KnE Engineering

Knowledge E
enriching | engaging | empowering

Conference Paper

Cyber-Physical Systems Technologies: Applications in Industry and Education

V. V. Potekhin, E. N. Selivanova, and V. P. Shkodyrev

Peter the Great St. Petersburg Polytechnic University, 29 Politechnicheskaya str., Saint Petersburg, 195251

Abstract

Industry 4.0 concept development forms new trends as cloud computing, big data analysis, the industrial internet of things, machine-to-machine technologies. Cyber-physical systems (CPS) paradigm is based on these trends and integrates of computation, networking and physical processes. Synergy Center at Peter the Great St. Petersburg Polytechnic University works in the areas of intelligent systems for data processing and control, motion control systems for robotics, complex automation and mechatronics as components of CPS.

Keywords: Industry 4.0, Cyber-physical systems, Digital twin; intelligent control system, automation, Global digitalisation, Practical-oriented online courses, Skills training, Joint international educational programmes.

1. Introduction

CPS are impacting on manufacturing and production processes to the extent that their effects are likened to a "fourth industrial revolution." Others use terms such as "smart production." The business case for introducing CPS is most immediately clear with large scale, complex manufacturing, where significant gains can result from early adoption. [1]

Researchers conduct fundamental and applied research in the field of intelligent robotics and control systems; practicing innovative technologies and hard- and software solutions for the problems of industrial automation and high-tech industrial control systems.

Engineers analyse the interactive environment of cyber-physical and robotic systems to create new solutions and mathematical models in the field of intelligent robotics and control systems, studies technologies of industrial object remote control, group control of team behaviour of collaborative robots and situational control in conditions of uncertainty in the framework of applied developments.

🔓 OPEN ACCESS

2. Results and Discussions

To provide increasing of effectiveness of industrial systems with achievement of the guaranteed product quality, the manufacturing digital transformation paradigm is applied. According to Industry 4.0 concept, adaptive, client-oriented automatic control of product life cycle is the basic approach in global manufacturing digitalisation. Such technologies as Big Data, Cloud Services, advanced analytic algorithms, have to be implemented to provide an effective control for complex technological processes. Therefore, different technologies operating information from Web as well as from field level and top level manufacture information systems should offer high degree of interoperability.

Digital twin technology is component of cyber-physical systems in framework of Industry 4.0 concept. Digital twin technology is one of the key modern areas of operational analysis and increasing the efficiency of industrial equipment. It provides for the construction of "live" digital models and virtual simulators for local use or as an implementation of the industrial internet of things concept. [2]

Expert and advisory diagnostic systems based on best practices can significantly reduce the costs of equipment maintenance, reduce the risks of their breakdowns, downtime and related material losses, and improve the efficiency and quality of technological processes. As a result of the development and verification of the architecture of Digital twins, the problem of intelligent control system developing for distributed industrial object was solved. This concept was developed and implemented in R&D projects in cooperation Russian industry companies – development of digital twin model of manufacturing control systems.

Peter the Great St. Petersburg Polytechnic University considers cyber-physical systems as important and prospective trend in science and education and implements it in educational activities and research projects. Implementation of cyber-physical systems concept in educational programmes is very important part of training future specialist and CPS systems developers. [3, 4]

Examples of mentioned above programmes are joint Master's degree programmes –"Intelligent systems" and "Distributed intelligent control systems". Programmes are developed in cooperation with European partner-universities: Leibniz University of Hannover (Germany), City, University of London (UK), Lappeenranta-Lahti University of Technology (Finland) and leading industrial companies Festo, Siemens, Schneider Electric. Students are offered to pursue opportunity to get wo Master' s degree (SPbPU and partner university), to get real project work experience during industry internship.

Programmes are developed and currently supported in framework of DAAD, Erasmus + projects.

Short term programmes – "Smart manufacturing and digital future", "Machine learning: theory and applications". Programmes provide students with fundamental and applied research activities in the field of intelligent robotics and control systems; practicing innovative technologies and hard- and software solutions for the problems of industrial automation and high-tech industrial control systems. Students analyze the interactive environment of cyber-physical and robotic systems to create new solutions and mathematical models in the field of intelligent robotics and control systems. Teams of students studies and demonstrate technologies of industrial object remote control, group control of team behavior of collaborative robots and situational control in conditions of uncertainty in the framework of applied developments.

Academic Center SPbPU–FESTO "Synergy" is another example of implementation of various approaches of curricula design, especially in international programmes. Centre works in the areas of intelligent systems for data processing and control, motion control systems for robotics, complex automation, electronics and electrical drives. Main efforts have been done for more efficient use of the intellectual potential and high-tech equipment available at the laboratories, particularly for developing new innovative educational programmes, [5, 6]
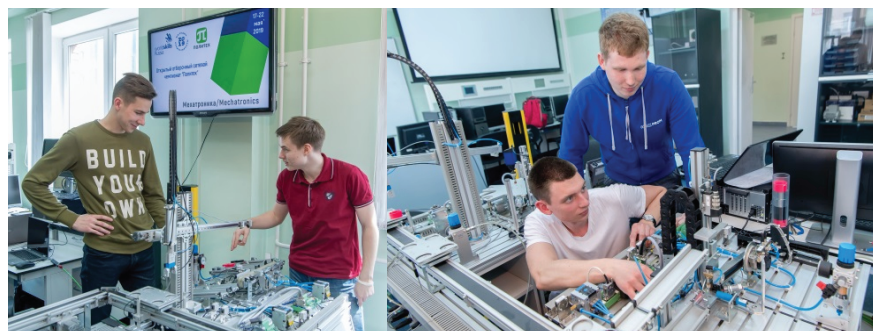

Figure 1: Practice-oriented education in Academic Center SPbPU–FESTO "Synergy"

Activities of Centre SPbPU-Festo «Synergy» are aimed at development of innovative practice-oriented educational programmes with active implementation of latest trends of Industry 4.0 in educational process. Centre takes active part in realisation of Master degree programmes in intelligent control systems, industrial automation and cyber-physical systems and implements its own short-term programmes in smart manufacturing and machine learning. Following demand of digital transformation of educational process Centre develops and realises massive online courses "Modern industrial electronics" and etc. [6]

3. Conclusion

The cyber-physical systems are a new generation of control systems and techniques which help promote prospective interdisciplinary research. Based on cyber-physical systems new production technologies are a designed and implemented in industry. To successfully develop cyber-physical systems paradigm new generation of engineers and wide competence specialists must be trained. Students should learn about cyber-physical systems concept in framework of innovative educational programmes in the field of automation, control systems, artificial intelligence and IT with opportunity to apply gained skilled during industrial internships.

References

[1] Shkodyrev V., Selivanova E., Potekhin V., Overmeyer L., Niemann B. Academic networking partnership in education and skill training on global cyber-physical environment. В сборнике: 35th ANNIVERSARY OF COOPERETION. 2019. С. 75-83;

[2] Turner C.J., Hutabarat W., Oyekan, J., Tiwari A. Discrete Event Simulation and Virtual Reality Use in Industry: New Opportunities and Future Trends, IEEE Transactions on Human-Machine Systems, 46 (6), (2016).

[3] Khokhlovskiy V.N., Potekhin V.V., Razinkina, E.M. Role of the SPbPU-FESTO «Synergy» Centre in the Development of Engineering Competences and Skills, EAI Endorsed Transactions on Energy Web and Information Technologies, 5 (19), (2018).

[4] Haskovic D., Katalinic B., Zec I. Support and Learning Functions of the Intelligent Adviser Module, Proceedings of the International Multiconference Network Cooperation in Science, Industry and Education (NCSIE), St. Petersburg, Russia, July 4-6, pp. 183-189, (2016).

[5] Potekhin V.V., Shkodyrev V.P., Potekhina E.V., Selivanova E.N. Double degree programme in engineering education: practice and prospects, Proceedings of 41st SEFI Conference, (2013).

[6] Mäkiö J., Mäkiö-Marusik E., Yablochnikov E. On Educating Cyber-Physical Systems in a Global Environment, Proceedings of the International Multiconference Network Cooperation in Science, Industry and Education (NCSIE), St. Petersburg, Russia, July 4-6, pp. 133-140, (2016).