Industry 4.0 laboratory of the University of Pannonia Nagykanizsa Campus

Sz. Jaskó, T. Holczinger, A. Skrop

Department of Applied Informatics, University of Pannonia, Zrínyi utca 18., 8800, Nagykanizsa, Hungary, jasko.szilárd@uni-pen.hu, holczinger.tibor@uni-pen.hu, skrop.adrienn@uni-pen.hu

Abstract: Digitization and the technologies provided by the Industry 4.0 strategy has changed the manufacturing industry significantly. This implies that stakeholders — universities, students, industrial partners — need to acquire new competences. In order to meet these needs the University of Pannonia Nagykanizsa Campus started to establish a fully automatized industrial laboratory. In this paper the architecture of the Industry 4.0 laboratory is presented.

Keywords: industry 4.0; digital factory; digitization.

1 Introduction

Digitization, the deployment of information technology and automation have great impact in manufacturing industry and manufacturing companies. The operation of manufacturing companies has changed significantly, it is switched from mass production to customized products and production. Industry 4.0 strategy includes several key technologies to digitize production flow or even the whole supply chain. The University of Pannonia Nagykanizsa Campus is establishing an Industry 4.0 laboratory. The goal of the laboratory is to cover most areas of factory digitalization.

Not only the production but the entire supply chain, i.e. from acquisition to customer services, will be modelled in the laboratory. It requires the integration of different research areas and technologies e.g. adaptive systems, data mining, machine learning, optimization, protocol technology, sensor and computer networks. These key technologies may provide to model the main elements of the fully automated industrial processes that leads to efficiency gains and allows to produce highly customized product at small lot size.

In this paper the idea and the structure of the laboratory is introduced. The paper is organized as follows. Section 2 describes Industry 4.0 concept. In Section 3 problem statement is presented. Section 4 presents the proposed system plan of the laboratory. Section 5 concludes the paper and suggests ideas for future work.

2 Industry 4.0 and learning factories

The innovation of technologies in industrial production leads the German government to start to promote the computerization of manufacturing the so-called fourth industrial revolution (Industry 4.0). This concept and the advancement of information technology strengthen each other. The continuous development of Cyber-Physical Systems (CPS), Internet of Things (IoT), Internet of Services (IoS), robotics, cloud- and cognitive computing, big data and augmented reality (AR) results significant change in production systems [1,2]. The Industry 4.0 term is specific mainly in Europe but the computerization of manufacturing system are not only restricted to the EU. In China the “Made-in-China 2025” concept, based on modern IT [3], is introduced to increase the efficiency and competitiveness of the production industry [4-6]. In the US, the “reindustrialization” of the manufacturing industry has started to reinvigorate it. Japan has introduced the “New Robot Strategy” to became the center of development and production of cooperative robots. Moreover, there are different strategies of different countries (e.g. France - New Industrial France, UK - high-value manufacturing, South Korea - advanced innovators’ strategy) but all of them based on the same goals [7]. All aforementioned strategies try to integrated the supply chains and the production systems which can help to make fully customized products [8].

All manufacturing firms should be prepared for the changes of Industry 4.0 taking into account the technology and the human perspectives. Most models are mainly focused on technology part [9-11] but the human operators also are important part of a manufacturing system [12-15]. With the newest IoT devices there is a chance to design machines which can replace human minds [16]. A research in US shows that about 47% of all employment will be at a risk of automatization/computerization by 2030 [17].

The Industry 4.0 is a widely researched area, systematic literature reviews are frequently published [4,18-20]. There are numerous learning factories which have focus on Industry 4.0. They look differently, they are used for different purpose and demonstrate different implementation aspects [21-25]. Some reviews represent the existing approaches of learning factories which are available in academia or in industry [26-29].

3 Problem statement

Nowadays, the technology changes too fast in our environment. Naturally, this process has advantages and disadvantage too. The complexity and the capability of these systems stand on incredible level. The knowledge that needs to create, update or operate these kinds of solution is also high. The fact is, the humanity has a big chance with this to do something really good. Probably, this will bring essential changes in all areas of our lives. But we can only use this opportunity if we can prepare ourselves in time.

Our goal is to create a multipurpose laboratory in the area of Industry 4.0. This solution will be able to use in the followings:

- The infrastructure of the laboratory will support the teaching of modern industrial processes. The students can learn about the structure and the interoperation of this modular architecture i.e. students can learn the functions, working flows and the place of the main units / components / elements / entities of the industry 4.0. In addition, they can understand the whole system and the relationship between each unit. Another very important goal is to maintain the motivation of students and their possibility to develop new capabilities of the system.
- The laboratory may serve as an infrastructural basis for useful industrial researches, which in the future can contribute to the development of the industry's 4.0 concept and its newer versions.
- It can become a cooperation and collaboration environment between the university and the industrial partners. The laboratory can demonstrate the possibilities of this new technology in practice. Moreover this environment makes it possible on the one hand to introduce and on the other hand to develop and test new technologies before industrial deployment.

An important design aspect is to develop the laboratory with modular structure. This property is important in many cases. One from these is that the capabilities of the laboratory can be expanded or modified with the help of minor improvements.

4 System plan

Our system will include all main components of a modern, fully automated industrial solution. This is necessary to reach the multipurpose operational area. Note that we want to model this process from the ordering of a customized product - through the production - to the customer's service. This activity requires coordinated work of numerous research areas. There are some dominant areas as example adaptive systems, data mining, machine learning, optimization, protocol technology, and sensor and computer networks. Figure 1 shows the logical structure of the system, where the tasks of each element are the followings:

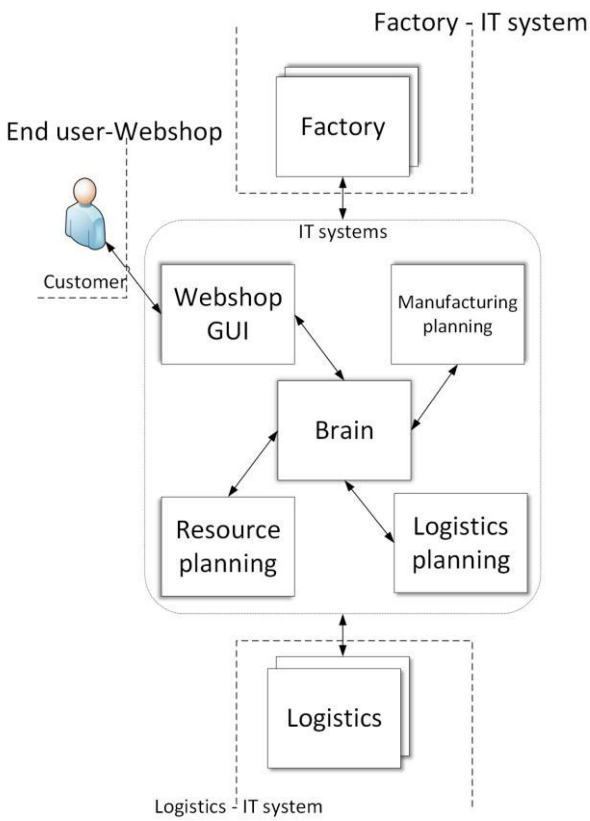

Figure 1

The logical structure of the system

- Customer: This entity indicates the manufacturing process. Note that this means the factory will only produce the ordered products.
- Webshop: The customer can manage (buy, modify, get information) his/her order with the help of this unit. This subsystem communicates with the brain unit.
- Brain: This is a central unit and the main functions of it are process controlling and information management: collection and transmission of information.
- Manufacturing planning: This unit determines the production scheduling and the raw material requirements based on the order.
- Logistics planning: This unit determines the scheduling of logistics for the manufacturing process based on the order.
- Resource planning: This unit selects the specific factory and logistics partner involved in the manufacturing process based on the availability information and manufacturing parameters.
- Logistics: This unit is responsible for transportation that provides information on its activities.
- Factory: The task of this unit is the physical production. It provides information on its activities.

It is important to note that the Web shop, the Brain, the Manufacturing planning, the Logistics planning and the Resource Planning are IT systems / services that work together in the process.

Because of its complexity, the system will be implemented in several phases. Therefore, the individual functions will be integrated step by step into the system. In the first phase, the Brain, the Factory, and the user platform will be developed in detail, while the other features will only appear with minimal functionality. Before the second phase, the operational experiences and the implemented industrial tasks will be analyzed and the exact specification of the second phase will be determined based on this research.

Figure 2 shows a block diagram of the Factory subsystem. The Brain subsystem communicates with the production support system and its controller communicates with the other external and internal subsystems of the Factory. The internal subsystems are responsible for the operation of the factory, including for example robots, conveyor belts, and machining units. Note that the important information from each subunit is processed and stored in an OPC / data collection system.

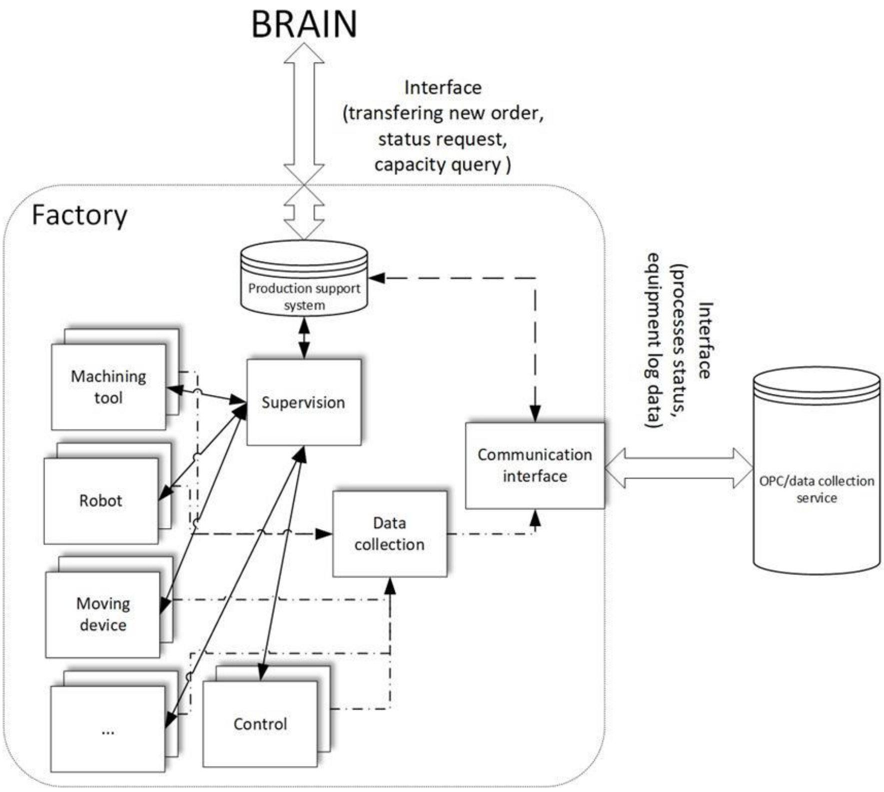

Figure 2

The factory subsystem

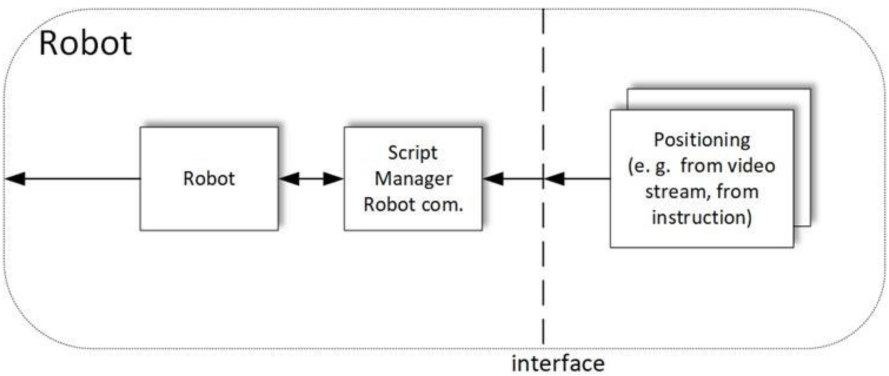

Figure 3

Block diagram of the robot element in the factory subsystem

In the case of the robot subsystem, as shown in Figure 3, a special interface has to be defined for the standardized data flow. Furthermore, a preprocessing unit must be developed to enable adaptive programming of the robot. Note that, most of the physical devices in the laboratory will belong to the factory subsystem.

Conclusions

The paper is represented the model of an Industry 4.0 based laboratory which is currently under construction in University of Pannonia Nagykanizsa Campus. The aims of the laboratory are teaching university students, making research in the field of Industry 4.0 and implementing industrial flows in small scale. The system mainly focuses on the information technology part of the automatization but the physical components of production systems also appear. The model of the laboratory is modular which enables to extend it later according to the industrial and academic needs.

The first phase of the realization is in progress. Most of the hardware are available on site and the development of interfaces of the first phase are close to finish. The next step will be a demonstration for a flexible production system with two customizable products.

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References

[1] Schmidt, R.; Möhring, M.; Härting, R.C.; Reichstein, C.; Neumaier, P.; Jozinovi´c, P. Industry 4.0-potentials for creating smart products: Empirical research results. In International Conference on Business Information Systems; Springer: Cham, Germany, 2015; Volume 12, pp. 16–27.

[2] Pereira, A.; Romero, F. A review of the meanings and the implications of the Industry 4.0 concept. Procedia Manuf. 2017, 13, 1206–1214.

[3] Wang, S.; Wan, J.; Zhang, D.; Li, D.; Zhang, C. Towards smart factory for industry 4.0: A self-organized multi-agent system with big data based feedback and coordination. Comput. Netw. 2016, 101, 158–168.

[4] Xu, L.D.; Xu, E.L.; Li, L. Industry 4.0: State of the art and future trends. Int. J. Prod. Res. 2018, 56, 2941–2962.

[5] Martin, K. Innovative Competition with Chinese Characteristics. The Case of 'Made in China 2025' in Relation to the German Industry. Bachelor's Thesis, 2018. Available online: https://openaccess.leidenuniv.nl/handle/1887/63733 (accessed on 7 September 2018).

[6] Shubin, T.; Zhi, P. “Made in China 2025” and “Industrie 4.0”—In Motion Together. In The Internet of Things; Springer: New York, NY, USA, 2018; pp. 87–113.

[7] Huimin, M.; Wu, X.; Yan, L.; Huang, H.; Wu, H.; Xiong, J.; Zhang, J. Strategic Plan of “Made in China 2025” and Its Implementation. In Analyzing the Impacts of Industry 4.0 in Modern Business Environments; IGI Global: Derry Township, PA, USA, 2018; Volume 23, pp. 1–23.

[8] Ford, S.; Despeisse, M. Additive manufacturing and sustainability: An exploratory study of the advantages and challenges. J. Clean. Prod. 2016, 137, 1573–1587.

[9] Lanza, G.; Nyhuis, P.; Ansari, S.M.; Kuprat, T.; Liebrecht, C. Befähigungs- und Einführungsstrategien für Industrie 4.0. ZWF Zeitschrift Wirtschaftlichen Fabrikbetrieb 2016, 111, 76–79.

[10] Lictblau, K.; Stich, V.; Bertenrath, R.; Blum, M.; Bleider, M.; Millack, A.; Schmitt, K.; Schmitz, E.; Schroter, M. Industrie 4.0 Readiness. Impuls-Stiftung des VDMA Aachen-Köln 2015, 52, 1–77.

[11] Schumacher, A.; Erol, S.; Sihn, W. A maturity model for assessing industry 4.0 readiness and maturity of manufacturing enterprises. Procedia CIRP 2016, 52, 161–166.

[12] Munir, S.; Stankovic, J.A.; Liang, C.J.M.; Lin, S. Cyber Physical System Challenges for Human-in-the-Loop Control. In Proceedings of the Presented as part of the 8th International Workshop on Feedback Computing, USENIX, San Jose, CA, USA, 24–28 June 2013; Volume 4, pp. 1–4.

[13] Hancock, P.A.; Jagacinski, R.J.; Parasuraman, R.;Wickens, C.D.;Wilson, G.F.; Kaber, D.B. Human-automation interaction research: Past, present, and future. Ergon. Des. 2013, 21, 9–14.

[14] Bidanda, B.; Ariyawongrat, P.; Needy, K.L.; Norman, B.A.; Tharmmaphornphilas, W. Human related issues in manufacturing cell design, implementation, and operation: A review and survey. Comput. Ind. Eng. 2005, 48, 507–523.

[15] Roitberg, A.; Perzylo, A.; Somani, N.; Giuliani, M.; Rickert, M.; Knoll, A. Human activity recognition in the context of industrial human-robot interaction. In Proceedings of the Signal and Information Processing Association Annual Summit and Conference (APSIPA), Siem Reap, Cambodia, 9–12 December 2014; Volume 10, pp. 1–10.

[16] Hawksworth, J.; Berriman, R.; Goel, S. Will Robots Really Steal Our Jobs? An International Analysis of the Potential Long Term Impact of Automation. Available online: http://pwc.blogs.com/economics_in_business/2018/02/will-robots-really-steal-our-jobs.html (accessed on 20 July 2018).

[17] Frey, C.B.; Osborne, M. The Future of Employment: How Susceptible Are Jobs to Computerisation. Available online: https://www.oxfordmartin.ox.ac.uk/publications/view/1314 (accessed on 15 November 2018).

[18] Liao, Y.; Deschamps, F.; de Freitas Rocha Loures, E.; Ramos, L.F.P. Past, present and future of Industry 4.0—A systematic literature review and research agenda proposal. Int. J. Prod. Res. 2017, 55, 3609–3629.

[19] Monostori, L. Cyber-physical production systems: Roots, expectations and R&D challenges. Procedia CIRP 2014, 17, 9–13.

[20] Zhou, K.; Liu, T.; Zhou, L. Industry 4.0: Towards future industrial opportunities and challenges. In Proceedings of the 2015 12th International Conference on Fuzzy Systems and Knowledge Discovery (FSKD), Zhangjiajie, China, 15–17 August 2015; pp. 2147–2152.

[21] Reuter, M.; Oberc, H.; Wannöffel, M.; Kreimeier, D.; Klippert, J.; Pawlicki, P.; Kuhlenkötter, B. Learning factories' trainings as an enabler of proactive workers' participation regarding Industrie 4.0, Procedia Manufacturing, 9 (2017) 354–360.

[22] Erol, S.; Jaeger, A.; Hold, P.; Ott, K.; Sihn, W. Tangible Industry 4.0: a scenario-based approach to learning for the future production, Procedia CIRP, 54 (2016) 113–118.

[23] Prinz, C.; Morlock, F.; Freith, S.; Kreggenfiels, N.; Kremeier, D.; Kuhlenkoetter, B. Learning factory modules for smart factories in Industrie 4.0, Procedia CIRP, 54 (2016) 7–12.

[24] Simons, S.; Abé, P.; Neserb, S. Learning in the AutFab – the fully automated Industrie 4.0 learning factory of the University of Applied Sciences Darmstadt, Procedia Manufacturing 2017, 9, 81–88.

[25] Elbestawi, M.; Centea D.; Singh, I.; Wanyama, T. SEPT Learning Factory for Industry 4.0 Education and Applied Research, Procedia Manufacturing 2018, 23, 249–254.

[26] Abele, E.; Chryssolouris, G.; Sihn, W.; Metternich, J.; ElMaraghy, H.; Seliger, G.; Sivard, G.; ElMaraghy, W.; Hummel, V.; Tisch, M.; Seifermann, S. Learning factories for future oriented research and education in manufacturing, CIRP Annals, 66(2) 803–826.

[27] Tisch, M.; Hertle, C.; Cachay, J.; Abele, E.; Metternich, J.; Tenberg, R. A systematic approach on developing action-oriented, competency-based learning factories, Procedia CIRP, 7 (2013) 580–585.

[28] Mavrikios, D.; Sipsas, K.; Smparounis, K.; Rentzos, L.; Chryssolouris, G. A Web-based application for classifying teaching and learning factories, Procedia Manufacturing, 9 (2017) 222–228.

[29] Tisch, M.; Metternich, J. Potentials and limits of learning factories in research, innovation transfer, education, and training, Procedia Manufacturing, 9 (2017) 89–96.