International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 13, Issue 5 [May. 2024] PP: 132-138

An Efficient Design of Automatic Pharmacy Warehouse Management Systems

D. T. Mai Phuong, Tran Van Chung, Nguyen Tuan Anh, Tran Duc Long
Faculty of Electrical Engineering, Hanoi University of Industry, Hanoi, Vietnam
Corresponding Author: D. T. Mai Phuong

ABSTRACT: *The relentless march of technology has opened new avenues for automation in industrial manufacturing. In today's landscape, Programmable Logic Controllers (PLCs) and image processing technology have emerged as a dominant force in product sorting and quality control processes. These remarkable advancements enable manufacturers to not only enhance productivity but also ensure consistent and precise product quality to previously unattainable levels. This is particularly crucial in high-precision manufacturing sectors such as food, pharmaceuticals, and automotive industries. By leveraging the continuous evolution of technology, the integration of PLC control and image processing technology has unlocked a new realm of intelligent and efficient automation. This paper concentrates on designing an efficient pharmacy warehouse management system by integrating PLC S7-1200 and image processing technology. Experiment results demonstrate the applicability of the proposed system.*
Keywords: *pharmacy warehouse management, PLC, image processing, QR code, identification.*

Date of Submission: 06-05-2024 Date of acceptance: 18-05-2024

I. INTRODUCTION

Pharmacy warehouse management plays a vital role in ensuring the timely and accurate dispensing of medications [1]. Traditional methods often rely on manual labor, which can be susceptible to errors and inefficiencies. To address these limitations, research is exploring the development of automated pharmacy warehouse systems. These systems integrate technologies like image processing and programmable logic controllers (PLCs) for tasks such as:

- Automated product identification: QR codes or other identification tags on medication containers can be scanned using image processing techniques.
- Real-time inventory management: Decoded information from the identification tags can be used by PLCs to update inventory databases and track product expiration dates.
- Automated sorting and transportation: Based on the decoded information, PLCs can control actuators and motors to sort and transport medications to designated locations within the warehouse.

The implementation of such systems has the potential to significantly improve the efficiency and accuracy of pharmacy warehouse operations, leading to better patient care. This paper focuses on the design, development, and implementation of a pharmacy warehouse system that employs image processing and Step SUMTOR motor control. The system utilizes a PLC S7-1200 as the central processing unit and a webcam for image acquisition. A Programmable Logic Controller (PLC) is a specialized industrial computer designed for automation tasks [2-5]. Unlike general-purpose computers, PLCs are ruggedized to withstand harsh factory environments and offer user-friendly programming languages like ladder logic. They excel at real-time process control, monitoring inputs from sensors and machines, and triggering actions based on programmed logic. PLCs are the workhorses of modern manufacturing, playing a critical role in automated production lines, assembly robots, and various industrial control systems.

In the field of computer science, image processing refers to the manipulation of digital images through the application of algorithms [6-12]. This encompasses a broad range of techniques aimed at either enhancing the visual quality of an image or extracting meaningful information from it. Common image processing tasks include noise reduction, filtering for sharpening or blurring, color space conversion, and object detection. These techniques find application in various domains such as medical imaging analysis, autonomous vehicles, and security systems.

Within the realm of image processing, QR code capture plays a significant role in automated data acquisition [13-18]. QR codes, known for their high data density and error correction capabilities, are widely used for product identification, tracking, and information dissemination. Image processing techniques are employed to effectively capture and decode QR code information. This typically involves several steps:

- Image Preprocessing: Captured images may undergo noise reduction and filtering to enhance the QR code's clarity and remove potential artifacts.

- Region of Interest (ROI) Detection: Image processing algorithms identify the specific region within the image containing the QR code, separating it from the background.

- Binarization: The ROI is converted into a binary image, where pixels are classified as either black or white, corresponding to the data modules of the QR code.

- Decoding: Specialized algorithms analyze the patterns within the binary image to extract the encoded information from the QR code.

By leveraging these image processing techniques, automated systems can efficiently capture and interpret QR code data, enabling applications in various industries such as supply chain management, product authentication, and mobile marketing.

This paper focuses on designing an efficient practical system to automatic pharmacy warehouse management. The experiment results demonstrate that the system operates stably, accurately identifies and categorizes boxes based on QR codes, and has a relatively fast transport time.

II. SYSTEM DESIGN

2.1. HARDWARE SETUP OF THE MODEL

The real-world model comprises two primary components: the control cabinet and the external mechanical structure (see Fig. 1). The external structure features a conveyor belt driven by sensor signals mounted on the conveyor body. This belt transports products from the drop-off point to the scanning and sorting station. Here, a camera utilizes image processing technology to read QR codes on each product. Based on the control algorithm programmed onto the Siemens S7-1200 PLC [11], the system receives signals from the image processing computer via the TCP/IP communication port. This information is then used to sort and move products to predefined positions within the storage area. The sorting operation is performed by a system comprised of two stepper motors [12], their lead screws, and a cylinder that facilitates product movement to nine designated storage positions. The system operates smoothly, automatically, and exhibits stable performance.

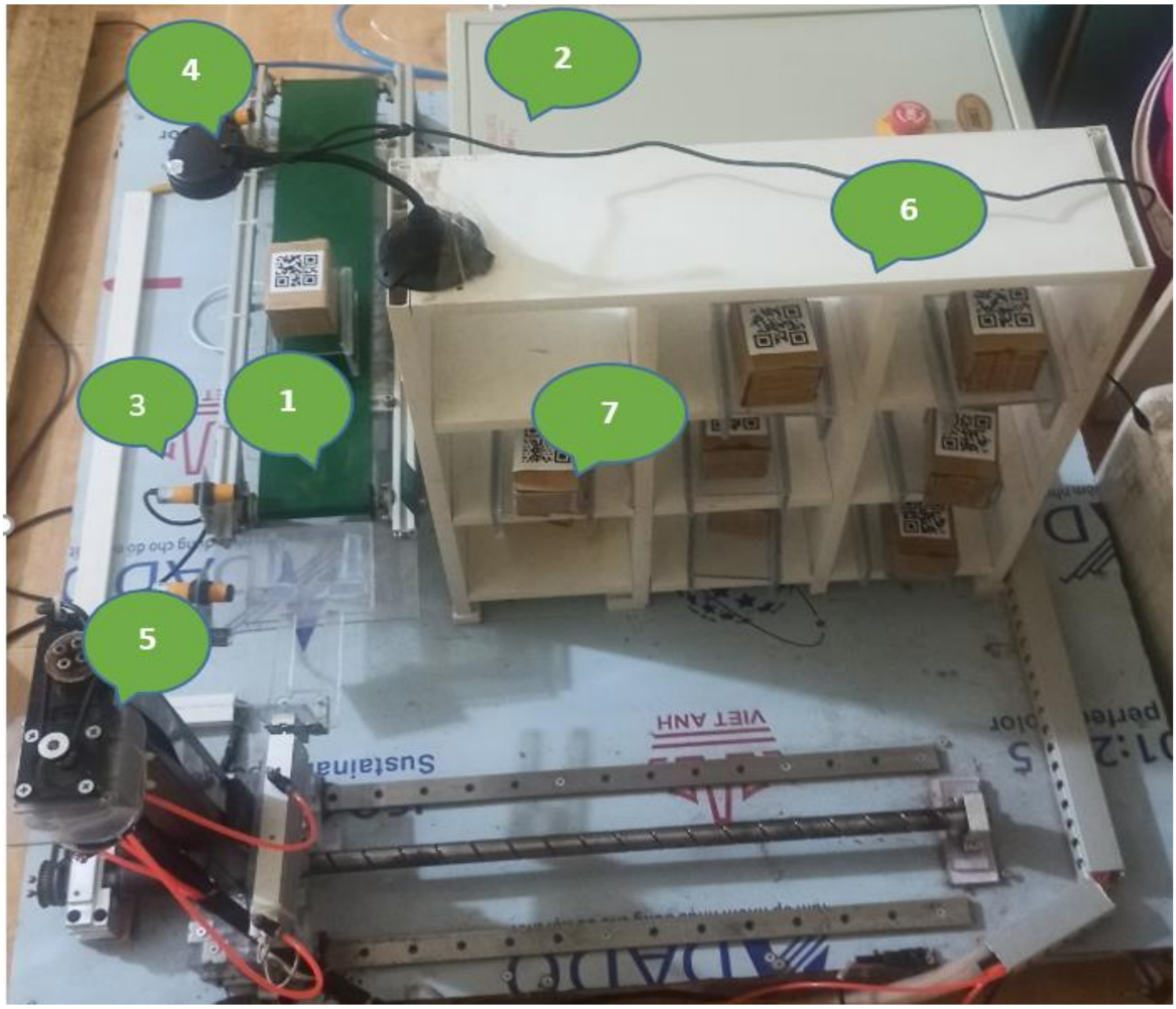

Fig. 1 Practical mode built in this work

The main parts of the system shown in Fig. 1 are listed in Table 1.

1	**Conveyor belt**
2	**Control cabinet**
3	**sensor**
4	**Camera**
5	**Step motor and lead screw system**
6	**Product storage**
7	**Sorted products**

Table 1. The main components of the model

The control cabinet includes the following components: a 2-phase circuit breaker, an intermediate relay, a PLC S7-1200, two step motor drivers, a power converter from 220V to 24V, terminal blocks and a 5/2 solenoid valve shown in Fig. 2. First, the system is supplied with 220V AC power through a 2-phase circuit breaker. This breaker then supplies power to the power converter, which transforms 220V AC to 24V DC. This conversion is necessary because all the devices in the control cabinet, as well as the control devices, operate on

24V DC. From this 24V source, power is distributed through terminal blocks and supplied to devices such as the PLC S7-1200 and two step motor drivers. The PLC S7-1200 receives signals from sensors on the conveyor belt [13](băng tải), cylinder, and step motor axes, using this data to control the system's operations. The conveyor belt is controlled via the Q0.4 output pin through an intermediate relay to protect the PLC. The two step motors are controlled via the output pins Q0.0, Q0.1, Q0.2 and Q0.3, which are connected to the drivers of the two motors. The cylinder is controlled via the Q0.5 output pin. Additionally, the PLC receives and processes signals from the image processing system of the control computer, and the entire system is managed through the WinCC interface, designed in the PLC S7-1200 program.

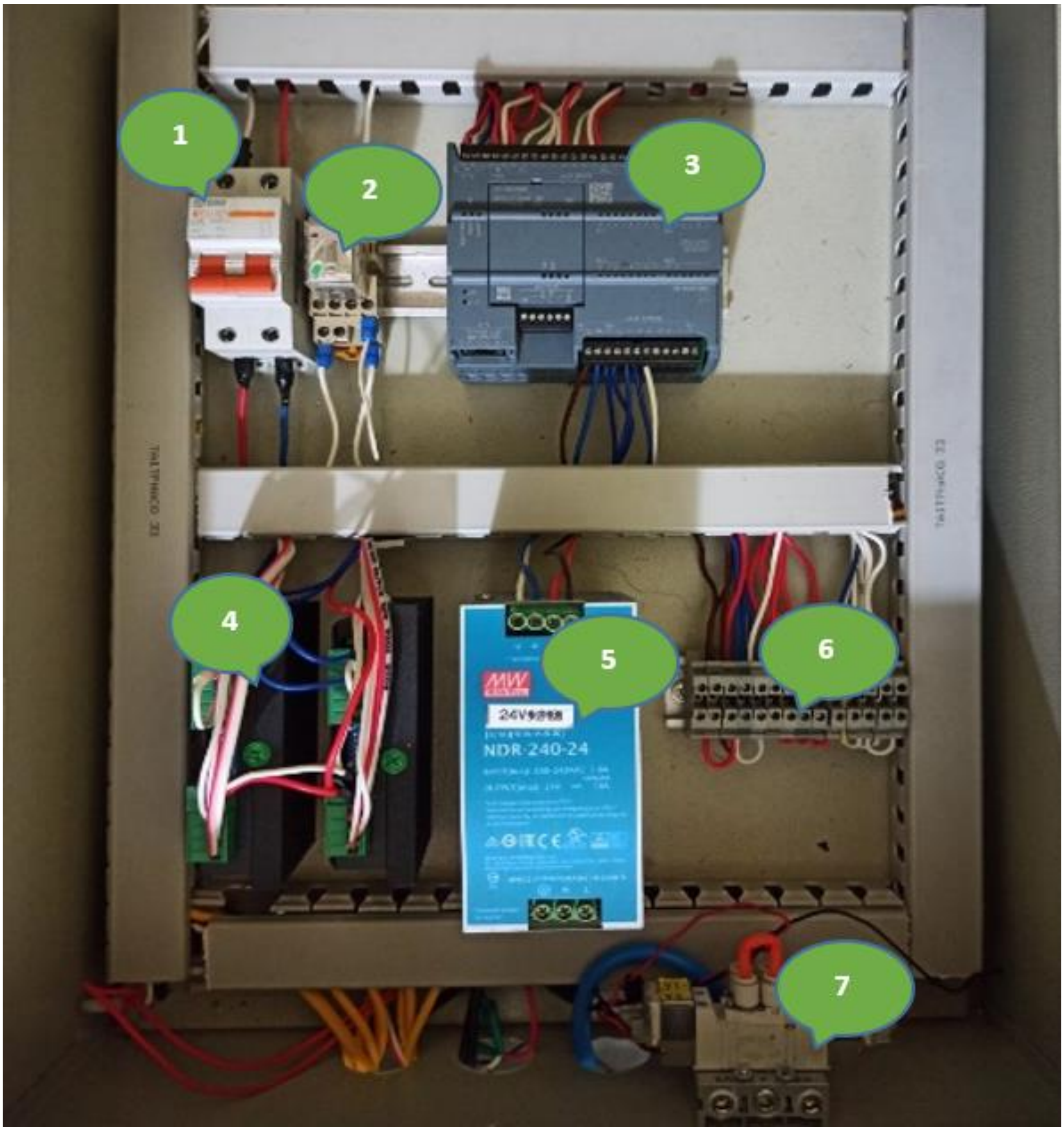

Fig. 2 Control cabinet

The devices included in the control cabinet are indicated in Table 2.

1	**2-phase circuit breaker**
2	**Intermediate relay**
3	**PLC S7-1200**
4	**Step motor drivers**
5	**Power converter from 220V to 240V**
6	**Terminal**
7	**5/2 solenoid value**

Table 2. Devices included in the control cabinet

2.2. SOFTWARE CONTROL SETUP

The system software encompasses two key components: a control program for the PLC S7-1200 developed on TIA Portal V17 [13, 14] and an image processing program implemented using PyCharm Community Edition. The PLC control program, acting as the system's central processing unit, manages various components like the conveyor belt, stepper motor drivers, and the 5/2 solenoid valve. It utilizes control algorithms and integrates the WinCC control interface for user interaction. The WinCC interface shown in Fig. 3, designed within TIA Portal V17, offers functionalities like speed control, forward and reverse motor rotation, saving and displaying axis coordinates, and visualizing the quantity of classified products.

The image processing program, analogous to the system's eye, reads product QR codes and transmits signals to the PLC to facilitate the sorting process.

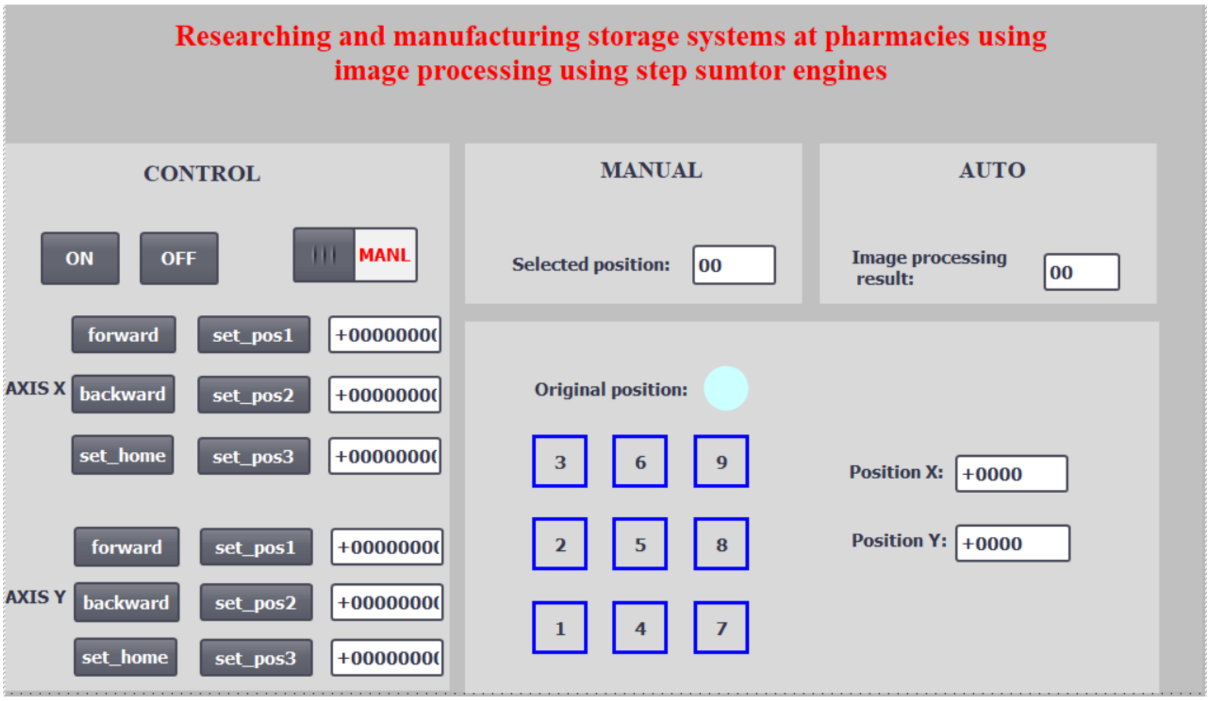

Fig. 3 WinCC system control interface

The control blocks consist of the following functional blocks:

1. The Control Block not only serves as the power source and regulates the forward and reverse movements but also stores the original position of the system's two axes. Additionally, it records and displays the movement positions of these axes. With each axis capable of three positions, the system can allocate nine positions for product classification, meticulously calculated and stored

within the system's programming code.

2. The Manual Block indicates the selected position for product storage.
3. The Auto Block displays the image processing results, indicating that the system will automatically classify products based on this outcome.
4. The Display Block showcases the classified product positions (with inventory), signals the return to the original position, and displays the current position of both axes.

Fig. 4 Image processing results

This work leverages PyCharm, a software environment for Python programming, to develop the image processing and product classification functionalities. The Python code integrates various libraries, with OpenCV being the most prominent. OpenCV is a widely used open-source library offering comprehensive computer vision and image processing capabilities. As a product reaches the designated barcode scanning zone, its QR code is captured by the webcam. The captured image is then displayed on the user interface for verification and subsequently transmitted to the PLC for classification purposes. Based on the decoded information, the PLC directs the product's movement to its predefined storage location. The image processing results are experimentally shown in Fig. 4.

III. CONCLUSIONS

This paper has presented the development of a system that integrates PLC control of a 3-axis system with a camera to achieve product detection, classification, and positioning. The system has been designed for continuous and synchronized operation.

(1) Key Features of the Proposed System:

- PLC Control Algorithms: The system leverages PLC control algorithms for efficient management of the 3-axis system.
- Modular Design: The system boasts a simple, easily installable, and adaptable structure, facilitating deployment and potential reconfiguration.
- Tunable Performance: By carefully adjusting relevant parameters, the system can achieve good control performance.
- Robust Control: The system's ability to eliminate stable errors and deliver a quick response enhances its overall reliability.

- High Stability and Noise Immunity: The system design prioritizes stability and offers good noise immunity, ensuring reliable operation in potentially noisy environments.

(2) Application of Image Processing Techniques:

This paper further emphasized the application of image processing techniques to enhance the system's capabilities. These methods contribute to improved product recognition, classification, and location accuracy, leading to overall system performance optimization.

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