

Automated Tennis Ball Collector

Swarna Bisane(B17145)*, Vaishali Gojra(B17148)¶, Komal Mahale(B17089)‡, Navya Varakantham(B17049)\$,Aishwarya Bhargav(B17073)†,Anuradha Meena(B17008)§

*b17145@students.iitmandi.ac.in , ¶b17148@students.iitmandi.ac.in , ‡b17089@students.iitmandi.ac.in , \$b17049@students.iitmandi.ac.in , †b17073@students.iitmandi.ac.in , §b17008@students.iitmandi.ac.in

Abstract—Over the recent years research in robotics and electronics has led to many applications in industries like sports, manufacturing, etc. In this project we have made a tennis ball collector. The motive of the project is to collect balls in the tennis court and return them back to players or coaches and thus saving time and energy of player from manually picking up balls during training sessions. The robot detects the balls present in the court with a camera and using image processing and IR sensor calculates the distance and location of of balls and collect all the balls. Apart from collecting tennis balls, it can also be used to collect different colour balls and separate them. The project has a huge scope in sports industry.

I. APPARATUS USED

SERIAL NO.—	COMPONENTS	QUANTITY
1.—	Raspberry pi 3	1
2. —	Infrared Sensor	1
3. —	Motor Driver(L298n)	3
4. —	DC motors(300 rpm)	4
5. —	Pi Camera(5 MP)	1
6. —	Chassis	1
7. —	Jumper wires	40(approx)
8. —	Breadboard	1
9. —	Lipo battery(12V)	1
10. —	Castor Wheels	4
11. —	Rack and pinion Gears	2

II. DESCRIPTION OF COMPONENTS USED

A. RASPBERRY PI 3

It is a credit card sized computer developed raspberry foundation for teaching of computer science. Just by adding SD card,mouse,keyboard it can be fully used like computers that can run same applications like computer.It uses 64bit ,1.2GHz ARMv8 chip, microSD card for storage,memory 1 GB. Connections include 4 USB ports,HDMI port,MicroUSB power input DSI display port,CSI camera port,SD card hold,40 GPIO pins(male headers).

B. D2016 INFRARED SENSORS

An infrared sensor is an electronic instrument which is used to sense certain characteristics of its surroundings.The emitter is IR LED and detector is IR photo



Fig. 1. Raspberry Pi

diode which is sensitive to IR light of same wavelength of IR LED.It lights up when IR receiver receive signal means an obstacle is detected.An IR sensor can be used as motion detectors to sense movement of any obstacle like vehicles, animals or other objects and are commonly used in automatically activating lighting system and security alarms.In our project we are using it to sense tennis ball.



Fig. 2. IR Sensor

C. MOTOR DRIVER(L298)

The function of motor driver is to take low current control signal and turn it into high current signal that can drive a motor.It comprises of microprocessors ,Ics which amplify current and power supply unit.

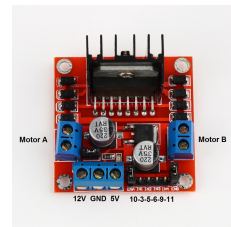


Fig. 3. Motor Driver

D. DC motors (300 rpm)

It is an electric component that converts electrical energy to mechanical energy when two magnetic field interacts .First produced by current in the coil and second by permanent magnets.When a current carrying conductor is placed in magnetic field,it produces torque which tends to rotate rotor.



Fig. 4. Motor

III. LIBRARIES

The image processing and movement of the robot was done using OpenCV various libraries of Python. Libraries Used

1. Numpy-

It is a library in Python which provides high level functions for mathematical and numerical calculations. This library is also used for storing generic data efficiently in multi-dimensional container. It also provides functions to integrate different types of data. This library is not pre-installed. It has to installed by the user.

2. cv2-

The whole image processing is done using this library. This library contains inbuilt functions which helps to identify the size, shape, colour and other characteristics of the object in front of camera. It also has high level functions to calculate the co-ordinates of the object placed in front of camera. It uses various functions of Numpy library for calculations. This library is not pre-installed. It has to installed by the user.

3. time

This library contains all the time-related functions. Many functions of this library are similar to functions of time.h in C/C++. In this project we have used time library as sleep which stops the code for some specific given time. It has been used to give delay for increasing efficiency of the robot. This library is pre-installed on PC.

4. RPi.GPIO

This library contains functions to control various pins(input, output and PWM pins) of Rasperry Pi. In this project, we've used this library functions to control motor's rotation and speed via motor drivers.

IV. ALGORITHM AND FUNCTIONS USED

The algorithm used has been divided into three parts.

A. Ball Detecting

1. Capturing image using camera
2. Processing image-
 - >Identifying colour and shape of the ball
 - >erarea enclosed by image of the ball
3. Finding ball with largest area i.e. finding the nearest ball to the robot.
4. Finding co-ordinates of centre and diameter of the nearest ball.

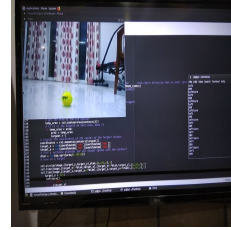


Fig. 5. Image1



Fig. 6. Image2

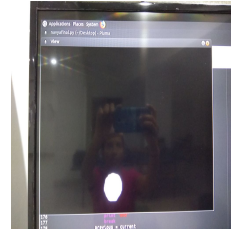


Fig. 7. Image3

B. Directional Analysis of motion of Robot

1. We have defined the width of window of camera as 700 cm.
2. The movement of robot is analyzed using x-co-ordinate of centre of the ball provided ball is present in window of camera.
 - >If $x < 325$
 - Robot moves in left direction
 - >If $325 < x < 375$
 - Robot moves in forward direction
 - >If $x > 375$
 - Robot moves in right direction
3. If there is no ball in window, it will rotate clockwise till it detects any ball.

C. Ball Collection Mechanism

1. Now ball is in front of the robot. It will move closer to the robot.
2. As the ball is a suitable close distance, IR sensor will sense the ball.
3. As the IR sensor turns HIGH, the robot will stop and the flaps will start rotating for 5 seconds and the ball will be collected.
4. Then after collecting the ball, it will look for another ball.

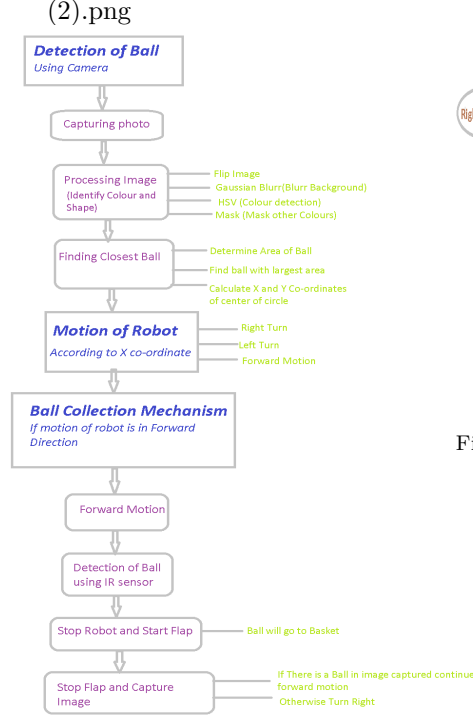


Fig. 8. Flowchart

V. DESIGN

A. Chassis

It consists a sheet of aluminum that forms the base of the robot. Four tyres (connected with DC motor) are connected to the base of chassis. On top of chassis, platform is made to hold Raspberry Pi, motor drivers, breadboard and camera. In the front, a U-shaped strip of GI (Galvanized Iron) is mounted on which camera and IR sensor are placed.

B. Ball collecting Mechanism

The system used for picking up balls consists of a single rotating shaft on which four flaps are mounted. It has a curved ramp below it. The flaps gives a little push which pushes ball to the curve ramp and the ball is collected in the container behind.

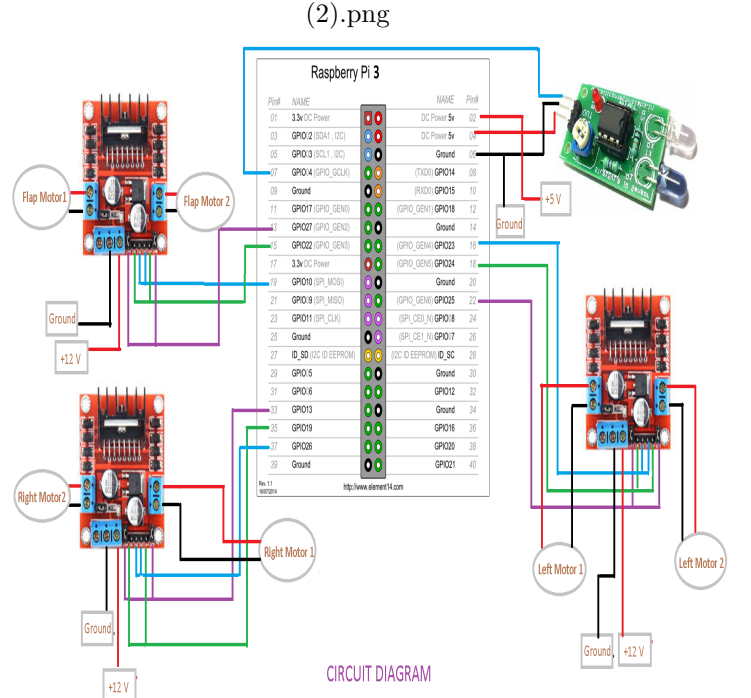


Fig. 9. Circuit Diagram

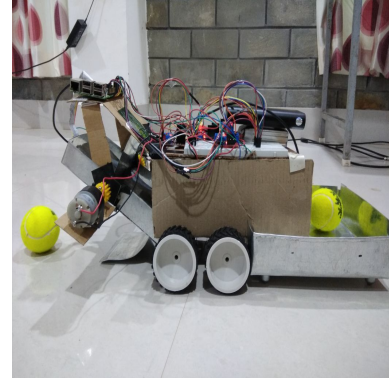


Fig. 10. Chassis

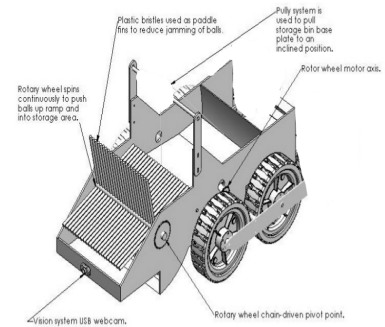


Fig. 11. Ball Collecting Mechanism

VI. FUTURE SCOPE

1. It can be extended to collect different balls (like golf balls or cricket balls) from the field. It has wide scope in sports industry.
2. It can also be used in para-Olympics. We can use the algorithm of ball detection and movement of robot and fix camera on wheel chair and collect balls manually.
3. After modifying the algorithm a bit, the same algorithm can also be used to track or follow a robot. Hence, it can also be used as a ball tracker.

VII. PROPOSED ALTERNATIVES

1. Human Controlled Manual Pickup

It involves use of a tool as shown in the following picture. In this, the player has to stop the game and collect the balls manually. This type of collector is cost efficient and portable but would be ranked very low in terms of speed.



Fig. 12. Manual Collector

2. Vacuum and Conveyor Collector

It uses a fan or blower to push all the balls present in the tennis court to the conveyor attached alongside the bot. The conveyor transports balls to one side of the court. It is portable and fast but is not financially suitable.



Fig. 13. Vacuum collector

3. Claw Collector

It is similar to our project. Only difference is in ball collecting mechanism. In this type of collector, a claw to pick and drop balls. It is very efficient and portable, but the cost is very high.



Fig. 14. Claw Collector

VIII. CHALLENGES FACED

1. Firstly there was a problem of weight imbalance due to more weight on one side with respect to the other side. Due to this reason, tyres did not align properly and hence its friction reduced which caused a problem in its movement.
2. The camera and the IR sensor have to be kept at an angle so that the image processing and sensing of the ball could be done effectively. But it was difficult to maintain that ideal angle, hence causing problems in image detection.
3. As we know, the speed and processing are inversely related. There was a problem of image processing of the ball while the bot is moving with the greater speed.
4. And the connections of the wires (jumper wires) with the motor drivers caused a problem as some of them were loose and there were bundles of wires which created a problem while rechecking them. Sometimes it was difficult to find what was the bug if the bot was not working properly.

IX. CONCLUSION

A prototype of tennis ball collector was developed and tested. The performance of robot was quite satisfactory. However more improvements can be brought by feeding more input data. The robot is very useful for players as it saves both time and energy wasted for collection of balls. Hence players can concentrate more on their game. The knowledge and experience gained was fruitful for us in the field of robotics. This project familiarised us with different electronic components like raspberry pi, pi camera and many more. We learned to look, search and find solutions to problems. It required a great team work and coordination with team-mates.

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