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Designing a Training Tool for an Industrial Robot Operating with a Programmable Logic Controller

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Abstract: The industry sector has a complex manufacturing process and technology, mainly utilizing robots and automation, which are necessary for factory operation. Many vocational colleges try to use methods to promote the students' experience of learning automation technology to control robots with a programmable logic controller (PLC). Preparing students who will use technology in Industry 4.0 with robot arm operation is essential. However, the learning tools used to practice based are high-cost, and the technology is constantly changing and evolving. Hence, this research aims to design a training tool for an industrial robot operating using a programmable logic controller (IRO-PLC). The proposal shows that the design training model can simulate steps of the learning activity to control the robot with PLC and then display it on the dashboard with an IoT device. It can increase the student's performance in practical vocational education training in future studies.

Keyword: industrial robot, PLC, learning factory

1. Introduction

Nowadays, manufacturing in Industry 4.0 must refer to the digital database connection and take advantage. It is a significant challenge for the industry. Consequently, training students and professionals must address these new demands (Fuertes et al., 2021). It should be absorbed and applied in education, primarily Industry 4.0 learning and 21st-century teaching focusing on sustainable development goals for innovative knowledge and skills (Nurtanto et al., 2020).

Using robots for education has a rapidly increasing rate. Due to the increasing interest in STEM (Science, Technology, Engineering, and Mathematics) education (Mamatnabiyev et al., 2023). Many studies presented that robot learning activities, such as gamified educational robots, improve student achievement and learning motivation (Yang et al., 2023). Furthermore, using students' guidance with web-based personalized learning improves vocational students' performance in industrial robotics (Wanichsan et al., 2021). The use of educational robots has increased rapidly over the past few years due to the growing interest in STEM education. Primarily, the educational robot for practicing the Internet of Things (IoT) using hands-on experiences increased (Mamatnabiyev et al., 2023).

Programmable Logic controllers (PLC) currently form a crucial technological basis for the automation of industrial processes. Hence, industry 4.0 assumed that these controllers would continue to be important and required to a considerable extent for the manufacturing process. (Langmann, et al., 2019). Some study designed of electro-pneumatic controlled color selector robot arm was performed with PLC (ŞAHİN et al., 2020).

The learning material or training tool was developed to solve the significant problems of the students' difficulty in understanding the basic concepts of the lesson and the lack of learning tools in the classroom. It was developed to solve the significant problems of the students' difficulty in understanding the basic concepts of the lesson and the lack of learning tools in the classroom (Abdullah et al., 2021). However, the existing training tool does not meet the course content requirements, and students need to understand due to the limitations of the training tool that unconnected actual situations and learning experiences.

This study focuses on designing a training tool to simulate the technology of controlling industrial robots' operation with PLC in manufacturing process. In the design process, we use a training tool consisting of a Mitsubishi FX5U PLC and a Dobot Magician 4-axis robot, and a belt conveyor.

2. Related work

2.1 Training of Industry 4.0 technology

Learning factories are understood to be environments that provide practical experiences to these professionals, preparing them in the best way possible for the requirements of Industry 4.0, such as information and communication technology, algorithms, and automation. Industry 4.0 integrates various sectors' digital technologies, automation, data exchange, and advanced manufacturing techniques. It represents a significant transformation in how products are designed, manufactured, and delivered, which are some key aspects of Industry 4.0. (Kipper et al., 2021; Li, 2022; Pozzi et al., 2023). The practical integration of the manufacturing processes and cutting-edge technologies of intelligent manufacturing is important in engineering education and related files (Wang et al., 2021). Therefore, learning industrial robots operating using PLC requires knowledge and practical skills efficiently learning outcomes, as shown in Table 1.

Table 1. *The learning outcomes of training concepts.*

Concepts	Learning outcomes
Programmable logic control	Use programmable logic control hardware.
Ladder programming	Write a PLC ladder program.
Industrial Robot	Use industrial robots in many tasks.
Connect the PLC to the robot	Control the industrial robot to complete the mission with PLC.
IoT dashboard	Display information on the dashboard

In addition, a dashboard displays essential information such as data, figures, and performance indicators in an easy-to-understand format. It provides generalizations to help users review, analyze, and decide based on the information presented. Node-RED is a development tool for connecting hardware devices. The application interface and the online service have a browser-based editor to enable co-wiring using a variety of nodes in the palette. The industrial flows automation created in the Node-RED tool and a programmable logic controller (PLC) can be stored, imported, and exported for information sharing as a dashboard in the gateway connected with the open platform communications unified architecture (Chookaew & Howimanporn, 2022).

3. Industrial Robot Operating System using Programmable Logic Controller

3.1 Proposed Training model

In this study, we designed a training tool that emphasizes the practice of students or employees based on Industrial 4.0. The training course contains practical activities that can perform the relevant tasks. To understand how to control robots with programmable logic controllers. We have training activities to carry out and prepare appropriate equipment or materials based on the concept. After that, the data shows on the IoT dashboard, as shown in Figure 1.

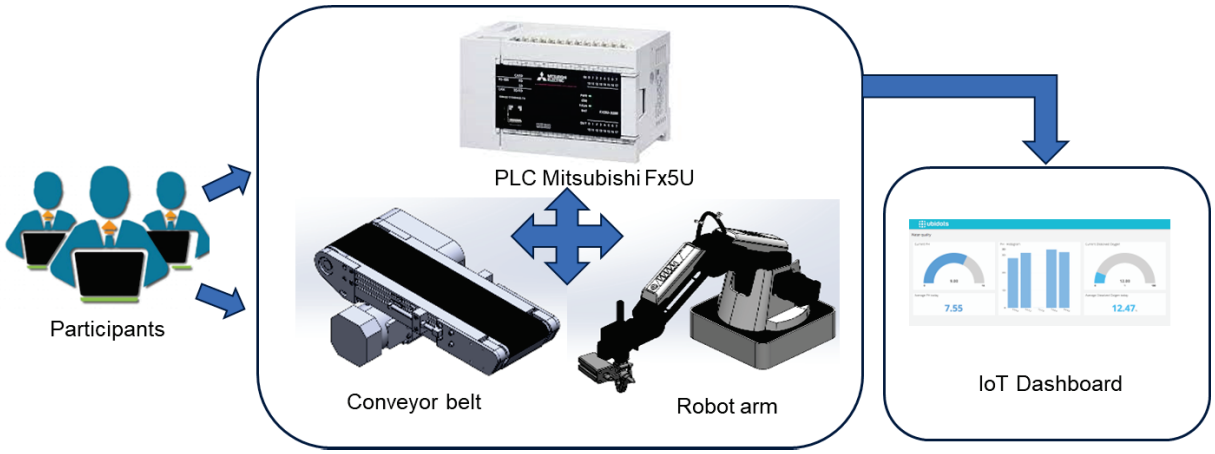

Figure 1. Training model framework.

3.2 Structure of Training kit

Structural design of the training kit, we have identified the performance of the training equipment that can be compared to the situation of robot control. Figure 2 shows the structure of training kits consisting of PLC (Mitsubishi FX 5 U) as a device that automatically controls machinery and Dobot Magician 4-axis robot arms pick and place the box in the pallet of missions.

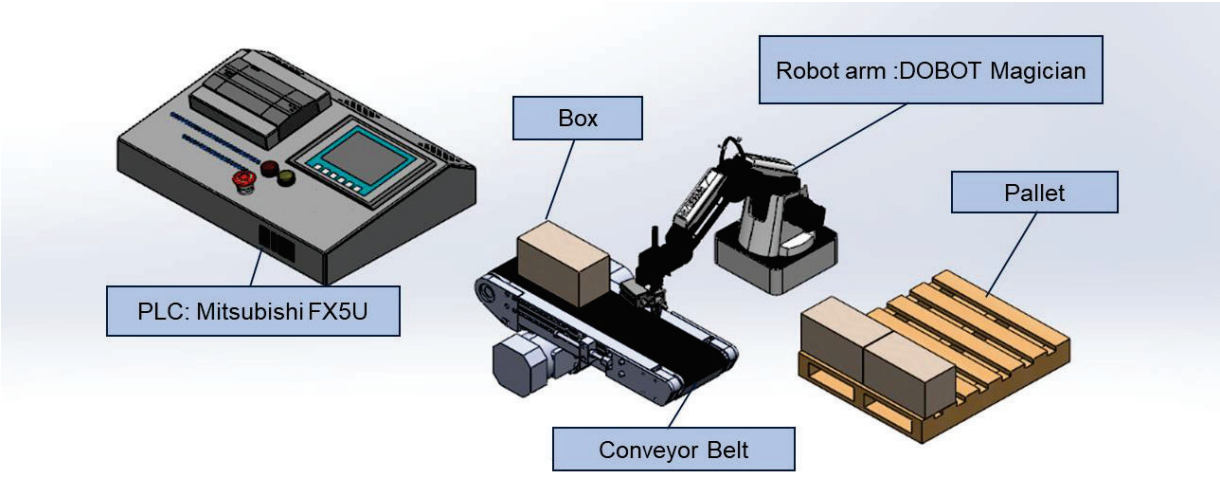

Figure 2. The structure of training kits.

3.3 Training Activity

We focus on supporting the vocational education students' understanding and practicing with robot control activities using PLC programs. They must work in groups to achieve the tasks that control the robot based on conditions and mission. They can set up the PLC station's structure and connect the conveyor belt and robot arm to pick and place, as shown in Figure 3.

Figure 3. Example of the student participating in training activities.

4. Conclusion and Future Work

This study proposes a training model consisting of a training tool for a robot control system using a programmable logic controller. Hence, this research aims to design a training tool for an industrial robot operating using a programmable logic controller (IRO-PLC). The proposal shows that the design training model can simulate steps of the learning activity to control the robot with PLC and then display it on the dashboard with an IoT device. It can increase the students' learning achievement who participate in training activities. We plan to develop the training tool and investigate the effectiveness of the proposed. In addition, we will compare the pre-and post-test students' performance. Furthermore, it evaluates attitudes and involvement toward training as part of future work.

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