Robotics Project [2021]
Pack a Ball

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Abstract

In this project we implemented a robot to pick a ball from a given surrounding and place it in a desired location in a Gazebo simulator using the Robot Operating System (ROS).

1 Introduction

Now a days, robots are being used to carry out a lot of activities to ease the efforts of humans. One such case is the cleaning of areas such as playgrounds, football and other sports stadiums, where we have a lot of balls to collect and stack them properly at some desired location or place within a large area. Keeping such a goal in mind, we aimed to implement a robot to pick a ball from a given surrounding and place it in a desired location. We used Gazebo and ROS for the implementation of our project. Gazebo [1] is an open-source 3D robotics simulator and Robot Operating System (ROS) [2] is a set of software libraries and tools that helps to build robot applications.

2 Related Work

Path planning: It is a list of sequential actions or responses which a robot performs to move from one destination to another. Generally path planning is shortest path which a mobile robot takes from start to destination with the most commonly used technique being A* algorithm with Djiktsra. To further divide the task of path planning, is self localization, map building and map interpretation. The LIDAR sensors are widely being used in almost all coming-of-the-age robots as they are very useful in perceiving the environment of a robot. [3]
Object detection: Object detection from images is a fundamental problem in image processing and helps us have a semantic understanding of images. To get a semantic understanding of images researchers use supervised learning techniques like Neural networks. Robots are being trained using libraries such as OpenCV to detect a specific object or a number of general objects. [4]
Robotic arm: Helper robots with different arms are being developed for domestic use to help with various tasks. A robotic arm is a type of arm which functions to simulate picking up objects or placing them at a particular place. Robotic arms are typically classified on the basis of degree of freedom. [5]

3 Design

We used various objects in the Gazebo simulator for our implementation, namely:

- **Robot Model:** The robot model we used was a ready-made robot in the Gazebo robotics simulator. The robot model we used has four wheels, a spherical torso with a gripper attached to it, one RGB camera and a LIDAR sensor.
- **Environment:** We created a small playground as our environment in Gazebo simulator for our robot model to traverse in and collect the ball.

- **Bucket:** We created a bucket marked with a red circular sign on it to be identified as a target for dropping the ball in by the robot model.

- **White Sphere Ball:** We created a small white ball in the simulator with mass 1 kg for our purpose.

4 Implementation

We used several Gazebo plugins including a skid steer drive controller, ROS joint control, and both camera and LIDAR controllers for our implementation. The robot is programmed to search its environment for a white ball. After the identification of the white ball, the robot approaches it until it is within close range of the ball, then it attempts to pick up the ball using the robot arm. After that it tries to find the bucket marked with a red circular sign, then it approaches the bucket while carrying the ball in its arm, and finally it drops the ball into the bucket. More precisely, we broke down the operation of our robot into eight modes and defined the head-states (torso), arm-states and the angles for arm joints to specify the movement of the robot in each mode. The eight modes are namely: search_ball, approach_ball, dock_ball (attach gripper to ball), pickup, search_bucket, approach_bucket, dock_bucket and dropoff. The mode in which the robot determines the target color, i.e. if it is searching for or approaching the ball then the target color would be white and if it is searching for the bucket then the target color would be red. The speed of the robot depends on the distance to the target. It slows down gradually as it approaches the target. The purpose of using RGB camera is to identify the target using its color and LIDAR sensor has been used to determine the distance between the robot and the target. The robot keeps switching between the above mentioned modes and that is in short, the whole functionality of the robot.

5 Challenges

The major challenge that we faced while implementing this simulation was maintaining the stability of the robot so that it functions properly. We had to pay attention to the shape and size of the robot and the target ball such that it is able to effectively grab the ball and does not fall off from its own weight or after grabbing the ball. Keeping in mind the shape and size, we also had to select appropriate spots on the robot for placement of our camera and sensor. The most difficult thing to do was adjusting of the position of the head and the arm in different modes of the robot. The arm makes use of several joints and the angles for each of these joints. Each of these robot modes had to be defined so that the stability is maintained throughout. Also, when the robot switches modes, the angles and the positions also changes. To ensure a smooth transition in ample amount of time was one of the challenge we encountered.

6 Results

On an average, 4 out of 5 times, our robot successfully manages to identify and pickup the ball and drop it in the bucket. Sometimes, the gripper picks the ball up but due to instability, it is unable to grab the ball and drops it. But since we have used a hash table to maintain the states of the robot, where the value 1 is updated in the hash table if the arm has picked the ball up, the robot searches for the bucket even if the ball is no longer in its arm. The value in the hash table gets updated to 0, only when the ball is dropped into the bucket and then the whole process of searching for another ball as target is repeated. Figures 1 and 2 shows the working of our robot in the simulator.

Figure 1: Robot picking-up the ball with the gripper

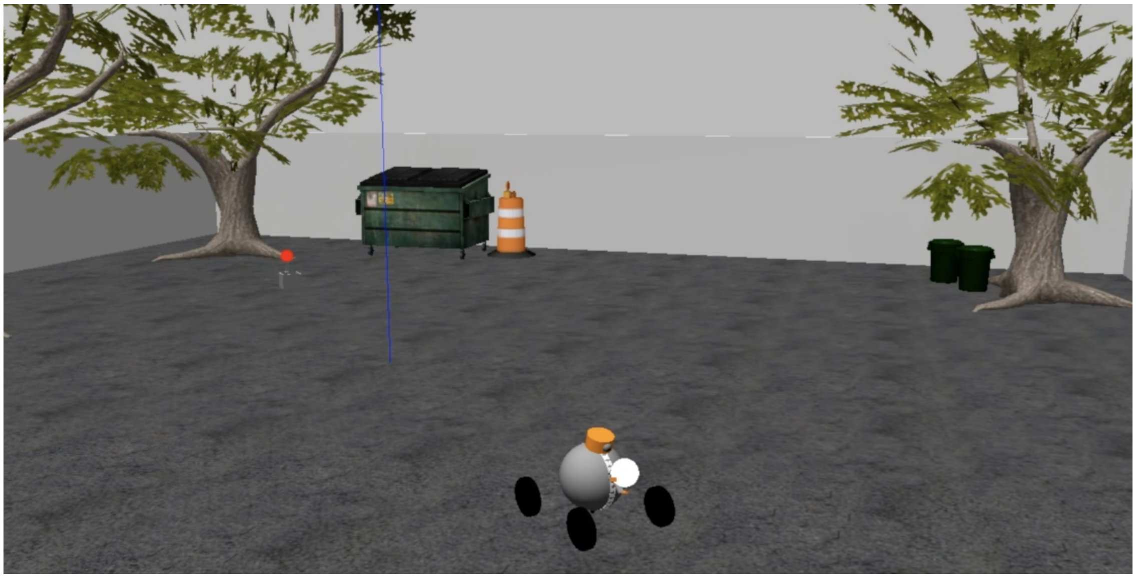

Figure 2: Robot dropping the ball in the basket

7 Conclusions

With our implementation and experiments performed during the development of this project, we can conclude that such a robot can be made outside the simulation with the basic equipment that we have used in our simulation. However, we would require more knowledge of ROS and would need to invest more time for improving its performance for getting more promising results for its application in real-life.

There are various applications of this robot in major sports such as in tennis, golf, football, etc. Such sports tournaments can use this robot to collect the ball and return it to the playing field instead of humans having to stand and continuously throw balls back. For example, in golf where the balls are tiny and difficult to be detected by human eyes, a robot can increasingly help to speed up the game and save time. This can also help to largely reduce operating costs of the matches.

However, in order to check the full performance and viability of such robots, we would need to build a physical robot and perform field tests in future. Also, in future studies, we can enhance our robot model to pick up balls of different sizes as well as improve our navigation system further to avoid trees, humans and nets.

In summary, this robot simulation project has been a great learning experience for us as a group and we are excited to see this project in action in real life situations.

References

[1] Gazebo *http://gazebosim.org*

[2] Robot Operating System (ROS) *https://www.ros.org*

[3] Path planning for autonomous aerial robots in unknown underground zones optimized for vertical tunnels exploration, Marco Moletta *http://kth.diva-portal.org/smash/get/diva2:1499089/FULLTEXT01.pdf*

[4] Are we done with object recognition? The iCub robot's perspective *https://www.sciencedirect.com/science/article/abs/pii/S0921889018300332*

[5] Toyota Research Institute's helper robot *https://www.tri.global/news/tri-teaching-robots-to-help-people-in-their-homes-2019-10-3/*