Journal of Technology and Exploitation in Mechanical Engineering
Vol. 3, no. 2, pp. 1–6, 2017

ISSN 2451-148X
Available online at: http://jteme.pl

Short Communication

LABORATORY OF INDUSTRIAL ROBOTICS AS SOURCE FOR OBTAINING OF PRACTICE KNOWLEDGES FROM CONTROLLING AND PROGRAMMING OF ROBOTS

Marek Vagaš [1✉], Vladimir Baláž[2]

[1✉] Technical University of Košice, Faculty of Mechanical Engineering, Prototype and Innovation Centre, email: marek.vagas@tuke.sk
[2] Technical University of Košice, Faculty of Mechanical Engineering, Department of Robotics, email: vladimir.balaz@tuke.sk

Submitted: 2017-12-05 / Accepted: 2017-12-05 / Published: 2017-12-20

ABSTRACT
The laboratory of industrial robotics aspires to deliver learning opportunities in Science, Technology, Engineering and Mathematics to communities where exposure is limited. The laboratory provides students with the resources to explore the fields of robotics in conjunction with high quality instruction and guidance from industry mentors. This laboratory is characterized by the need of robotics knowledges into traditional secondary vocational schools, which should provide the basic as well as advanced experiences, to address the needs of students, teachers and employees at different education levels. In this paper, we present the development of main workplaces for support virtual Moodle courses, as well as the training and relevant research.
KEYWORDS: industrial robot, parallel robot, robot SCARA, dual arm robot MOTOMAN

1. Introduction

Robotic education has traditionally relied on standard classroom lectures combined with laboratory experiments to make students understand this discipline in theory and practice [1]. However, availability of fast computer connections and powerful Internet servers facilitates currently developing a hybrid approach in which students experiment with theory in virtual environments before starting actual laboratory experiments [2].

This approach has several advantages, including safety, unlimited laboratory availability, better curriculum integration and increased flexibility. The disadvantage of this approach is that it is not supported by standard equipment and commercial products, and that each laboratory must invest a significant amount of time to implement a useful set-up [3]. During setup however, students in the laboratory acquire valuable expertise in a very important field, i.e. remote control of complex robotic systems. Furthermore, development of virtual laboratories for robotics education provides significant benefits for universities that do not have a large variety of engineering courses and laboratories, since the same laboratory can provide experimental support to a range of topics and classes requiring different expertise and schedule [4].

In particular, TUKE laboratory of industrial robotics is in the process of developing a series of virtual experiments, connected to real laboratory experiments, which cover a few aspects of basic control theory, robotic analysis and programming, software architecture, teleoperation, and robot motion planning, see Figure 1.

Fig. 1. TUKE industrial laboratory for education and research

Industrial robot control and programming is a sub-field of robotics in which position and/or velocity of multiple axes in a machine are controlled in a synchronised manner [5]. Robot implementation is widely used in all types of industries including packaging, assembly, textile, paper, printing, food processing and semiconductor manufacturing. It is in the heart of just about any automated workplaces and process [6].

RUSOS project target groups are often engaged in projects where robotics knowledge is an absolute must since industrial automation is designed primarily around specialised motion control hardware and software. Employees are expected to realise robotic workplace design and integration using standard controllers and robots as the primary building blocks for automation/mechatronics applications [7]. In these applications, the target groups must be knowledgeable about component selection from manufacturer catalogues based on the design specifications of the system, different types of robots, path generation, typical industrial path algorithms, trajectories tuning, offline and online programming [8].

2. Laboratories

This laboratory project is bifunctional. First, we present the current status of the project RUSOS possibilities by Moodle course and show that it contributes significantly to the students and teachers' education not only in robotics, but also under more general educational themes. Second, we take advantage of various kinematics of robots and present the development and lessons learned since project realisation, see Figure 2. By doing so, we hope to improve the robotics learning experience of target groups in future at the class, and also help to other universities, companies and research centres that have a similar curriculum by sharing this long-term experience [9].

2.1. Workplace with parallel robot ABB

Main equipment of this workplace is a parallel robot from ABB company, IRB 360 Flexpicker, see Figure 2. It has been the leader in state-of-the-art high speed robotic picking and packing technology. Compared to conventional hard automation, the IRB 360 offers much greater flexibility in a compact footprint while maintaining accuracy and high payloads [10]. This robot is capable of the fastest picking applications and have been optimised for packing applications. The robot has outstanding motion performance with the shortest cycle times, precision accuracy, and high payloads.

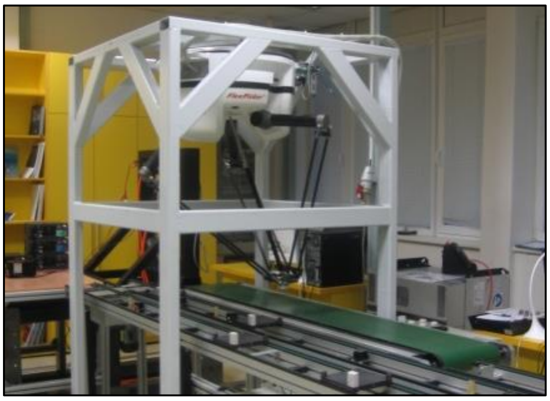

Fig. 2. Workplace with parallel robot ABB

The purpose of the workplace is to range information used to compute the dimensions and recognise objects moving on a conveyor belt. Geometric and recognition information is then passed on to the parallel robot for further action. The camera should be mounted facing the conveyor belt. Different target objects are placed on the belt [11]. The belt is moved at different speed and the objects placed on the belt are segmented. This workplace design is currently in semi-finished phase and still being developed

2.2. Workplace with industrial robot OTC ALMEGA-AX-V6

The workplace with industrial robot is equipped with welding fixtures that are peripheral devices of robotised workplace determined to accurate positioning of welded parts toward to robot, see Figure 3. It is controlled by control system of robot or superior system [12]. Welding fixture of robotised workplace should be firmly attached or fixed through suitable type of positioner equipped with holder for fixture with one or more axes.

Fig. 3. Workplace with industrial robot OTC ALMEGA-AX-V6

Target groups acquire at this workplace knowledge of programming available for achieving a welding program. A teach pendant is the method to be used. This pendant operates by selecting a coordinate system (joint, world, tool, or user) and moving the robot to each desired position [13]. Each position that is desired for the robot to move to in the program is set by pressing a button to save that point. The positions must be set precisely to avoid collisions with the workpiece and fixture. The speed for each move is set manually using knowledge about the type of weld and material that is being welded [14].

2.3. Workplace with dual arm robot MOTOMAN SDA10F

The workplace with dual arm robot MOTOMAN SDA10F gained great popularity and recognition among the professional and laic community in Slovakia, see Figure 4. Our first pioneer applications included simple handling, assembly tasks, and fun apps. This two-arm robot is an evolutionary step in the development of robotics, with its 7 degrees of arm freedom (7DOF / arm) leading to kinematic redundancy, allowing for example turning the robot arm around its axis and thus manoeuvring out of the dangerous area of objects or human beings.

Fig. 4. Workplace with dual arm robot MOTOMAN SDA10F

Target groups learn at this workplace side by side directly near to robot. The term human-robot cooperation means mutual interaction, which complement each other, for example during assembly, handling, palletising and de-palletising, surface treatment and various technological operations. In such cases, the use of robot in cooperation with the man seems to be an ideal choice [15]. The robot can be used in control and debug applications, which reduce the possibility of human error. It can get into hard to reach places, reach unmatched accuracy and accelerate people's monotonous work.

2.4. Workplace with robot SCARA

The workplace with robot SCARA is designed to increase robotics knowledge in the field of controlling and programming such workplaces and to verify and test the proposed algorithms [16]. Main part of this workplace is an industrial robot SCARA, type YK600K with QRCX control system together with Omron F150-3, camera system, see Figure 5.

Fig. 5. Workplace with robot SCARA

The interconnection between camera system and the CP1H control PLC is ensured via the RS232C PLC CP1L. Control unit is realised by a touch panel, where two modes can be chosen -- manual and automatic. The pallets are driven by an output conveyor with a palletising and de-palletising unit driven by stepper motors [17]. The individual mounting components are in two vibratory trays and one vibration conveyor.

Components from vibratory trays are taken by robot from fixed positions. The components from the vibrating conveyor are moved to the conveyor belt, and transported below the cameras, where their positions are aligned. After that – sent to the workplace control system (PLC CP1H), which issues commands for the QRCX robot control system [18]. The robot receives component coordinates on the input conveyor and moves to the desired positions, where the part is grabbed and then stored on the pallet. The palletiser and de-palletisation system provides for empty pallets and removal of full pallets. Workplace is equipped with a replacement effector system in case there is a change of components in the workplace.

3. Conclusions

The presentation of industrial laboratory status and its in-depth description, as well as examples of the basic and advanced workplaces available for the target groups have shown that it is a very important part of a broad robotics curriculum. In addition, by providing target groups with hands-on experience with real robots, it also develops their problem-solving, teamwork, and observation skills. It has also been noted that flexibility is a vital aspect, as it allows them to explore more particular subjects that arouse their curiosity.

Furthermore, the evolution of the virtual Moodle class over the RUSOS project duration has taught us important training materials about this kind of course that are also relevant in different applications. The hardware and programming environment should allow target groups to develop their creativity. It is hoped that the created learning materials learned, and important robotic workplaces presented in this paper might be of use to others pursuing similar educational projects.

Acknowledgements

This paper is the result of the Project implementation: University Science Park TECHNICOM for Innovation Applications Supported by Knowledge Technology, ITMS: 26220220182, supported by the Research & Development Operational Programme funded by the ERDF.

The paper presents results of researches supported by EU within the project RUSOS „Robotics for teachers of secondary vocational schools”, 2015-1-SK1-KA202 - 008970, under the ERASMUS+ Programme. This publication represents only the author´s opinion and neither the European Commission nor the National Agency is responsible for any of the information contained in it.

4. References

[1] C. Cosma, M. Confente, D. Botturi and P. Fiorini, "Laboratory tools for robotics and automation education," 2003 IEEE International Conference on Robotics and Automation (Cat. No.03CH37422), 2003, pp. 3303-3308 vol.3. doi: 10.1109/ROBOT.2003.1242100

[2] Belavý, C.: Základy automatizácie a merania. Bratislava: Nakladateľstvo STU, 2012. 183 s. ISBN 978-80-227-3839-2.

[3] Hajduk M., Balaz V., Koukolova L., Zubrzycki J. "Proposal of multi robotic cells for production lines" Edited by: Hajduk M; Koukolova L. Conference: 13th International Conference on Industrial, Service and Humanoid Robotics (ROBTEP). Applied Mechanics and Materials Vol. 613 pp. 60-65. DOI: 10.4028/www.scientific.net/AMM.613.60

[4] Olaru, A., Oprean, A., Olaru, S., Paune, D. Optimization of the neural network by using the LabVIEW instrumentation, IEEE ICMERA 2010 Proceedings, ISBN 978-1-4244-8867-4, IEEE catalogue number CFP1057L-ART, pp.40-44, 2010.
[5] https://labs.wsu.edu/robotics-and-automation/automation/
[6] A. Piotrowski, T. Nieszporek. Setting up a work centre based on the Profibus network, In.Applied Mechanics and Materials, Vol. 282 (2013),pp. 51-58.
[7] Bukoveczky, J., Gulan, L., Schmidtova, C., Izrael, G.: Fundamentals of mechanical engineering. Bratislava: Vydavateľstvo STU, 2016. 168 s. ISBN 978-80-227-4623-6.
[8] J. Lalonde, C. P. Bartley and I. Nourbakhsh, "Mobile robot programming in education," Proceedings 2006 IEEE International Conference on Robotics and Automation, 2006. ICRA 2006., Orlando, FL, 2006, pp. 345-350. doi: 10.1109/ROBOT.2006.1641735
[9] Peciar, P., Fekete, R., Peciar, M.: Procesné strojníctvo II. Bratislava: Vydavateľstvo STU, 2016. 177 s. ISBN 978-80-227-4540-6.
[10] Hajduk, M., et al.: Trends in industrial robotics development. In. Applied Mechanics and Materials, Vol. 282, ISSN 1660-9336, pp. 1-6. (2013)
[11] Poppeová, V. – Čuboňová, N. – Uríček, J. – Kumičáková, D.: Automatizácia strojárskej výroby. Žilina EDIS – vydavateľstvo ŽU, október 2002, ISBN 80-8070-009-5.
[12] Beniak, Juraj - Križan, Peter - Matúš, Miloš - Kováčová, Monika: The operating load of a disintegration machine. In: Acta Polytechnica. – ISSN 1210-2709. - ISSN 1805-2363. - Vol. 54, No. 1 (2014), s. 1-5
[13] Duchoň, F.: Snímače v mobilnej robotike. Bratislava: Nakladateľstvo STU, 2012. 97 s. ISBN 978-80-227-3801-9.
[14] Šolek, P., Sztankay, J.: Inžinierska mechanika I. Bratislava: Nakladateľstvo STU, 2013. 114s. ISBN 978-80-227-4024-1.
[15] Skařupa, J., Mostýn, V. Metody a prostředky návrhu průmyslových a servisních robotů. 1. vyd. Košice : Edícia vedeckej a odbornej literatúry – strojnícka fakulta TU v Košiciach, Vienala Košice, 2002. 190 s. ISBN 80-88922-55-0.
[16] Vítečková, M., Víteček A.: Základy automatické regulace. Ostrava: VŠB - Technická univerzita, 2006. ISBN 80-248-1068-9.
[17] M. Kelemen, T. Lipták, I. Virgala: Elektromechanické systémy: TU Košice, SjF, 2016. 184 s.. ISBN 978-80-553-3105-8.
[18] Homišin, J., Bigoš, P., Sága, M., Němeček, P., Dejl, Z., Harlecki, A., Gancarczyk T., Pešík, L., Vereš, M., Gaduš, J., Stadnicki, J.: Súčasné trendy optimalizácie strojov a zariadení, C-Press Košice 2006, ISBN 80-8073-656-1