Object picking using robotic arm mounted with a camera for detection using image processing

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Abstract- **In lieu of making today's world working environment better for humans, the field of robotics has taken up new challenge these days with devices like humanoid type robot which works on human command. Robotic arm is one of the most important parts of the humanoid. In this paper, the design of robotic arm that can be used to pick up objects of given shape and color is described. The robotic arm works with a voice command from user. This arm is realized using servo motor for joints of robotic arm, Bluetooth module, Arduino Uno, MATLAB software and a mounted camera. The designed robotic arm is practically implemented to demonstrate its effectiveness such that it is able to pick objects of given shape and color using voice command from user. The task is completed using control of servo motors via Arduino board/ MATLAB software and a camera.**

Keywords—Bluetooth*; image processing; robotic arm; servo motor; voice control.*

I. INTRODUCTION

Robots suffer major shortcomings because of their limited abilities for manipulation and interaction with human [1]. Human being has always tried to make machine which can behave like human on commands. The world is progressing day by day and we have come up with various types of innovations to make the human dream possible thus making world a better place.

Robot executes different task repeatedly with high precision, thereby many functions like collecting information and studies about the hazardous sites where it is too risky to send human inside [2]. Humanoid robots which seem to be future today is one such innovation which can not only solve daily life problems but can also be helpful in case of calamities. Voice recognition is the process of taking the spoken word as an input to a computer program. This process is important to virtual reality because it provides a fairly natural and intuitive way of controlling the simulation while allowing the user's hands to remain free [3]. One such solution for the common aim is provided in this paper proposing a voice controlled robotic arm which is capable of identifying a structure of given color and shape using artificial intelligence provided. Projects have been made which mainly focuses on how to control or interface the robotic arm by human's voice commands to do a particular task that is to pick an object by detecting and classify it accordingly [4].The voice recognition feature in [3] was improved as user can command arm using only a single instruction. With the development of robotic arm discussed in [4], image processing was introduced and artificial intelligence was implemented for automatic functioning of color and shape detection. This hand can be used to defuse bombs using color detection and many such applications thus saving human resource from danger. The robotic arm consists of servo motors for arm movement, a Bluetooth module with a certain range for real time analysis, a Camera mounted in the claw Arduino Board as brain of the entire working mechanism. The working of the arm starts by taking a voice command from the user then processing it through the Arduino to MATLAB thereby moving the arm using servo motors and serving the purpose to identify the correct figure.

II. MECHANICAL STRUCTURE

The mechanical structure of robotic arm is based on robotic manipulator with similar functionality and design as human arm. The arm consists of 3 links and 4 joints as shown in Fig.1.

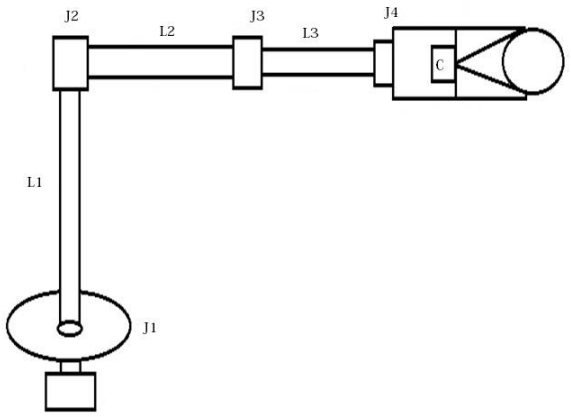


Fig.1 Structure of Robotic arm

A. *Joints*

The robotic arm consists of four joints which can be seen from Fig.1. The joint J1 namely base joint is analogous to body joint of human which lets them rotate in either direction with 180° rotation similarly the servo motor attached to the base allows whole arm system to move from left to right.

Second joint or J2 is called the shoulder joint which is analogous to shoulder movement of human body; it consists of servo motor which controls the next two joints and camera of the robotic arm.

Elbow joint i.e., J3 is the joint with 180° rotation as possible with human body which connects two links L2,L3 and also controls the position of camera mounted on wrist joint along with claw.

Last joint J4 is called wrist joint which is mounted with a camera and gear coupled claw. The gears move with the movement of servo resulting in opening and closing of claws. The mounted camera C (Fig.1) sends signal to MATLAB which in turn is connected to servo via Arduino for various positions of camera.

Fig.2 Gear coupled claws

B. *Links and Claws*

From the Fig.1 it can be seen that there are mainly three links in the arm. L1 connects base joint (J1) to shoulder joint (J2); it has been manufactured to withstand torque calculated using [5][6] of all the other links and the camera. It acts like the spinal cord for the whole system.

Now shoulder joint (J2) and elbow joint (J3) are connected via link 2 (L2); its length is less as compared to L1 to reduce the torque acting on J2 for more stability. Third link L3 connects joints elbow joint (J3) to wrist joint (J4).

Claws are coupled to motors through gears Fig.3 then one of the gears is connected to servo motor where clockwise motion of servo results in opening of claw and anti clockwise results in closing of claw thus grabbing the object.

III. ELECTRICAL COMPONENTS

The electronics for making the mechanism running includes Arduino Board, Bluetooth module, Servo motors and camera as shown in Fig.3 Thick arrow shows the data flow via electrical connections of the components. Single lined dual arrow between Arduino and MATLAB represents two way connections simultaneously. Dotted line between servo motor and camera represents mechanical coupling between them.

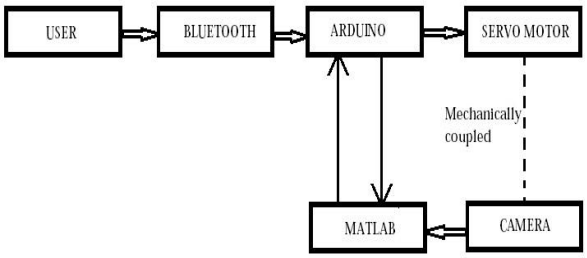


Fig.3 Methodology of robotic arm

A. *Bluetooth module*

Bluetooth is a wireless technology standard for exchanging data over short distances. It uses short-wavelength radio waves in the band from 2.4 to 2.485 GHz, from fixed and mobile devices, and building personal area networks. The module is used for connectivity between the user and the Arduino. The activating command input for the arm is given in the form of voice from the user and then send to Arduino using android application.

B. *Arduino*

The board used for this robotic arm is Arduino UNO. The Uno board consists of a microcontroller based on the ATmega328P. The various factors to choose and work on Arduino include its nominal cost, clear and easy programming and the extensive availability of the hardware as well as the software. Only one UNO board is used for controlling the entire mechanism therefore it acts as the brain of the working structure. The board has taken various controls in the entire process to serve the purpose which includes the process of collecting the command from the user via Bluetooth, then coding the input in a form that is usable by MATLAB and feeding it to the latter, thereafter moving the servos to align the camera with the object of desired color and shape and moving the gears to hold the object finally.

C. *Servo Motors*

These are the actuator that are specialized for high-response, high-precision positioning. It is best known for its capability of accurate rotation angle and speed control . There are 5 servo motors that have been used in the complete robotic arm. Servos are being controlled by the intellect of the arm i.e. the Arduino as per the position of the camera with the object.

D. *Camera*

A camera in today's world is an optical instrument for capturing images that can be stored locally or transmitted to another location for future use. The functioning of the camera in this project is similar to that of a human eye i.e. detecting things around or sensing objects without any physical contact. The task of this device in the arm is locate the instructed object of a specified color and shape so that the geared claws that are being moved with the help of servo and controlled by Arduino, are able to pick the correct object. The camera is connected to MATLAB/Arduino Uno.

IV. IMAGE PROCESSING

The image processing takes place using MATLAB, the flow chart for image processing has been shown in Fig.4. MATLAB has been used for detection of desired object from set of various different objects using image processing. Initially the camera captures the view Fig.5 (a) and is stored in MATLAB and is converted into grayscale image Fig.5 (b). The obtained image is processed for a single color (Red in this case) using RGB filter for red color such that only red objects are visible in binary format Fig.5(c).

Now bounding box and extent function of MATLAB is used for shape detection (square in this case) Fig.5 (d). After the desired object of given shape and color is detected, then centroid of contour is compared to centroid of camera view to calculate position and distance of claw from object and sent to Arduino (dark filled arrow Fig.4).

Thus for various position of camera image is captured and processed until the contour and camera view centroid matches Fig 6(a). Then claw moves forward with the help of servo until the contour covers around 65% of camera view.

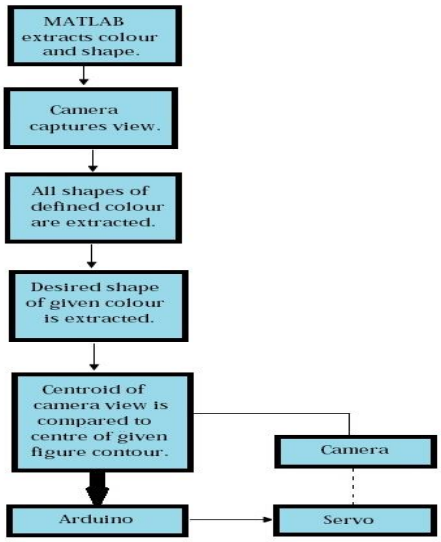
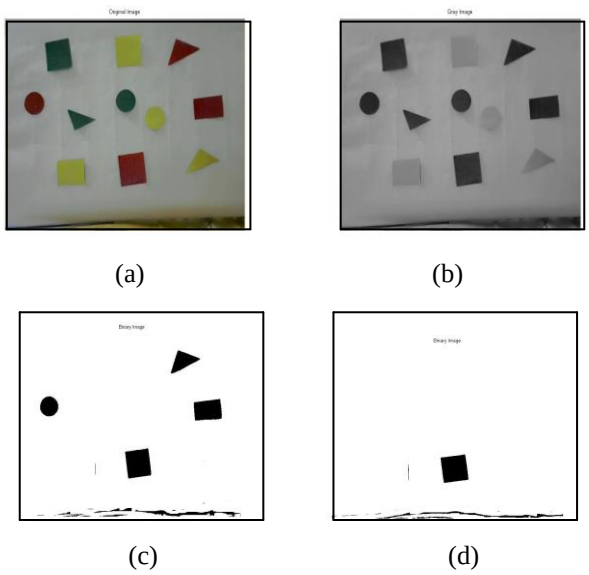


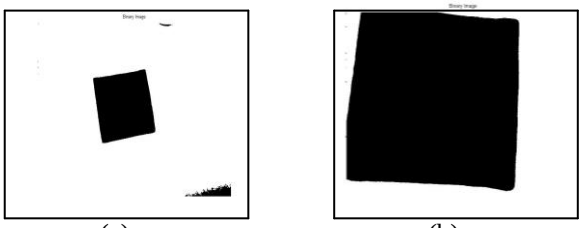
Fig.4 Flow chart of Image Processing



(a) (b)

(c) (d)

Fig.5 Different levels of image processing
(a)Original Image (b)Grayscale Image
(c)All red objects in binary
(d)Red Square in binary



(a) (b)

Fig.6 (a) Centroid matching (b) Final image

V. Experimental Implementation of Developed Robotic Arm

A voice controlled robotic arm is designed and developed to identify to a structure of given shape and color. The experimental setup for the same is shown in Fig.7. The developed robotic arm is used to pick object and its working is explained with the help of a flow chart shown in Fig.8. The process is initiated from the voice command given by the user let's say "Red Square" in this case. The voice command goes to Arduino via Bluetooth module. Arduino extracts the words from the received signal "Red", "Square". A code is assigned to this combination which is then sent to MATLAB.

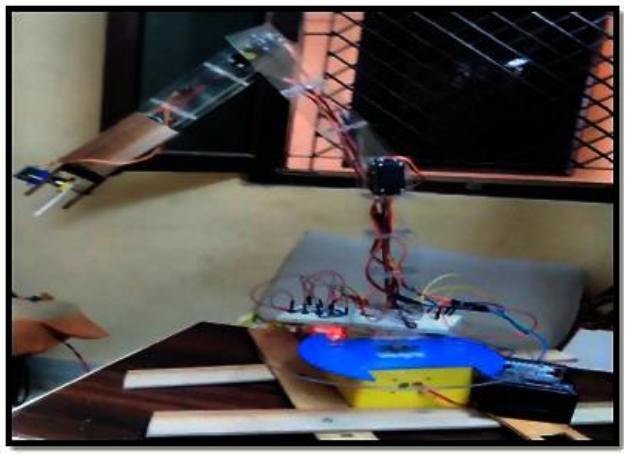


Fig.7 Robotic Arm

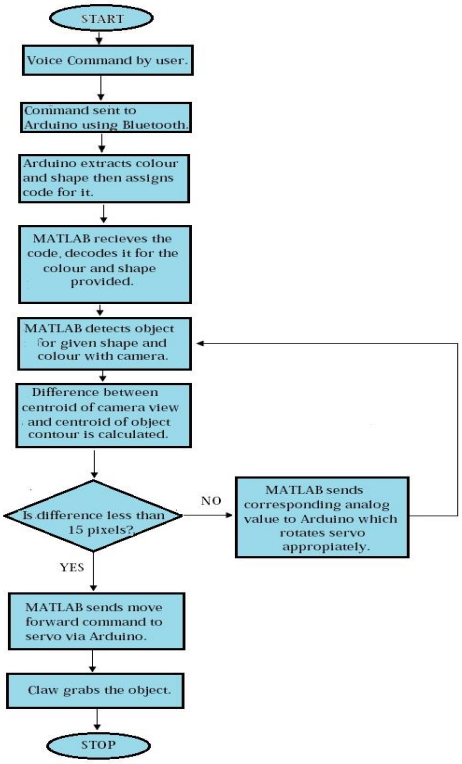


Fig.8 Flow chart of robotic arm working

MATLAB decodes the information received and starts the camera for processing. Camera captures the view and stores it in the form of image which is then converted into grayscale by MATLAB. Appropriate RGB filters are applied for colored detection i.e. Red, such that the next image shows only the red figures from the view. Bounding box and extent method of MATLAB is used for shape detection (i.e. Square).

So, now the new image shows red square in binary format where black represents object and white is the background. Now centroid of object contour is calculated and its difference is calculated from centroid of camera view. The pixel difference is passed on to Arduino in form of analog signal. Arduino moves the servos of joint J1 and J2 in order to reduce the difference between two centroids.

Again, the camera captures image from new position and difference is estimated again until the difference is less than 15 pixels. Now again the difference is sent to Arduino which moves servos from joint 3 & 4, in order to approach the target .Again a new image is captured and sent to MATLAB which calculates the contour area and send command to Arduino when the contour area is more 65% of total area. All the motors stop and grabbing mechanism starts to work.

VI. Conclusion

In this paper, a voice controlled object picking based on color and shape robotic arm was implemented practically using Arduino/MATLAB, servo, camera and Bluetooth. The robotic arm works with a voice command from user. The robotic arm is realized using servo motor for joints of robotic arm, Bluetooth module, Arduino Uno, MATLAB software and a mounted camera. The designed robotic arm is experimentally implemented to demonstrate its effectiveness such that it is able to pick objects of given shape and color using voice command from user. This hand can be used to defuse bombs using color detection and many such applications thus saving human resource from danger. The robotic arm consists of servo motors for arm movement, a Bluetooth module with a certain range for real time analysis, a camera mounted in the claw Arduino Board as brain of the entire working mechanism.

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