ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2014

Object Sorting Robotic Arm Based on Colour Sensing

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ABSTRACT: In this paper a project is proposed to separate the objects from a set according to their colour. This can be usefulto categorise the objects which move on a conveyer belt. The proposed method of categorisation is based on colour of the object. In this project the system categorise balls of three different colours. The detection of the particular colour is done by a light intensity to frequency converter method. The robotic arm is controlled by a microcontroller based system which controls DC servo motors.

KEYWORDS: Robotic arm, Microcontroller, Light to frequency converter, DC servo motor.

I. Introduction

Mainly the colour sorters are used in agricultural machineries like rice sorter, beans sorter, peanut sorter etc. Colour sorters are used in other industrial applications also like quartz sand sorter, plastic granule sorting of coloured nuts and bolts etc. It reduces the human effort, labour and cost. It also increases the efficiency since the mechanised sorting is much faster the manual sorting.An ARM7 based microcontroller LPC2138, which is a 32 bit microcontroller with RISC architecture is programmed to control the robotic arm. The TCS3200 light intensity-to-frequency converter senses the colour and produce a square wave with varying frequency depends on the colour of the object to be picked up. Four DC servo motors are used in the construction of the robotic arm.The arm of the robot is constructed using aluminium brackets. Four types of brackets are designed for this purpose, two types for holding the servos and two types for length extension and interconnections. The ball picking gripper which is controlled by a servo is attached and the tip of the arm.

II. Literature Survey

To reduce human efforts on mechanical maneuvering different types of robotic arms are being developed. These arms are too costly and complex due to the complexity and the fabrication process. Most of the robotic arms are designed to handle repeated jobs. In design of the robotic are different parameters are to be taken care. The design of mechanical structure with enough strength, optimum weight, load bearing capacity, speed of movement and kinematics are important parameters. In electronic design the specification of the motors, drives, sensors, control elements are to be considered. In the software side the reconfigurability, user interface and implementation and compatibility are to be considered.

The paper prescribed in ref. [4] deals with the designing and implementation of Synchronized Robotic Arm, which is used to perform all the basic activities like picking up objects and placing them. The robot interact with its by means of arm and gripping device but there is no sensors.

The KUKA youBotis released their new 5-DOF arm with 2 finger gripper for educational and robotics research [8]. Camera is available as an accessory and the processing software has to be developed. There is no simple sensor which is attached to it. The advantage with youBot is it operates on open source platform.

Regarding the control software for the robotic arm standard software are available. The CAD based drawing can be used to manipulate the movement of the robotic arm and a CAM software can convert the drawing into motion codes[5]. Currently many Open Source based software are also available for the CAD/CAM design. Linux CNC is one of the popular open source CAD/CAM software.

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A. Ramakrishna et.al. in ref [6] proposed a system to design and implement a robotic arm based on haptic technology. The haptic feedback is mainly provided based on potentio meters and not through any highly sophisticated system. The technology is having a serious problem in feedback and can be improved by using optical sensors at the arm.

III. PROPOSED SYSTEM

The working model of the project is divided in to different sections like detection, control section, mechanical assembly and working.

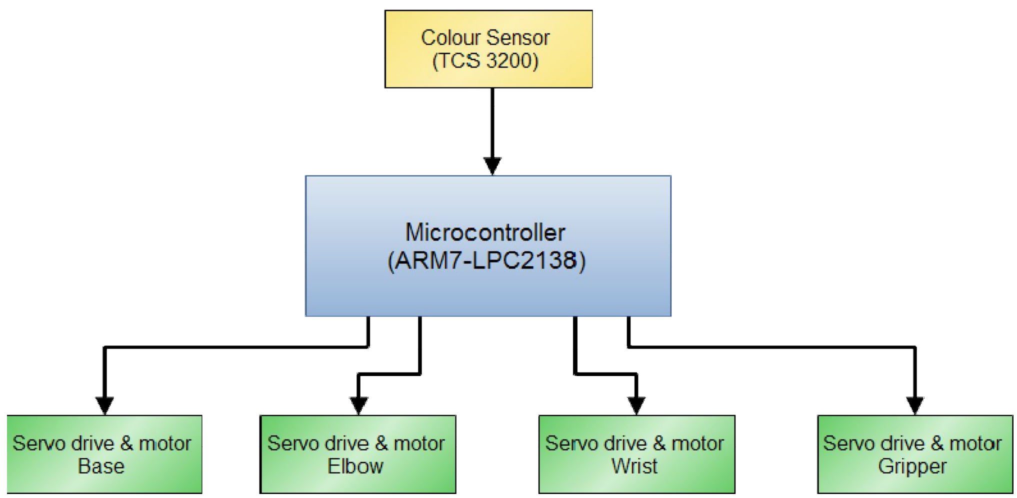

Fig.1Block Diagram of the proposed system

Different mechanisms can be used for detection of the object. For the trial run of the project the colour based detection has been selected. Since the optical sensors are used without much processing of the input data the sensing is done at a faster rate. The colour sensor itself provide direct signal to the microcontroller after detecting the object. The main operation of the microcontroller is limited to servo motor control and the overall response is expected to be better. The L293D driver ICs are used to drive the DC servo motors. The drivers are fast enough to deliver the pulses at required speed to the motors.

IV. DESCRIPTION OF THE BLOCK DIAGRAM

A. COLOUR DETECTION

This section is used for detecting the colour of the balls to be sorted. There are many colour sensing ICs available today. In different ICs the properties vary such as colour differentiating ability, output format, price, speed, resolution etc. In this project TCS3200 is selected.

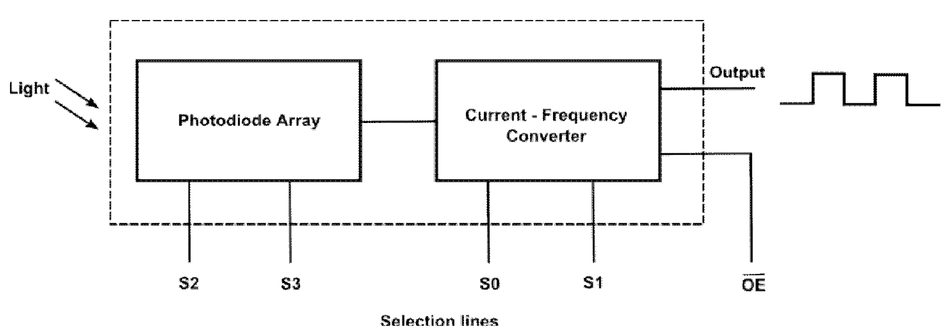

Fig. 2Block Diagram of Colour Detector TCS3200.

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The TCS3200 is a programmable light-to-frequency converter that combines configurable silicon photodiodes and a current to frequency converter on a single monolithic CMOS integrated circuit. The output is a square wave (50% duty cycle) with frequency directly proportional to light intensity.

The full-scale output frequency can be easily scaled by one of three values via two control input pins. Digital inputs and digital outputs allow direct interface to a microcontroller or other logic circuitry. Output enable places the output in the high impedance state for multiple-unit sharing of a microcontroller input line. In TCS3200, the light-to-frequency converter reads an 8x8 array of photodiodes. Sixteen photodiodes have blue filters, Sixteen photodiodes have green filters, Sixteen photodiodes have red filters, Sixteen photodiodes are clear with no filters.

The four types of photodiodes are interdigitated to minimize the effect of non-uniformity of incident irradiance. All photodiodes of the same colour are connected in parallel. Pins S2 and S3 are used to select the group of photodiodes (red, green, blue, clear) are active. Photodiodes are 110µm x110µm in size and are on 134µm centres. Output-frequency scaling is controlled by two logic input, S0 and S1. The internal light-to-frequency converter generates a fixed-pulse width train. Scaling is accomplished by internally connecting the pulse-train output of the converter to a series of frequency dividers. Divided outputs are 50% duty cycle square waves with relative frequency values of 100%, 20% and 2%. Because division of the output frequency is accomplished by counting pulses of the principal internal frequency, the final output period represents an average of the multiple periods of the principle frequency.

B. MICROCONTROLLER

In this project ARM7 based microcontroller LPC2138 is used which is a 32 bit microcontroller with RISC architecture. It has 48 I/O lines.The data output from TCS3200 is a waveform with 50% duty cycle and a frequency proportional to the intensity of the light reflected from object. The frequency proportional to the intensity of the light reflected from light. The frequency proportional to the of the waveform if calculated using the microcontroller by finding the time elapsed between two successive high pulses which will give the time period of a pulse. The time thus obtained can be substituted in mathematical equations which will give the frequency of the waveform. The time period elapsed between two successive pulses is measured by using external interrupts, when a high pulse is appeared at the external interrupt an interrupt is generated and corresponding ISR routine is executed. The first interrupt generated will start the timer. The timer value will be inversely proportional to the frequency of the waveform,with a convenient relation the respective frequency is calculated.Since the frequency of the waveform is proportional to the intensity if the reflected light from the object which is very much related to the colour of the object and the colour of the object can be decoded from the frequency of the pulse train. Once the colour of the ball is detected, the ball is picked up from the rail and drops it in the right basket using the robotic arm. The robotic arm movement is anticipated by using servo motors. Rotation of the servo motors converted to arm movement. That angle of rotation is based on the duty cycle of the waveform appearing on the control pin of the servo motor and it remains in that position as long as the waveform continues. The PWM for controlling the servo motors are generated by the microcontroller according to the colour input to the servo motors are controlled by the different four output pins of the microcontroller.

C. ROBOTIC ARM STRUCTURE

The robotic arm is controlled using servo motors whose degree of rotation is controlled by the on timer of the pulse rail appearing at its control input. According to the structure by the robotic arm various degree of rotation for the servo motor are assigned to carry out the operations.

The arm of the robot is realized using aluminium brackets. Four types of brackets are designed for this propose. Two types of the brackets are for holding the servo motors and two types for the extensions and interconnections of the robotic arm.

D.WORKING

The colour sensor identifies the colour of the ball and it sends the data to a microcontroller which controls the arm motion according to the colour of the ball. The motion of the servo motors are controlled in a manner so that each ball is dropped into a respective boxes place in a predetermined position.

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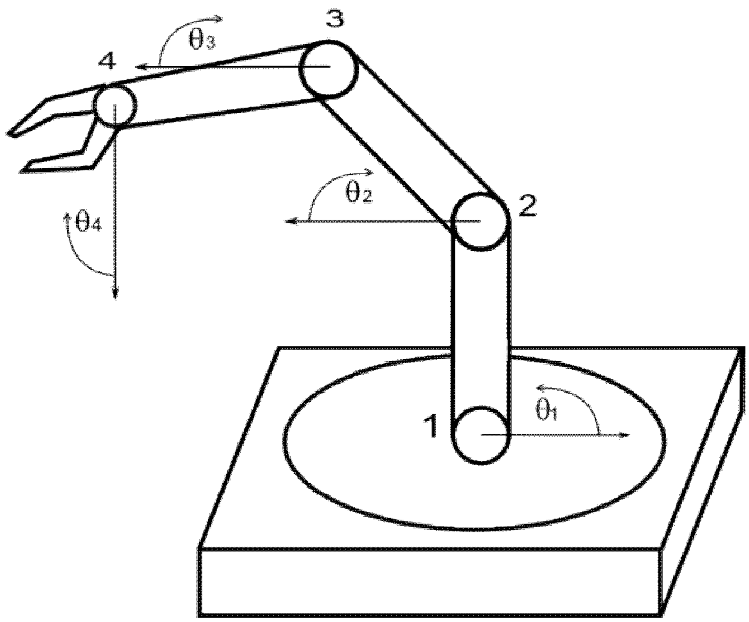

1. Servo Motor at Base — θ_1 – Degree of rotation of base and pole
2. Servo Motor at Shoulder — θ_2 – Degree of rotation Shoulder
3. Servo Motor at Elbow — θ_3 – Degree of rotation Elbow
4. Servo Motor at Wrist — θ_4 – Degree of rotation of wrist (Gripper)

Fig. 3 Robotic Arm Structure.

The time taken by the robotic arm for a single motion is set to approximately 0.5 seconds. Eight steps of motion of robotic arm are required for a ball to be picked up and to be dropped in the correct basket.That includes motion of arm from the default position, picking a ball, motion to the correct basket, dropping the ball to the basket and return to the default position. The number of steps taken by the arm to pick the ball and drop the ball counts to seven steps and from there to back to default position needed one step. Approximate time needed for the microcontroller to identify colour of the ball is around one second. Therefore the total time needed for picking and dropping the ball including identifying the colour is around five seconds.

Four motors are used in the robotic arm. One to control the rotational motion of the base, one to control the angle at the elbow, one to control the wrist movement and last one to control the gripper, that is to hold and drop the ball. The figure 3 shows the initial position of the robotic arm when power is applied and the robot is ready for operation.

A lever mechanism is used for opening and closing the gripper. So a single motor is enough for the gripper control. Fingers come closer to pick and hold the ball and move apart when it drops the ball. Two positions are designed for the fingers by using a single servo motor. One in close position and the other in open position. Two motions are permitted for the motors at wrist and elbow that is to move up and down.

Then by controlling the finger motion the ball is picked. After picking the ball arm return back to initial position by rotating motor at the wrist and elbow to default degrees. Here only one position of servo motor at finger varies from default position and the position of the motor. The motion of the motor at the base is controlled as per the colour of the ball. The base motor is made to rotate to four different positions. One is the default position which keeps the arm directly above the sensor module. Other three motions keep the arm above the appropriate colour boxes. Two boxes are placed left to the base, one at extreme left and the other one located between extreme left and default position and one box at the right. Angle of rotation of the base motor for each motion is described below

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Consider the colour of the ball is red and ball is to be dropped in the box at the right side. The rotation of the base motor is based on the colour of the ball picked up. The value of the degree assigned to the base changes according to the ball colour and the arm position itself above the right box to which the ball is to be dropped.Now the ball is to be dropped. The ball is dropped in the correct box and now it has to be return to the initial position to pick up the next ball. Base motor rotates CCW and the arm will be in the default position.

TABLE I
DEGREE OF ROTATION OF DIFFERENT SERVO MOTORS OF THE ROBOTIC ARM FOR DIFFERENT OPERATIONS

Move	Motion/ Motor	Base Servo	Elbow Servo	Wrist Servo	Gripper Servo
	Default/ Power On	85	80	125	40
1	Arm lowered	85	120	145	40
2	Pick The Ball	85	120	145	75
3	Return to Default	85	80	125	75
4.1	Move to Correct box (Red) right side	135	80	125	75
4.2	Move to Correct box (Yellow) left side	35	80	125	75
4.3	Move to Correct box (Green) extreme left side	5	80	125	75
5	Arm lowered	135	120	145	75
6	Drop the Ball	135	120	145	40
7	Arm moved up	135	80	125	40
8	Default	85	80	125	40

Rotation of the motors mentioned is in degrees

V. RESULTS AND DISCUSSION

This paper presents the design, development and construction of a robotic arm, which can pick and sort objects of different colour. The mechanical structure of the robot was assembled using aluminium brackets which helped to reduce the weight without losing the mechanical strength. The aim of the project was to have a fully functional robotic arm which sorts different coloured balls and the target is achieved successfully. In the final run of the project red, yellow and green balls were successfully sorted. The colour sensor IC TCS3200show almost stable response in various sunlight conditions.

The system is working with open loop. A better resolution can be achieved if closed loop control is incorporated. The system responses are a little bit slower than expected. It can be improved by using a more advanced colour sensor and microcontroller. User interfaces also can be provided as a modification which will enable the on demand reconfiguration of the movement in a better way.

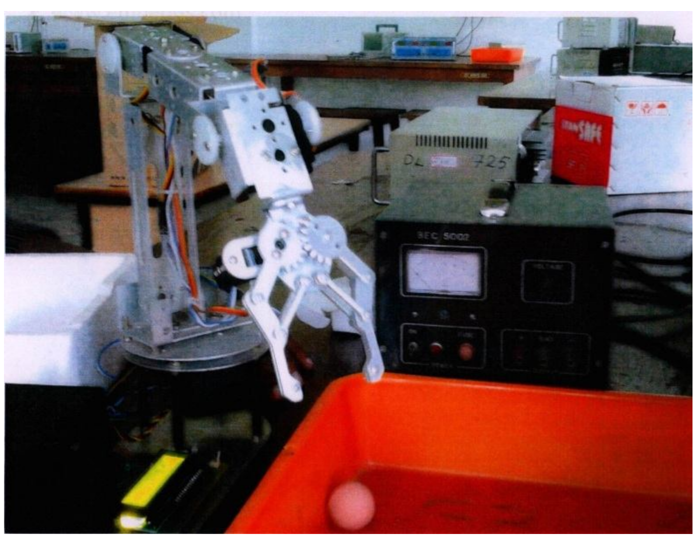

Fig. 4 Implementation of Robotic Arm

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VI. CONCLUSION

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BIOGRAPHY

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