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Six axes robotic arm aiding machine vision

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Abstract - *In the future, operations in the factories will be done by autonomous robots that need visual feedback to move around the working space avoiding obstacles and to complete the information provided by other sensors to improve their positioning accuracy. This paper discusses the development of a robotic arm integrated with machine vision. This work analyzes accuracy, range and performance of robotic arm in the working environment of a factory which is considered as the constraint. The developed model included a conveyor system for delivering the products, laser sensor for detecting the products, barcode scanner module and an LCD screen displaying the details of the tray. The robotic arm, controlled by Arduino Mega 2560, was able to place the products at the various destinations accurately. The instructions to place the product was preprogrammed in the controller. The processing of the image scanned by the barcode scanner was done by Raspberry Pi 2.*

***Key Words*: Arduino Mega 2560, Barcode scanner module, Laser sensor, Machine vision, Raspberry Pi 2**

1. INTRODUCTION

Automation or automatic control is the use of various control systems for operating machinery equipment to carry out various processes in factories. The biggest benefit of automation is that it saves labor, energy and materials. It also improves quality of the product. The term automation was not widely used before 1947, when General Motors established the automation department. It was during this time that industry was rapidly adopting feedback controllers, which were introduced in the 1930s. Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical and electronic components [1].

Nowadays, the use of robotic arm is common in several logistics for moving packages from one end to the other. In some industries, robotic arm is used for fault detection applications with complex designs. Industries find many benefits in employing tasks to robots [2]. Due to their high accuracy levels, robots can produce higher quality products and also reduce the time needed for quality control. By increasing the efficiency of production process, industrial robots can thus be used to achieve higher profitability levels. Industrial robots are often used for performing tasks which are deemed as highly laborious, repetitive and hazardous for humans. For a typical person, working continuously with high efficiency is not possible. In case of a robot it can work continuously for long time at maximum efficiency [3].

2. METHODOLOGY

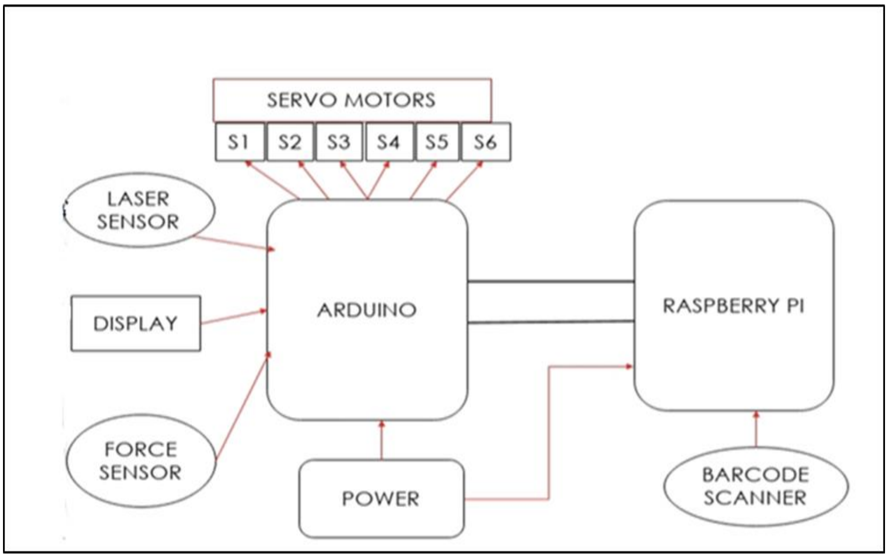

Fig -1: Electric circuit design of six axis robotic arm aiding machine vision

The objective of the project was to create a completely automated sorting device and was designed in the following way. The movement of the robotic arm was synchronized to pick up the objects from the base of the chute conveyor [2]. It classified the bar-coded and non-bar-coded objects present at base of chute and placed the objects in its respective preprogrammed trays. Fig. 1 shows the electronic circuit design of six axis robotic arm system. This eliminates the monotonous work done by human while improving the speed and accuracy. The barcode sensor received the data and sent signal to the microcontroller. The arduino actuated the servo motors of robotic arm to move and place the product at designated locations automatically.

2.1 Component Description

The entire experimental setup consists of a robotic arm made of aluminum sheet and seven motors including four MG996R motors, two MG90S motors and one MG995 motor. Arduino mega 2560 is used as the main controller while raspberry pi acts as sub controller responsible for controlling the signals related to the barcode sensor module. Bar code sensor module has 32 bit processor for quick and efficient one dimensional scanning. Data is transmitted through USB 2.0 cable [6]. Laser transmitter emitting laser of wavelength 650 nm and non-modulator tube laser receiver is responsible for detecting the presence of product. LCD module having dimensions of length 16 cm and width 2 cm integrated with I2C adapter is used. A gripper with the claws having width of 4.5 cm is responsible for picking and holding the object. The gripping force is measured by a round shaped force sensor. The sensor can detect whether the gripper is holding the object or not. Other accessories include three trays namely tray 1, tray 2 and tray 3 and a hollow tube made of foam board.

2.1.1. Arduino Mega 2560:

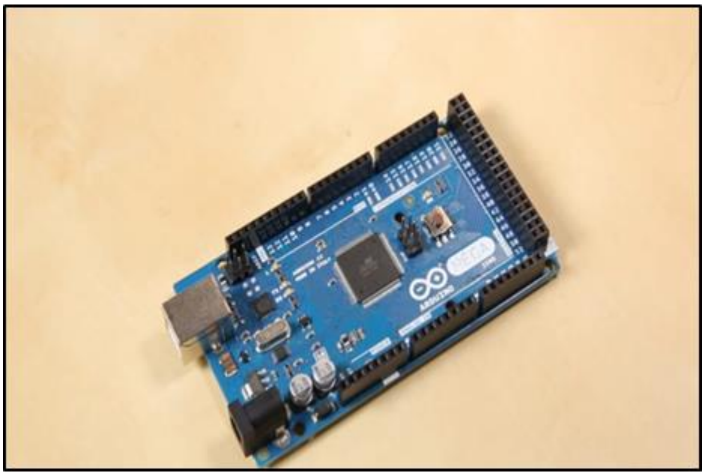

Fig -2: Arduino at Mega 2560

The Arduino Mega 2560 shown in figure 2 is a microcontroller board based on the mega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller. USB cable connected to a computer or with an AC-to-DC adapter or battery can power the Arduino [7].

The Mega 2560 can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or a battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack [8]. Leads from a battery can be inserted in the GND and V_{in} 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, the 5V pin may supply less than five volts and the board may become unstable. While operating at more than 12V may cause the voltage regulator to overheat and damage the board. The recommended range is 7 to 12 volts. The mega 2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the boot loader), 8 KB of SRAM and 4 KB if EEPROM [9].

2.1.2 Raspberry Pi 2:

Raspberry Pi 2 shown in fig. 3 boasts a Broadcom 900 MHz quad-core ARM Cortex-A7 processor with 1 GB of RAM. The speed up varies between applications. Single-threaded CPU benchmarks the speed up by as little as 1.5 times, while Sunspider is around 4 times faster and NEON-enabled multicore video codecs can be over 20 times faster. 6x is a typical figure for a multi-threaded CPU benchmark like SysBench. Raspberry Pi 2 was able to run Windows 10 [10].

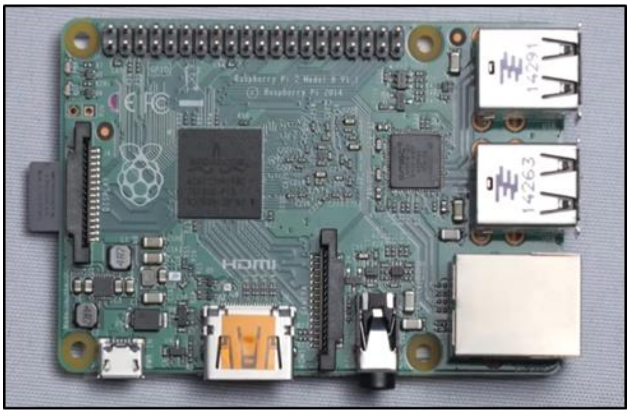

Fig -3: Raspberry Pi 2

2.1.3 Robotic arm

The Robotic Arm design concept shown in fig. 4(a) was based on ABB IRB 4400 palletizing robot. It has a working envelope of 400 mm. It was made of thickened hard aluminum alloy which is corrosion resistant and light-weight. All the moving joints used high quality bearings for better performance. The base of arm used full-steel bearing, which made the arm more stable.

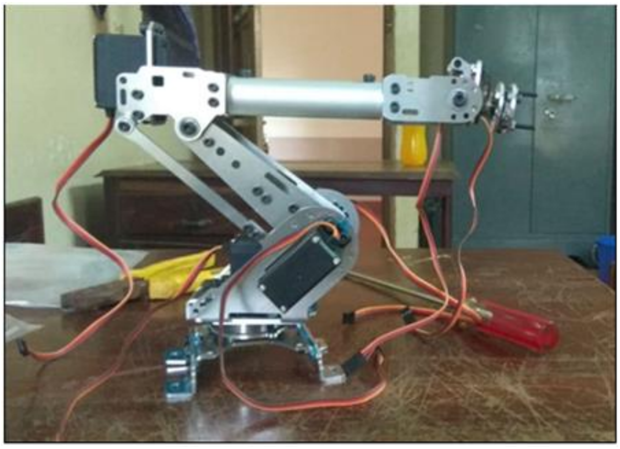

Fig -4: Robotic arm

2.1.4 End Effector

The End effector shown in fig. 4(b) had an overall length of 108 mm and an opening width of 55 mm. It was also made of Aluminum alloy in order to make it light weight and strong. MG995 Servo Motor was used for gripping. Moreover it had a clamp total width of 98 mm and was manufactured with the help of Roinco from Bombay Electronics, Grant road, Mumbai.

Fig -5: End effector

2.1.5 Servomotors

Servo motors are DC motors with feedback and loop circuitry. They consist of a motor coupled to sensor for motion feedback, through a reduction gear box [4]. The robotic arm used four MG996R metal gear servos and two MG90S metal gear servos to ensure lasting power. MG996R comes with a torque of 11kg-cm at 6.0V and with dimensions 40.7×19.7×42.9 mm. MG90S comes with a torque of 2.2 Kg-cm and with dimension 22.8×12.2×28.5 mm. Gripper also used a servo motor for gripping which is MG 995 similar in size to MG996R but having less torque which is sufficient to grip. These motors aided in achieving high resolution, accurate positioning, fast control response and constant torque throughout the servo travel range and excellent holding power. These were also purchased from TowerPro from Bombay Electronics, Grant road, Mumbai.

2.2 FLOW CHART

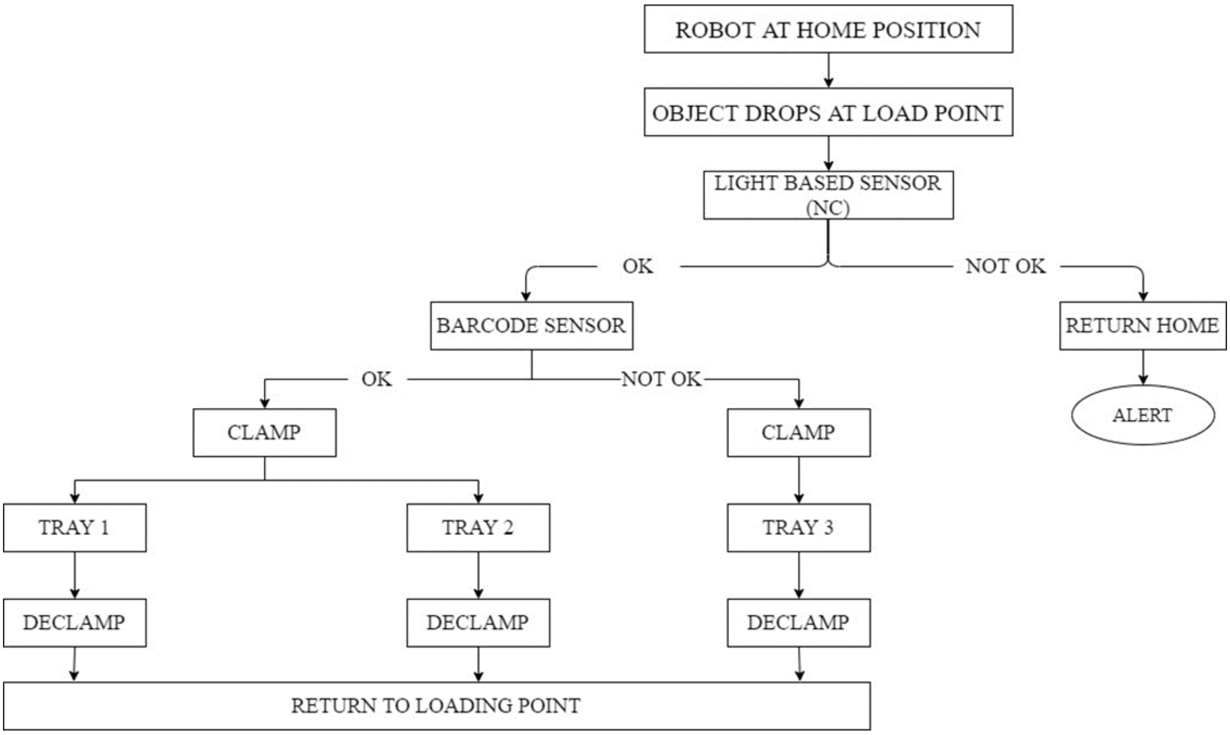

Fig-6: Flow chart of the working process

The working process of the robotic arm aiding machine vision shown in fig. 5 is explained as follows; when the product is at the base of the chute, it causes an obstruction to the path of the laser. The laser receiver stops receiving the laser signal from the transmitter. It enables the LCD to display "The object is detected" message and a signal is passed to the barcode reader. It analyses the bar code within a 5 second lag period. It also causes the robotic arm to move from its home position towards the object. There are three cases possible after the analysis depending on the data obtained from barcode reader. If no data is obtained from the barcode sensor within the 5 second lag period, a signal is passed on to the robotic arm to pick up the product and place at tray 3. Tray 3 denotes absence of barcode or a defective product. If there is a barcode, it is detected within the 5 second time lag.

The data is then analyzed and classified into two categories, namely item 1 or item 2. The LCD modules display the tray number where the object was placed. If there is no object buzzer module gets triggered. Similarly LCD module display that "No object is present". The signal from barcode reader trigger the robotic arm, to place items 1 and 2 in to tray 1 and tray 2 respectively. After the robotic arm displaces from the home position, if the light based sensor remains closed for 10 seconds the robotic arm returns to home position. In case of emergencies a switch is provided to return the arm back to its home position.

2.3 JOGGING OF ROBOTIC ARM

Jogging or teaching of robotic arm is a process used to teach industrial robots the movements it should utilize and locations it has to reach. It is done by using a teach pendant. Fig. 6 shows the code used for jogging. It involves manually moving the robotic arm in the desired direction [1].

The steps involved in jogging are,

STEP 1: ARDUINO CODE

Upload the code to the Arduino.

STEP 2: CONNECTION

Connect servo with Arduino and potentiometer

1st terminal of potentiometer with +5v

- 3rd terminal of all potentiometer with GND
- Middle terminal of potentiometer with A0
- Red wire of servo with +5 v
- Black/Brown wire of servo with GND
- White wire of servo with pin 9

STEP 3: POWER

Give proper supply to Arduino and control the robotic arm by varying the position of potentiometer knob.

```
#include<Servo.h>
Servo servo_test;
int angle = 0;
int potentio = A0;
void setup()
{
    servo_test.attach(9);
}
void loop()
{
    angle = analogRead(potentio);
    angle = map(angle,0,1023,0,79);
    servo_test.write(angle);
    delay(5);
}
```

Fig-6: Code for jogging of robotic arm

2.4 ROBOTIC ARM MECHANISM

From fig. 7, six axes of movements shown by the robotic arm are depicted. The six axes robotic arm prototype was successfully built. It made use of seven servo motors including one for gripper movement. The servo motors used included four

MG 996R, two MG 995 and one MG 90S. Torque reaches up to 2.2Kg-cm for MG 90S, 11 Kg-cm for MG 996R and 9.1 Kg-cm for MG 995. The motor at base of robotic arm rotates about axis 1 with coverage around 270 degrees. Forward and back extension of robot's lower arm was due to two motors rotating about axis 2. The motor rotating about axis 3 caused raising and lowering of robot's upper arm. As the motor rotates about axis 4, the robot's upper arm and wrist attached to it rotates about the same axis. The tilting motion of the end effector which raises and lowers the end effector of robot's arm is done by employing motor. The motor caused the end effector to rotate. Finally a rotating motor and accompanying gear controlled the jaws of the grip.

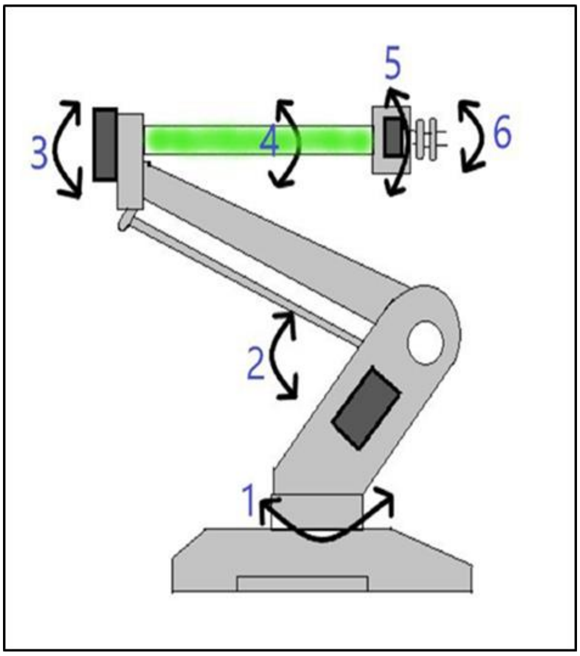

Fig-7: Schematic of six axis robotic arm

3. CONCLUSIONS

This paper presents the design, development and implementation of a robotic arm, which can accomplish simple yet repetitive tasks, such as sorting. The project can work successfully and segregates different objects using sensors. The sensor handling system drives the pick and place robot to pick up the product and place it into designated place with good accuracy and low time consumption.

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