Robotic Arm with Robotic Vision for Automated Material Handling Operations

Deepak Gupta, Sandeep Jaiswar, Prasad Bagwe

Abstract— Image processing in today's world grabs massive attentions as it leads to possibilities of broaden application in many fields of technology. This paper represents a color and shape sorting system with application of image processing. Procedure of image processing involves capturing the image of object with help of camera andprocessesing in matlab for identification ofits color and shape for sorting purpose. The sorting process is based on an operative methodology which has inclusion of operative selection process in which objects are detected and classified using a decisional algorithm and selected in real time with involvement of automated material handling system. After being detected, the object undergoes pre-defined actions. These actions are simulated by the signals sent by microcontroller to the servo motor which are assembled in specific manner to form an arm like structure for carrying out suitable operations. After the operation is done, the system retrieves its original assigned position for the purpose of continuous flow of result coordinated with high speed and better accuracy.

Index Terms— Decisional algorithm, Image processing,MATLAB, Microcontroller, Material handling system, Robotic arm, Servo motor.

1. INTRODUCTION

Robotic vision is a process of extracting, characterizing and interpreting information from image of a 3D object. It involves camera hardware and computer algorithm to allow robots to process visual data from the world. For example, a system could have 2D camera which detects an object for the robot to pick up. Robotic vision is targeted at manipulation and interpretation of image and use of its information in robot operation control. Unlikely pure computer vision research, robot vision must incorporate aspects of robotics into its techniques and algorithms, such as kinematics, reference frame calibration and ability of robot to physically effect the environment.
Material handling is the movement, protection, storage and control of materials and products throughout manufacturing, warehousing, distribution and consumption [8]. Manual handling refers to the use of a worker's hand to move individual containers by lifting, filling, lowering or carrying them. It can expose worker to a physical condition that can lead to injuries that represent a large percentage of the over half of million cases of musculoskeletal disorders and often involves strains and sprains to the lower back, shoulders and upper limbs [9].
Most of the existing material handling equipment is only semi-automated because a human operator is needed for task like loading,unloading and driving that are difficult or too costly to fully automated, although ongoing advances in machine intelligence and robotics have made it possible to fully automate and increasing number of handling task by sensing the environment and physical information of material with the help of Robotic Vision and various sensors.

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2. SCOPE

The robotic arm with robotic vision is a working model of color and shape sorting system which can effectively utilized in industries such and production lines, manufacturing lines, packaging industries etc. it canteam up with automatic trolley system which will help them to move to the desired prescribed location after the process of sorting is done. It can also be used in daily life such as sorting of fruits based on its size and shape. After some modification in the robotic arm, it can be used to pick heavy and large objects that will make the system really practical. Using this bot, one can increase the efficiency of his system, increase in productivity and it will be overall cost effective for them.

3.LITERATURE REVIEW

Traditionally, the object sorting process used to be done manually. However, this method has many disadvantages such as increase in the cost of the product, slowness and inaccuracy due to the human mistake. Quality inspection, sorting, assembly, painting, packaging etc. were used to be done manually, but after the rapid involvement in the field of robotics, the automation industry has undergone a complete makeover and the technology of object recognition using robotic vision is used for such work [1].
In many packaging industries, counting and sorting of the object is the major task that needs to be done and that can be fulfilled by the effective use of this technique and the accidents which used to cost human life can no more be seen. It not only increases the production rate of manufacturing industry but also reduces the effort of material handling reducing overhead expenses [2].
The efficient flow of material in production house or any production system is important, therefore material handling is the crutial part of design for most production systems,

thereforeoptimisting the total standard time we should optimize material handling operation [8].

4. METHODOLOGY

Robotic vision system may be defined as the process of extracting, characterizing and interpreting information from images of a 3-dimentional world. This information is further used to identify an object and determine its location. Robotic vision is primarily targeted at manipulation and interpretation of image and use of this information in robot operation control by which various industrial task can be performed.
Function of robotic vision system which will assist robotic arm are:

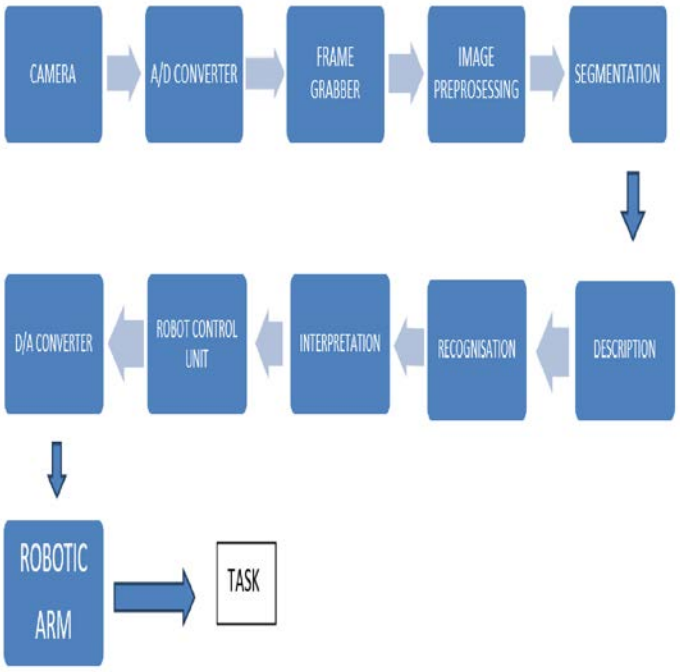

Fig.1 Function of robotic vision system

CAMERA
Web camera is used to capture images of objects. These images are used by MATLAB for detection of color, size and shape of object.

A/D CONVERTER
As manipulation of image in MATLAB in done by computer, there is need to convert the Analog signal into Digital signal for computer processing.

FRAME GRABBER
A frame grabber is an electronic device that captures individual digital still frames from analog video signal or a digital video signal. These still frames are send to image processing unit i.e. in MATLAB.

IMAGE PREPROSESSING
It deals with techniques like noise reduction and enhancement. Capturedimages contain noise, which must be removed. MATLAB provides various filters for noise removal. Some of the functions available for noise removal are: imadjust, medfilt2. The preprocessed image frame is stored in computer memory for further processing.

Fig 2. Images before and after pre-processing

SEGMENTATION
It is the process of identifying a group of related pixels for locating connected regions or areas of image having similar characteristics. It consists of Thresholding, Region growing and Edge detection.

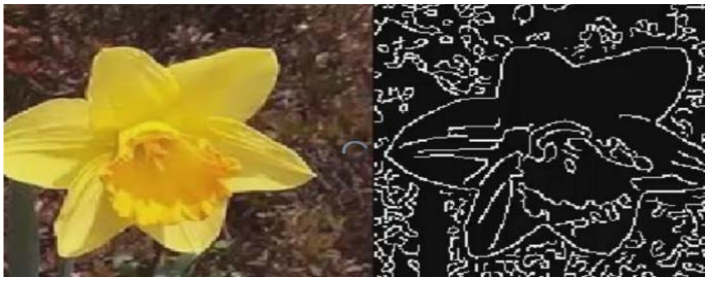

Fig 3. Imagebefore and after segmentation process

DESCRIPTION
The parameters like shape, size, perimeters etc. helps to describe the object in the image. This information is extracted from the image for and object for further object identification process.

RECOGNISATION
It deals with the unique identification of objects in image. For object identification, image comparison technique is used which use the previous stored data of object to compare.

INTERPRETATION
After identifying the object from image certain task is executed by the robotic arm which is stored in Robot Control Unit.

4.1 DEVELOPMENT OF ROBOTIC SYSTEM

Colour and shape are to two important features of many objects used or produced in industry. These features will help the system to dffrentiate between two objects. The sytem will consist of a camera mounted in workspace to detect the object

through its features using image prosessing with MATLAB. This technology can be used in material handling in logistics and packaging industry where the objects moving through a conveyer belt can be separated using a colour and shape detecting robot.

HARDWARE IMPLIMENTATION

The hardware implementation deals in:
1. Arduino Uno: A micro-controller board which iscompatible with webcam and motor drives. This component is the heart of the system. Other components will be connected to this.
2.A webcam which is to be mounted in workspace andconnected to USB port of the PC. The specification of camera are as follows:
-CMOS camera with plug and play USB connection
-Support variety of video format
-Frame speed required 30 fps.
3.A moter driver which will connect the servo and stepper motors with main micro-controller board.

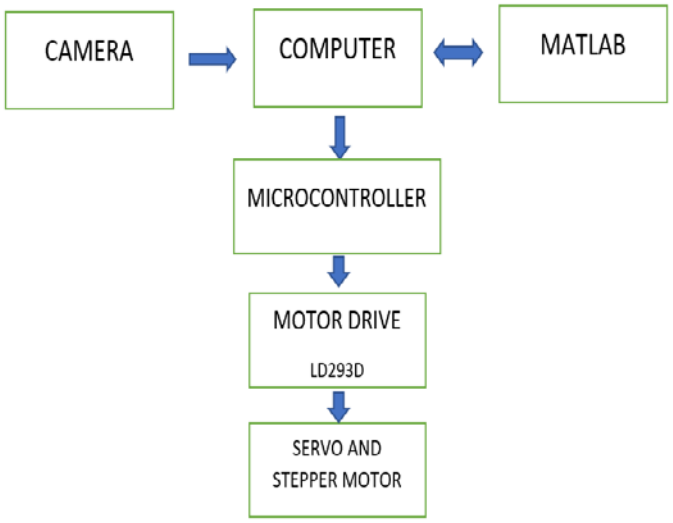

Fig 4. Basic Block Diagram of System

ROBOTIC ARM SETUP

Many different motors are available in the market like servomotors, stepper motorcar synchronous motors, dc motors with and without gears. These different motors are used according to their applications and requirements for e.g. If we want high torque and precise position we need to use servo motors, if we want to only position and if high torques not required then stepper motors are used. Dc geared motors are used where we need high torque. For only smooth motion DC motors are used.Here we have used stepper motor as though servo is best suited for robotics it wasn't economically viable.
Stepper motors are of many types for e.g. Variable reluctance motors, permanent magnet motors and hybrid motors. After the above steps have been done, now is time to design the desired robotic arm. There are many ways to design a robotic arm but several questions needed to be pointed out before designing it such as what is object to be lift, how far can the arm stretch, how many degree of freedom robotic arm have after these things the robotic arm can be constructed and assembled with microcontroller chosen.
Taking accessibility into the matter 6-degree of feedom robotic arm will be of best suit here. Robotic arm constructed here consist of 4 servomoter and 1 stepper motor. The function of each moter are below:

Servo Motor 1: This servo is used gor gripping mechanism will will hold the object. For our model 7kgcm servooter is ideal one.
Servo Motor 2: This servo will act as a wrist servo will work same as human wrist. Considering low load factor low torque servo of 15kgcm is best suited.
Servo Motor 3 and 4: Servo 3 and servo 4 are elbow and shoulder of arm respectively as shown in Fig 5. Best suited servos are 20kgcm.
Stepper Motor: Here Stepper motor provides 360-degree complete horizontal rotation to robotic arm.

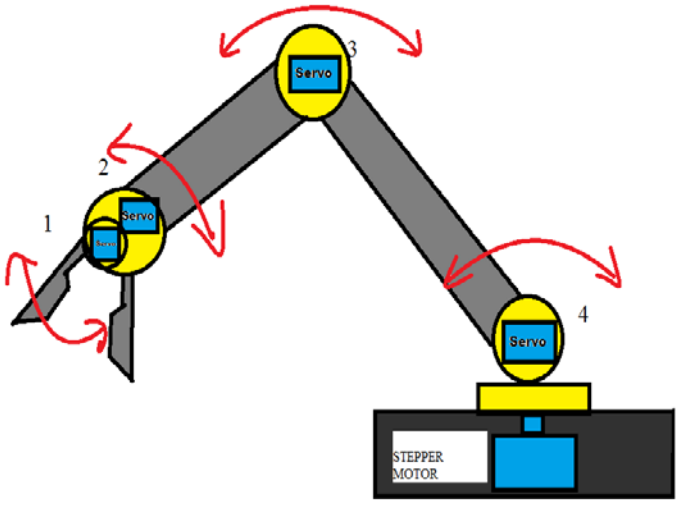

Fig 5. Design of Robotic Arm

4.2 SHAPE DETECTION ALGORTHM

Steps involved in shape detection algorithm are:

Step 1: Read/Capture Image
Image of the object is captured by the camera during the video preview. MATLAB provide function
Image=getsnapshot (video). These images are in RGB format and each image in MATLAB represent 3D matrix and each pixel is represented by an element of a matrix whose size corresponds to the size of the image.

Step 2: Converting RGB image into black and White ImageThis process is done in two steps. The RGB image is first converted to a two-dimensional grayscale image. The grayscale image is nothing but a matrix that holds the luminance (Y) values of the image. The luminance image is then converted to black and white (binary) image by a process called thresholding. MATLAB provides a function, BW = im2bw (I, threshold) that converts the grayscale image I to a binary image.

Step 3: Recognize boundaries of objects
The image is now a two-dimensional array with binary elements. Boundaries of the objects are recognized by first setting a single pixel on the object-background interface as a starting point and moving in a clockwise or counter-clockwise direction and searching for other object pixels. MATLAB function for this step is,
[B, L] = bwboundaries (BW, 'noholes') returns a label matrix L where objects and holes are labeled. Option 'noholes' will accelerate the processing by preventing bwboundaries from searching for inner contours.

Step 4: Finding areas of objects and area filtering
The area of object is nothing but area of pixel imposing that object which can easily be calculated by summing the number of pixels within the boundary extent. The image is filtered to remove small, isolated noise pixels by inverting it. The area of object can be given by MATLAB function
Stats = regionprops (L, area) where L represent label matrix.

Step 5: Finding bounding box of the object
The bounding box of an object is an imaginary rectangle that completely encloses the given object and its sides are always parallel to the axes. MATLAB function
Stats = regionprops (L, Boundingbox) will return the coordinates of rectangle. Using boundry of imaginary rectangle we can fing the area of that rectangle.

Step 6: Finding ratio of areas for given object
The next step involves finding the ratio of the area of an object to the area of its bounding box. In MATLAB, this ratio is known as the Extent and is a very useful parameter:

Extent = Area of the object/ area of bounding box

For circles, this value is around 0.7853, irrespective of the radius. The corresponding value for rectangles and squares is approximately 1.0000, provided the sides are parallel to the axes and the bounding box and sides overlap.
Extent can also be obtained by MATLAB function
Stats=region props (L, Extent). By using the value of extent and coordinates of bounding box we can easily determine shapes like square, rectangle, circle, ellipse, triangle and hexagon.

4.3 COLOR DETECTION ALGORTHM

For finding color of the object, the algorithm uses RGB colour space of image of object. The colours defined for classification are Red, Green, Blue and Black.

Step 1 and Step 2 are same as Shape Detection Algorithm.

Step 3: Colour Recognition
In the Colour Recognition Algorithm, centroid pixel of the object whose colour is to be detected is extracted. A MATLAB Function, P = impixel (I, x, y) is used which returns the values of pixels in the specified image, I, where x and y are the centroid values. Now in the 3D matrix of RGB colour space, if the value of the specified centroid pixel has more value in Red space than blue or Green, then consider that pixel Red. Similar goes with Green and Blue.

4.4 RESULTS

Result of Color Detection with MATLAB:

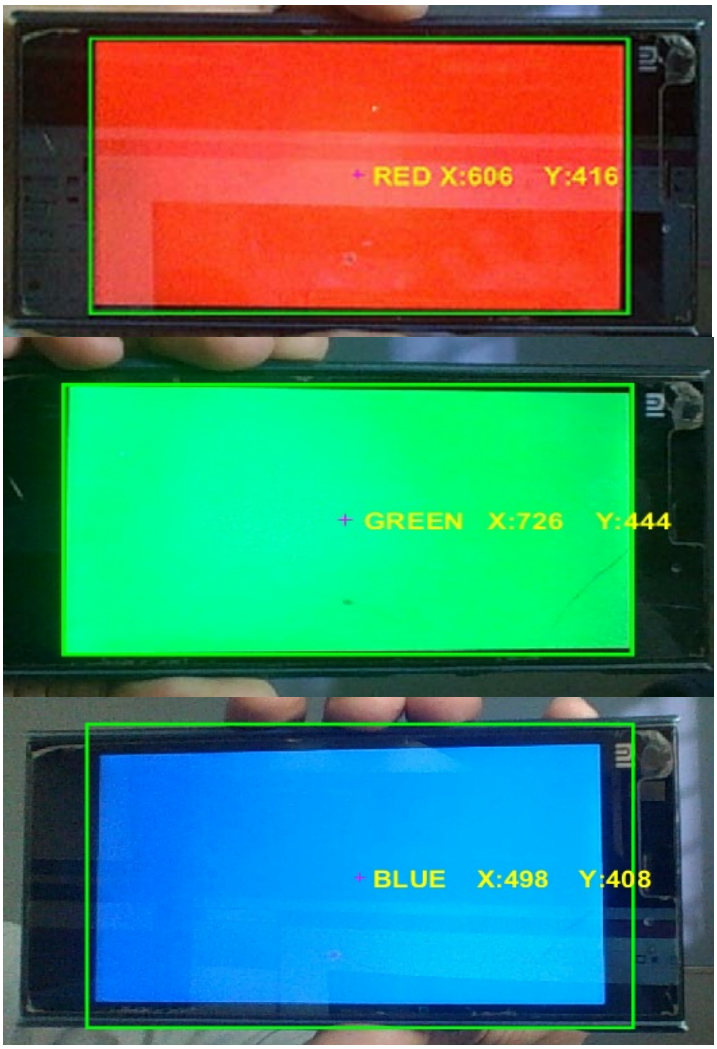

Fig 6. Color Detected (RED, GREEN and BLUE) with their Centroid

Result of Shape Detection with MATLAB:

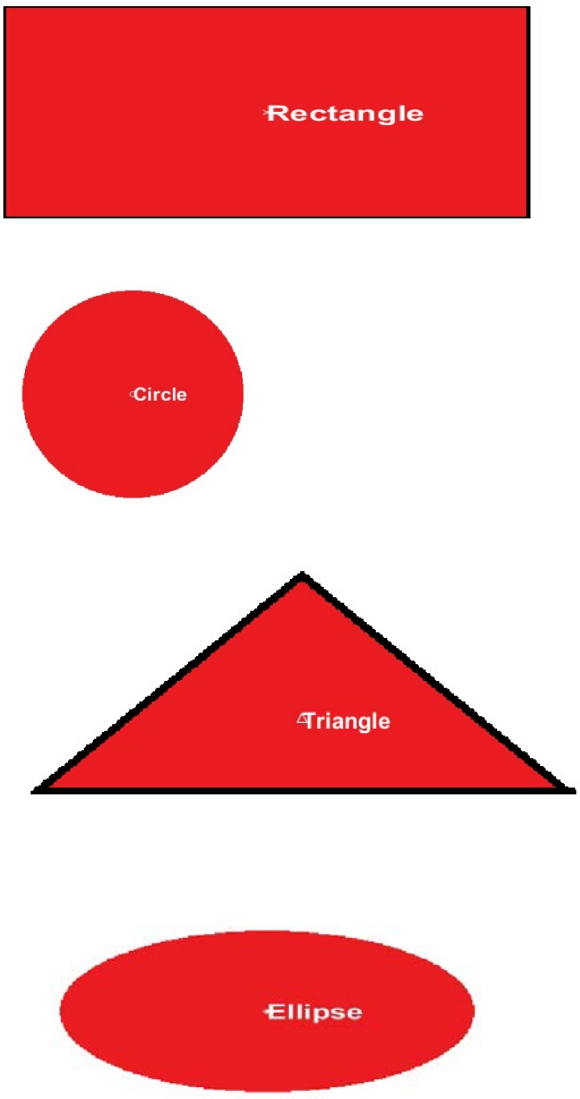

Fig 7. Shape Detected (Rectangle, Circle, triangle and Ellipse)

5.Conclusion

The above system focuses on finding the shape and the color of the objects and perform tasks like object sorting, pick and placewith the help of 6 DOF robotic arm in required places such as packaging industries, assembling industries, manufacturing industries etc. to efficiently do autonomous material handling task. The system is developed with a view to decrease the human effort since it eliminates the man power required to manage the object queue and also to short the object. It is cost effective and efficient compared to manual and semi-automatic material handling systems as it eliminates human error and provide complete automatic venture.

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7.References

[1] International Research Journal of Engineering and Technology (IRJET)Object Sorting by Robotic Arm Using Image Processing by Taniksha Singh, Dnyanesh, Dhaytadak, Pradnya Kadam, R.J. Sapkal

[2] International Journal of Emerging Technology and Advanced Engineering Automation of Object Sorting Using an Industrial Roboarm and MATLAB Based Image Processing by Prof. D. B. Rane, GunjalSagar S, Nikam Devendra V, Shaikh Jameer U

[3] International Research Journal of Engineering and Technology (IRJET) Volume: 03 Issue: 04 | Apr-2016

[4] International Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Issue 2, February 2015)

[5] International Journal of Electronics, Electrical and Computational System IJEECS ISSN 2348-117X Volume 5, Issue 7

[6] International Journal of Science and Advanced Technology (ISSN 2221-8386) Volume 2 No 9 September 2012.

[7] IJCSNS International Journal of Computer Science and Network Security, VOL.14 No.3, March 2014

[8] "Material Handling and Logistics U.S. Roadmap" . MHI. January 2014. Retrieved 2015-05-08.

[9] "Ergonomic Guidelines for Manual Material Handling" (PDF). California Department of Industrial Relations. 2007. Retrieved 2015-05-15.

[10] International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 2, Issue 7, July 2013

[11] International Journal of Advanced Computational Engineering and Networking, ISSN: 2320-2106 Volume- 1, Issue- 7, Sept-201