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Designing a Sorting System using Machine Vision Training Kit for Mechatronics and Robotics Engineering Students

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Abstract: Machine vision is even more critical for sorting workpieces in quality control of automated production systems for Industry 4.0. Use the image processing system principle to inspect the workpiece with a high-speed vision sensor camera. It results in high accuracy of sorting performance and can replace labor in automated production processes. The learning process of vision sensors used for inspecting workpieces with industrial cameras for mechatronics and robotics engineering students is concerned. Most barriers need more teaching materials due to the relatively high cost of the training kit. That is causing students' lack of knowledge and practical skills during the professional training experience in the workplace. This study proposed designing a sorting system using a machine vision (SSMV) training kit for mechatronics and robotics engineering students. It can be a learning tool to promote the students' learning in related fields, automated manufacturing systems, and engineering education.

Keywords: Machine Vision, Industry 4.0, engineering education

1. Introduction

Current technology machine vision will have many of these tasks in production by quality control to inspect the workpiece. Sorting workpieces are a topic in the production process with automatic control systems to sustainably increase the country's competitiveness and elevate the country's industry into Industry 4.0 (Eduardo et al., 2020). An automated control system for sorting people with machine vision uses a programmable logic controller to centralize automation (Li, 2020; Li et al., 2023). In addition, the sorting system with machine vision data results are displayed in real-time on the dashboard. At present, many members are often referred to as open (OPC-UA) on the Node-Red dashboard (Chookaew & Howimanporn, 2022). Many studies have found that learning the factory concept appropriate for engineering education, especially teaching, and learning about vision sensors, can develop the students' competency by learning from the training kit (Louw & Droomer, 2019). Penumuru et al. (2020) propose an automated material identification method with machine vision and machine learning algorithms to enhance the cognitive abilities of machine tools and material handling devices in Industry 4.0.

This study proposed designing a sorting system using a machine vision (SSMV) training kit for mechatronics and robotics engineering students. It can be a learning tool to promote the students' learning in related fields, automated manufacturing systems, and engineering education.

2. Related Works

2.1 Machine vision

Machine vision or computer vision is a field of artificial intelligence (AI) and computer science that focuses on enabling machines to interpret and understand the visual world. It involves the development of algorithms and technologies that allow computers to process and analyze visual information, such as images and videos (Javaid et al.,2022). Machine vision is significant in sorting workpieces for the quality control of automated production systems for industry 4.0 technology (Li et al., 2023; Chookaew et al., 2022). Machine vision application in the industrial sector is talent learning and training in colleges and universities for educator design learning process (Chaoqun et al., 2023). Benbarrad et al. (2021) presented using machine vision for predicting the most suitable parameters of production processes to obtain a defect-free item by identifying the defective products and continuously improving manufacturing processes based on quality management requirements in Industry 4.0.

2.2 Learning outcome

We analyzed the curriculum's learning objectives for mechatronics and robotics engineering students and requirements from the industrial sector about applying industrial technology and devices, especially vision sensors, for inspecting workpieces with industrial cameras. Hence, learning outcomes are essential to measure student achievements after completing the learning activity. In this study, the learning outcomes aligned with the concept of a sorting system using a machine vision training kit for students are shown in Table 1.

Table 1. *The learning outcomes*

Concepts	Learning outcomes
1. Machine Vision system	Able to use a vision sensor for inspection to sort materials.
2. Programmable Logic Controller (PLC)	Able to use PLC to control the operation of hardware devices.
3. Ladder programming	Able to write ladder logic programming for operating with PLC.
4. Pneumatic cylinders	Able to write programming to control pneumatic cylinders for sorting materials.
5. Dashboard	Able to display the data or information on the dashboard with Node-RED.

3. Designing the SSMV training kit

3.1 Elements of Training

This study focuses on designing the training processes to foster students' understanding of the principle of machine vision and the operation of sorting object systems. Figure 1 show the process diagram of the SSMV consisting of three elements as follows:

- *Input:* This phase is first in the production line that uses a vision sensor to inspect types of material with a machine vision system. The student can understand and use devices to input image data.
- *Process:* This phase is process control. We employ the programmable Logic controller (PLC) model Omron NX1P2 to process the sorting system machine vision between input and output. The student can program to control the sorting system.
- *Output:* This phase shows the data output after the complete process. A Node-RED dashboard receives data from PLC (Omron NX1P2) to display the visual inspection data on a monitor or a web browser. The student can show all data on a mobile device.

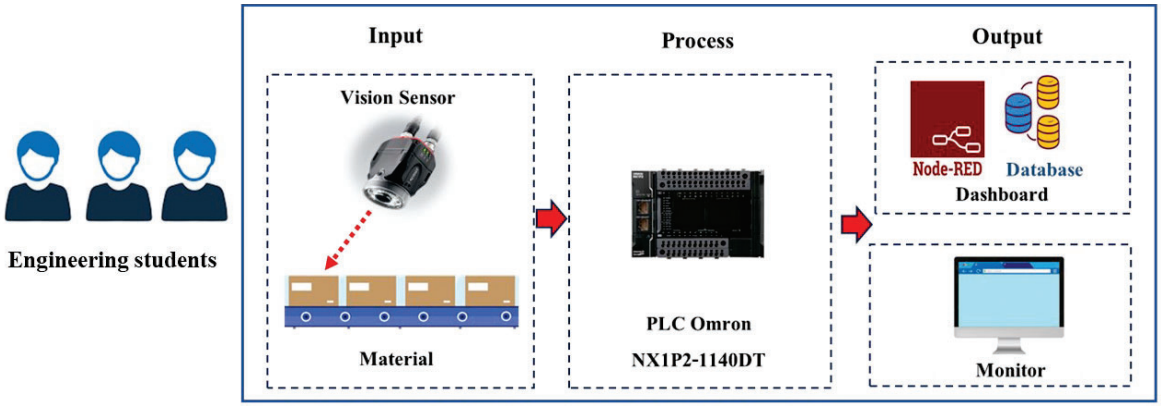

Figure 1. The process diagram of the sorting system using machine vision.

3.2 Design of training kit

Figure 2 shows the structure of the machine vision training kit, we have designed the machine vision process based on factory learning concept. This training kit consist of:

- A structure body is an aluminum profile, conveyor, storage materials, storage OK materials, and storage OK Materials.
- Switch control is four switches (Emergency switch, stop switch, start switch, and reset switch) for control machine vision training Kit.
- The sorting unit consists of Cylinder 1 for sorting the OK part and Cylinder 2 for sorting the NG part.
- The workpiece detection unit uses a vision sensor (Keyence IV-500CA).
- Programmable Logic Controller (PLC) (Omron NX1P2) is an element that automatically controls the sorting system using machine vision.

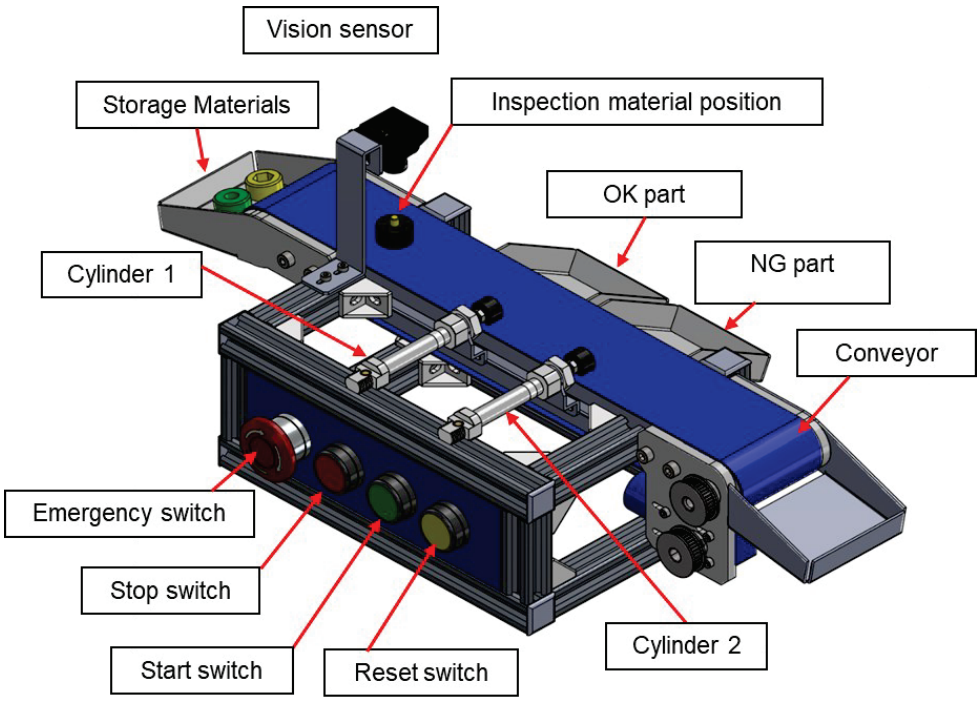

Figure 2. The structure of the machine vision training kit

3.3 Dashboard

A dashboard is a user interface that provides a consolidated visual representation of various data and metrics. It is designed to give users a quick and comprehensive overview of the state of an industrial process that involves data-driven insights. In this study, we use a Node-Red tool then create a dashboard that displays the number of inspections of 3 types of workpieces from the vision sensor. Each class will separate the characteristics of good (OK), defect (NG), and the total number of workpieces in each sorting. However, it allows students to study and analyze the data to determine the efficiency of the SSMV (see Figure 3).

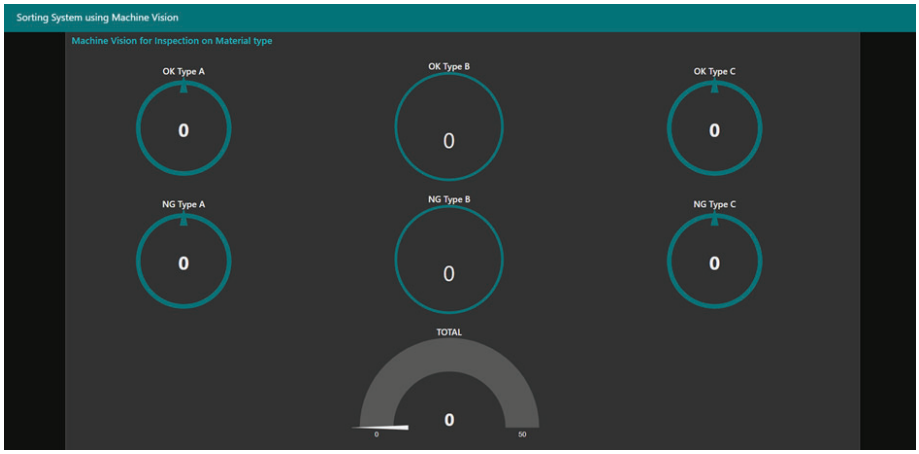

Figure 3. The screen snapshot of the Node-RED dashboard.

4. Conclusion and Future work

This paper presents designing a sorting system using a machine vision (SSMV) training Kit for mechatronics and robotics engineering students. This proposed application of machine vision to visual inspection material for automatic sorting is implemented for mechatronics and robotics engineering students based on factory learning. In addition, to encourage students to master using vision sensors, PLC programming skills, and building dashboards on a Node-Red tool. To ensure that this learning kit can improve the students' learning achievement and motivation, we plan to implement it with the students in future study.

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