearly defined time.

A. Determining the architecture of laboratory learning bench

To clarify the components of cyber-physical system for hardware emulation of the head press and explain the sequence of its design, an architectural diagram of the media platform for remote support of laboratory workshops was built (Fig. 1). As a result, the hierarchy of modules was formalized, the features of their interaction were determined to implement the coordinated functioning of integrated environment for studying the heat press operation.

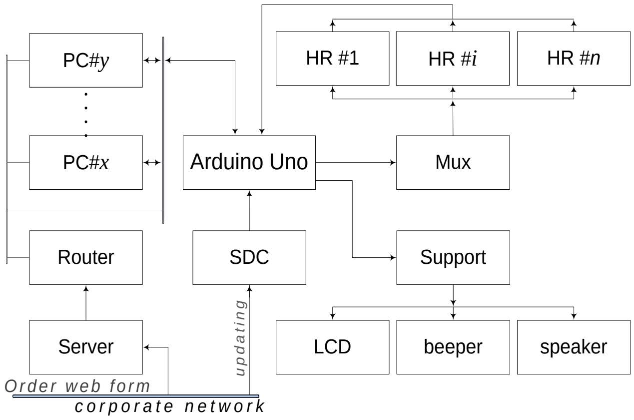

Fig. 1. Architecture diagram of heat press environment emulation

It was decided to choose the Arduino Uno computing platform [7] as the analytical apparatus of the designed cyber-physical system, respectively, the conceptual models of the conditioned expansion boards [8] are located as building on. The circulation of data in the environment of our remote laboratory begins with the receipt of a package of job tasks through network devices for information transmission.

Another module of the system is the memory card drive (SDC), which is implemented on the controller board and stores the corporate database with the parameters of raw materials and consumables. The content of the database is synchronized through the corporate network using the extended end-to-end production format xJDF [2].

For the supporting visualization of the transition processes of the printing order, the project provides a liquid crystal display. Audio support of production stages or emergency situations is provided by a speaker (headsets) with Bluetooth data acquisition A separate primitive alert can also be provided by a piezoelectric beeper integrated into the controller periphery (Fig. 2).

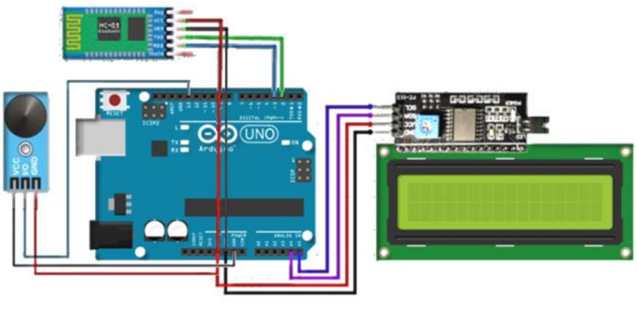

Fig. 2. Connecting peripherals for accompanying notification

To connect the models of actuators of industrial equipment in the control system introduced a multiplexer [9] located on the architectural diagram in the control area (Fig. 3). Models of actuators are implemented on hardware registers (HR), which emulate the temperature setters of heat presses. A folding device is also made on one of the registers that simulates a heat press group with a flat-panel heating element.

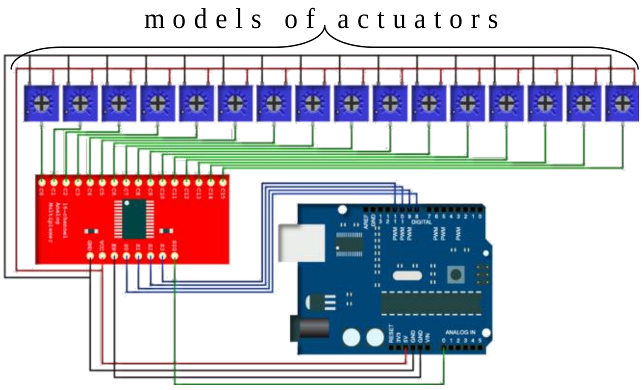

Fig. 3. Implementation of a multiplexer on CD74HC4067 shield

The procedure of fulfilling a printing order begins with combining the characteristics of raw materials obtained from the order web form. These characteristics determine the course of further technological process. After receiving information about the features of intermediate product for order, the analytical apparatus in the calculation area initiates a query to the database.

As a result of processing the industrial content of data-base, the cyber-physical system receives the parameters of terminal actuators. Such parameters in the presented project include the temperature and time required for manufacture of quality products, as well as the ID of the target heat press, which covers a group of relevant registers (Fig. 4).

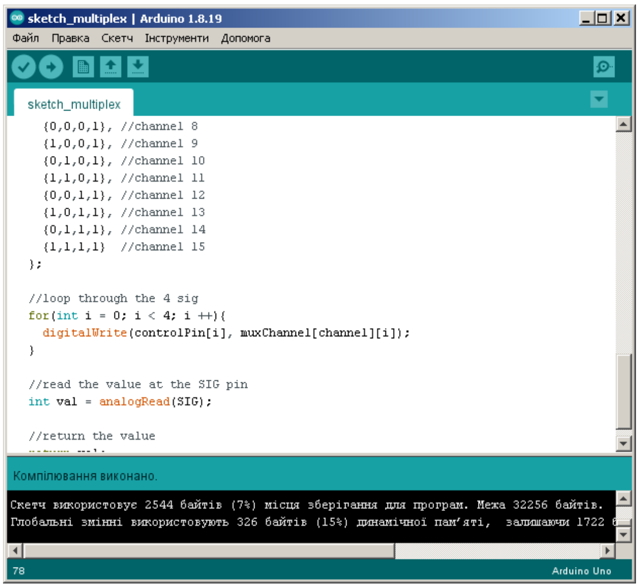

Fig. 4. Fragment of sketch for actuator initiation

The end user terminal in the presented project is a personal computer. An ordinary desktop, laptop, tablet, etc. can serve as such a device. The corporate network through the academic server delivers to end terminal information with the characteristics of registered printing order, obtained through the client web form of the operational printing institution.

The applicant as a user of the laboratory bench can view, analyze and clarify this information. It can also identify further work scenarios for the cyber-physical platform. As a result of such intervention of an incompetent operator, there may be discrepancies due to inconsistencies in the parameters of the transition process. Such discrepancies can be observed in the information regions of the display of the end terminal and the LCD supporting visualization module. The student must draw his own conclusions from the abnormal situation [3].

B. Accompanying information on the production stage of thermal-transfer process

To further attract the student's attention when performing laboratory exercises to study the work of the heat press, a list of reasons for the accompanying notification within the designed system was organized (Table 1).

TABLE I. PRODUCTIONS SITUATIONS OF ACCOMPANYING NOTIFICATION

Event	Information	Bipper duration
Order	Receipt of the order	Delay(200)
Warming	Start heating the element	Delay(200)
Readiness	The heat press is ready to work	Delay(200)
Beginning	The timer started	Delay(200)
Completion	The heat press has finished its work	Delay(200)
Error#255	Heating element error	Delay(30)×3
Error#E0	Low temperature	Delay(1800)
Error#E1	Sensor error	Delay(40)×4
Error#E02	Failure of the temperature control unit	Delay(30)×1
Error#E03	Control unit failure	Delay(30)×2
Error#E19	Sensor short circuit	Delay(100)×3
Error#E20	Breakdown of the sensor	Delay(100)×2
Error##P01	Breakdown of the folding mechanism	Delay(100)

A series of information on production errors attracts special attention here. The fact is that when building electronic devices, the producer hopes for quality and smooth operation of its components, providing "protection from fools" and maximizing the human factor removing. But electronics also has the property of making mistakes, breaking, certain components may fail, which can interfere with the smooth operation of the entire system.

However, electronics have an advantage – each of the errors can be predicted in advance, and therefore the producer sews in the SPD of the device instructions for notification of the occurrence of a fault to eliminate it in time [1]. The error base is based primarily on the intended purpose of the end device. Secondly, such databases are turn out on the actual common errors of electronic devices, which is also important to ensure good system performance. Electronics errors can occur anywhere, regardless of device purpose. Such errors can be the failure of main components of electronic part of the system, coding problems, program errors, and wear of parts. Therefore, before talking about specific errors of a particular device, it should first review the general errors when working with electronic devices.

As mentioned earlier, such errors are usually fragments of the electronic part, connecting wires, etc., which have failed. Also here can be contribute programming errors. Error codes are designed to report a specific problem and are abbreviated to save volume and speed up transmission. The analytical device converts the received code into the inscription clear to the operator for which it is also possible to generate audio messages or simply to reproduce by a beeper sequence. In some cases, the analytical apparatus itself can determine a set of measures to correct the error identified by the received code. In this case, depending on the mode of the laboratory workshop, the student is asked to choose the option of troubleshooting.

Thereby, the given list of production situations (Table 1) is quite suitable for operative computing and dynamic administration of the active subject-information environment of the emulation of the heat press. The main scenario of the workshops is implemented on the basis of requests and subsequent decision-making, when the student independently builds a strategy for researching the subject area using the available toolkit of the laboratory bench, while developing skills to predict the adequacy of the expected result.

CONCLUSIONS

In this research the technique of deploying the components of the academic cyber-physical system as a "device shadow" was tested on the basis of information about the parameters of the job task and the current state of industrial equipment from the production line in real time. The proposed corporate channel based on the end-to-end JDF production format within the IIOT concept coordinates the efforts of local nodes of the profile learning experiment environment throughout the value chain of the printing order, emulating missing resources beyond the subject area.

Further development of the project will be to formalize the mechanism of virtual laboratory scenarios, clarification of the means of accompanying visualization, in particular the selection of information regions of the end terminal, and sample of optimal protocols for forecasting, self-tuning and adaptation in the interaction of disparate professionally oriented cyber-physical systems and industrial strategic planning processes.

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