A Training Model of An Auto Storage/Retrieval System

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Abstract

AS/RS is a key industrial automation system that has drastically reduced the workforce needed to run a warehouse. Via a computer-controlled system, many intensive labour jobs are taken over by the system, including tediously moving and sorting heavy load from the minute of receving until shipping to customers, intensive paperwork to record goods receiving and order receipts. Somehow, in real business, the system is always complex in the perspective of engineering considerations, depending on the nature of the business, tending to upgrading and modifying from time to time. This project is intended to develop a training model of AS/RS for the engineering students. The learning curves are provided through three levels in the system integration. The device level illustrates basic input and output devices that are carefully chosen. The controller level processes all input information from the input devices and host computer. The supervisory level implements graphic user interface for system monitoring and control for the operator. The training model also emphasizes in three design concepts, flexibility, expandability and modularity.

Keywords:

ASRS, WMS, flexibility, expandability, modularity

Introduction

Computer Integrated Manufacturing (CIM) system is well-known as 1. Group Technology (GT), 2. Computer Aided Design and Manufacturing (CAD/CAM), 3. Flexible Manufacturing System (FMS), 4. Industrial Robot, 5. Automatic Warehouse [4,5,6], Automated Storage and Retrieval System (AS/RS) is a computer-controlled system for depositing and retrieving goods from defined storage locations. AS/RS is importance to improve the efficiency of operation of a warehouse or a distribution centre. The structure and cost effective design of an AS/RS are studied by [2,4,10]. Some papers [3,7,8] are investigating effective cycle time of the system. These systems are mostly varying in business nature and scale. In general, these systems are complex. Few papers have studied the education model of the system. We-Min Chow [9] had stated that flexibility will not only allow a broad spectrum of application environments but is also a major contribution in extending application life; expandability is closely coupled with flexibility and will allow application in areas not yet defined. Finally, modification and maintenance are greatly enhanced if the system is modularized in a meaning manner.

This project is intended to develop a training model for the engineering students. The training model is equipped with these objectives for learning. The objectives are:

- To learn design concepts that apply flexibility, expandability and modularity in the integration;
- To understand the supervisory level that implements an industry communication protocol for networking PLCs and a host computer with a customized application software.
- To understand the controller level that enhance systematical sequential programming methods;
- To understand the device level that tells the students to choose a sensory device for input and an actuator for output based on the application

Approach and Methods

General System Description

The system layout is shown as Figure 1. The system is defined into smaller functions such as receiving, material handling system (MHS), rack and storage/retrieval mechanism (SRM), load/unload, picking and sorting, labeling and packing, shipping and warehouse management system (WMS). Figure 2 shows the controllers and the communication layout. All sensors and actuators are allocated at the device level; the PLCs are allocated at the controller level, networked via a serial communication; the

WMS is the supervisory level, custom-built using an MSVB.net and Omron Compolet. By system function categorization and modular hardware structure, this system demonstrates the concepts of flexibility, expandability and modularity.

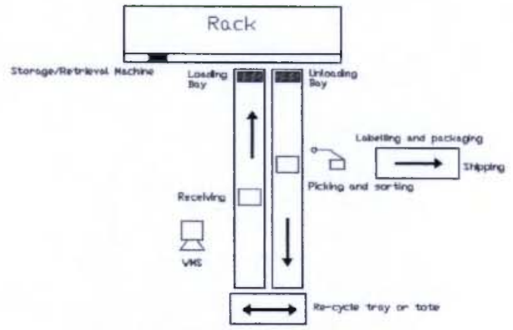

Figure 1: The System Layout

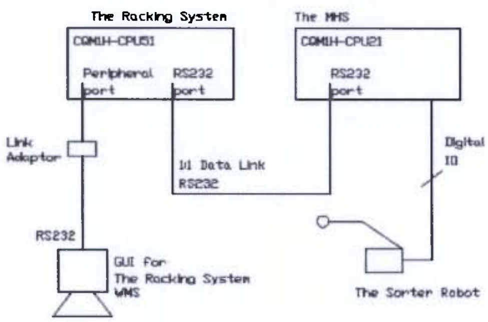

Figure 2: Controllers and Communication Layout

MHS (Receiving, Load/Unload, Picking and Sorting)

Receving, Load/Unload, Picking and Sorting are lying along the MHS, with predefined handshaking protocols; the receiving with the WMS; Load/Unload with the racking system; MHS with the sorter robot. Both serial communication and digital inputs/outputs are assigned for the purpose.

The Racking System

The racking system is the core of the system. It consists of a SRM, driven by two servomotors, traveling in (X, Y) and a rack. Figure 3 shows the coordinate of the (X, Y) system, multiplying with pulses number. Each rack cells is attached with two data information, i.e. the product identification (ID) and the product stored sequence (Seq.). The data search scans from top to bottom, left to right as shown in Figure 4. Three major functions are defined:

- Action Mode: 'Bridge', 'Storage', 'Retrieval' with First-In-First-Out (FIFO) or Last-In-First-Out (LIFO) criterion selection.
- Job lists
- Memory monitoring and management

A custom-built WMS provides a graphic user interface for storage/retrieval instructions, auto/manual operation as well as rack data management.

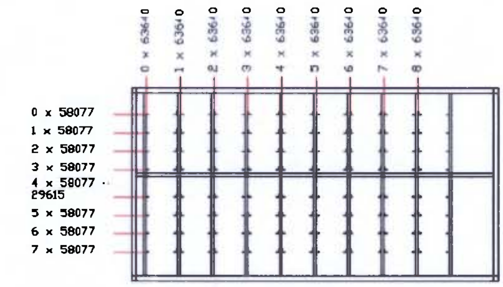

Figure 3: The Coordinate System in pulses number

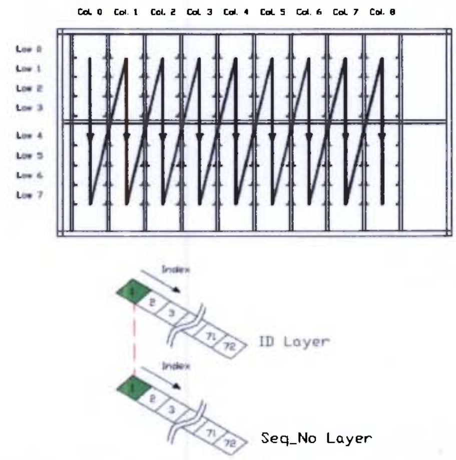

Figure 4: ID Layer, Seq_No Layer and the data search sequence

Programming Method

This system has applied 'Divide & Conquer' technique in solving complex automation sequences. Besides, a 'Black Box' concept is presented where a series of relevant sequences are blocked into a box, with well-defined I/Os, as shown in Figure 5. A 'Black Box' gives portability and ease of usage without knowing in details what is inside the box. For example, a typical SRM action would include 'Bridge', 'Storage' and 'Retrieval'. The SRM block would automatically in operation when the action is chosen (Mode), enable, ID_No, Seq_No and (X, Y) given and lastly triggered. Moreover, the 'Black Box' can be interconnected to become a system as shown in Figure 6.

Result and Discussion

The system can perform auto/manual operation at the supervisory level, the WMS, at the fingertip of a user. At storage, the user needs to identify a product ID without specifying any rack location. Same goes at retrieval process. The system has shown the capability of storing multiple products and retrieving them based on FIFO or LIFO criterion without fail.

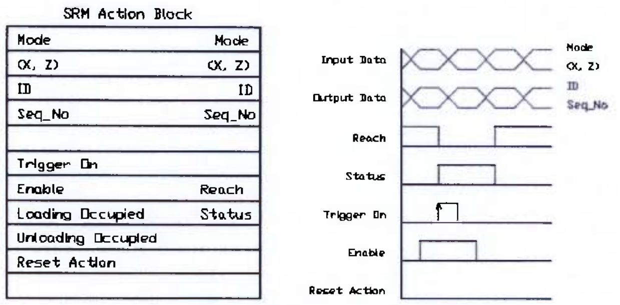

Figure 5: Sample of a 'Black Box' and it's defined I/Os

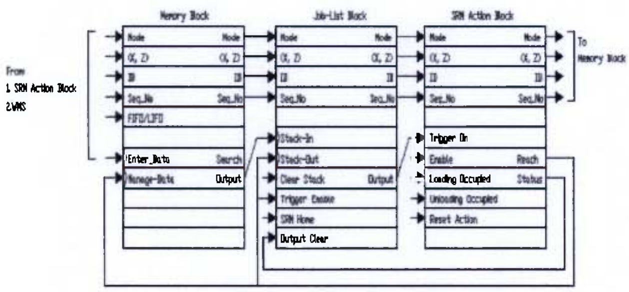

Figure 6: Function Blocks Interconnected

Conclusion

As a conclusion, AS/RS complex tasks are "divided and conquered", into smaller system. Systematical programming planning using flow chart method demonstrates the concept of simplicity and the benefit in linguistic format. The introduction of 'Black Box' has greatly increased repeatability and reusability in program. The system is easily expanded and equipped with better hardware such as scanner, RFID and Ethernet.

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