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Automated Shipment Sorter

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Abstract

Automated sorting system could be used in manufacturing, transportations, mail services and port applications. The importance of efficient sorting is the high speed, security, tracking, signature, and committed delivery times. Thus in this work, an automated system was created for shipping to speed up the process of sorting in efficient technique. The methodology behind this project is to create a main conveyor for all the containers to locate on. Each container is labeled with a barcode to contain the necessary information to be sorted in exact destination. The sorting is done using a robotic arm that holds each container from the main conveyor and place it on the correct conveyor to reach its final target. To test the complete system, a labeled container with barcode will be placed on the main conveyor. Then, it will take the responsibility to deliver the container to the other end.

Keywords: *Automated; robotic; conveyor; sorting; system*

1. Introduction

With the development in online retail and the expanding decent variety of client requests, the need has expanded for high-blend low-volume distribution centers that have the operational adaptabilities to adjust to changes in item composes and amount [1]. Along these lines, operational efficiencies of such stockrooms should be made strides. In such distribution centers, one of the fundamental tasks is the request picking, which is to gather the arranged items by going to a few retires inside a broad stockpiling region. The physical burdens put on laborers in this activity are not insignificant [2].

To decrease the operational expenses of request picking when all is said in done stockrooms, there are a few sorts of computerization frameworks. In any case, these have some operational confinements and can be connected to just distribution centers suited to them [3].

For instance, settled gear, for example, a programmed stacker and a sorter can't deal with various kinds of items simultaneously. What's more, it is troublesome for the gear to acclimate to changes in item amount in light of the fact that their sizes are unchangeable. In this manner, settled hardware isn't reasonable for high-blend low-volume distribution centers [4].

Then again, for request picking activity in high-blend low-volume distribution centers, a framework has been proposed where mechanized guided vehicles bring whole retires including the arranged items to the laborers rather than the specialists moving to the racks [5]. This framework can lessen the physical burdens put on laborers, and be effortlessly acclimated to changes in item amount by changing the quantities of automated systems and mobile racks. Be that as it may, for the situation where each arranged item is very unique and every rack in the distribution center has few arranged items, the framework is less proficient than specialists voyaging and bringing. Also, the framework can't robotize either grabbing arranged items from the racks or arranging them [6-8]

Besides, when the viable frameworks that computerize arrange picking activity are brought into distribution centers where the tasks are right now performed by specialists, the hardware must be entirely changed. All things considered, there are couple of high-blend low-volume stockrooms where arrange picking task is computerized [9-11].

According to shipping in Jeddah seaport [12], it is actually suffering from a lot of problems such as time delay for submitting and delivering the containers to the traders, inefficient services in transforming the containers inside the port also lack proper equipment’s [12-14]. Robotic arm can solve lot of problems in shipments. Therefore, it fulfills the market needs with fewer workers. That’s mean it will help ports to be more organized in shipping and faster to deliver.

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Thus in this work an automated system was created for shipping to speed up the process of sorting in efficient technique. The objective of the automated shipping sorter is to sort the delivered packages automatically by using a robotic arm, conveyors, barcodes, sensors, and finally the software into the correct location. Briefly stating, the delivered packages that are to be sorted are located on a conveyor belt, a robotic arm reaches and grabs a package from the belt, a sensor then reads the barcode of the package, and accordingly, the robotic arm determines where to place the package. There are three conveyors that lead to three different locations.

2. Specification and Features

2.1 Overall Description

The projects operational concept starts by a set of boxes on a moving conveyor belt (Main Conveyor). As shown in Figure 1, when a box passes through the infrared sensor located at the end of the belt, the conveyor's movement will stop due to the signal loss between Tx and Rx for a full 100ms allowing the robotic arm to deliver the box to the required conveyor belt (A, B or C) and go back to resume its default position at the head of the Main Conveyor. The second stage starts by a barcode reader scanning the barcode on the box and transferring its decoded ASCII equivalent to the microcontroller in the SSC-32 chip via a parallel port connected to the PC, which in turn will command the robotic arm to pick up the box and move it to one on the three remaining convey or belts (A, B or C) depending on the barcode printed on the box, the targeted conveyor will lose the signal between its IR sensors causing the belt to move for a specified time of 4 second. After that the arm will go back to its default coordinates to process the next box in position on the Main Conveyor and the process is repeated on the remaining boxes available. C language was used in programming the Atmel ATMEGA 168 microcontroller, while the robotic arm was programmed using the LYNXMOTION's RIOS software specified for its robotic arm kits and the infrared sensors were used to enable the automated aspects of the process denoting the lack of human mediation once the process is started.

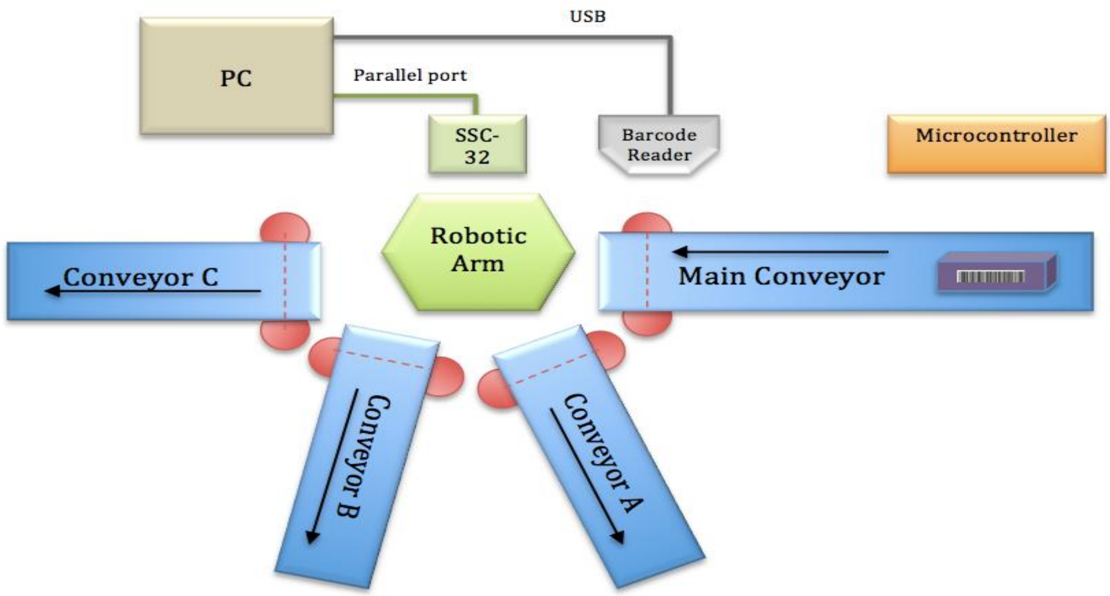

Figure 1: Block Diagram

2.2 Tools

The tools used in this work consist of:
1. One LYNXMOTION robotic arm kit.
2. Four conveyor belts (Main Conveyor, A, B and C) respectively. 3. Five different servomotors (AL5B Robotic Arm).
4. Two Microcontroller kits (on for IR and motor circuit and another for the SSC-32 Chip).
5. Four Infrared sensor set made of a transmitter (Tx) and receiver (Rx). One at the end of the (Main Conveyor), and the other 3 at the beginning of conveyors A, B and C respectively.
6. Barcode generating online software.
7. Barcode scanner.
8. Matlab software.
9. The Robotic arm Interactive Operating System (RIOS).

3. Design Overview

Automated shipment sorter project sorts labeled containers with a barcode by placing them on the main conveyor and it will do everything until it reaches the final destination. The Figure 2 shows a complete cycle for sorting containers since it is located on the main conveyor until it reach its target.

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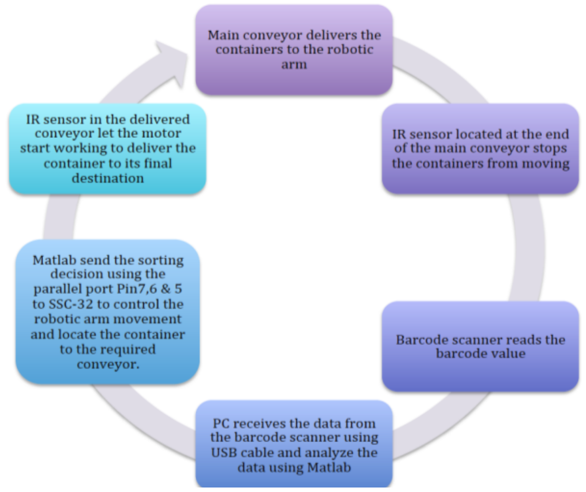

Figure 2: Complete cycle of sorting

3.1 Main Conveyor Block

The Main Conveyor is the conveyor that delivers the boxes to the robotic arm to be sorted. This conveyor consists of rubber belt and two wheels. One of the wheels is connected to a DC motor to move the belt. The microcontroller is who turns the DC motor on and off. The MOSFET 2N7000 was used to work as a switch. The motor is connected to 6 V and its other end is connected to the drain of the NMOS. When the microcontroller pin is high (5V), the gate has enough voltage to turn on the motor by connecting the source to ground. The opposite is true, when the gate voltage is zero that means the motor circuit is not complete and it will not work. At the end of the conveyor, there is infrared emitter and phototransistor that positioned linearized to each other with few centimeters separated to detect any object pass at the end of the conveyor. When the sensor senses an object at the end of the conveyor, it sends high signal to the microcontroller to stop the DC motor after 100ms to give chance for the box to stop near the robotic arm gripper and let the barcode reader scans the labeled code on the box. Table 1 shows the work load on main conveyor.

Table 1: Main Conveyor

Phototransistor	MCU PIN value	DC motor status	Explanation
Not Receiving signal	5V	Off after 100 ms	The object reached to the end of the conveyor.
Receiving Signal	0V	On	No object to be sorted let the Conveyor move until the other Object

			reach.

3.2 Barcode Block

The barcode block contains two main parts. The first part is the barcode generator. It is software that converts the alphabets, characters and numbers to a barcode varying in widths and spacing of parallel lines. The barcode generator was used in this project to generate three different barcodes as shown in Table 2by using RACO Industries website link.

Table 2: Barcode

Code 39 / ASCII Code	Barcode
1	
2	
3	

After that, several copies were made from the three barcodes and attached to the boxes that required to be sorted. Each barcode contains the necessary information for sorting. For example, the box that contains barcode 1 should be located at conveyor A, the box that labeled with barcode 2 should be located at conveyor B and the box that marked as barcode 3 should be located at conveyor C. The second part in this block is the barcode scanner that is located at the end of the main conveyor, near the IR sensor. When the main conveyor stops moving, it gave the barcode scanner the chance to start reading the barcode value that was labeled on the box before. After that, the barcode scanner converts the code back to the original text to read the necessary information and send it to SSC-32 to take the decision for sorting. This process is broke down to several steps. First of all the barcode scanner is connected to a PC using a USB cable to read the information written on the boxes and converts it back to ASCII code to analyze it through MATLAB software. The MATLAB analyzes the data that it received from the barcode reader and sends its result through the parallel port cable to SSC-32 by using three wires only.

3.3 Three Conveyor Block

The three conveyors are similar to the main conveyor and they have the same circuit but the in programming they are different because they move in the opposite direction. Since the sorting process is almost done in this stage and the object is toward the final destination far away from the robotic arm. The infrared transmitter and phototransistor are located linearly at the beginning of each conveyor in this block to control the DC motor indirectly through a microcontroller. The table 2 shows the main function of these sensors and the DC motor in

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each conveyor. As it's clear from table 3, the conveyors normally are not moving until the robotic arm place an object at the beginning of one of the conveyors and cut IR signal between the transmitter and receiver. At that moment, the conveyor start moving for 4 seconds to deliver the object at the other end of the conveyor, then it goes back to its normal mode.

Table 3: Three conveyors function

Gate of phototransistor Value	MCU PIN Value	DC Motor status	Explanation
Receiving signal	0V	Off	No object on the conveyor to deliver
Not receiving signal	5V	On for 4 sec	An object was positioned and the beginning of the conveyor to deliver

3.4 Microcontroller

The microcontroller ATMEGA 168 is the heart for the conveyors system. It controls all the conveyors actions based on the received inputs from the IR sensors. The C language was used to program the microcontroller using mostly if and while statements. Figure 3 shows the microcontroller connection.

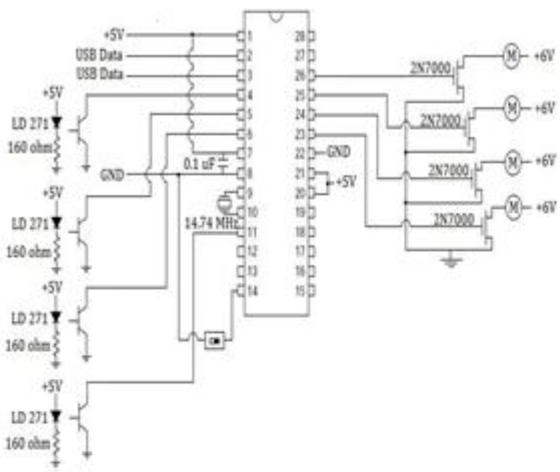

Figure 3: Microcontroller connection

3.5 Robotic Arm Block

The Robotic arm consists of the hardware that creates the skeleton shape and size for the arm, servomotors, SSC-32 and RIOS software. SSC-32 is the electronic kit for this robotic arm. It is a kit that contains microcontroller, the servomotors interface, and computer interface to download the code from RIOS software to the microcontroller unit in SSC-32 board by using serial cable (RS 232). The servomotors are connected to SSC-32 board to move the robotic arm based on the software installed in the microcontroller in SSC-32 board. However, RIOS software is a short for Robotic arm Interactive Operating System. This program is for controlling the Robotic Arms with the servo controller. It makes positioning the arm easy. By using RIOS software, 16 sequences were created and each sequence saves the final orientation position of the end effector (x, y, z). The sequences were created by changing the servomotors values for the base, elbow and gripper and keep the others with a constant angle

4. Verification and Validation

ATMEL 168 microcontroller connected within electronic circuit to be tested. This circuit has many electronic components such as crystal oscillator, LCD screen, voltage regulator (7805), SPDT switch, wires, 0.1uF capacitor and 1K Ohm resistor.

Al5B Arm is used in our Automated Shipment Sorter project; it has many pieces that can be assembled to build it up, each piece has its own test and configuration. This robotic arm has 5 servos. first servo called HS-485 where located inside the round black box (base) and the end of arm. Second servo motor is HS-755 which located in the top of the box. Third servo motor is HS- 645 Mg elbow which located in the middle joint, fourth servo motor is HS -422 which is the gripper.

Our conveyors in this project were constructed by using Lego. A motor was connected to the conveyor wheels, 6 wires comes out form this motor with different colors. The whole wires were grounded expect the white wire which was connected to drain of the NMOS transistor in the infrared receiver and transmitter circuit. This infrared receiver and transmitter sensors were placed at the beginning of each conveyor. When conveyors in rest status, the infrared receiver and transmitter were connected. When there is no connection between them that means there is an object on the conveyor. Therefore, the infrared transmitter and receiver circuit sends signal to the microcontroller, consequently, the microcontroller respond immediately by sending commands to the motor to start work.LAG-960U has been chosen to be the barcode reader for Automated Shipment Sorter project.

The reader was connected to the USB port on the PC, therefore, a beep sound was heard, indicating the test confirmation; however, the red light was on, indicating that the reader is ready for any operation mode.

There are two scan mode can be set to protect the leaser engine trigger on / good read off(default) and continuous /trigger off/delay time out Trigger on/good read off (default) setup: To activate the scanner the trigger button was pressed, the scanner read the barcode. Immediately the scanner deactivated itself whether

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reading the data was successfully or not, so it was adjusted to a specific time out for configuring the unsuccessful data. Continuous / triggers off/delay time out setup: The trigger button initially was pressed to activate the scanner and operate the reader in the continuous trigger mode. Some procedure was followed to set a specific timeout for non-reading barcode

Three barcodes were used in this project. The system was tested where all containers were labeled by a barcode; the containers were placed on the main conveyor, while they were moved on the belt, the barcode was scanned by the reader and compared within MATLAB code. During the comparison, the IR sensor where placed at the end of the main conveyor was sensed the container. Thus, the motion of the main conveyor was stopped. Following that, the robotic arm was picked up the container and placed it in the correct conveyor depending on the readings from the reader. 1- The reader scanned the barcode “a”. Therefore, the container was picked up by the robotic arm and moved to the conveyor one. 2- The reader scanned the barcode “b”. Therefore, the container was picked up by the robotic arm and moved to the conveyor two. 3- The reader scanned the barcode “c”. Therefore, the container was picked up by the robotic arm and moved to the conveyor three.

While testing the whole system together a lot of challenges were faced whether to the conveyors, SSC-32 chip, sensors and motor circuit. Due to the limited budget, Lego MINDSTORM was used to build the conveyors because most of the conveyors are industrial and it is too expensive. As result some mistakes were detected while constructing the conveyors; the rubber belt was expanded by the time especially during motor’s test. Also, the rubber belt was not moved smoothly because it was collided by the conveyor’s legs. Moreover, the conveyors required a fixed stand to adjust the sensors on it. At the beginning, the sensors were not linearized. But by using some tools such as super and gun glue, rulers, the sensors were adjusted linearly.

Additionally, a gate was built on the main conveyor to make the containers move in straight line. This solution was found to increase the accuracy of picking up the containers by the arm’s gripper. According to the SSC-32 chip, a lot of time was spent to figure out the digital inputs. Understand the inputs and the outputs of the chip, read the guide manual to test the input. Regarding to the sensors, variable resistor was used to test the distance from the transmitter to the receiver by looking at the intensity of the led light where attached in the circuit. Also, the wires that come from the sensors were labeled by its own name avoiding the interconnection between the inputs and the outputs of IR. Connectors were used to make the whole circuits of the system organized. As result of hard work and a lot of efforts, the project has been done and the system was worked properly as expected.

5. Conclusion

There are a variety of reasons behind this project in a different direction whether for academic reasons, business, market needs or such a shipments problems. Regarding to the academic reason, this project depends on the control system robotic field and how to approach the target of this project by controlling each component as studied through the whole academic levels, for example, controlling a robotic arm to pick up the assigned container and put it on the conveyor, using microcontroller, and buildup a hardware components physically. This project is shed the light on the robot arm for sorting blocks or containers in the ports. The project incorporated microcontroller to control the whole hardware components of the system using ‘C’ language, robotic arm to carry containers from area to area, conveyors to move this containers to the shipping area in organized way. Barcode is dependent in the system to sort each container that passes through specific convey or to its assigned shipping area.

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