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DESIGN AND FABRICATION OF A PROTOTYPE OF OBJECT SORTER BASED ON COLOR AND SIZE THROUGH A BELT CONVEYOR SYSTEM

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Abstract*-Belt conveyor is a material handling device which is used for object transferring. This paper focuses on manufacturing a prototype of object sorting system based on precise height and color (black and white) through a belt conveyor that is rotated by a DC wiper motor. Sensors detect an object and three mechanical hands move the object to the predetermined location (such as bucket). It is observed that it takes approximately 5 seconds to detect white color objects and sort them out according to their height while it requires nearly 10 seconds distinguishing black objects of shorter length. The taller and black color objects are thrown away to the end of the conveyor.*

Keywords: Object transferring, height, color, object detection

1. INTRODUCTION

Determining real time and highly accurate characteristics of small objects in a fast flowing stream would open new direction for industrial sorting processes. The present paper relates to an apparatus and method for classify in and sorting small sized objects, using electronic systems and advanced sensors operating on the basis of geometric and physical characterization of each element. The proposed selection process is based on a multi sensor characterization, and more specifically on crossed optical and impedimetric analysis of the objects to be sorted. Parallel guides, also called channels, are created on a slanted plant support. The objects to be sorted are immersed in a continuous free falling flow along guides.

By another way this project can be treated an automated material handling system and can be designed as following way. It synchronizes the movement of robotic arm to pick the objects moving on a conveyor belt. It aims in classifying the colored objects which are coming on the conveyor by picking and placing the objects in its respective preprogrammed place. Thereby eliminating the monotonous work done by human, achieving accuracy and speed in the work[1].

The project involves color sensors that senses the object's color and sends the signal to the microcontroller. The microcontroller sends signal to circuit which drives the motors of the mechanical arm to remove the object from the conveyor to a specified location.

1.2 Objectives

To construct a prototype object sorter on the basis of height and color through a running belt conveyor using a mechanical arm which eliminate the unexpected objects or let go the accurate objects in the predetermined bucket.

2. PREVIOUS STUDIES

2.1 Belt Conveyor

A conveyor belt (or 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.

A wide variety of related conveying machines are available, different as regards principle of operation, means and direction of conveyance, including screw conveyors, vibrating conveyors, pneumatic conveyors, the moving floor system, which uses reciprocating slats to move cargo, and roller conveyor system, which uses a series of powered rollers to convey boxes or pallets[2].

2.1.1 History of Belt Conveyor:

Conveyor belts have been in service since at least the dawn of the Industrial Revolution in England (the first such belts were made from leather or canvas and served as flimsy, short-distance transportation systems for sacks of grain), the scale and scope of their application continued to expand. By the turn of the 20th century, conveyor belts were being used to unload materials of significant weight – things like lumber and wooden shingles – from out of railcars in Northern cities such as Minneapolis. With the discovery of electric energy and the consequent automation of production that electricity enabled, it was only a matter of time (1919) before the first automated ―roller conveyor was used for automotive production by none other than Henry Ford[3].

2.2 Object Sorting

The applied sorting systems consist of a conveyor road for the separation and steadying of the material, a detector which is placed underneath or above the

conveying belt or in the area of the material discharge, and a valve bank which blows out the material component that is to be sorted positively[4].

2.2.1 Inductive sorting

In metal recycling, the magnetic separation and the Non-Ferrous Metal Separation (NES) are established technologies. Both of them are mass flow methods in which the material properties of metals (monetizability and/ or electrical conductivity) are exploited by a (static or temporally fluctuating) magnetic field constantly attached to the whole width of the material flow. With these methods more than 95% of the magnetizable steel („iron—) and non-ferrous metals are recovered in shredding companies. Latest studies show a recycling rate of 98% [FRANCOIS, 2003].The introduction of automatic, sensor-based sorting systems offers for the operator on the one hand the possibility to reduce costs (investment costs and operating costs in contrast to personnel costs), on the other hand the prospect of higher earnings due to a more efficient recovery of residue metals [4].

2.2.2 X-Ray Sorting:

In X-ray sorting the material transported by a conveying belt is X-rayed and the intensity of the transmitted radiation is measured by X-ray line detectors. This method corresponds to the X-raying of luggage e.g. at airports [4].

2.2.3 Color Sorting

Color sorting systems are used very often e.g. in glass recycling and in the food industry. Color sorting, like NIR-sorting, is a surface-sensitive method. This means that coated or varnished objects in principle cannot be detected in a material-related way. Nevertheless, there are aims in recycling for which color sorting is an economic solution. This is especially the case in plants where the materials that are to be checked have passed shredding stages beforehand (e.g. shredders in metal processing) that remove the beforehand existing surface coatings or that break up the material in a way that with utmost probability uncoated fracture faces can be observed[4].

2. METHODOLOGY

3.1 Hardware and Electronic Components:

- Arduino-Uno
- 12V DC wiper motor
- Servo motor
- IR proximity sensors
- LM324 (Op-amp)
- 7805,7806 (DC to DC converter)
- Belt conveyer system
- Mechanical hand.

3.2 Construction Method:

- Study the mechanical structure of belt conveyor.
- Connect all the components and complete of belt conveyor system.
- Study the circuit structure.
- Connect the DC motor with the structure.
- Connect the servo motor with the structure.
- Place the IR sensor with the structure.
- And finally use the belt conveyor for acquiring necessary purpose.

3.3 Block Diagram of Working Principle:

In Fig. 3.1 describes briefly the desired working method of my total project. It shows the algorithm or sequence, which way my project will work. At first the sensor will detect the white large or small object and then black large or small object. After detecting these,objects will be sorted in desired bucket.

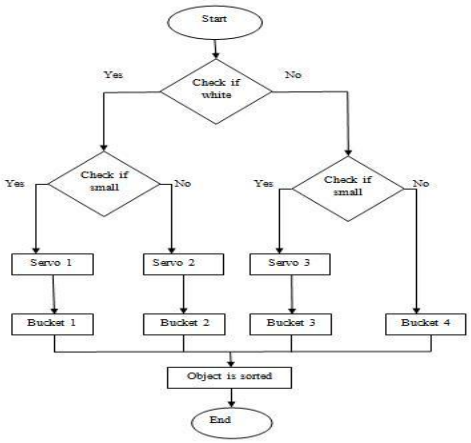

Fig. 3.1: Block diagram of working principle

3.4 Block Diagram of Circuit Design:

The brief descriptions of electrical settings of my project are shown in figure 3.1. At first IR sensors collect analog signal of color and height from the objects which then send to Op-amp and Arduino to transform digital signal. These digital signals then used to command servo motor what to do,

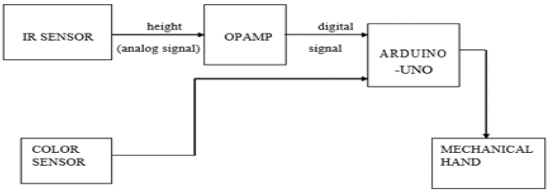

Fig. 3.2: Block diagram of circuit design

4. CONSTRUCTION OF PROTOTYPE OF OBJECT SORTER

4.1 Design:

The aim of this project is to construct a prototype of object sorter through a belt conveyor based on color (black and white) and height. The structure can execute automatically its operation. While designing this, there are three segments of constructing methods were implemented, which are accordingly:

- Mechanical Structure
- Electric Circuit

- Software development.

4.1.1 Mechanical Construction:

4.1.1.1 Body:

The base structure is made of stainless steel. It is 30 inches long, 10 inches wide and 16 inches high. There are 4 rollers attached to the base in equal spacing about 10 inches. In its one end, 6 inches below the top surface, there is a wiper motor mounted. The wiper motor was previously coupled with gear to reduce its rpm. Then a sprocket is combined with the outer end of gear. Another sprocket was combined with the front roller. This combining process was made by arc welding. The
end. It is done for reducing the output rpm more. Because less rpm provides less speed of the belt. The two sprockets were linked by a chain. There is another small roller attached at 15 inches just beneath the top surface. It has tightened the slack side of the belt. There are three horizontal wooden pieces mounted on the top. These were joined with 2 inches screw. These are helping to implement main circuit, sensors and servomotors. In fig. 4.1 there is shown main structure of the project.

Fig. 4.1: Structure of body

4.1.1.2 Belt:

Belt is one of the main components of this project. Here belt is used for conveying the several types of objects in a certain direction. In the sense of cost, availability I used textile belt. There are many kind of belt used in industrial application. Some kinds of belt are described as following:

- Textile belt
- Cotton fabric belt
- Polyamide fabric belt
- Polyester fabric belt
- Aramid fabric belt
- Rip stop belt etc[5].

Here I used two 2 inches wide polyester belt. Hence it has a greater surface which is helpful to convey bigger objects. It has also less friction index which provides an advantage when the object will be moved by the mechanical hand. The belt is aligned horizontally with the structure.

4.1.1.3 Hand:

To sort the object mechanical hand is the important part. The hand is made of hard paper like switch paper board. This type of material is light in weight. Hence it is easy to move with light duty servo motor. There are three hand used at three servo motor in my project. Hands are attached to the servo with glue. Each hand is made of an angle 120 degree, as it can move the object easily. Fig. 4.2 shows the hand on the structure.

Fig. 4.2: Mechanical Hand

4.1.2 Electrical Construction:

4.1.2.1 12 Volt DC Wiper Motor:

Fig. 4.3 shows the DC motor that will be used in this project. This rotates the roller of belt conveyor. The roller shaft is welded with this motor. Power is transmitted from the motor to the roller shaft of the conveyor belt. Fig 4.3 shows the motor attached with the Structure.

Fig. 4.3: 12V DC Wiper Motor[6].

Fig. 4.4: Wiper motor attached with structure.

4.1.2.2 Servo Motor:

Servomotor is a motor used for position or speed control in closed loop control systems.For this aim; it has implemented proportional-integral, fuzzy logic and adaptive neuro fuzzy inference system respectively at the variable working situations to the simulation model which has prepared at the MATLABprogramme for improvement the servo motor performance[7]. The servo motor I used, shown in Fig. 4.5. Components of the motor shown in Fig. 4.6

Fig.4.5: Servo motor[7].

Fig.4.6: Components of servo motor[7].

4.1.2.3 Arduino-Uno:

The Arduino-Uno (Fig. 4.7) is a microcontroller board based on the ATmega328 (datasheet).It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a

reset button. It contains everything needed to support the microcontroller; simply connected it to a computer with a USB cable, and with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial-converter. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may get overheated and this may damage the board. The recommended range is 7 to 12 volts[8].

Fig. 4.7, Fig. 4.8 and Fig. 4.9 represent Arduino-Uno component, pin diagram of Arduino and Arduino block diagram respectively.

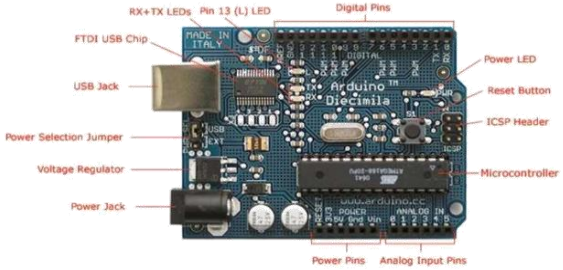

Fig. 4.7: Arduino components[9].

The power pins (Fig. 4.8) are as follows:

>VIN. The input voltage to the Arduino board when it is using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). One can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

>5V.This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage the board.

>3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current drawn is 50 mA.

>GND. Ground pins.

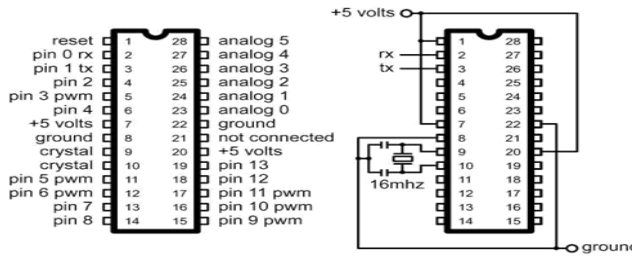

Fig. 4.8: Pin diagram of Arduino-Uno[9].

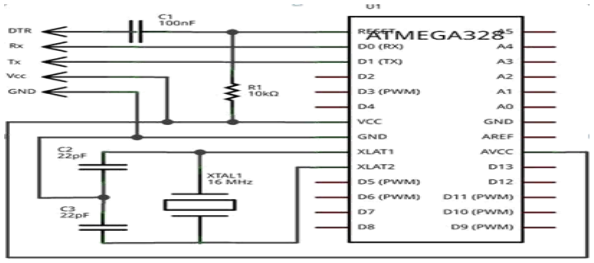

Fig. 4.9: Arduino block diagram[9].

4.1.2.4 7805:

7805 is a voltage regulator integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The voltage regulator IC maintains the output voltage at a constant value. The xx in 78xx indicates the fixed output voltage it is designed to provide. 7805 provides +5V regulated power supply. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels[10].Fig.4.10 shows the LM7805.

Fig. 4.10: LM7805[10].

4.1.2.5 7806:

The LM7806 series of three terminal positive regulators are available in the TO-220 package and with several fixed output voltages, making them useful in a wide range of applications. These devices can be used with external components to obtain adjustable voltages and currents[11].

Fig. 4.11: LM7806[11].

Features:

- Output Current up to 1A
- Output Voltages of 5, 6
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

4.1.2.6 LM324:

LM324 is a 14pin IC consisting of four independent operational amplifiers (op-amps) compensated in a single package. Op-amps are high gain electronic voltage amplifier with differential input and, usually, a single-ended output. The output voltage is many times higher than the voltage difference between input terminals of an op-amp.

These op-amps are operated by a single power supply LM324 and need for a dual supply is eliminated. The conventional op-amp applications can be more easily implemented with LM324.

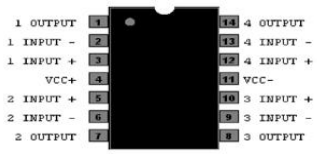

Fig 4.12: LM324[12]. Fig 4.13: Pin Diagram of LM324[12].

4.1.2.7 IR Proximity Sensor:

This proximity sensor, is easy to build, easy to calibrate and still, it provides a detection range of 35 cm (range can change depending on the ambient light intensity). However, this sensor can be used to measure the speed of object moving at a very high speed, like in industry or in tachometers. In such applications, ambient light ignoring sensor, which rely on sending 40 KHz pulsed signals cannot be used because there are time gaps between the pulses where the sensor is 'blind'. The solution proposed doesn't contain any special components, like photo-diodes, photo-transistors, or IR receiver (Fig. 4.16) ICs, only a couple if IR LEDs, an Op amp, a transistor and a couple of resistors. In need, as the title says, a standard IR led is used for the purpose of detection. Due to that fact, the circuit isextremely simple, and any novice electronics hobbyist can easily understand and build it. An infrared sensor is an electronic device that emits and detects infrared radiation in order to sense some aspect of its surroundings. Infrared sensors can measure the heat of an object, as well as detect motion. Many of these types of sensors only measure infrared radiation, rather than emitting it, and thus are known as passive infrared (PIR) sensors. It is the same principle in all Infra-Red proximity sensors. The basic idea is to send infra red light through IR-LEDs, which is then reflected by any object in front of the sensor

Fig 4.15: IR Emitter[13]. Fig4.16:IR Receiver[13].

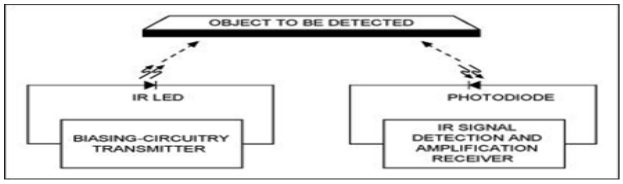

Fig 4.17: IR Sensing Block Diagram[13].

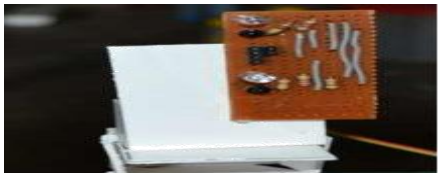

Fig. 4.18: IR used in the structure

4.1.2.8 Resistance:

The electrical resistance of an electrical conductor is the opposition to the passage of an electric current through that conductor. This is used to drop the voltage across a conductor.

Fig 4.19: Resistance[14]. Fig 4.20: Variable resistor[14].

4.1.2.9 Overall Circuit:

To obtain the purpose of this project depends on the structure of the circuit. It is important as it controls the servo motor with the signal of IR sensor.

It contains several parts such as,

- An Arduino-Uno
- IR sensors(emitter and transmitter)
- An Op-amp(LM324)
- Voltage regulator(LM7805 and LM7806)
- Variable resistance
- Several resistance (330Ω, 1KΩ, 20KΩ etc.)

In figure 4.21 there is shown the complete circuit of my project.

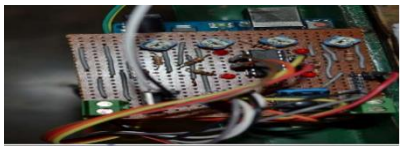

Fig. 4.21: Main Circuit

After all the mechanical and electrical components being set on the structure, my full project has been accomplished. Total structural view of my project is shown in figure 4.22.

Fig. 4.22: Overall Project

4.1.3 Software Development:

The software used to communicate the sensors with the circuit and servo; therefore it fulfills the objectives of this project. This programming is enlisted in Appendices A.

5. RESULT AND DISCUSSION

5.1 Result

When all the mechanical, electrical constructions and software development are done completely, then a 12 volt DC power source supply power to the wiper motor. Wiper motor rotates the belt conveyor continuously. When an object is kept on the belt, it moves along the belt. At the position of sensor, the objects are detected by their height and color. IR sends a signal to a servo motor as object's feature. The servo then rotates to extract the object. In this system taller and lower height white color objects are extracted to opposite direction, which takes time only 5 second from beginning. The black color and

lower height object is extracted by third servo, which takes only 10 second time. The black color and taller height object is not moved by the mechanical hand, it has just thrown away to the another end of the conveyor.

5.2 Limitation

The main objective of this project is to reduce time and labor in sorting application. But there are found some limitations in this project. These are:

>This system cannot sort small object (i.e. below 5cm).
>This system is bulky and heavy compare to prototype.
>Heavy objects cannot be sorted by this system.
>This system can sort only four types of objects.
>Many components used in this system are not sophisticated.
>Limitations mentioned above occurred for minimizing cost complexities of the project

5.3 Recommendation

This system would be more useful if some steps be taken down, such as mechanical, electrical and software development.

Mechanical development could be done by reducing the weight. Light weight material such as wood can reduce the weight. It also reduces the probability of short circuit as it is an insulator. Further it has low corrosiveness compare to steel. It is easy to mount anything to the wood easy and cost effective.

Electrical development can be done by using high quality electrical equipments. There can be used camera as sensor which will be able to detect objects more than four types including smaller objects. If heavy duty servo motor be used, it could sort more heavy objects.

6. CONCLUSION

In this paper I have discussed about my project. Finally my project can work successfully and separate different objects using sensors. Now a day's industrial application processing should take lesser time and power economic. In sorting application my project can help to acquire those objectives. The sorting method of my project is also something new, as it can sort based on both size and color. Though there are some limitations in my project, it can be avoided by doing some mechanical, electrical development. After modification of this project, it can be used in industrial sector at a large scale. This could be a blessing in sorting phenomenon.

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