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Design and Development of Automatic Color Wood & Metal Sorting and Counting Machine

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ABSTRACT: Sorting of different products has been reported to be complex and a global problem in the industry. It is a very tiresome industrial process and continuous manual sorting creates consistency issues and involves a lot of man power. This paper describes a working prototype designed for automatic sorting of objects based on the color, wood, metallic appearance and dry light weight object. TCS3200 sensor is used to detect the color of the products and a metal detector is used to detect the metals. The ATmega328 microcontroller is used to control the overall process. The objects when placed on the conveyor belt, it is sorted out based on color sensing, wood and metallic behavior of the object and is relocated to specific location. The identification of the color is based on the frequency analysis of the output of TCS3200 sensor and the identification of metal is based on the output of the metal detector. When the object moves on the conveyor belt, the color sensor and the metal detector give the input to the microcontroller which then gives the command to the robotic arm to perform the task. DC motors are used to control the movement of the conveyor belt and gripper. Arduino Nano microcontroller is used to program and give the commands. L293D motor driver is used to drive the motors in different directions and a LCD display makes the system user friendly. An air blower is provided for removing the light weight objects like dry waste, dirt, dust etc.

Keywords: Conveyor belt, DC motor, TCS3200 color sensor, Metal detector, LCD display, Microcontroller, Arduino Nano.

1. INTRODUCTION

The ability to differentiate colors is essential for human's life as it gives us the awareness about the changes in surrounding through our vision[1]. Moreover, by exploiting the ability of color capture, intelligent machine gains the function to differentiate, sort and organize. Color sensor systems are increasingly being used in automated applications to detect automation errors and monitor quality at the speed of production line. They are used in assembly lines to identify and classify products by color. The objectives of their usage include checking the quality of products[2-3], to facilitate sorting and packaging, to assess the equality of products in storage, and to monitor waste products[4]. Consequently, there is an abundance of color sensors and the choice is often application-driven. Low cost and simple color sensors are preferred over sophisticated solutions for less demanding applications where the top priority is cost and power consumption.

This project includes sensors that detect color, wood and metal of the objects then send the input to Arduino Nano which in turn adjusts DC motors. Based upon the color, wood and metal detected by the sensors, the gripper will move according to the angle of 90°, 180° and 270° depending on the position of placing the objects in the containers based on the color, wood and metal.

2. PROBLEM FORMULATION

Nowadays, the efficiency of the product is regarded as the key to success. The efficiency of the product may include the speed of the production, lowering material and labor cost, improving quality and decreasing the rejection. The automatic sorting of products has been reported to be complex and a global problem. Sorting of the different products is a very tedious industrial process and continuous manual sorting creates consistency issues and involves a lot of man power. The industrial challenge that often occurred in industry involves sorting of products based on their color and metallic appearance in diamonds industry, food industry and metal industry. The eyes will always take some time to see an image and project this to the brain to initiate visual sensation. After the brain has received the image, it will take some time for the brain to determine the color of the object too[5].

The other challenge is the accuracy of sorting process by an operator is very low in current industry. This is because an operator will need to handle hundreds or thousands of objects each day, tiredness will usually cause some fault when color is being divided or sorted.

3. PROBLEM SOLUTION

The above problem statement can be minimized by designing an automatic sorting machines based on the color and the metallic appearance of the products. Taking all the things under consideration this project is developed which is very useful for industries. Color detecting sensor is used to detect the color as well as wood and a metal detector to detect metal. The ATmega328 microcontroller is used to control the overall process. The objects when placed on the conveyor belt are sorted out and relocated to specific location. In order to overcome the challenge of accuracy with the sorting process, a counter (IR Sensor) is placed at the one side of the conveyor belt to count the number of products sorted.

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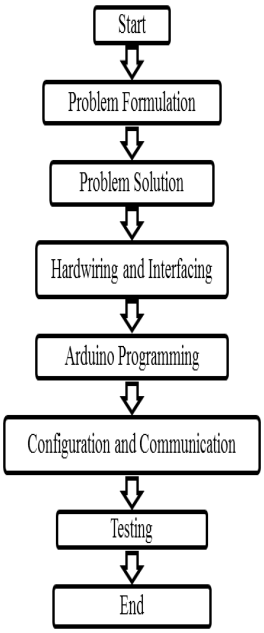
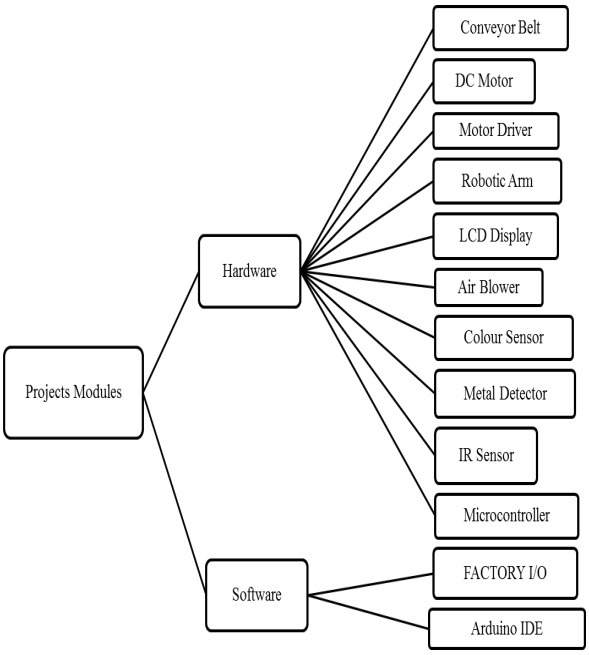
4. METHODOLOGY ADOPTED

To go through with this project, a very specific methodology is adopted for the successful completion and execution of this project. The methodology adopted for this project is explained with the help of flow chart.



5. PROJECT MODULES



5.1 Conveyor Belt

A conveyor belt is the carrying medium of a belt conveyor system. The belt is looped around each of the rollers and when one of the rollers is powered (by an electrical motor) the belting slides across the solid metal frame bed, moving the product. A belt conveyor consists of two or more pulleys, with a continuous loop of material - the conveyor belt - that rotates about them. One or both of the pulleys are powered, moving the belt and the material on the belt forward. The powered pulley is called the drive pulley while the unpowered pulley is called the idler.

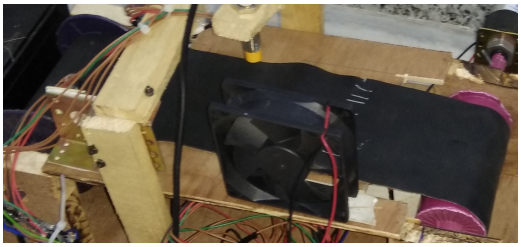


Figure 1: Conveyor Belt

5.2 DC Motor

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy.

This project has three DC motors in the following locations:

- In conveyor belt
- In robotic arm (gripper)
- In base of robotic arm (360 degree)

The specification of DC motor used in this project is:

Voltage- 12V

Current- 200 mA

Power (P) - 2.4 watt

Speed (N) - 10 rpm

Torque generated by DC motor is-

$$P=\frac{2\pi NT}{60}$$

$$T=\frac{2.4*60}{2*\pi*10}$$

T= 2.29 N-m

Figure 2: DC motor

5.3 Motor Driver

L293D is a dual H-bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal. This

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higher current signal is used to drive the motors. Here we are using L293D as the motor driver which is a 16-pin IC that can control a set of two DC motors simultaneously in any direction.

Figure 3: Motor driver

5.4 Robotic Arm

It is also known as gripper. In a gripper the jaws or claws which physically grasp by direct impact upon the object. They are based on different physical effects used to guarantee a stable grasping between a gripper and the object to be grasped. Here, we are using a gripper for grasping the product, which will pass through the sensors and then move to the gripper which put the object in the respected containers.

The DC motor is used to control the opening and closing movement of the gripper. The DC motor receives its signal from the microcontroller for performing the operations. The gripper (2 jaws) is designed especially for grabbing the objects running on the conveyor belt and dropping to the specified locations with the help of a DC motor[6].

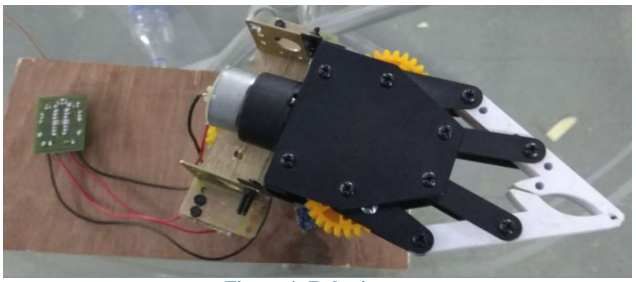

Figure 4: Robotic arm

5.5 LCD Display

A liquid-crystal display (LCD) is a flat panel display, electronic visual or video display that uses the light modulating properties of liquid crystals. In this project, we are using 16x2mm LCD display which has 2 horizontal lines comprising a space of 16 displaying character.

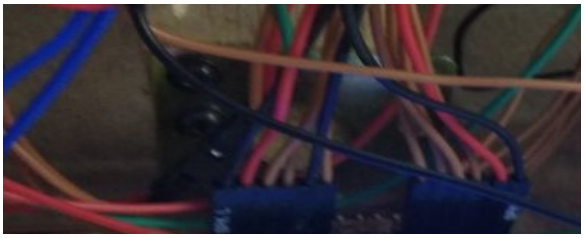

Figure 5: LCD display

5.6 Air Blower

A centrifugal fan is a mechanical device for moving air or other gases. Dry waste is separated based on their weight. Due to the high density and weight, wet waste refuses to be blown off even in the presence of a high speed blower. This technique is made to distinguish dry light waste. A relay will control the ON and OFF of a high speed air blower. As blower blows, the belt halts and light weight objects are thrown out into the dry bin via collecting chamber.

Figure 6: Air blower

5.7 Color Sensor

In our project we are using TCS3200 Color Sensor which is a complete color and wood detector, including a TAOS TCS3200 RGB sensor chip and 4 white LEDs. The TCS3200 can detect and measure a nearly limitless range of visible colors. Applications include test strip reading, sorting by color, ambient light sensing and calibration, and color matching, to name just a few.

Figure 7: Color sensor

5.8 Metal Detector

A metal detector is a device which responds to metal that may not be readily apparent. The simplest form of a metal detector consists of an oscillator producing an alternating current that passes through a coil producing an alternating magnetic field. If a piece of electrically conductive metal is close to the coil, eddy currents will be induced in the metal, and this produces an alternating magnetic field of its own. Any metal objects (targets) within the electromagnetic field will become energized and retransmit an electromagnetic field of their own. The detector's search coil receives the retransmitted field and alerts the user by producing a target response.

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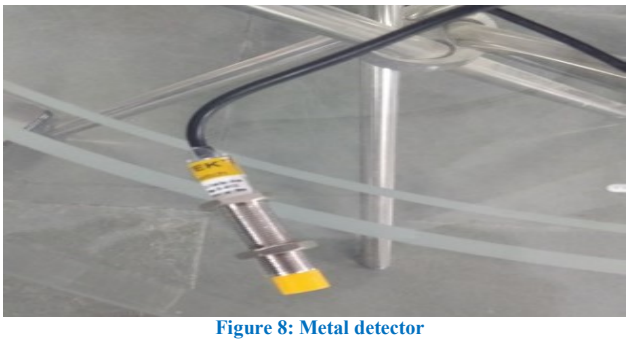


Figure 8: Metal detector

5.9 IR Sensor

IR Sensors work by using a specific light sensor to detect a select light wavelength in the Infrared (IR) spectrum. When an object is close to the sensor, the light from the LED bounces off the object and into the light sensor. This results in a large jump in the intensity, which we already know can be detected using a threshold.

Here, we are using IR sensor for counting of object such that it provides us the data about the number of objects which are coming for sorting.

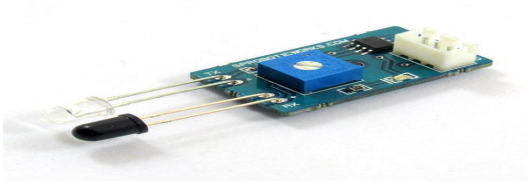


Figure 9: IR sensor

5.10 Microcontroller

In this project microcontroller Arduino Nano (ATmega328) is used for motion control and object detection. The microcontroller works on the set of instructions that are pre-programmed by the programmer and stored in the memory. It then takes the instructions from its program and one by one operates as per the instructions and carry out the required operations.

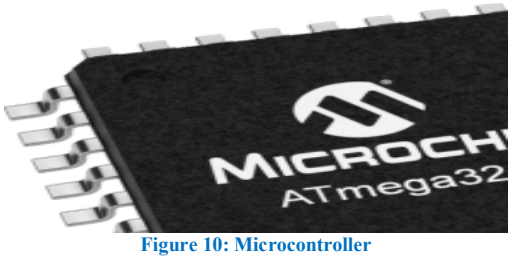


Figure 10: Microcontroller

5.11 Factory I/O

Factory I/O is used for creating an environment of a factory in virtual ground and also stimulates it. In Factory I/O we can make 3-D CAD model of any factory for stimulating.

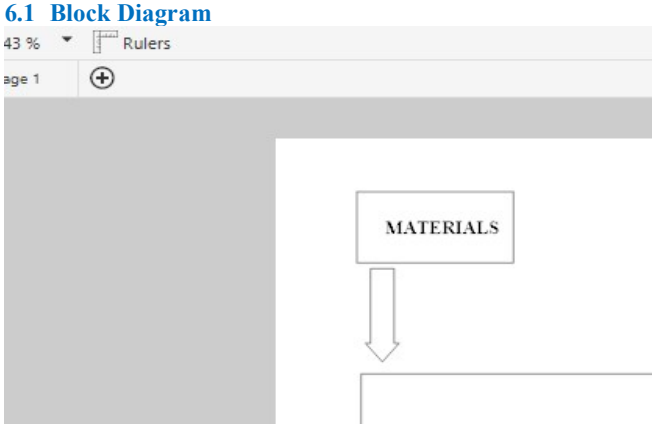
5.12 Arduino IDE

The Arduino Integrated Development Environment or Arduino Software (IDE) contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

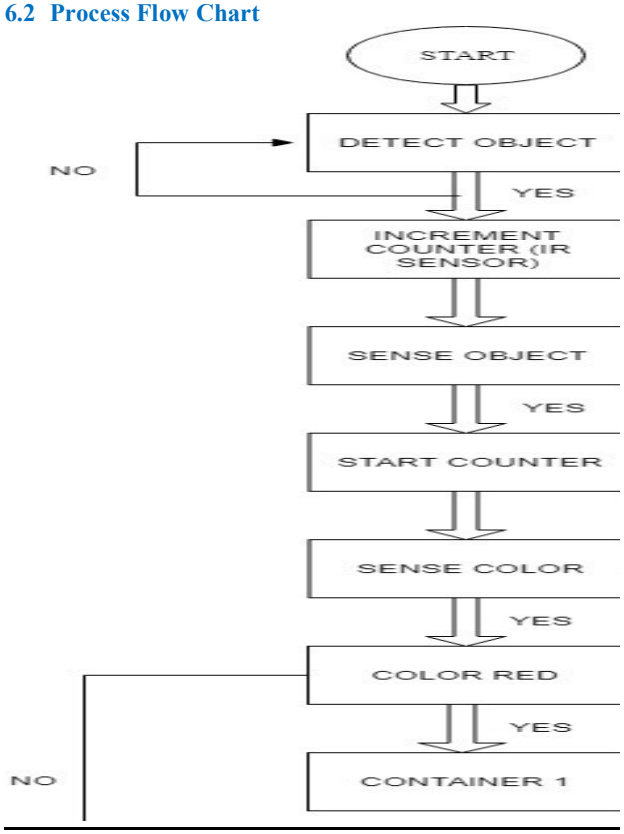
Here, in our project we are writing all the programs on the Arduino IDE as it is easy to understand and learn.

6. DESIGN DESCRIPTION

6.1 Block Diagram



6.2 Process Flow Chart



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6.3 Working of the System

- In this project the power supply is given to the motor of the conveyor belt and the blower by connecting to the laptop battery and Arduino Nano to the 5V DC power supply.
- When the objects passes on the conveyor belt, the IR sensor will start counting the number of objects which is shown as "Object No." on the LCD screen.

Figure 11: LCD showing object count

- When the object passes through the color sensor, the LCD will display what color of object is passing through either "Red Detected" or "Wood Detected".

Figure 12: LCD showing object count with color detection (Red)

Figure 13: LCD showing object count with wood detection

- When the object passes through the metal detector, the LCD will display "Metal Detected".

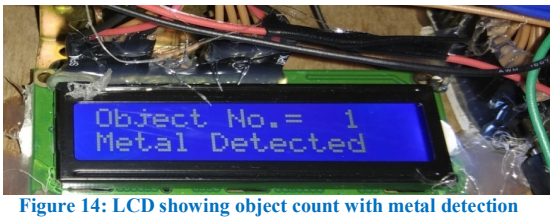

Figure 14: LCD showing object count with metal detection

- When the dry and light weight object passes through the blower, it will blow the light object like papers which are neither sensed by colour sensor nor by metal detector.
- If METAL is detected then the robotic arm will lock the object in its grip and will move 90° counter clockwise and put the object in the container.
- If WOOD is detected then the robotic arm will lock the object in its grip and will move 180° counter clockwise and put the object in the container.
- If RED is detected then the robotic arm will lock the object in its grip and will move 270° counter clockwise and put the object in the container.

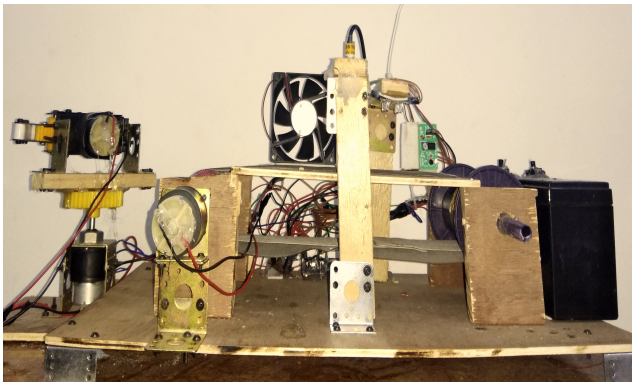

Figure 15: Physical prototype model (front view)

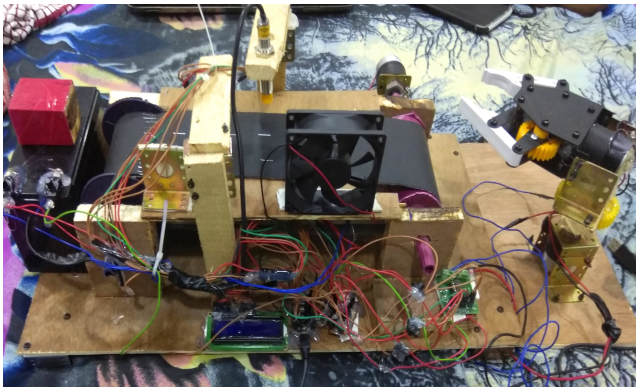

Figure 16: Physical prototype model (top view)

7. RESULTS

It would be very inexpensive to implement the 5S (Sort, Set in Order, Shine, Standardize and Sustain). With tight tolerances to machining, calibration would be very quick as the sensors should output very similar results. Verifying each sensor would still need to be done to be sure a faulty reading wasn't being output.

7.1 Time Cost

Once the object is placed on the first conveyor belt takes less than a second to reach the IR sensor. From IR sensor to the color detector, it takes 4.4 sec and (if the color is RED), then from the color sensor to the object drop, the time required is 12.6 sec, so the total time taken from the object input to the object output is 17 sec. From IR sensor to the color detector, it takes 4.6 sec and (if it is wood), then from the color sensor to the object drop, the time required is 10.6 sec, so the total time taken from the object input to the object output is 15.2 sec. From IR sensor to the metal detector, it takes 5 sec and (if it is metal), then from the metal detector to the object drop, the time required is 7.6 sec, so the total time taken from the object input to the object output is 12.6 sec. These time values are dependent on the speed of the dc motors used and the place of placing of the object.

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7.2 Reliability

The failure rate for the machine would be dependent based off of the sensor that was used. For the current setup, a failure rate of 20% would be accepted. This is because with the TCS3200 sensor, the values for color overlap. This is a problem if a darker pink is sensed or a lighter red. Each might be read as the wrong color. If a new color sensor was implemented, an ideal failure rate would be 0.01%. This system would be very reliable; however, each feeding tube would be set to the correct height to eliminate the possibility of jamming. Without jamming, the machine would continue without problem.

8. CONCLUSION

In this highly competitive industrial manufacturing, the management of the integrity of supply of a product from raw material to finished product through quality manufacturing is of very much importance. For the product bearing high quality and dimensional accuracy is mandatory. With the modernization of automatic color, wood and metal sorting system, the sorting of products and the accuracy of sorting process can be minimized. This project can help to minimize the industrial issues of sorting and improve efficiency. Though it has some limitations, but by having done some modification this concept can be implemented in wide range of application.

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