

การพัฒนาอุปกรณ์ควบคุมและแสดงผลสำหรับระบบการเรียนรู้การผลิต โดยใช้เทคโนโลยี IIoT

Control and Display Development for the Production Learning System Using IIoT Technology

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บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อพัฒนาอุปกรณ์ควบคุมและแสดงผลสำหรับสถานีประกอบและคัดแยกภายในระบบการเรียนรู้การผลิตของคณะวิศวกรรมศาสตร์ มหาวิทยาลัยนราธิวาสราชนครินทร์ โดยใช้เทคโนโลยี IIoT เพื่อเน้นการพัฒนาอุปกรณ์ควบคุมและแสดงผลสำหรับกระบวนการผลิตเพื่อการศึกษา งานวิจัยนี้ได้บูรณาการ Node-RED และ NETPIE เพื่อควบคุมระบบและแสดงให้เห็นถึงการประยุกต์ใช้งานที่ประสบความสำเร็จในสถานีการผลิต 3 แห่ง ได้แก่ สถานีกระจายชิ้นงาน สถานี Pick and Place และสถานีคัดแยก ระบบนี้แสดงถึงการทำงานแบบอัตโนมัติด้วยการใช้ Programmable Logic Controller (PLC) และการตรวจสอบและควบคุมระยะไกลอย่างมีประสิทธิภาพผ่าน IIoT โดยบรรลุเป้าหมายในการเพิ่มประสิทธิภาพของการควบคุมและแสดงผลในกระบวนการผลิตเพื่อการศึกษา ผลการทดลองระบุว่าระบบสามารถทำงานได้อย่างถูกต้อง โดยสามารถแยกชิ้นงานที่มีความลึกหรือตื้นในชิ้นงานหรือภาชนะได้ด้วย ความแม่นยำร้อยละ 83.3 นอกจากนี้ ระบบยังสามารถแยกชิ้นส่วนสีแดง สีดำ และชิ้นส่วนโลหะได้ด้วยความแม่นยำร้อยละ 93 วิธีการนี้ช่วยลดเวลาในการผลิต ลดเวลาหยุดทำงาน และลดต้นทุนการผลิตโดยรวม

คำสำคัญ : ระบบควบคุมและแสดงผล, IIoT, อินเทอร์เน็ตของสรรพสิ่ง, Node-RED, Netpie

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การพัฒนาอุปกรณ์ควบคุมและแสดงผลสำหรับระบบการเรียนรู้การผลิต โดยใช้เทคโนโลยี IIoT

Control and Display Development for the Production Learning System Using IIoT Technology

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Abstract

This research aims to develop control and display systems for assembly and sorting stations within the Production Learning System at the Faculty of Engineering, Princess of Naradhiwas University. By leveraging IIoT technology, the focus is on creating control and display systems for educational manufacturing processes. The research integrates Node-RED and NETPIE to control the system and demonstrates its successful application in three production stations: Distribution, Pick and Place, and Sorting. The system showcases automatic operation using a Programmable Logic Controller (PLC), and effective remote monitoring and control via IIoT, achieving the goal of enhancing manufacturing process control and display for educational purposes. The experiment results indicate that the system functions correctly, separating defective parts based on depth or shallowness within workpieces or containers, with an accuracy of 83.3%. Additionally, the system accurately identifies and separates red, black, and metal parts with a 93% accuracy rate. This approach reduces production time, minimizes downtime, and lowers overall production costs.

Keywords : Control and display systems, IIoT, Internet of things, Node-RED, Netpie

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1. Introduction

Now, industrial plants rely on skilled personnel due to rapidly evolving technology. Some companies with limited budgets struggle to hire sufficient skilled employees, making it difficult to maintain thorough system control. This can lead to issues like raw materials being input but not output, particularly during periods of increased production demand, hindering output. Therefore, implementing employee rotation to oversee and maintain machinery is crucial.

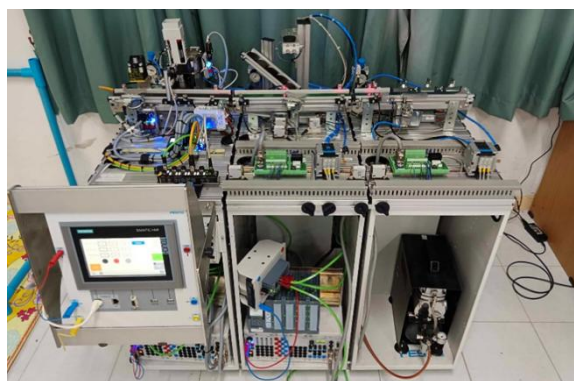
Industrial Internet of Things (IIoT) leverages IoT technology to enhance industrial efficiency, productivity, and visibility. By utilizing connected devices, sensors, and machines, IIoT collects data on equipment performance and other critical parameters. This data is transmitted wirelessly through gateways and networks to IIoT platforms for analysis and visualization. IIoT platforms facilitate remote monitoring and control of equipment and processes, enabling remote control and automation.

The Faculty of Engineering at Princess of Naradhiwas University operates an automated replica watch production line for educational purposes. This system employs a Programmable Logic Controller (PLC) integrated with an electro-pneumatic system to control production processes. A Supervisory Control and Data Acquisition (SCADA) system monitors and displays system performance. Students can utilize this system to learn about various aspects of automated production control, including:

- Current production rate (piece /minute)
- Total production quantity (piece /month)
- Waste rate (units/production quantity)
- Machine status (working/not working)

- On/off switch (display and control)
- Machine failure (normal/error)

A measurement system with sensors collects data on these parameters. However, the current system still requires human operators to work directly with the machines. To bridge the gap between academic knowledge and future technological advancements, it's essential to consider implementing remote monitoring and control capabilities, as illustrated in Figure 1



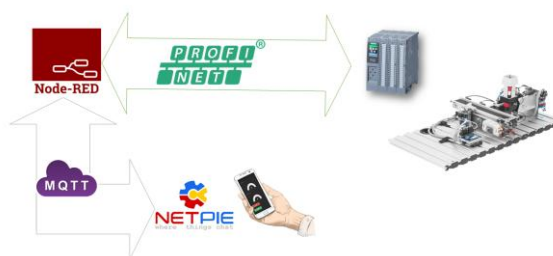
Figures 1 Production Learning System Faculty of Engineering Princess of Naradhiwas University

This Production Learning System is a simulated production system featuring a system for sorting, assembling, and storing workpieces, as well as controlling and displaying results on the machine screen. Students can design and install this entire system. This research, therefore, aims to develop a control and display system for the manufacturing industry using IIoT technology. This system would enable employees to control production processes via Control and Display Systems on smartphones or notebooks connected to the internet network.

2. Methods

This research has utilized Node-RED and NETPIE in IIoT. Node-RED is an open-source visual programming platform that enables users with little coding experience to develop IIoT applications. By using a drag-and-drop interface, users can connect pre-built nodes (functions) to visually design workflows for data processing, analysis, and visualization. The available nodes cover various functionalities, such as data acquisition, communication protocols, data analysis, and visualization. This flexibility and customization capability allows for the creation of tailored IIoT solutions without requiring extensive coding knowledge. NETPIE is an IIoT platform that collects data from sensors and devices and securely stores it in the cloud. It also offers data visualization and analytics tools, such as dashboards, to visualize, analyze, and understand the collected data.

In summary, Node-RED and NETPIE synergistically empower IIoT development and implementation. Node-RED simplifies the process of building custom applications, while NETPIE provides the essential infrastructure and tools for data management, analysis, and application hosting. To facilitate data exchange between the Network Platform for Internet of Everything (NETPIE) and the Programmable Logic Controller (PLC), Node-RED acts as an intermediary. Node-RED connects to the PLC via an Ethernet network known as Process Field Network (PROFINET), a specialized industrial network designed for connecting and controlling equipment in industrial automation. For data transmission between Node-RED and NETPIE, the MQTT protocol is employed to efficiently send and receive data, as illustrated in Figure 2.



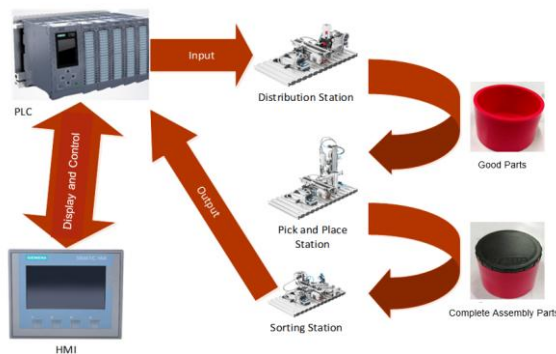
Figures 2 Principles of data transmission of Node-RED and NETPIE

When the system is running, the desired quantity of each color or metal object can be selected via the NETPIE Dashboard or HMI screen. Upon initiating the Distribution Station, it commences releasing pieces and sorting them into good and bad categories. Defective pieces are segregated, and the number of these is displayed on the NETPIE Dashboard and HMI screen. Good pieces proceed to the Pick and Place Station for cover assembly. Subsequently, the workpieces are transferred to the Sorting Station for color and metal separation and collection. Job types and results are displayed on both the NETPIE Dashboard and HMI screens. The system's operational principle is divided into two primary components: 1) the production system and 2) the IIoT system. The production system is the operational process controlled by a Programmable Logic Controller (PLC). A Human-Machine Interface (HMI) will be employed to display data and receive commands for the station. The system comprises three stations: the Distribution Station, the Pick and Place Station, and the Sorting Station. The Distribution Station is the primary workhorse, responsible for:

- Releasing workpieces
- Separating workpieces by color

- Separating metal workpieces

Inspecting workpiece depth. Workpieces that do not meet the specified depth criteria will be deemed unusable. The Pick and Place Station assembles workpiece covers. The Sorting Station stores workpieces by color and separates metal workpieces. A detailed flowchart illustrating the production system's workflow can be found in Figure 3



Figures 3 The production system

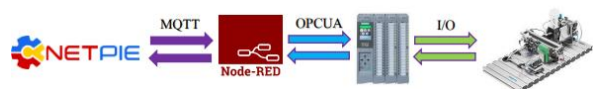
Distributing Station: The process begins with a workpiece being ejected from a magazine and conveyed along a belt. A depth check separates workpieces based on color and material. Subsequently, a depth inspection determines whether the workpiece is within acceptable tolerances. If not, the belt diverts the unusable workpiece to a collection point. Otherwise, the belt directs the acceptable workpiece to the Pick and Place Station for the next stage.

Pick and Place Station: Workpieces arriving from the Distributing Station are conveyed to an assembly location guided by a positioning mechanism. An air cylinder then picks up the workpiece and assembles it with another component. The assembled workpiece is then

conveyed to the Sorting Station for further processing.

Sorting Station: Workpieces from the Pick and Place Station are transported on a conveyor belt to a separation point. Here, color and material differences between workpieces trigger a diversion mechanism. An air cylinder acts as a barrier, redirecting the appropriate workpiece onto a conveyor leading to its designated box, thus concluding the process.

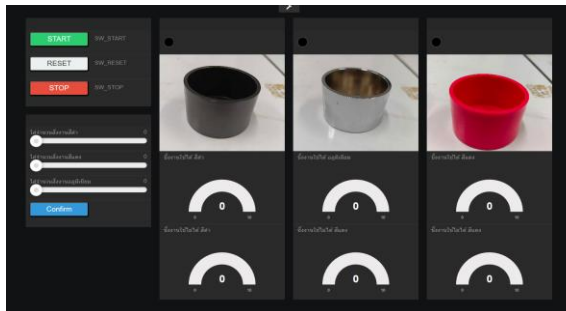
The IIoT system is controlled via the NETPIE dashboard, with Node-RED serving as an intermediary to enable NETPIE to send and receive data from the PLC, which in turn controls the station's operations. The NETPIE dashboard provides three primary control buttons: Start, Stop, and Add. The "Number of Workpieces" field displays the quantity of workpieces required. A flowchart or flowchart system, as illustrated in Figure 4, provides a visual representation of these processes.



Figures 4 Production Learning System Faculty of Engineering Princess of Naradhiwas University

The NETPIE Dashboard page enables the creation of buttons, display of results, and visualization of running situations. These values are then transmitted to Node-RED, an intermediary that facilitates the Dashboard's control over the Station. The Station's operation relies on a PLC to issue commands and define the work processes. The NETPIE Dashboard features a user-friendly graphical user interface (GUI). In the top left corner, there are Start, Reset, and Stop buttons. The bottom left section

includes a slider for adjusting the number of workpieces, along with color-coded buttons (black, red, and metal) and a Confirm button to quickly validate the entered quantity. The middle row displays the counts for black fines, metal fines, and red fines. The bottom row shows the number of black, metal, and red defective items, as illustrated in Figure 5.



Figures 5 GUI design on the NETPIE Dashboard

3. Result

Experimenting with the working systems of all three stations. Distributing Station, Pick and Place Station, and Sorting Station yielded the following results. This experiment aimed to measure the depth of workpieces on the Distributing Station to facilitate separation. The workpieces were positioned face up (in a conforming orientation). A total of 30 pieces, comprising 10 black pieces, 10 red pieces, and 10 metal pieces, were randomly placed and tested, as outlined in Table 1.

Refer with: Table 1, this experiment is an experiment to separate good pieces in order to proceed with the next step in the production process. But there will be damaged workpieces caused by the workpiece being not in the face-up format or the depth value of the workpiece not matching the set value. Most of the time,

mismatched depth values will occur with the workpiece. Black workpiece

Table 1 Experimental results

Type	Quantity	Conformity product	Nonconformity product	True
 Black	10	5	5	50%
 Red	10	10	0	100%
 Metal	10	10	0	100%
Efficiency				83.3 %

The color separation experiment was run on the Dashboard and compare with product on production line. Adding 10 black pieces, 10 red pieces, and 10 metal pieces, with random placement of the pieces refer with: Table 2

Refer with: Table 2, this experiment is an experiment on ordering work on the Dashboard to make the production system work. In this

Table 2 Results of testing work orders on Dashboard

Type	Quantity	Conformity product	Nonconformity product	True
 Black	10	10	2	80%
 Red	10	10	0	100 %
 Metal	10	10	0	100 %
Efficiency				93%

experiment, it can be seen that every workpiece works, but there will be black workpieces that do not work correctly due to the sensor not being able to detect the black workpiece, etc.

4. Conclusion

This research is conducted with the objective of creating a control and display system for a simulated production process using IIOT technology for use in the manufacturing industry using Node-RED and NETPIE so that it can be used to control industrial automation systems. From the scope of the production system, it was found that all 3 stations, namely Distribution Station, Pick and Place Station, Sorting Station, can control the machine from the control panel and have an HMI display screen, use PLC for control and processing, and the system works in a single-handed manner. Automatic As for the scope of the IIOT system, it was found that the control is through the Dashboard of NETPIE and shows the results of the production process that controls the operation of the station. You can press the Start button, the Stop button, and the Add button to be able to count the number of workpieces and display the desired number of workpieces using Node. -Red alerts when there is an error in the production process.

This research was accomplished according to the stated objectives and scope. where the production system the machine can be controlled from the control panel. There is a display screen. The production system works automatically. PLC can be used for control and processing, and the IIOT system can display the results of the production process. Machines can be controlled through the Dashboard using

Node-Red and can be notified when there are errors in the production process.

In future research, Testing and refining the system with real industrial equipment in collaboration with local manufacturing companies by offering workshops and training programs to faculty and students on implementing IIoT in real-world industrial applications. Developing case studies showcasing the system's success in specific scenarios and its potential benefits for local industries. By addressing these considerations and leveraging your existing research as a foundation, you can successfully adapt and scale your IIoT system for real-world industrial applications, contributing to enhanced efficiency and innovation in the manufacturing sector.

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