ISSN 2350-1022

International Journal of Recent Research in Mathematics Computer Science and Information Technology
Vol. 3, Issue 1, pp: (18-22), Month: April 2016 – September 2016, Available at: www.paperpublications.org

Color Tracking Robot

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Abstract: **This Project describes a visual sensor system used in the field of robotics for identification and tracking of the colored object. The program is designed to capture an Object through a Camera. It describes image capturing and processing techniques, followed by an introduction to actual robotic application to trace the Object using the serial COM port of the PC. The whole system of making a robot to follow an object can be divided into four blocks: image acquisition, processing of image, decision-making and motion control.**

Keywords: **µC (Microcontroller), USB: Universal Serial Bus, LED: Light Emitting Diode.**

I. INTRODUCTION

The aim of the project is to build a vision based color tracking robot which is driven by wheels and controlled by a computer and can also detect color using a software. The variation in horizontal and vertical axis of detected object generates control signal which are send to the microcontroller which will direct the motor driver to track and follow the object. Image acquisition can be achieved by using a PC-based webcam or a digital video camera. This device will capture the image and send it to the camera processor for further processing in the computer. Its main function is to convert the light energy received into electrical signals. Image processing involves conversion of RGB color images into gray scale images, setting of threshold levels, saturation of the features into binary images and setting of cut-off values to remove noise in the binary image. The captured images of the object are processed in MATLAB using color detection and tracking algorithm. Decision-making is done through the software program and motion control through either software or constant. Many samples of the object are captured and processed and judging from the variation in the position of the object, decision is made by the color tracking algorithm about the direction in which the robot should head and accordingly controlling commands are given to the robot to follow the object. The slight change in the axis of the object being tracked generates control signals which are sent to the microcontroller. In our project, we use the color information of the object to track it. It will be a cost-effective, lightweight and a simple robot that will give us the optimal output. This robot can be used in the field of robotics, in surveillance systems or combined with the robotic arm and used as a crane to pick and place objects and various other applications.

II. BLOCK DIAGRAM OF COLOR TRACKING ROBOT

Fig. 1 shows the basic interfacing and wired connections in the project and gives us an overview of the project and how it will work. The robot is controlled by PC using USB-VCOM. In PC the software to control robot car will be installed while the webcam tracks the coloured object and sends command to robot via COM port, Microcontroller receives data from PC and controls the two DC motors using motor driver IC's. The body of the robot is moving by three wheels using two gear motors, PC COM-USB Interface and motor driver circuit.

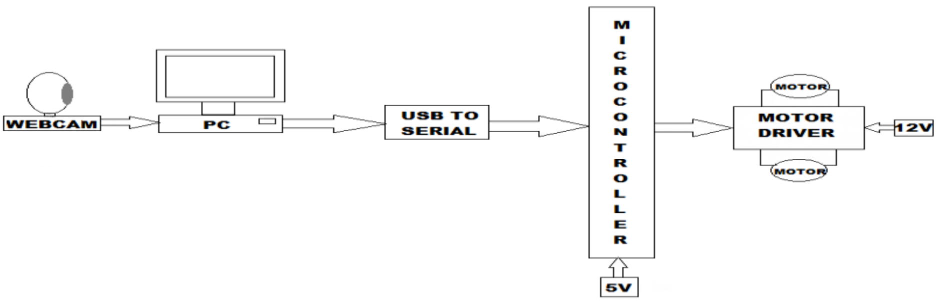

Fig. 1 Block Diagram of Color Tracking Robot

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Since Laptops may also be used for processing which may not necessarily have an inbuilt serial port, USB to serial converter has to be used for interfacing with the microcontroller. We are using serial communication instead of parallel communication for minimizing the number of lines for interfacing and optimizing the system. Based on the variation in the input of the microcontroller and the program that is flashed into it, the uC will cause movement of the motors by giving its output to the input of the motor driver ic which enables the movement of the motor. The uC helps in the collecting the serial data from the rxd port and accordingly giving commands to various output ports The motor driver is required to provide the motors with 12V power supply while the uC works on 5V. Five directions of the motors are tracked, namely, i) moving forward, ii) moving backward, iii) turning right, iv) turning left and v) stop. The major parameters of the project are the resolution of the camera, the frame rate, etc. The color detection is done based on a range of values above and below the actual value so that there is no hindrance in the working of the project due to external environmental changes (brightness or dark) and the object can still be detected. More importantly the distance of the object doesn't matter as long as it is in the camera resolution frame.

III. PRINCIPLE OF WORKING

The robot takes images of its surroundings repeatedly and tracks the expected object and generates controlling signals based on the position of the object on the image plane. Based on camera principles the image plane is divided into segments for five different commands. The location of the object keeps on changing as the position of the camera changes. This principle leads to development of five different commands. The commands are forward, backward, left, right and stop.

IV. SOFTWARE IMPLEMENTATION

The algorithm ensures guaranteed tracking of the object if the object is found anywhere on the image plane There are two algorithms in this project, namely, Object Detection and Color Tracking Algorithm and Motion Control Algorithm. Color Detection and Tracking Algorithm to detect the object of the specified color and take decisions on where the object is moving while Motion Control algorithm shows how the microcontroller when given command by the computer will control the motors to achieve the goal of tracking the object.

The flowchart for object detection and color tracking and motion controller algorithm is as shown

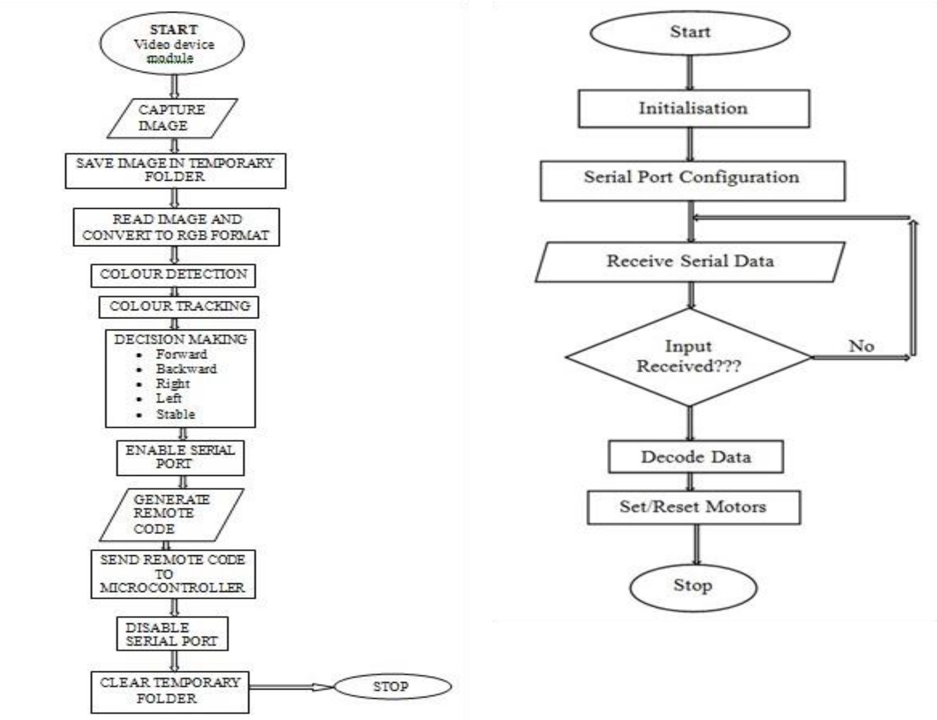

Fig 2. Flow chart for Object Detection and Color Tracking and Motion Control Algorithms

The entire program for the above mentioned two algorithms are divided as follows.

A. Image Acquisition:

The first task in the proposed system is to take a live video feed from the image acquisition device. The live video feed is converted into a sequence of frames for applying the image processing algorithm. The 'getsnapshot' command of MATLAB is used, which converts video feed into an image array and immediately returns one single image frame from the video input object in the format 'Height X Width X Number of Bands', where Height and Width are as specified in the ROIPosition property and number of bands associated with the live video feed is as specified in NumberOfBands property.

B. Determination of axis for the image captured:

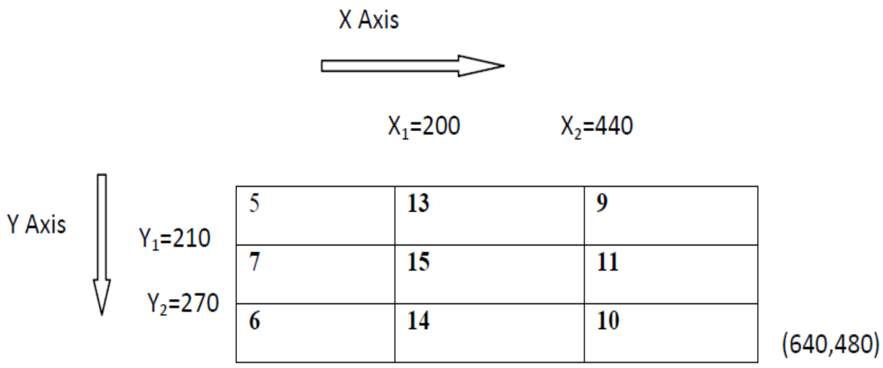

Fig. 3 Fundamental Diagram Of Axis

In this part of algorithm, the frame obtained is divided into sections using its parameters height and width. The 'size' command of MATLAB is used to store the value in a row array. The fundamental diagram of axis is as shown above with resolution 640X480.The logic behind this algorithm is as follows where x1,x2 are points on X axis and y1,y2 are points on Y axis.:

x1=x/2-120; ....(1)

x2=x/2+120;..(2)

y1=y/2-30; ....(3)

y2=y/2+30; ....(4)

C. Colour Detection:

The next part of the algorithm is to do the calibration for detecting the color of the object. RGB component of the image is stored in separate arrays[4]. A lower and upper limit is set for the red, blue and green components and if the value of pixel is in that range for the image obtained, then that pixel is set white otherwise it will be set to black. Thus for color detection, thresholding technique is used by converting RGB image into binary image. Objects having a radius of less than 20 pixels is removed by opening it with a disk shaped structuring element[4].

D. Object Tracking:

In this part of the algorithm, the centre of mass of the object is computed and the object is tracked. Once the desired binary image is obtained, all the connected components in a binary image is computed using 'bwlabel' command of MATLAB and stored as total number of connected components and label matrix. The row and column for all pixels belonging to the object is found and the mean of row and column are computed to give the centre of mass for the object[7].

E. Serial Communication and Decision Making:

Communication of the algorithm with PIC microcontroller is done through serial data transfer. To access the serial port of the computer using MATLAB, a serial port object has to be created using the code.

ser=serial('COM3') ....(5)

In the 'ser' object, the type, name and port is automatically configured. Thus data is transferred to PIC microcontroller using serial port COM3. The position of the centre of mass of the object in the co-ordinate system determines the motion of the robot with the help of decision table. A remote code is generated and send to the microcontroller via the serial port object. The microcontroller drives the motors according to the information send by MATLAB.

In the Motion Control Algorithm, the crystal oscillator frequency is defined and port pin declarations including necessary library modules are made. The microcontroller will receive the serial data, decode the data and set or reset motors accordingly. If no data are available, it will wait and fetch data after a pre-defined timeout.

V. IMPLEMENTATION RESULTS

On noting down a few experimental values from the output, we can detect the response of the microcontroller to different values:

TABLE I: Implementation Results

VALUE OF 'e'	TYPE OF MOTION
e = 13	Forward
e = 5 or 6	Left
e = 9 or 10	Right
e = 14	Back

VI. COMMENTS ON THE RESULTS

After implementing our project, we came across the following four results. First, when the object to be tracked is detected above the centre of the coordinate axis shown in the webcam screen, the microcontroller in the robot responds with a 'Forward' motion and drives the motor which in turn makes both the wheels move in the forward direction towards the moving object. Second, the microcontroller interprets the 'Left' motion when the object is moved to the left from the centre of the web cam screen within its frame and the wheel on the right side gets driven by the motor to take a left turn. Third and similar to second result, the microcontroller interprets the 'Right' motion when the object is moved to the right from the centre of the web cam screen within its frame and the wheel on the left side gets driven by the motor to take a right turn. When the object to be tracked is detected below the centre of the webcam screen, the motor driver drives both the wheels in a reverse direction and interprets 'Backward' motion. There is a delay of about 5 seconds in which the object is detected and the samples are captured by the webcam.

VII. CONCLUSION

The concept of the robot presented here in this project makes the use of webcam for acquiring images and instructions from computer to perform physical movement. Among the important features of this robot is that any of its physical movements can be controlled effectively through the use of software. Controlling process has been made much more accurate at the cost of programming complexities. The robot is far cheaper than any other existing equivalent vision based robot. The programming in software made it possible to provide adequate signals with as less a time delay as we could manage which enabled the robot to manoeuvres fluently. Further modification of this robot includes giving it additional sensors like sonar and infrared or attaching it with the robotic arm and allowing it to pick and grip and drop the tracked object along with making the robot completely wireless.

ACKNOWLEDGEMENT

All the authors are thankful to the entire teaching and non-teaching staff of Usha Mittal Institute of Technology for their immense support and motivation.

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