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Computer Vision Based Object Grasping 6DoF Robotic Arm Using Picamera

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Abstract—**This article presents a project to design a robust robotic arm which can perform multifunctional tasks. The controller of the manipulator is based on Arduino mega 2560 Microcontroller. The aim of the project is to focus all axes of manipulator to lift, carry and unload the objects at a desired location. This requires a precise drive motion control that incorporate electric motors as a drive system. Further experiments are done to implement a camera based 3D vision system integrated with a computer vision algorithm to recognize object deformation and spatial coordination to control the deviation from the original training. The 3D visualization systems are able to detect the objects as well as their distance from the End-effecter and transmit the signals to the drive system. The vision system requires a separate computing hardware capable of processing complex vision algorithms. We utilize Raspberry pi microcontroller for processing the vision data, separately making the vision system capable of recognizing the specified object as per program commands.**

Keywords-robotic arm; computer vision system; color detection; object recognition

I. INTRODUCTION

The contemporary research reveals that AI has successfully adapted to the evolving field of computer vision. The evidence suggests that modern manufacturing is contingent on robotics [1]. A robot can be defined as a programmable, self-controlled device consisting of electronic, electrical and mechanical units. Generally it is a machine performing in place of a living agent. To pick and place objects is the major task in industrial environment [2]. Robotics include the coordination of a wide range of disciplines (techniques), including kinematics, signal analysis, information theory, artificial intelligence and probability theory. An automated arm is a robot manipulator, typically programmable with comparable capabilities to a human arm.

In this study, a robot arm system is intended to perform multifunctional tasks. It detects and identifies red color item and grips the item and drops it in a desired location where an image of items is taken through a camera. All items in the picture are recognized utilizing image processing methods and every single distinguished items' coordinates are controlled on the computer and sent to the robot arm

II. RELATED WORK

Computer vision is a field that incorporates techniques for acquiring, processing, analyzing, and understanding images. Through these techniques, high-dimensional data is converted to numerical or symbolic data [3] [4] [5]. In the realm of AI, CV attempts to emulate the capacities of human vision via electronical observations and understanding of images [2]. Computers are preprogrammed in many applications that make utilization of computer vision to play out a particular undertaking. Recently, learning based method are likewise usually utilized for that kind of application [6], [7], [8]. This context implies the conversion of visual images (the input of retina) into depictions. Subsequently, the interface will identify other points of views inspire proper activity. This image comprehension can be viewed as the unraveling of representative data from image information, utilizing models built with the guide of geometry, material science, insights, and learning hypothesis. Image segmentation is based on color intensity and texture. It

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is utilized as a part of numerous applications, for example, region-based segmentation, feature-based edge detection, and thresholding based or model based [9]. Computer vision has additionally been depicted as the endeavor of mechanizing and incorporating an extensive variety of procedures and portrayals for visual observation. As a scientific discipline, computer vision is concerned about the hypothesis behind manufactured frameworks that concentrate data from pictures. This image information can take many structures forward, for example, video successions seen from various cameras or multi-dimensional information from a medicinal scanner. Computer vision tries to apply its hypotheses and models to the development of computer vision frameworks [10].

There are various analysis incorporating computer vision with robot arm in literature. One such learning technique involves using acknowledge points, in minimum of two photos, enabling a robot to grip an item. The overall accuracy of these techniques was 87.8% [8]. In another research, computer vision was utilized to control a robot arm [11]. Few colored bottle stoppers were put on joints' of the robot arm, the joints were perceived by means of these stoppers, utilizing image recognition techniques. These two different research robot models were supposed to play the game “rock, paper, scissors” against an opponent [12]. In these two investigations, an immersed in camera, which utilized pictures of opponent's hand, suggested contenders’ moves via computer vision techniques. One of, among them, random moves have been played [12]. While in another research, the robot successfully reads opponent’s hand and using CVT robot configures its fingers, hence beating the opponent [12]. In another work, the developments of a robot arm are controlled by a human arm’s developments utilizing a wireless connection and a vision system [13]. One of these investigations shows a self-ruling robot framework including a computer vision [14]. In their work, the robot arm can play out the assignment of self-ruling item arranging as indicated by the shape, size, and color of the item [10]. In another work, an instructive robotic arm plays the assignment of recognizing an arbitrarily put object, picking it and moving it to a predefined compartment utilizing a computer vision [15].

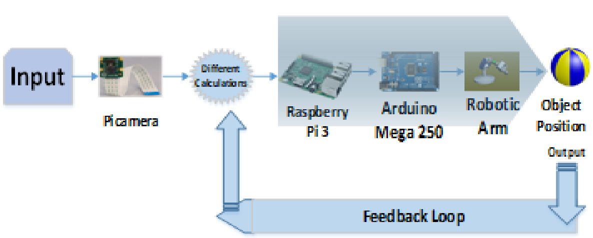

Figure 1. Block diagram of the system.

III. HARDWARE ARCHITECTURE

Hardware architecture (hardware design model) involves the identification of a system’s components and their interrelationships. It allows hardware designers to comprehend how their components permeate into a program architecture and provide to software principle designers consistent information impaired for software development and integration. The hardware architecture of my system is shown in Fig 1.

A. Picamera

Picamera is an official product of Raspberry pi Foundation. It takes pictures, records video, and applies image effects which is used as an input.

B. Raspberry pi

The Raspberry Pi is a series of small single-board computers that is used to handle complex and heavy algorithms like computer vision

C. Arduino

Arduino is an open-source electronics platform based on easy-to-use hardware and software. It is mostly used to control the servos through programming.

TABLE I. 6DOF MANIPULATOR ALUMNI ROBOT ARM KTIS BASE W/SERVO

S.no	Parameters Name	Description
1	1x	Mechanical claws
2	5x	Hard aluminum alloy multi-bracket
3	3x	Hard aluminum long U bracket
4	1x	Hard aluminum L-shaped bracket
5	2x	Hard aluminum U-beam
6	3x	Bushing bearings imported
7	6x	Metal helm
8	6x	MG996R Servos
9	3x	Servos Extension cord
10	Package Weight	0.950kg (2.091b.)
11	Package Size	40cm x 30cm x 20cm (15.75in x 11.81in x 7.87in)s

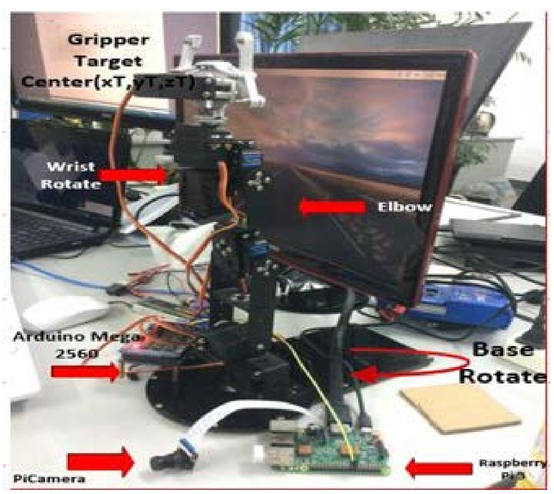

Figure 2. Robotic arm complete kit.

D. 6DOF Manipulator Alumni Robot Arm Kits Base W/Servo

The 6DOF aluminum robot arm kit, is a robotic arm system that has six degrees of freedom (6DOF) and a claw to pick up and manipulate objects. The mechanic links of the robotic arm are built using hard aluminum brackets, in different shapes with a multitude of predrilled holes for fixings and attachments etc. The list of all components in robot arm kit is shown in Table I. Fig. 2 is the image of complete kit of robotic arm with microcontroller and Picamera.

IV. COMPUTER VISION ALGORITHM

Our system is based on two algorithms: Algorithm 1 and Algorithm 2.

Algorithm 1 is the algorithm of red color detection which is utilized to identify the object of red color. In this algorithm, for each pixel, the distance (D) between pixel value and reference color value, is computed. Whereas, the threshold value is set manually in accordance with tolerance level given to algorithm, which is a constant value (a high value of Threshold considers "less clear" red pixels as red, whereas a lower value of Threshold will make the algorithm quite "strict"). If the distance (D) is less than Threshold, pixel is selected otherwise not.

Algorithm 1 Red Color Detection

Input:
Image (RGB)
Functions:
Red Identity ()
Repeat:
For each Pixel
1: Compute the distance (D) between that pixel value and reference color value
2: If D < Threshold then
Current pixel is accepted
Else
Current pixel is NOT accepted
Output:
Detect red color from red color channel (1:0:0)

Algorithm 2 is the algorithm of identification of object's position which also used in our robotic arm after the Algorithm 1. As the Algorithm 1 identifies the object, on that time Algorithm 2 saves object's location and then it compares the object's location with claw position. If the difference is more than error then claw moves one step and then again compares the locations. It will do the same work until the difference is less than error. As the difference between them is less than error then robotic arm picks the object and drops it in a desired location.

Algorithm 2 Identify the position, pick and drop object

Input:
Image (RGB)
Functions:
Pick ()
Drop ()
Initialization:
Claw position ((x1,y1),(x2,y2))
Object position ((x1',y1'),(x2',y2'))
Repeat:
1: Calculate the distance (d) between claw position and object position
2: If d < Ɛ
Claw position = Object position
Else
Claw position = Claw position + Δ Claw position
Output:
Identify the position, pick and drop object.

V. WORKING OF THE ROBOTIC ARM

This work has successfully completed the zoned functionality for robot arm. A model robot which can rotate, magnetize item, lower and raise its arm, controlled all over by microcontroller is constructed successfully. The development board is assembled and it utilized the required method for the right operation of the controller. The advancement board has been interfaced to the servo and (DC) motors.

Fig. 3 is describing the working flow of the system. First, the computer vision detection model uses the camera and takes continuous video to detect the red objects. It uses different filters on the video to mark the center of the object with a circle. Second, the raspberry pi sends the serial signal to Arduino, which in turn, generates the command and sends signal to robotic arm. Robotic arm is then activated, collecting object and dispatching it to the desired destination. These tasks are completed by servos with six DOFs embedded in Arduino programs.

If the red object is not detected, robotic arm does not perform any operation.

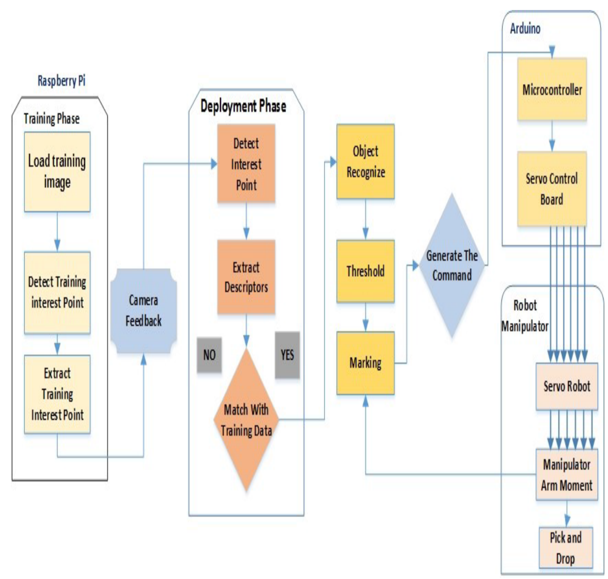

Figure 3. Working f;low of the system.

VI. EXPERIMENTAL RESULTS

A. Testing the Functionality of Vision System

Our project has the functionality of vision system. In vision system, first of all, our algorithm detects the color of object from its particular range i.e., if it is red then system marks green circle on the center of the original picture. It sends the serial signal to Arduino, which will execute its preprogramed command. If the detected object is red, claw opens and bends a little, grips, lifts and rotates the object towards desired location. The claw then opens and places the object at given coordinates. Afterwards, the claw closes and moves back to its original position to get ready for next object.

We use another object for detection which is not given in coordinates and except red color then it will not move and it will not pick that object because except red it will not detect different colors of object. It will wait only for red color's object otherwise it will not move to any direction.

Fig. 4 and Fig. 5 are the outputs which come after implementation. In Fig 4, it is detecting the red color object and after detection it is marking the green circle on the center of the original image. In the other picture (Fig. 5) the robotic arm is picking the object after detection.

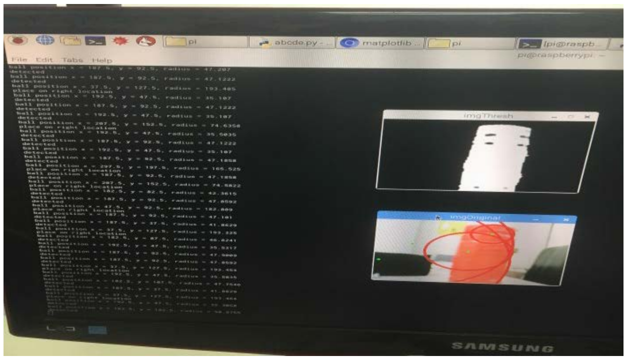

Figure 4. Object identified using computer vision algorithm.

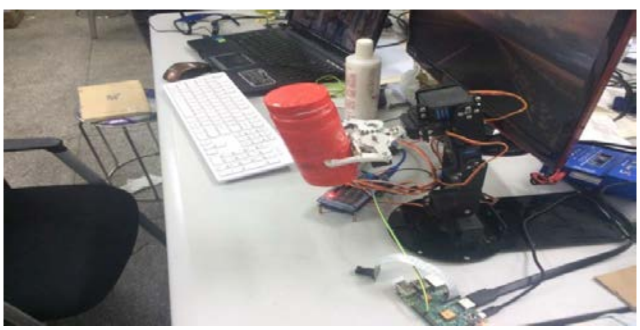

Figure 5. Picking and droping the object.

TABLE II. THE LIFE AND DEAD ZONE OF SERVOS

Servos	Life zone	Dead zone
1	0^0 to 310^0	311^0 to 360^0
2	40^0 to 320^0	0^0 to 39^0 , 321^0 to 360^0
3	50^0 to 290^0	$0^0$to 49^0 , 291^0 to 360^0
4	0^0 to 230^0	231^0 to 360^0
5	0^0 to 300^0	301^0 to 360^0
6	0^0 to 180^0	181^0 to 360^0

B. Testing the Maneuvariablity of Arm/Manipulator

There are 6 servos in the robotic arm because our project is based on six Degree Of Freedom (6 DOF) and they can move in different directions, for example, they can do pitch yaw and roll its elbow and each servo has attached on different places in mechanical structure of robotic arm. In the robotic arm each servo will move on different angles to pick up the object and drop it at the desired location. Each servo has its life zone (the area in which servo can move) and dead zone (area where servo cannot move). After performing experimentations we got the following results which is shown in Fig. 6 and Table II which is describing the life and dead zone of robotic arm.

Figure 6. The life and dead zone of servos.

C. Testing the accuracy of the grasping object

TABLE III. TESTING THE ACCURACY OF THE GRASPING OBJECT

Parameters	**Robotic Arm**
Number of Axes	6 axes
Payload	3 kg
Reach	500mm
Weight	11kg
Speed	1m/s

VII. CONCLUSION

In this paper we present our experience with 6 DOF articulated robotic manipulator and 3D vision systems. We developed a robotic arm which can perform multifunctional tasks with the help of computer vision. It performs some different functions by focusing all axes of the manipulator to a desired objects and unload at a desired location.

A 3D vision system based on a camera and a computer vision algorithm to recognize object deformation and spatial coordination/deviation from the original training. The 3-D visualization systems is able to detect the objects as well as their distance from the end-effector and will transmit the signals to the drive system. The vision system would require a separate computing hardware capable of processing complex vision.

VIII. FUTURE WORK

Today, robots are doing human labor in all kinds of places. Best of all, they are doing the jobs that are unhealthy or impractical for people. This frees up workers to do the more skilled jobs, including the programming, maintenance and operation of robots.

Future works aimed is implementing the wireless protocol so that operator at one end can control the robotic arm wirelessly at the other end. Voice recognition to control a robotic arm over voice. And the most advanced to make it mind-controlled robotic arm by connecting to existing neurons or to electrodes implanted into the human brain to decode the signals from the brain and use them to control a robotic arm.

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