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Robotic arm control using human interface through color detection

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ABSTRACT

In present times, industries face common obstacles like shortage of time and workers which leads to inefficient production. A feasible solution for this problem can be achieved using robotics. Robots save a lot of time and robots are designed for specific tasks according to ones needs. Furthermore, we can make use of image processing methods for better results. This paper presents a way to control a robotic arm through detection of a specific colour. In this paper, we have proposed a method by which a webcam detects a particular coloured-patch attached to a human arm using the colour coding techniques in MATLAB. The coordinates of that coloured-patch with respect to the video output screen are sent to the microcontroller, which in turn results in the movement of the robotic arm. The process is quick and inexpensive, for individual and industrial applications, thereby increasing the growth of the industry. The robot can be interfaced using various micro-controller, here we have used the Arduino Uno which is a microcontroller board based on the ATmega328. Arduino controlled robot is interfaced with the computer which mimics hand gestures according to the movement of the coloured-patches present on the human arm. The movement of the arm is detected on the basis of the movement of the coloured object present on it, using a webcam and MATLAB functions. According to the movement of the arm, the robot, which is being interfaced with the computer, is also moved in desired directions. This results in an inexpensive and effective way for controlling the robot via an interface between the human and the machine.

Keyword: *Colour detection, MATLAB, Robot, Arduino, coordinates, arm, movement.*

1. INTRODUCTION

Robotic arms are being used in so many wide range of areas including lifting heavy objects and carrying out tasks that require accuracy and repetition. Realizing the future aspects of robots and due to its easy manner of operation used in domestic, industrial and military purposes a robotic arm is prepared by merging image processing and embedded technique. This project is a robotic arm that can be controlled via the movements of different coloured-patches on a human hand. This can be used for picking-and-placing of objects and various other tasks can be done with little modifications.

It helps to reduce need of labours, 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.

This project uses the colours coordinates to control the motion of a robot. A webcam or camera attached to a PC takes live video of the movement of the colours, detects the presence and position of that object using colour coding and image processing. The movement of the object is tracked from the live video after taking snapshots from the video captured. The object movement is quantified and used to determine the direction and distance moved by a servo motor resulting in the movement of robot via human's hand gestures.

In order to simplify human's tasks the demand for the robots has increased tremendously. Therefore increased opportunities for many people to operate the robots have emerged. There exist different types of controlling techniques. Some of them can be complex than the others. Many people often find it difficult to operate a robot using complex remotes that control the robot by pushing buttons or accelerometers. This paper presents a more modern way of controlling the robot which has a concept of copying the human gestures based on specific colours.

Colour is one of the most important characteristics of an image, if colour in a live video or in a digital image can be detected, and then the results of this detection can be used in various industrial and scientific applications. Colour detection is the fundamental step in many computer vision systems. In this paper Image Processing toolbox in MATLAB is used for detection of a particular colour in a given image. There is a wide variety of algorithms and methods for image processing which are present by default in the Image Processing Toolbox.

The robot in this project will move according to the movement of the colours detected via image processing in MATLAB. The x and y coordinates of the detected coloured-patch's centroid will be recorded and tracked. The changes in the position of the centroid will define the motion of the robotic arm.

This technique needs more filtering options such that no other colour should be present at the background of recording. We have to eliminate this problem. This method can be used for one degree of accuracy and improvements are possible up to 0.1 degree or less than that. Arduino micro controller is connected to the robotic arm, for controlling that robotic arm. The laptop or PC can be interfaced with the robotic arm via different micro controllers. A program for catching the coordinates of the coloured part will command the servo motors to move according to the movement of the coloured part. After increasing the accuracy this project, it can be used in more complex fields like medical field.

2. LITERATURE REVIEW

Many studies and implementations of image processing techniques have been done so far. The technique suggested in this paper is an application of the already present studies.

2.1 *Different Colour detection in an RGB Image* [1]

Arshi Prabhakar et al. (2017) have explained the process of detection of specific colours from an image in MATLAB in great detail. They have also mentioned some other ways of detecting colours from an image for example; they mentioned about a study in which neural networks is used for detection of colours in an image. The approach is based on membership probability of experts assigned to different colours such as red, green and blue, and the final decision is taken by the neural networks.
MATLAB is prominent for its simplicity. A straightforward algorithm or program can be designed using MATLAB commands and statements to extract a particular colour from an RGB image. Image processing is so convenient in numerous fields. Extraction of a particular colour from a RGB image or extraction of a particular area of interest for our needs is important as it produces so many applications that we can implement. We don't need to and don't have to work on the whole image.
An RGB image is a blend of three different colours: red, green and blue. These colour contents are extracted separately from one another. These colour contents are extracted by using the inbuilt functions and commands provided by MATLAB.

2.2 *A COMPARATIVE STUDY ON THE POSITION CONTROL METHOD OF DC SERVO MOTOR WITH POSITION FEEDBACK BY USING ARDUINO [2]*

Amirul Syafiq Sadun et al. (2016) have done a substantial comparative study on using a servo motor with Arduino. The DC servomotor angular position and movement can be controlled at a specific angle by using a control signal which is different from Direct Current (DC) motors. In recent times Arduino has been prevalently used in a wide range of control approaches, particularly in the closed-loop systems with servo motors because of its efficiency. The DC servo motors can be controlled via different methods that can be used by using Arduino for example: Arduino Integrated Drive Electronics (IDE), Support target for Simulink (Support Package) and Arduino Input/Output (IO) Package.

A servo motor is defined as an actuator that has the capability to be controlled precisely in terms of rotary and angular position [3]. Servomotors are widely used in various applications ranging from robotics to CNC machinery or automated manufacturing. Simplest of the servomotors use position-only sensing through a potentiometer and bang-bang control of the motor, that is: either the motor always rotates at full speed or is stopped. This type of servomotor is not prevalent in industries, but it is the basis of the simple servos which are used for radio-controlled models. More sophisticated servomotors use optical rotary encoders to measure the speed of the output shaft [4] and a variable-speed drive to control the motor speed [5].

3. TOOLS AND TECHNIQUES

This project is developed using MATLAB, which is used to capture the live video and coordinates of the colour to control robotic arm. Arduino is used for the interfacing of servo motors with the MATLAB code to move them.

3.1. MATLAB: IMAGE PROCESSING TOOLBOX

MATLAB is a high-performance language for technical computing. The name mat lab stands for matrix laboratory. MATLAB is an environment for numerical computation and visualization**.** Here MATLAB tool provides vast variety of algorithms for image enhancement, analysis, object colour detection, etc. Figure-1 below shows the basic steps for developing this project.

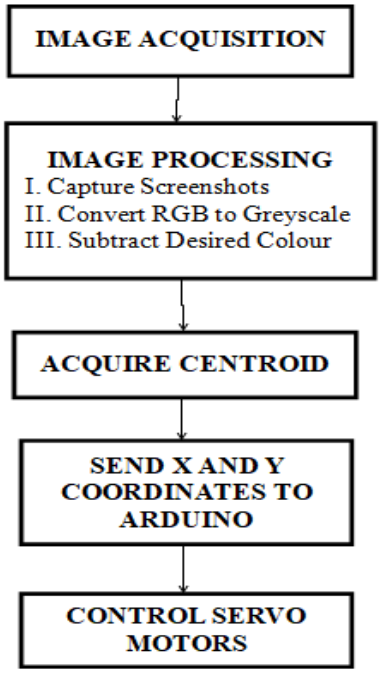

Fig -1: Flow chart of whole project

The first stage of any image processing task is to have an image for further operations on it. One can capture it from the camera or load a previously clicked image from the memory. Since we are going to control the robotic arm using the live video, the images will be snapshots from the live video captured.

MATLAB provides an adaptor known as "winvideo". It is used for capturing live video using a webcam or the inbuilt camera in the PC or laptop.

The Image Acquisition Toolbox is used for acquisition from any generic video interface. We need to install the Image Acquisition Toolbox Support Package for OS Generic Video Interface. This includes any cameras that use the Windows Video (winvideo), Macintosh Video (macvideo), or Linux Video (linuxvideo) adaptors. The correct files will be installed, depending on the operating system one is working on [6].

3.1.1. Detection of a Particular Colour

An RGB image is a colourful image which consists of fixed values of colour contents for every pixel. These colour contents have different values ranging from 0 to 255. MATLAB provides inbuilt functions and commands to extract the required colour content from the RGB image. A colour detection algorithm identifies pixels in an image that match a specified colour or colour range. The colour of detected pixels can then be changed to distinguish them from the rest of the image.
We first have to convert the RGB image to a grayscale image. Image is filtered and converted into grayscale image. Then we can detect a particular colour of our choice and it is subtracted from the image. Now image is converted to black and white. The portion with specified colour is represented as white colour and all remaining portion is left black. We will use coloured patches on our hand for detection of movement of the arm. Here two types of colour i.e. red and green colour are used for the detection. Red colour will help in movement of the robotic arm and green colour will be used for the gripper of the robotic arm.

3.1.2. Recognizing Boundaries and Centroid of Detected Part

MATLAB provides a function known as "stats = *regionprops* (BW, properties)" returns measurements for the set of properties specified by properties for each connected component (object) in the binary image, BW. "stats" is struct array containing a struct for each object in the image. We can use regionprops on contiguous regions and discontiguous regions.

Regionprops (BW,'centroid'): this code is used for obtaining the centroid of the detected part. A Bounding box is the smallest rectangle containing the region, returned as a 1-by-Q*2 vector, where Q is the number of image dimensions. Regionprops is a function in MATLAB which is used to measure properties of image regions. Regionprops comprises of various other function within it such as 'area', 'centroid', etc that can be used to get various properties of image. Figure-2 shows the detection of red colour from an already saved image in the system. It also shows the bounding box around the detected portions with their centroid.

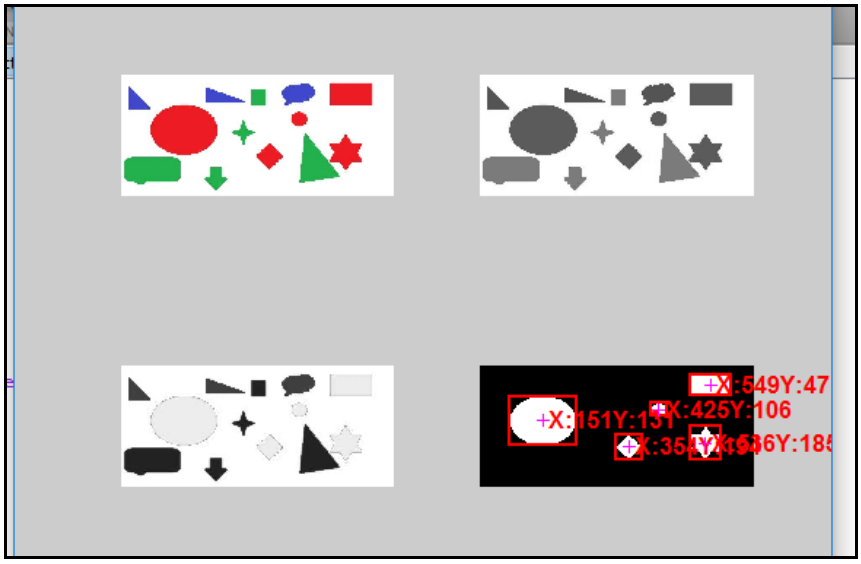

Fig 2: Image showing red colour detection and centroids

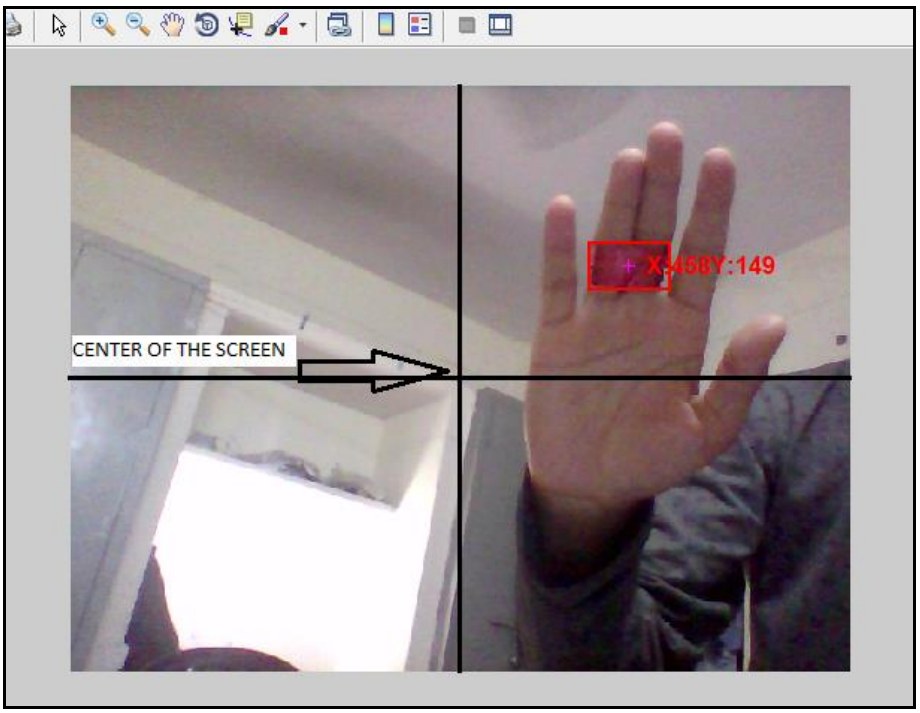

Fig 3: Image showing the detection of coloured-patch

3.2. ARDUINO UNO

Arduino Uno is a microcontroller board which is based on ATmega328P microcontroller. Arduino Uno board consists of 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a point for USB connection, a power jack point and a reset button. It has every feature needed to support the microcontroller. We can simply connect it to a computer with a USB cable or an option to power it with an AC-to-DC adapter or battery is also available. You can fiddle with your UNO without worrying too much about doing something wrong, because it only costs a few dollars [7].

Arduino provides ample number of inbuilt libraries for a variety of hardware. The servo motors in the robotic arm can be controlled using this microcontroller. We just have to add a servo header: <Servo.h> file to communicate with the servos. In Arduino we simply have to state the position of servo and the conditions to move them.

The coordinates of the detected image is sent to the microcontroller. We have to specify the conditions for the position of the coordinates with respect to the video output screen so that servos move according to the motion of the detected colour. The data is then sent to the servos for motion of the robotic arm.

4. CONCLUSIONS

Using colour detection algorithms in the MATLAB, a program has been made which can detect red, green colours. Also, the coloured object is being enclosed inside a bounded region along with the centroid of that region.

MATLAB provides a function known as "stats = *regionprops* (BW, properties)" returns measurements for the set of properties specified by properties for each connected component (object) in the binary image, BW. "stats" is struct array containing a struct for each object in the image.

This project explores the use of the motion of colours to control the motion of a robot. A webcam or camera attached to a PC captures live video and takes continuous snapshots of the movement of the colours (a red and green coloured-patch in this case), detects the presence and movement of that object using colour detection and image processing, and tracks the motion of the coloured-patch in subsequent snapshots. The object movement is quantified and used to determine the direction and distance moved by a servo motor resulting in the movement of robot via human's hand gestures.
One of the limitations of labelling of connected components for colour detection is that if more than one object is present in the live video capture, then controller will not get the coordinates of the desired object.

5. REFERENCES

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