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Object Sorting by Robotic Arm Using Image Processing

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Abstract - *In today's era, small scale and large scale industries faces common hindrance like shortage of time and workers which leads to inefficient manufacture. A proper result for the above problem can be achieved using robotics. Furthermore, for meticulous result, image processing methods can be beneficial. This paper broach one of the applications to sort objects using robotic arm. This method of sorting is quick and doesn't require continuous surveillance, thereby increasing the growth of the industry. Hence it leads to better production and income.*

In this paper, computer vision is carried out with assistance of Open CV and the robotic arm, which is motored by microcontroller. Different algorithms build in microcontroller, enables the robotic arm to either sort the objects based on fault like missing drill holes, improper shape or some other faults.

Key Words: Binary Segmentation, MATLAB, Robotic Arm, Servo Motor, Webcam

1.INTRODUCTION

The sorting of objects using robotic arm is extensively used in the industries. It helps to reduce need of labors, increases production and stipends of industry. In the complicated and unbearable sorting and the work which can't be done by human hands it is the most productive method.

Similarly, the influence and impacts of digital image on modern society are also huge. Image processing has become such a crucial component in modern science and technology that many task would not be attempted without it. It is used in computer vision, robotics, medical imaging, microscopy and many other fields.

The field of robotics is blooming with a fast speed in recent years and many progressive technologies are coming with their own advancement. Robots due to its easy manner of operation are used in domestic, industrial and military purposes. By merging image processing and embedded technique this paper recommends a robotic arm that can detect fault and efficiently sort objects.

2. OBJECTIVES

1. To separate faulty and correct objects.
2. To provide mechanization to the process using robotic arm.
3. To analyze the properties of the object.
4. To design easy and simplified algorithms.
5. To count and display count of the objects on both LCD and smart phone

The robotic arm used in this project work is used to sort the object moving on moving disk. Depending upon faults detected into predetermined categories.

This robotic arm is controlled by the microcontroller used i.e. PIC16F877, which is a 40 pin microcontroller. This microcontroller programs the stepper motors used in robotic arm. The magnet is used to hold objects which is fitted at the tip of robotic arm.

The software devilment is a vital task in the proposed project development. The software is entirely coded in MATLAB to check the fault present in the object and separate them from correct ones. Thus by using fully automated system, the time required for the sorting process is reduced to great extent.so proposed system is fast, accurate, economical, robust and cost efficient.

3. SPECIFICATIONS

Hardware specifications:

- Microcontroller (LPC2138)
- Robotic Arm
- Rotating Disk
- Web Camera
- MAX232

Software specifications:

- MATLAB

4. BLOCK DIAGRAM

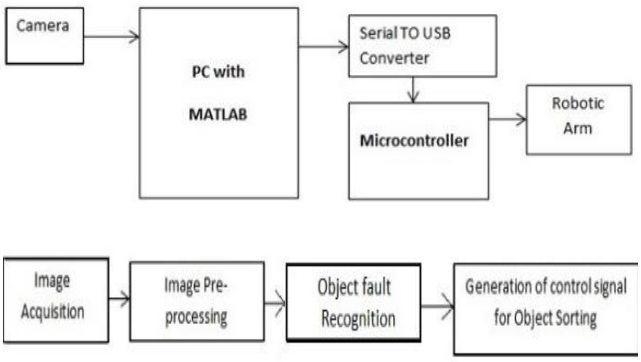

Fig-1: Block diagram

5.BLOCK DIAGRAM DESCRIPTION

A. Microcontroller:

The PIC16F877 microcontroller with real-time emulation and embedded trace support that combines the microcontroller with 32 kB, 64 kB, 128 kB, 256 kB and 512 kB of embedded high *speed Flash memory.*

Due to their tiny size and low power consumption, these microcontrollers are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. It has following features

Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules.
  - Capture is 16-bit, max. resolution is 12.5 ns.
  - Compare is 16-bit, max. resolution is 200 ns PWM max. resolution is 10-bit.
- Synchronous Serial Port (SSP) with SPI (Master mode) and I2C (Master/Slave).
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) – 8 bits wide with external RD, WR and CS controls (40/44-pin only)

Analog Features:

- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (VREF) module
  - Programmable input multiplexing from device inputs and internal voltage reference
  - Comparator outputs are externally accessible

B. Serial to USB converter (MAX232):

MAX 232 transforms signals from an RS 232 serial port to signals acceptable for use in TTL compatible digital logic circuit. It is a dual driver/receiver and typically converts the Rx Tx, CTS and RTS signals. MAX232 is purposed for application in high-performance information processing systems and control devices of wide application.

The MAX232 is a dual driver/receiver that includes a capacitive voltage generator to supply voltage levels from a single 5-V supply. Each receiver converts TIA inputs to 5-V TTL levels. These receivers have a typical threshold of 1.3 V, a typical hysteresis of 0.5 V, and can accept ±30 V inputs.

C. Robotic arm:

Robotic arm is just like a human arm which is made of three stepper motors which will have different configuration of mechanical motion.

Of all motors, step motor is the easiest to control. It's handling simplicity is really hard to deny - all there is to do is to bring the sequence of rectangle impulses to one input of step controller and direction information to another input. Direction information is very simple and comes down to "left" for logical one on that pin and "right" for logical zero

Most of the outer phase of the robotic arm is made of plastic parts. The features of robot are functional base, base rotation, elbow, and wrist motion. The 3 motors operate the release, lower and lift.

Maximum lift: 100g.

Dimensions: 9” L* 6.3” W*15”

D. Camera:

In this project, the camera used is Zebion opal 2231. It provides image input on which the algorithm is performed. The main features of this webcam are plug and play unit, CMOS sensor, adjustable focus of 3 cm to infinity, and a frame rate up to 30 FPS.

The high quality inch sensor with microphone has the sensor resolution of 300K. The video format is 24- bit true color AVI.

Table-1: Camera specifications

Still Image Sensor Resolution	20 megapixels
Video Sensor Resolution	300 K megapixel
Sensor Type:	1/4 CMOS Sensor
Video Capture Resolution:	1600 x 1200
Frame Rate	30 fps
Image Capture Resolution:	5120 x 3840

6. WORKING

Step I. Object Placement:

It is the first part of the system in which all objects that are to be sorted are placed on the rotating disk. object as metallic chip with drill holes are used. Hence these objects having different size, shape and colour are to be placed on the rotating disk. Object placement should be done as one chip get sorted after that another chip is placed on the rotating disk. After placing a chip on the rotating disk, start rotating disk for further processing.

Step II. Image Capture:

After placing the chip on the rotating disk, the rotating disk is takes a stable position. The camera used in this case will be overhead and it will take the snapshot of the object for fault detection purpose. With the help of camera real time image of a chip is taken. This image should be good quality and which is send to PC with MATLAB software.

Step III. Image Processing:

The image captured by the camera is then transferred to the PC in which different image processing algorithms are applied on it. Important terms related to image processing:

Pixel: Pixel is the building blocks of an image. In other words, a pixel is the smallest possible image that can be detected on your screen.

RGB Image: An image is composed of the three primary colors, Red, Green and Blue. Hence is called as RGB image.

RGB value: All colours which we see around us can be made by adding red, blue and green components in varying proportions. Hence, any colour of the world can uniquely be described by its RGB value which stands for Red, Blue and Green values.

Binary Image: An image that consists of mainly black and white pixels.

Grey scale Image: It contains intensity values ranging from a minimum (absolute black) to a maximum (absolute white) and in between varying shades of grey. Typically, this range is between 0 and 255.

Firstly, the image, that is captured by the camera is send to the PC via microcontroller, is a RGB image. This RGB values are converted into grey scale values. Then this grey scale image is converted into binary image using thresholding. Thresholding is the simplest method of image segmentation. From a grayscale image, thresholding can be used to create binary images. Thresholding replace each pixel in an image with a black pixel if the image intensity 'im' is less than some fixed constant 'th' (that is, im<th) or a white pixel if the image intensity is greater than that constant.

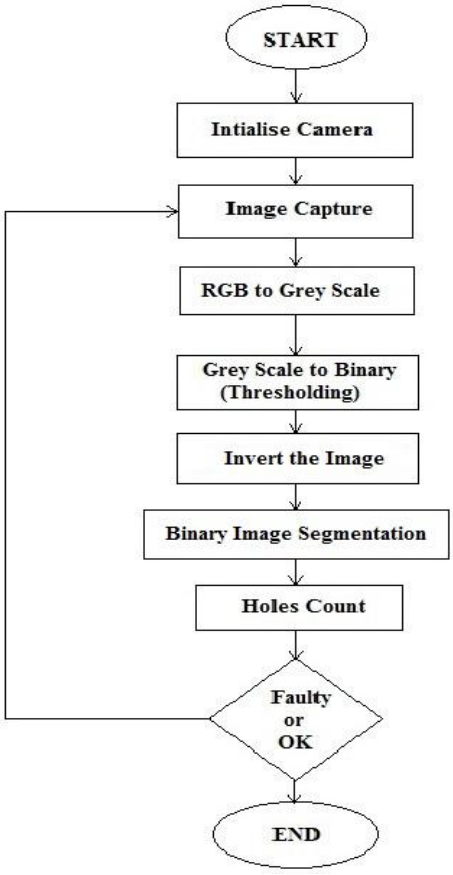

Fig-2: Flow chart

This binary image is then inverted i.e. the black pixels are converted into white pixels and the white pixels are converted into black pixels for simplification. This inverted image is saved as a new image and using binary image segmentation the no. of holes in the image is counted. If the no of holes is more or less than the required no. of holes the object is faulty and if the no. of holes is as per requirement, then the object is correct. Thus by counting the no. of holes in the image, the fault present in an object can be detected.

Step IV. Instruction to Rotating Disk:

Once the fault is detected, the PC via microcontroller sends commands to the stepper motor present on the disk. This stepper motor rotates the disk in a circular motion. By rotating the disk, the object is moved from the camera and bought under the robotic arm.

A stepper motor is a brush less DC motor whose rotor rotates in discrete angular increments, when its stator windings are energized in a programmed manner. Thus the stepper motor helps move the object to the robotic arm where the sorting takes place.

Step V. Instructions to Robotic Arm:

It is basically 3 axes' robotic arm. This is used to send a chip to different position. If chip is non faulty then the robotic arm picks the metallic chip and places it in a container to its right and the chip is faulty, the robotic arm picks the metallic chip and places it in a container to its left. This is achieved due to the instructions given to the stepper motors present in the robotic arm by the PC via microcontroller.

In stepper motors, Rotation occurs because of magnetic interaction between rotor poles and poles of the sequentially energized stator windings. The rotor has no electrical windings but has salient and/or magnetic poles. Thus stepper motor is a digital actuator whose input is in the form of programmed energization of the stator windings and whose output is in the form of discrete angular rotation.

It is a type of mechanical arm, usually programmable, with similar function of a human arm. The links of such a manipulator are connected by joints allowing either rotational motion or translational displacement. The robotic arm in this paper moves vertically and horizontally according to the instructions feed to it. These motion help achieve the desired result

Thus object sorting based on fault detection is performed with the combination of image processing and robotic arm.

7. ADVANTAGES

1) High extent of intellect.
2) Fully automatic venture.
3) Failure rate is low with long life.
4) Speed of operation is high
5) Highly productive.
6) Reliable performance and maintenance.
7) High accuracy; scope of error can be reduced to great range.

8. APPLICATIONS

The robots find numerous applications in industrial, domestic, medical, pharmaceutical and hazardous environment where human life is at risk. Some major applications are:

1) *Industry:* object sorting arm can be used in manufacturing industries to sort the objects based on fault like missing or mistaken drill holes, dimensions, weight etc.

2) *Medical*: robotic arm ae used in tele surgery and also helpful for accurate surgeries.

3) *Defense*: Robotic arm can be used to diffuse the bombs.

4) *Hazardous environments*: robotic arm can be used in environment such as coal mines, radiation places which is either perilous or dangerous to access.

5) Robotic arm can be used in space examination programs.

9. RESULT

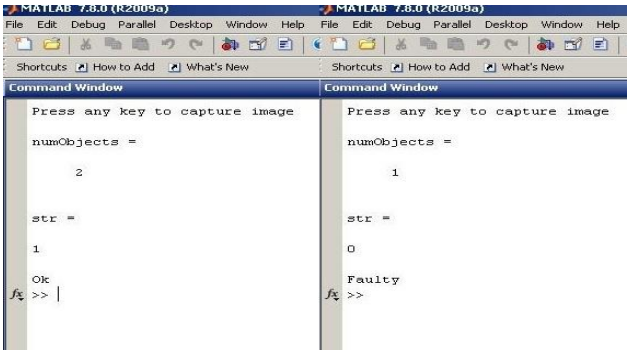

Fig-3: MATLAB Output

The sorting device sorts the objects depending upon the faults present in the objects successfully with the aid of the robotic arm and MATLAB program in image processing using binary segmentation algorithm. The webcam offers as an eye of the system which captures the real time image of the objects.

The robotic arm picks the faulty feature objects and places it at predetermined place, while good quality object continues its motion on rotating disk and they are collected by the robotic arm differently in object carrier system. The LCD shows the object count with the state of the quality of the object.

10. CONCLUSION AND FUTURE SCOPE

The proposed system will be a sample version, so for a large scale manufacture the number of robotic arms, cameras and length of disk system can be attributed. Moreover, modified model of robotic arm can be used to pick large and heavy objects and sort them effectively.

Usually, image capture is a complicated challenge as there is a chance of high ambiguity due to the external lighting conditions. Similarly, while assembling objects from disk system by a robotic arm there is deviation in the weight and size of an object. Therefore, future designs can be modified so that the objects can be sorted steadily. Automatic Trolley system can be created to lead the sorted objects to their desired locations.

This paper offers practical laboratory applications in robotic operation and computer vision. It describes the implementation of the robotic arm which can handle the appliances that are enforced and helps to sort these objects according to their faults.

This application provides the hands-on experience which is necessary for robotics knowledge. It gives total explanation of the methods that are fundamental for robotic arm.

The merging of real-world problems with complex imagery can upgrade image-processing applications. The object sorting procedures are executed using image processing technique. Thus the robotic arm is moving in desired direction.

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