Pick-up Balls Robot With Obstacle Avoidance Function

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1. Abstract

Nowadays, most of the pick-up balls robot on the website are applying long tube to collect balls. However, precise positioning and large container are both needed in this method. After considering our robot’s building style and the CPU performance of the Jetson Nano, we decide to propose a pick-up balls system with push down method, that is, we are able to collect the ping pong balls on the ground without having accurately positioning and large container.

In this report, we assemble the robot by ourselves, then install ROS2 Foxy version into Jetson Nano, and integrating the messages from our robot’s Mecanum 4 wheels’ base, IMX219-83 stereo camera module, RPlidar-A1, and the servo motor. At last, we successfully put forward a pick-up balls system with push down method, and our robot can detect ping pong ball up to 1.5 meters and is able to collect the balls with maximum speed of 1.5m/s. In the real applications, it can dodge obstacles and pick up the orange ping pong balls on the floor.

2. Contents

(1) Background/Motivation

After watching picking ball tools with push down method on the website, we recognize this is relatively easy to achieve with a single servo motor and doesn’t need a very precise robot positioning system owing to large cross-section area of this tool. Thus, we start to think if we can apply this method into our robot.

(2) Purpose

In this report, we propose a pick-up balls system combined with our handmade robotic arm to make the robot clean the ping pong balls on the ground efficiently.

(3) Method

First of all, we setup our robot with the following steps. At first, we assemble the robot by ourselves with the help of 3D printing. Secondly, we install ROS2 foxy version into Jetson Nano, and begin to set up the sensors of our robot, including doing the camera calibration with our IMX219-83 stereo camera module, and turning on RPlidar-A1 to check the position accuracy of detected obstacles. Thirdly, in order to make ROS2 receive the data send from our robot base, we deal with the serial problem between Arduino Uno and Jetson Nano. After completed, the ROS2 node is able to send the target speeds to Arduino Uno and four wheels speed can be fully controlled by the Mecanum 4 wheels kinetics and the PI control, this is our first version of robot odometry.

Moreover, we establish our robot's unique URDF by the concept of Link and Joint, and it gives us a clear look in the RVIZ2. Last but not least, we enhance our robot odometry by the Extended Kalman Filter algorithm to fuse the ICM20948 IMU on our stereo camera module and the first version of robot odometry, created our enhanced edition of odometry and publish to the tf node for the further applications. That's all we done with the robot setup.

Next, we design our robotic arm by the combination of popsicle sticks and a box. Then, we start to develop our pick-up balls system from the ros2_explorer package (wrote by DaniGarciaLopez). Through the modification of the parameters in the wanderer_server, we successfully make our robot to move in an unknown space without hitting the walls or obstacles. In addition, with the help of the article "Ball Tracking with OpenCV developed by Adrian Rosebrock on September 14, 2015", we develop our ball_detect service to make our robot approach the ping pong ball once the ball is detected by the camera. Moreover, we program our action_server by ourselves for the robot to collect the balls on the ground with the servo motor, and the turn-around function when finishing ball-picking. In the end, we propose our pick-up balls system with the verification of collecting the orange ping pong balls on the field.

(4) Results

Specification of our robot

Hardware specification of our robot (exclude arm) Length, width, height (cm)	23, 23, 24
The furthest distance the camera can detect (cm)	150
The maximum speed of our robot (m/s)	0.15
The maximum loaded ping pong balls (number)	About 10
The cross-section of our container of robotic arm Length, width (cm)	18, 10
Positioning deviation allowed X, Y (cm)	±9, ±5 (half of containers' spec.)
The time it takes to pick up a ball Arm down, arm up (s)	1.05, 1.05 (total 2.1s to pick up a ball)
Success rate to pick up a ball (%)	About 75

(4-1) The priority of obstacle avoidance is higher than picking balls, thus robot can pick up ping pong balls without bumping into walls or obstacles.

(4-2) Because our camera can judge the ball's color far from 1.5 meters, hence turn around after picking ball is a crucial step making the whole process efficiently.

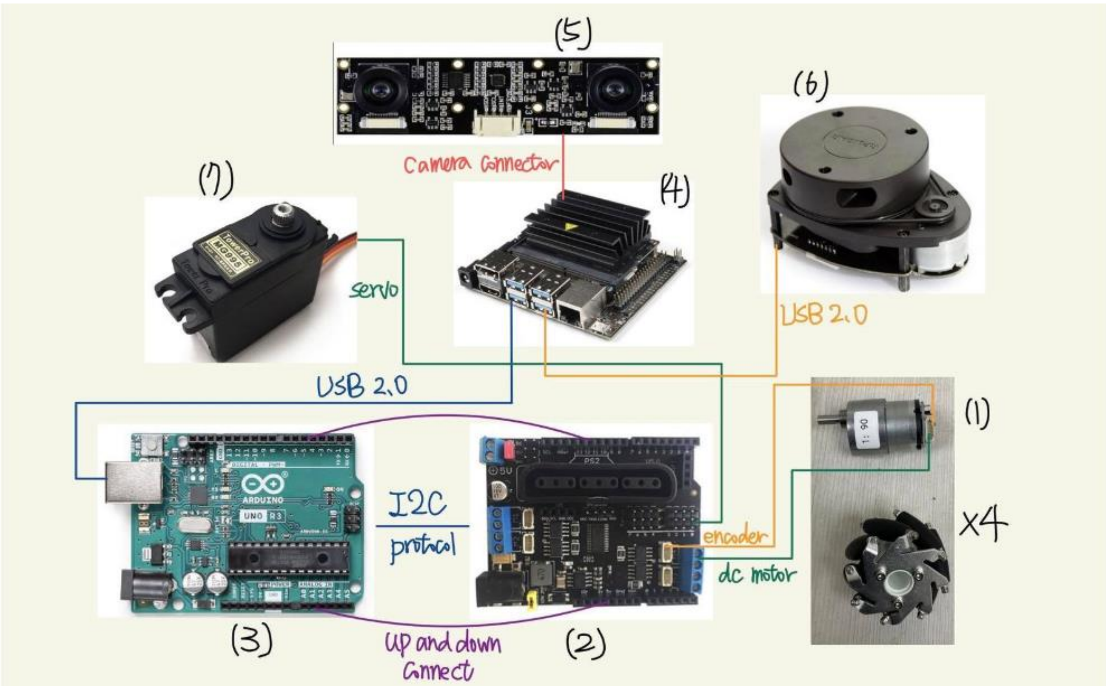
(4-3) When the robot turns around without finding ping pong balls after picking up given number of balls, the whole system will come to the end.

(4-4) Owing to the large cross-section area of our robotic arm, we just need to make the robot to stop in the specific range of direction and distance between the balls, and the robot can easily pick up ping pong balls.

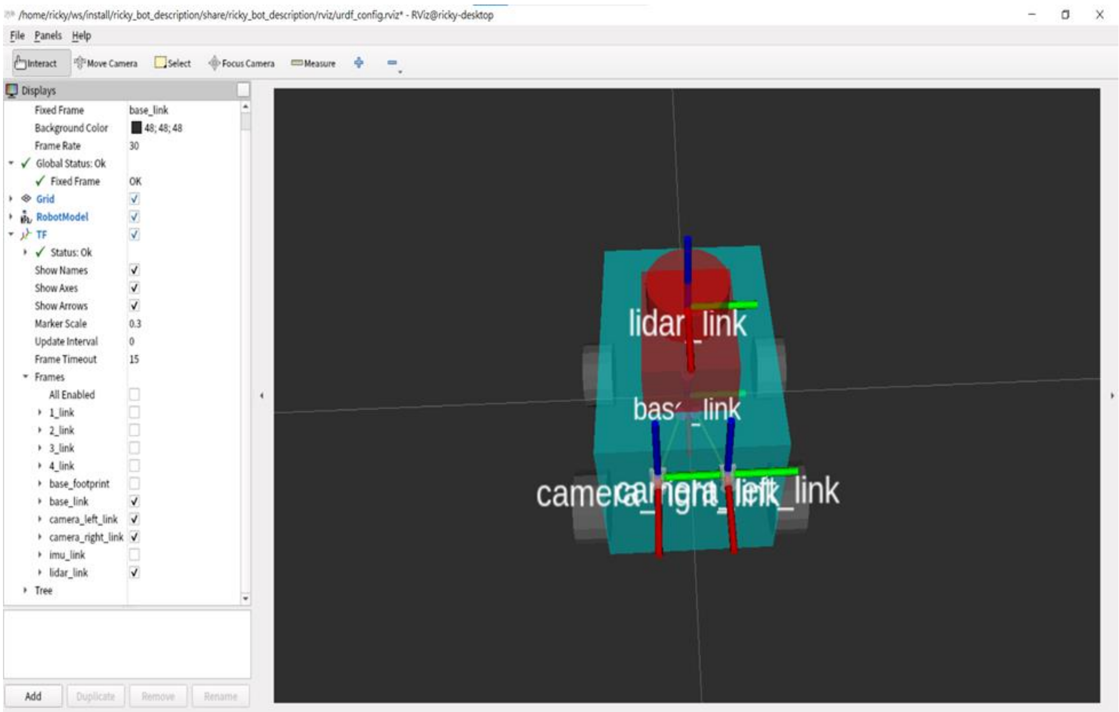
(5) Conclusion

Although our robot with proposed system can successfully collect orange ping pong balls on the ground without hitting the obstacles, there are some disadvantages for us to improve. First, we can try to use the camera calibration results to detect the ping pong balls by color and the depth. What's more, creating map in RVIZ2 will also help us to position our robot freely. At last, adding the function of recording path to our wanderer_server will also improve the efficiency of picking balls.

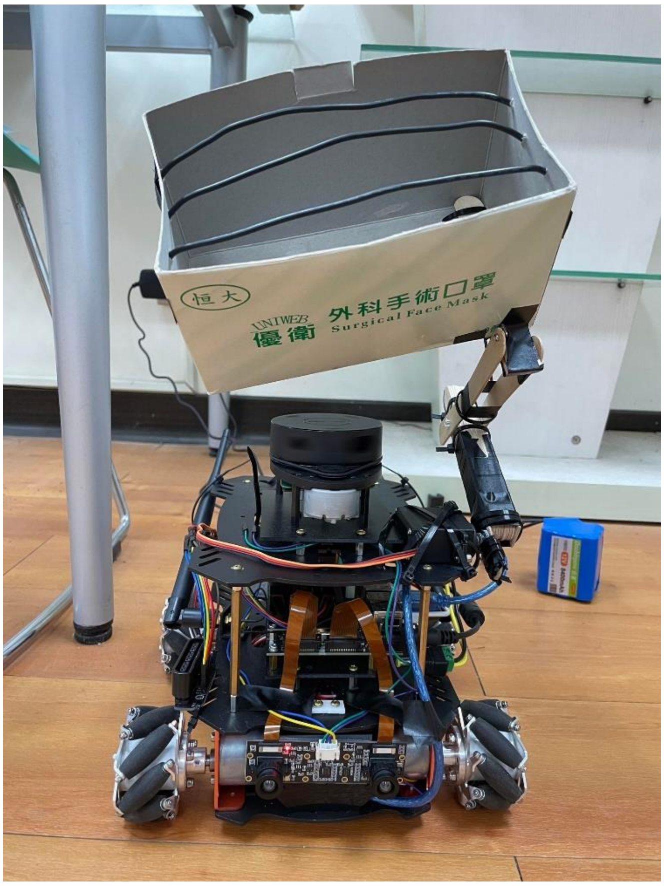
3. Reference images



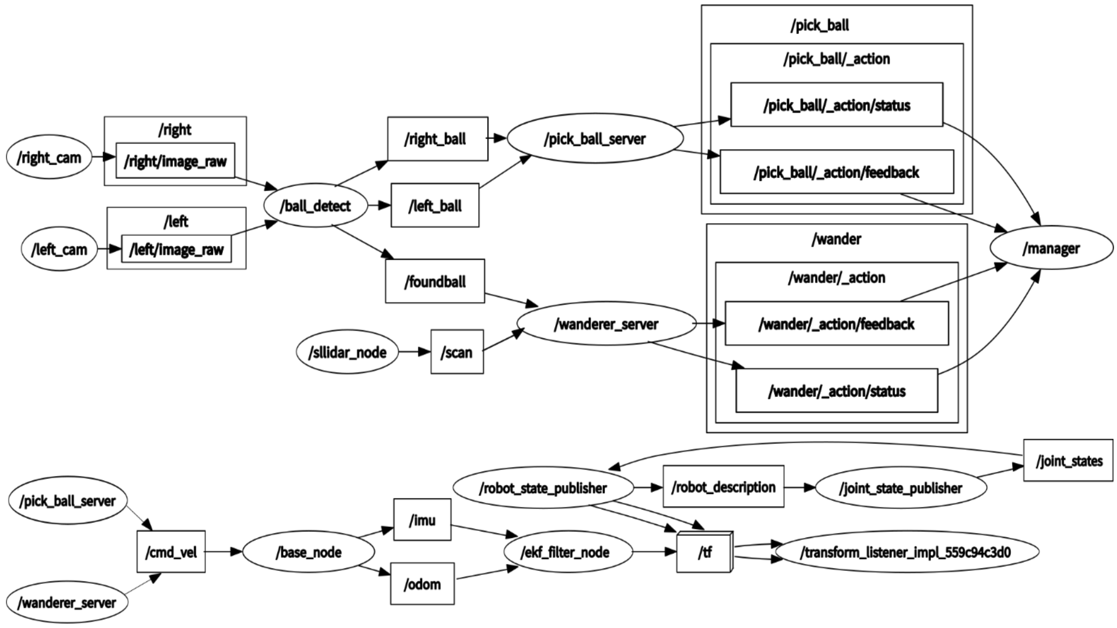
(Fig. 1 Our robot's connected graph)



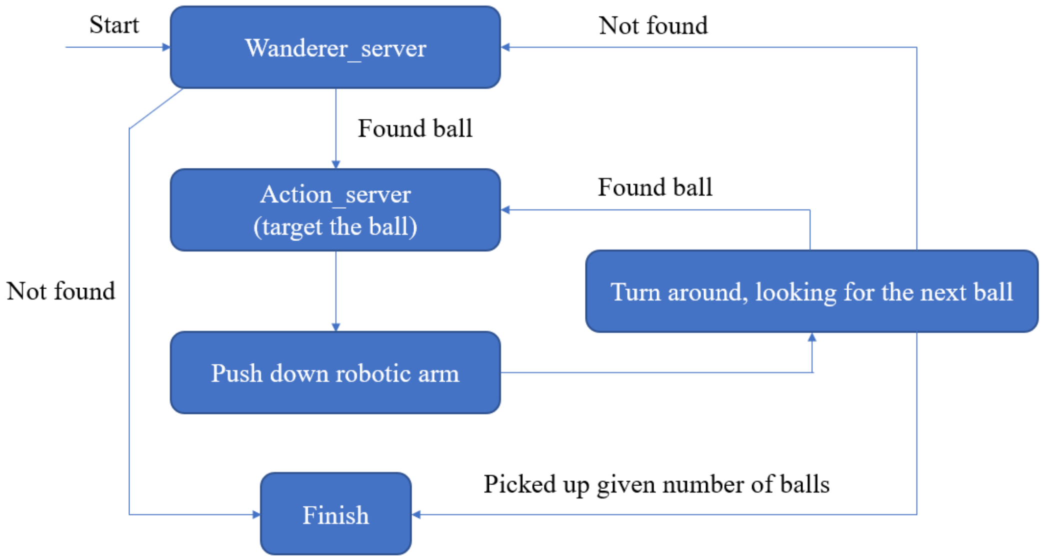
(Fig. 2 Our robot model displayed in RVIZ2)



(Fig. 3 Our robot's front view)



(Fig. 4 Node graph of our robot)



(Fig. 5 overall system flow)

4. Review and reflections

From this graduation project, we first realize that there are a lot of knowledges included in a robot. As we want to solve a small problem regarding to the usage of sensors or the calibration of sensors, we are able to find out many researches related to them most of time. Secondly, we benefit from the structural diagrams like rqt in the Robot Operating System (ROS), these graphs with topic and node concepts allow us to understand what we are doing, and how the small components of a system communicate with each other. Thus, this enables us to think the things systematically. Thirdly, there are both mechanical and electrical problems solved in our project. We have ability to build a robot with a lot of components, supply different voltages to Arduino Uno and Jetson Nano, fixed Jetson Nano and Lidar position by 3D printing, control the motors by Arduino code, and integrate the messages from wheel encoder and sensors to complete our project. Hence, we are very glad to see our robot completes missions we gave. What's more, through the weekly reports and the feedbacks from our advisor and senior, we learn the way to find the problems and solve them sequentially and systematically. Last but not least, 3 members teamwork enables us to accomplish our project successfully. Although there are 3 different opinions among us, we can always integrate them and find out the best solution.

***Demo film: https://youtu.be/QSKHtR_TQ2c**