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Vision-Based Object Tracking for an Omni-directional Platform

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Abstract

The Mecanum wheels were invented in 1970's in Sweden by Bengt Llon. These wheels allow for not only a Forward, backward and turning around a curve motion but allow sideways strafing and rotation in the clockwise or anticlockwise direction along its axis. These wheels give a robot platform the amazing capability of omnidirectional movement and allow the platform to have a holonomic motion which allows them to navigate through congested and confined environments. The aim of the paper is to describe the working of a Mecanum wheeled robot and explain how Computer vision and image processing concepts can be implemented to such a platform using Microprocessors and Microcontroller such as Arduino for it to track and follow a colored object. The Open CV platform available in Python libraries will be utilized for pattern recognition of colored objects which is a form of image processing. Due to the holonomic nature of the Platform the platform will strafe sideways and move forward backward according to the position of the object received through the camera.

Keywords: *Arduino: Holonomic: Open CV: Mecanum: Computer Vision*

1. Introduction

Omni-directional wheels and Omni-Directional platforms are increasing in popularity day by day. They are most used on mobile platforms such as mobile robots or forklifts that allow for omni-directional movement for easier handling of goods when compared to conventional wheels as they not only provide movement that is observed by conventional wheels but also allow for side-to-side strafing and allow for rotations along its axis.

Vision is the ability to see or the state of being able to see. It is the one of the most important sense that a human posse and it is the sense with the highest bandwidth of information when compared to the sense of hearing, taste, touch, and smell. It is the sense that can help the brain analyze its environment very easily. Giving the sense of vision to a computer can be highly beneficial as computers are very good at computing dense number of equations in short amount of time and have better latency in reacting to a situation. This is one of the main reasons Computer vision was born. Computer vision currently is seen in every field or industry and its applications are numerous.

There are many ways a user can apply Computer vision concepts to their projects. One such way is by the implementation of Open CV. Open CV is an open-source library for image processing, Computer vision and Machine learning purposes. It allows the user to integrate Computer vision concepts with various applications and it can be implemented in almost any platform.

By giving the sense of vision to a Omni-directional Platform will allow the platform to track an object without any human control and allow the platform to follow the object. This project utilizes the open-source library Open CV and uses the available image processing techniques. The code for the platform is written in python and the motors on the platform are controlled with the help of an Arduino.

2. Layout of the Omnidirectional Platform.

The platform is a 4 wheeled platform which consists of Mecanum wheels which are a type of Omni-Directional Wheels. To drive the motor an Arduino Uno is utilized along with a Adafruit motor driver shield. The Arduino Microcontroller receives Serial Communication from a Computer vision-based python program that will be running on a separate Personal Computer. For the purpose of the project the platform is designed to strafe left and right and move forward and backward. The structure of the platform is shown below.

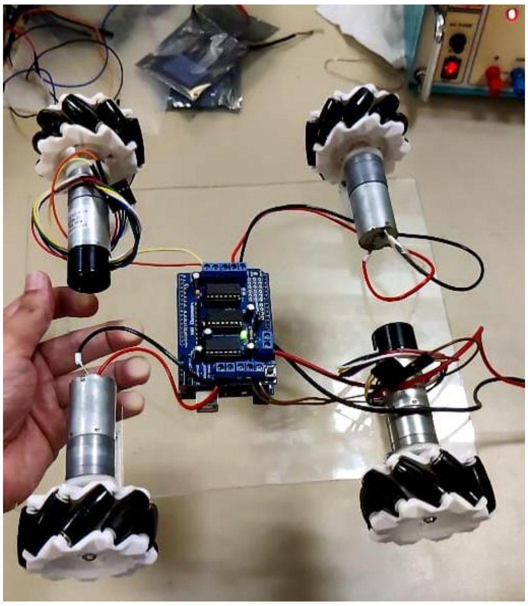

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Fig 1 : Mecanum wheel Platform.

2.1. Mecanum wheels

The mecanum wheel when compared to conventional wheels, has additional rollers along its rim which are attached to it in a θ = 45-degree angle to the platform. The addition of the rollers at the rim allows for movement in cross-sectional direction which is one of the main properties of using a mecanum wheel.

The Mecanum wheels for a 4-wheel platform require to be of 2 types. Left type tire and Right type Tire. These wheels need to be placed in a particular fashion to achieve omnidirectional movement. The mecanum wheels are arranged in such a way that when an axis is drawn from each wheel, it coincides in the center. The wheels are arranged in such a fashion such that the inner wheels present on the wheels are arranged in a 45˚ angle. There are 2 different sets of wheels where one set is placed in the same direction diagonally, mean-while the other set of wheels are placed on the opposite side diagonally. To move the complete arrangement of the robot using mecanum wheels, it does not follow the conventional method of movement of wheels. These wheels must be moved independently, have to be coordinated with the rest of the wheels and finally have the same speed. The rollers arranged on the mecanum wheel cause frictional force in the 45˚ angle while moving forward or backward.

2.2. Force Analysis

Consider Net Force F_N responsible for movement of the platform in a particular direction, F1, F2, F3, & F4 forces by wheel 1, 2, 3 & 4 respectively. The project requires only forward, Backward and Left to Right strafing movement.

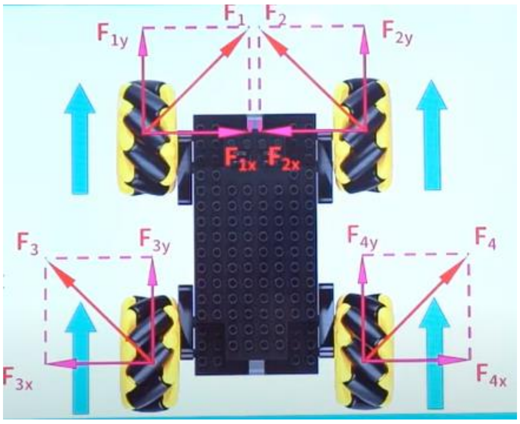

Fig 2 : Forward/Reverse Movement for Platform – Images taken from-https://ubtecheducation.com.

To achieve Forward motion all the wheels are rotated in the same direction or Forward direction. On splitting Individual wheel Forces into their component forces for each wheel Fx and Fy for each wheel are obtained. If we observe carefully, we notice that the component frictional forces in the y axis direction all cancel out and the forces left out are the Fy component frictional forces, therefore causing a forward motion.
This gives us the equation for Net Force as:

$$F_N y = F_1 y + F_{2y} + F_{3y} + F_{4y} \quad , \quad F_{Nx} = 0 \, ,$$
$$F_N = F_{Ny}$$

To achieve a reverse motion the wheels are driven in the opposite direction and a negative Normal Force is achieved.

Consider below figure to understand Strafing motion.

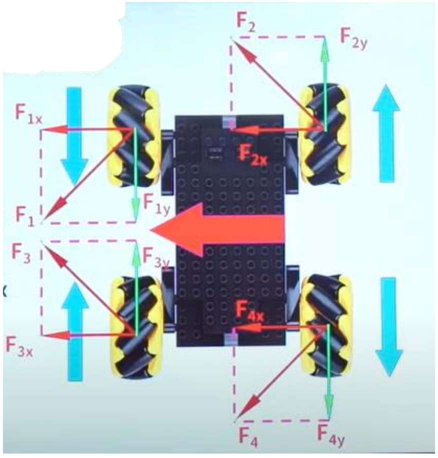

Fig 3: Left/Right Movement for Platform – Images taken from-https://ubtecheducation.com.

To achieve strafing motion, in this case towards the left, Wheel 1 and Wheel 4 are driven in Reverse whereas Wheel 2 and Wheel 3 are driven in Forward directions. By analyzing the Force components on each wheel, we observe that frictional forces in the Y axis cancel each other out and the net force constitutes of only the frictional forces in the horizontal or X direction which allows for the movement of the platform in the left direction. To achieve movement in the right directions, the direction of each motor rotating is exchanged, and the Net force is obtained as a negative of the horizontal frictional force.

$$F_N x = F_1 x + F_{2x} + F_{3x} + F_{4x} \quad , \quad F_{Ny} = 0$$
$$F_N = F_{Nx}$$

3. Vision-Based Object Tracking

3.1 Wireless Method for Camera Configuration

Object tracking of an object in the Field of view of the camera is done with the help of a Mobile Phone Camera that sends a live stream through a Wi-Fi connection to the Open CV python program running on a Personal Computer System. A hotspot is setup on the mobile phone and the system is connected to the hotspot. An App called IP Webcam runs on the mobile Phone that sets up a server to live stream the video feed and this video feed is accessed by the python program with the help of a URL.

3.2 Object Recognition

The object of interest in the case of the project is a red ball. A computer vision algorithm would be unnecessary as image processing techniques are enough to identify the red ball in the field of view of the camera. Images on a computer are made up of tiny bricks called pixels. These pixels constitute of RGB values which is an acronym for RED, GREEN and BLUE which allows the pixels to have any color possible. Through These RGB value adjustment and readings a color can be identified and set according to the user.

However different lighting conditions can make an object look like it has a different color in the image obtained by a computer. HSV stands for Hue Saturation Value and these values can help identify a color in different lighting condition by adjusting their HSV values. Each color has a different HSV value range, and these are unaffected by lighting conditions.

As the object of interest is a Red coloured object, The HSV value for such an object is found to be within the range of 151, 149, 88 for lower HSV values respectively and 179, 255, 223 upper HSV values respectively. By using these values we can create a filter or a Mask that filters and removes out every colour except the colour that has the HSV value of the range mentioned previously. The result is obtained below.

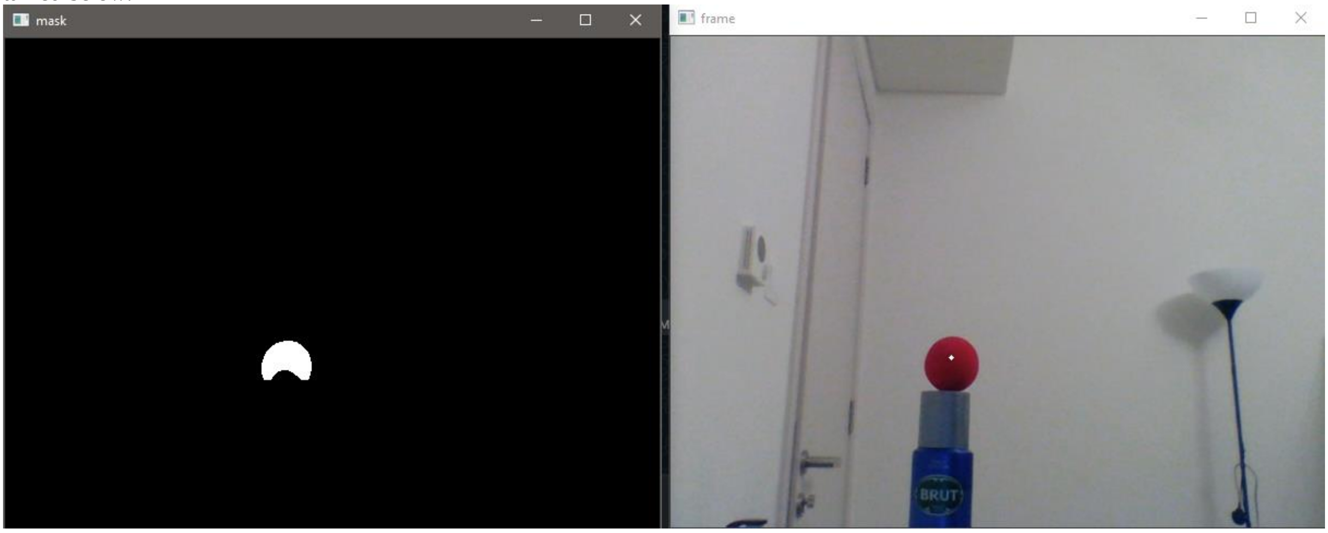

Fig : 4 Red colour observed in the right window after applying HSV mask in the left window

3.3. Finding Location of the Object

Since the Camera is placed on the Omnidirectional Platform, the program needs to know where the object is with respect to the platform. Consider the Camera to be placed in the centre of the platform, therefore if the object is on the left side of the bot the object would appear on the left side in the obtained image and same for the right side. To understand whether the object is on the left or right the use of mask window utilized.

In a mask window pixel either have the value of 255 which represents a white pixel or 0 which represents a black pixel. After a red object is detected, the mask will change the pixel value of the corresponding pixels where the Red object is present to 255. The location of these pixel values can be found out by checking the value of each pixel. Then an average can be obtained by running a function that can tell us the Midpoint of the object of interest.

The window of the mask is of the size 600x480 in the x and y direction. Therefore, each pixel is numbered from left to right as 0 to 600 in the x direction as it is the only direction, we need to know whether the object is left or right. Therefore, the centre of the camera is taken as pixel number 280 up to pixel 330. If the average lies between this range that means that the object is right in front of the platform. If the average value is less than 280 or greater than 330 that refers to the object being left or right side of the omnidirectional platform, respectively.

To increase the efficiency of the program a gaussian blur is utilized as it removes the noise when the HSV mask is applied and can help give a better average the object is under the influence of different light sources.

3.4. Moving the Platform

With Respect to the project only Forward, Backward and Strafing Actions of the omnidirectional platform are considered. To achieve the mentioned movements 4 mecanum wheel motor needs to be operated on independently in different patterns which have been discussed. The Arduino Uno Receives commands from the python program based on the location of the object with respect to the camera. The python program through serial communication dictates the Arduino to move in which direction when the object is on the left and right. However when the object is centred the platform needs to move towards the object. A problem is brought up as Images and camera do not offer any depth perception. However, Sudo depth perception can be obtained by finding the area of the highlighted pixels in HSV mask.

If the area of the highlighted mask is small that refers to the object being far away and similarly if the area of the highlighted pixels in the mask is large that means the object is close. A threshold can be set by observing the area of the object when its placed close to the platform to know when to stop the platform in front of the object.

Therefore, first the platform orients itself by either strafing left or right and centre the Red ball in its field of view. Once its centred the program observes the area of the highlighted pixels in the mask and sends command to the Arduino to move the motors forward until a certain threshold of area is reached. At this point a stop command is sent and the Platform stops in front of the object.

4 Flowchart of the program Algorithm

With the help of the Pyserial library available in python, Serial communication between the Arduino and a python programme can be established. By detecting the location of the object of interest, Integer data is sent serially which represent a different command. Therefore if the object is on the left the serial data ‘1 ‘ is sent which instructs the Arduino to move the platform to the left . Serial communication can be established with the help of a Bluetooth module or by using a serial connector between the System and the Arduino UNO.

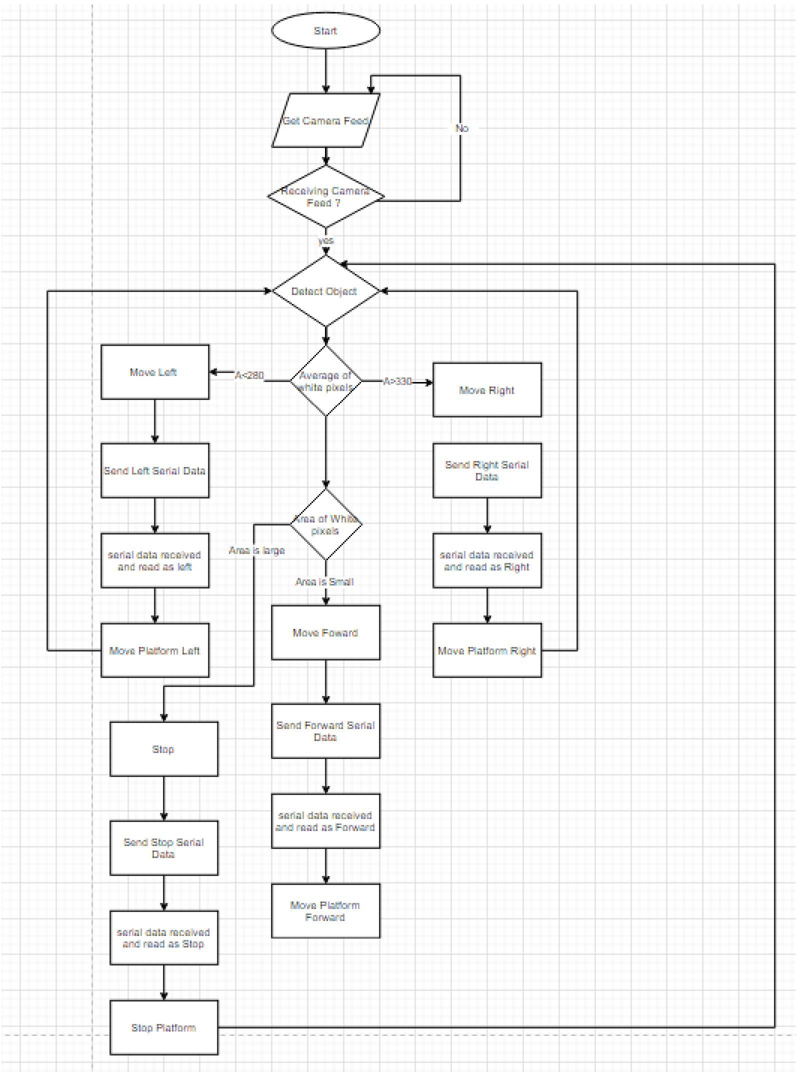

Fig 5 : flowchart of program algorithm

5. Results

The following figure given below are the test results of finding location of the object with respect to the omnidirectional platform and sending corresponding serial data to the Arduino uno to move the omnidirectional platform and allow it to track the object of interest.

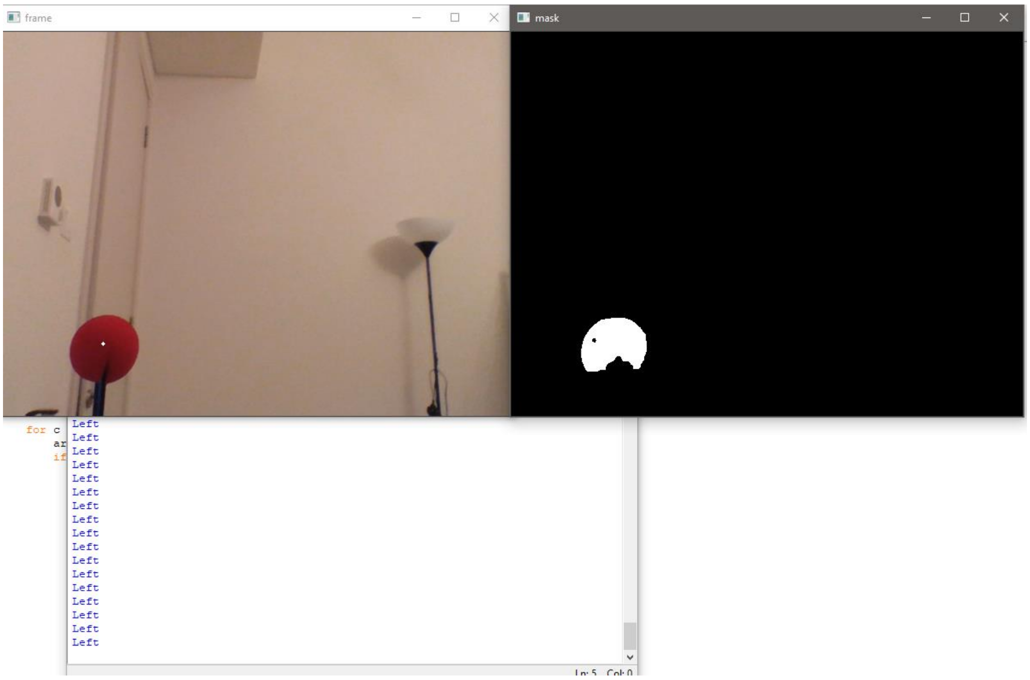

Fig. 6: Detection of object location, depth perception and serial communication of commands to the Arduino .

6. Conclusion

An omnidirectional Mecanum wheeled robot can be used for several other applications by implementing concepts of image processing and computer vision. In the project the Omnidirectional platform can track the Red object of interest based on the feedback it received from the camera about object. Detection of object, determining the location of the object and depth perception of the object are all done with the help of Open source Open Cv library, this allows the platform to track the object successfully.

By implementing cameras and allowing the platform to have a sense of vision has really helped in the process of automation of this project. The project can be updated and improved on by allowing the program to identify complex objects such as a Cup, Boxes or allow it to follow a human by understanding gesture recognition and human body skeleton and implement more complex computer vision and machine learning libraries such as tensor flow.

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