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Colour Tracking Autonomous Bot

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Abstract:
A surveillance robot usually uses cameras to spy and observe a specific target. The robot can do so from a static stand point akin to a CCTV (Closed Circuit Tele-Vision) which does not move around but is stuck to one place or else it can act as a robotic car. When surveillance is done using a robotic car, larger range and better efficiency is gained. Also, the very process of surveillance can be done in various ways. The first type of surveillance is if it is real time (video-based) or not (surveillance happens at a later time after video is taken). This project uses real time tracking of an object. The second type of surveillance is if it is camera based or non- camera based (following a scent using sensors or maybe using cameras in IR range). The third type of distinction in surveillance is factor or property of an object used to track it. Since this project is camera based so factors like odour of an object is redundant. However, the possible ways are object detection (by using Deep Learning), facial detection (in case of Human as object) or using colour of object (as is used in this project).

***Keyword:** Autonomous bot, colour detection, Real time tracking, Surveillance robot*

1 INTRODUCTION

This colour tracking Surveillance robot can be implemented commercially in an economical manner in hazardous industries like mining industries to track movements of uniform wearing workers to stop them from coming in contact with hazardous regions [1]. It can also be employed in industries like defence industries to ensure unauthorized employees do not enter restricted areas [2]. The robot has a camera placed over the chassis which is employed to stream the movement of the bot to the user. This robot can be remotely controlled by the user by using a local host system [3].

Our project aims to provide a human user,with remote access control on the device thus making our device available in two modes of working i.e. autonomous and semi-autonomous. This improves the handle-ability of our system. A user can control the direction of the movement of the robot, using remote access from a host system [4]. It is proposed to develop a mobile application in order to provide remote access with increased modularity.

2 METHODS AND MATERIALS

2.1 Hardware

Components

The main components of this system are Raspberry Pi, Web Camera and a standard run of the mill Robotic Chassis.

Raspberry Pi

In this project Raspberry Pi is used. The Raspberry Piis a cost effective, miniature computer that is integrated with a standard computer. It comes with different specifications in different models namely Raspberry Pi 2/3/3B/3B+/4 launched by Raspberry Pi foundation. It is useful in conducting small experiments or creating micro projects in the field of IoT and Electronics [5]. It is a gateway for students into the world of microcontrollers and micro-processors.

USB Webcam

USB Webcam is used to detect the images and colour. It can be connected to a computer or to the USB port of Raspberry Pi, thus the ease of working increases manifolds. The camera sends the video to the

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computer from where the user can view the photos and videos and can upload it to the cloud if desired [6].

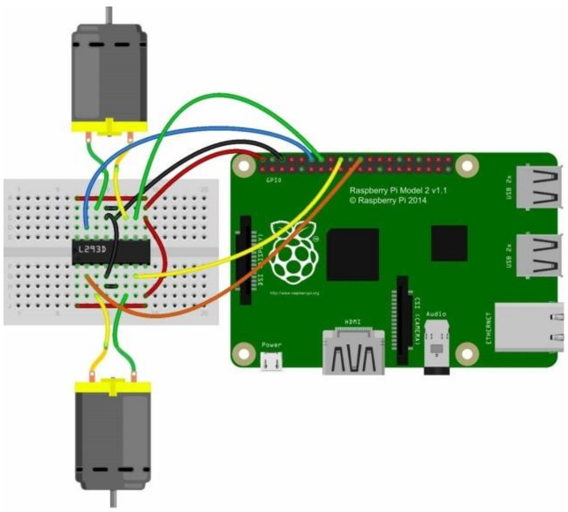

Fig. 1. Schematic of the proposed colour tracking autonomous bot.

Circuit and Setup

The skeleton of the robot can be created either by using hand-made chassis or ready –made ones which just need to be attached using a guide or manual. The job of powering the Raspberry Pi is ordinarily conducted by a power bank. All the components are placed on the chassis in a manner that the chassis isn't overcrowded and spread out in a manner that the weight is balanced. Adhesives are used to secure all the components in place. Figure 1 shows the schematic of the proposed colour tracking bot. The hardware setup of the bot is shown in Fig. 2.

Working

The main aim of this project is that the robot will automatically adjust itself to keep track of the blue (or any other hard-coded color) colored object. Initially object will be in the center of the frame and the motors will be in the off state and as soon as object starts moving, robot car will become active. Since now the object is going outside the set frame, accordingly robot motors will adjust it to turn in the direction in accordance with the logic set in the program.

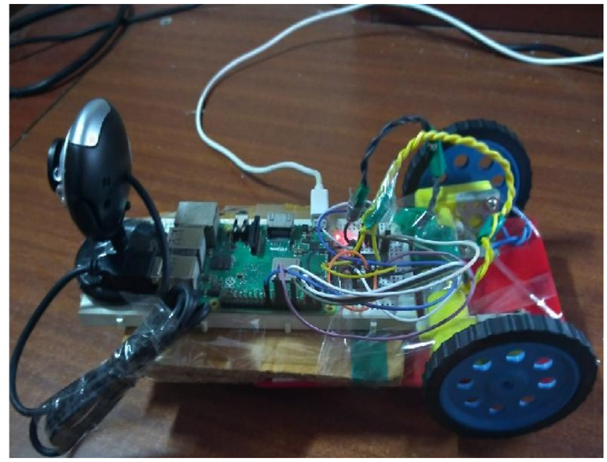

Fig. 2. Hardware setup of the proposed bot.

For example, to turn right if less than 280 and turn left if greater than 320.First the lower and upper boundaries of the color bluein the HSV color space need to bedefined. Then the frame is read by the user who needs to pre-process the frame a bit. Then the actual localization of the blue ball inthe frame occurs by making a call to cv2.inRange.

Initially lots of contours have been detected in the frame by *cv2.findcontours()* but robot need to detect the contour with the largest area that is when the object will be detected. Then robot needs to draw a rectangle around the object and if the object moves out of sight, then robot will automatically adjust itself to keep track of the object. The motors will get activated and the robot starts moving in the desired direction.

Also to more precisely keep track of the object so that it stays in the centre of the frame, robot draw a thick circle in the centre of the frame using the *cv2.Circle()* function and adjust its thickness.

2.2 Transfer Characteristics

In this project, the output is constituted of several small sub-actions which include movement of the object affecting the work of the camera; this in turn generates movement of the car. The transfer function gives the relation (generally in Laplace form) between the output/response of the system with respect to the

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input of the system.Here in this project, there are 2 types of transfer characteristics: One for the camera and other for the motors of the car.

Here along with the distance moved by the object, the direction of movement is important too. The movements of object causes object to move away from the center of the frame of the camera, so the car moves to bring object to the center.

Let *m*be the movement factor, *p* be the frame position and *u* be the unit step function.

$$m(t) = \begin{cases} 1,\ p > 320 \\ u(280 - p) + u(p - 320),\ \ otherwise \\ -1,\ p < 280 \end{cases} \quad (1)$$

Considering, 1 implies left wheel moves as object moves right of frame and -1 implies right wheel moves as object moves left of frame (Eq.(1)). The equations (Eq.(2-5) show that H(s) is the transfer function w.r.t. frame position, M(s) isthe movement factor in s domain, P(s) is the frame position in s domain.

$$H(s) = \frac{M(s)}{P(s)} \quad (2)$$

$$M(s) = \frac{(e^{-320s} - e^{-280s})}{s} \quad (3)$$

$$P(s) = \frac{1}{s^2} \quad (4)$$

$$H(s) = \frac{M(s)}{P(s)} = (e^{-320s} - e^{-280s})\text{s} \quad (5)$$

Motor

Voltage applied to the armature of a dc motor can be varied to control the speed of the dc motor. A separately excited dc motor with variable armature voltage finds application as a drive motor in a variable speed drive. A phase controlled rectifier is employed to provide the variable armature voltage [4,7].

2.3 Software

Installation and configuration of Motion tool

Motion is a very well known software tool built especially used in surveillance and security systems. It helps in determining the motion of an object and disturbances in a particular area and also captures it by recording it at regular intervals. This software is open source, so can also be used in Raspbian OS on the Raspberry Pi. Motion needs to be installed on the Raspbian OS and when synchronized with the camera, returns the live video feed to the controller at specific intervals of time. To view the live feed, motion needs to be initialized and rendered on the particular website, where the particular port and the IP address of the Raspberry Pi is enabled, so that the live feed is fetched and is showed on the webpage.

To start, the RaspbianOS needs to be updated. The following command is used to update the Raspbian OS.

sudo apt-get update

Motion tool library is installed on the OS.Now the motion file present in the /etc/default/motion path, is edited where the motion daemon is enable be making it to YES, thus make it to run everytime.To edit this either *nano* or*gedit* editor can work on the OS.

Then the motion file is then saved with this configuration.

One important thing in motion is to enable the permissions for the destination or source directory in which all images and videos are saved. The path for this is */var/lib/motion/*.So in order to remove the errors regarding this; motion has to be set as the owner of this particular directory. To enable this, the given command can be used.

sudochownmotion:motion /var/lib/motion/

For checking the service status of the motion software the given command can be used:

sudo service motion status.

The final step to install motion is to configure the configuration file present in the given path directory */etc/motion/motion.conf*. In order to fetch the live

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video feed on the particular network and the webpage the local host streaming needs to be turned off. Otherwise the feed will only be available to the Pi itself and will not be shared on any other network.

sudonano /etc/motion/motion.conf

The editing can be done using *nano* editor. The following command can be used to run the editor:

sudonano /etc/motion/motion.conf

Now the motion tool is installed and configured on the system and can be used. Hence in order to get video feeds, the motion software is rebooted using the following command. The cam is connected to the Raspberry Pi. Also the particular ipaddress on which the Raspberry Pi is running that address and the particular port is opened on a browser on the Pi.

sudo /etc/init.d/motion restart

Thus when this particular page opens up on the raspberry Pi the live feed from the camera automatically starts, as the live feed from the motion is embedded in the *img* source in the html code. The most important feature is that the live feed can be viewed on any device connected to the same network, either it be mobile phones laptops or pc systems. Also, the live video viewing as used here is cheap and easy to use. To reboot the Raspbian OS the given command is used.

2.4 Code Summary

Numpy module is used for preprocessing of the data. The pins of the Raspberry Pi are controlled by the RPI module.

The track of the time is controlled by the time module. Functions have been defined for the movement of the car (left,right etc.).

For doing the heavy load work of image processing, *OpenCV* library is used,due to its accessibility and detailed documentation. Also specific commands make it very user friendly and beneficial to the project [8,6].

Each frame on the webcam is taken, if the object is inside that frame, car will be inactive i.e. stop state. If the car moves outside the frame, car will become active.

Images from live webcam was taken with *cv2.videoCapture* command.To efficiently pre-process the image, converting images from RGB to HSV using *cv2.cvtcolor()* command.To detect a specific color object, *cv2.inrange()* command needed.To find continuous objects like car, contours are used calculated by *cv2.findcontours()* command. User can draw a rectangle around the car (object) with help of *cv2.boundingrect()* command.With the *cv2.circle()* command program will draw a thick circle in the center of the frame and for the closed loop here aim will be that the robot will always try to be in the center of the frame.

3 RESULTS AND DISCUSSIONS

The proposed system follows an object of specific color. It can follow an object having multiple colors or different objects having different colors. Any color that is to be followed by system is hard-coded into the system. Our web camera cannot move itself, so to track movement of the target; the whole vehicle has to move in the direction of movement of target.

The simple way by which the target is kept in the loop is by tracking the centre of the object (target). In this way, the system has a rather simple one point reference for the target. In the use case, the blue object (here the blueface of a Rubik’s cube) is taken as the target and is moved to elicit a response from the system. Figure 3 depicts the activation of the motors, and by the continuous tracking of the blue color object. The response of the system isshown in Fig. 4.

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Fig. 3.Continuous tracking and following of the specified color (blue here) objectby the robot.

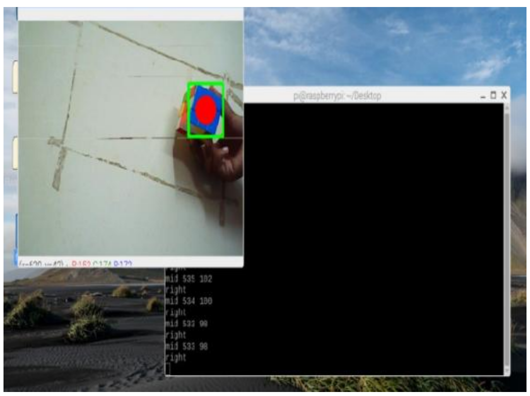

Fig. 4. Detection of blue colored object displayed on host screen.

With a better camera, the system can have increased modularity. General purpose controllers like Raspberry Pi have their own set of limitations. The system is also controlled by a remote host, which can provide it basic commands like to move right, left, front or back. The system should have the sensitivity and the speed at which it detects the change and reacts [9]. To obtain better accuracy in this aspect, tailor-made processors and controllers need to be used [10].

4 Conclusions

Regarding the application of this system, it can be targeted for some large industries and some niche ones too. The system can be implemented in industries where employees have restricted access (defense industries). It can be used to monitor if employees approach too close to any hazard (mining industries). It can do all of this only if employees wear a uniform preferably of a single color, so they can be tracked using this feature.

It can be potentially converted into an infantile monitoring system or it can be tailor made into a geriatric support system. These are niche industries, so the proposed system would have to go some changes to suit specifications of the customer. These systems would also require internet access, to surveil on infants or to receive alerts from senior citizens in case of emergency. Here the primary feature is color of object but it can be combined with other features like dimensions, intensity etc. to get far better results.

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