CISC 3060 CLASS PROJECT: Color Task

Fall 2022

1. Overview

Your class project is to construct a ROS program that will control the Turtlebot Gazebo robot so that it uses visual navigation and obstacle avoidance to search for and go to each of four colored targets in turn.

The color task world is shown in Figure 1. A small section of each of the walls of the enclosed.world gazebo world file have been replaced with differently color objects (black, white, yellow, orange). Four large blue columns have been placed in the center of the enclosure. The robot will start in the center of the four blue columns, and then navigate using visual sensing to each of the orange, white, yellow and black targets in that order. The robot cannot know the locations of the targets and must search for each of them visually.

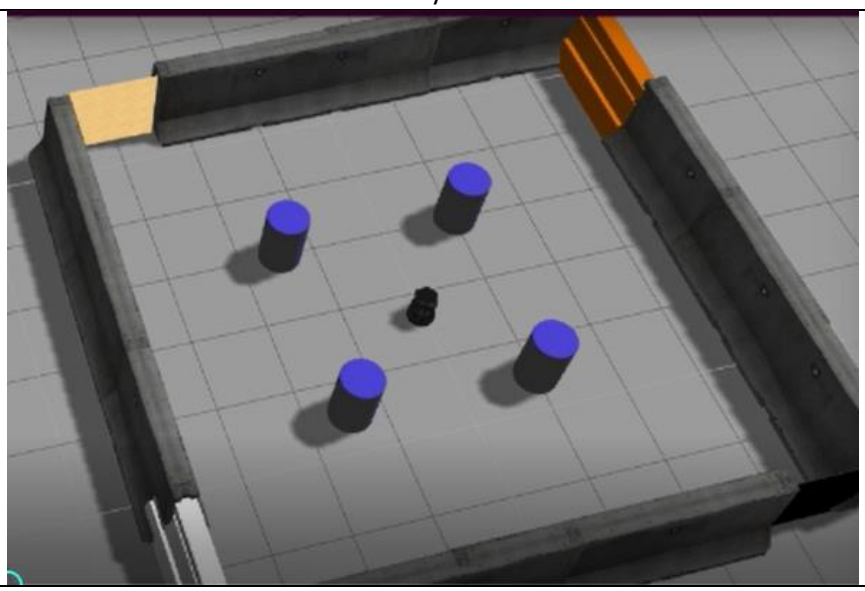


Figure 1: The Color Task World

Once the robot is close to the first target, it should calculate its position and the time that has elapsed since it started. It should write this information into the image of the target and store it as a file called goal0.jpg. It should store goal1.jpg after it finds the second target and so forth. The objective is to make the run *as quickly as possible*, but without any knowledge of the locations of the targets, and without hitting anything along the way.

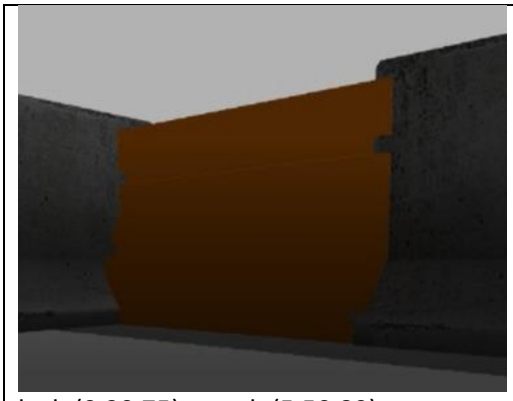
Each lab group will field one robot part of your final presentation will be to run the course from a random start position that you will be given. The fastest team wins!

2. Color targets

There are 4 color targets. You can identify the targets using the cv2.inRange function. The upper and lower color ranges for the targets are shown in Figure 2. You can certainly adjust these values if you think you can get better performance.

You should use the cv2.moments function to extract the area and target center. You can use the measurement of area as an estimate of the distance from the target. An area of 50 is probably close

enough to the target (and 80 is probably too close) for all of the targets. Again, you can adjust this value if you think you can get better performance. However, the robot does have to be close to the target (informally) before it can consider the target reached. It cannot just see the target from the other side of the enclosure and consider that as enough.



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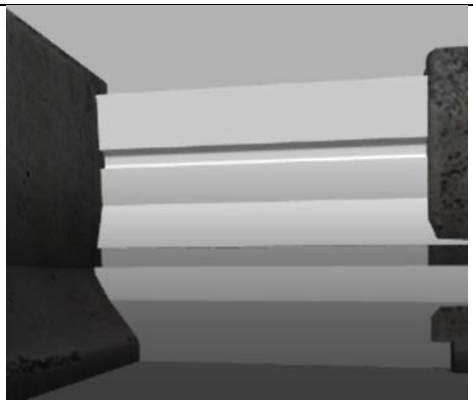

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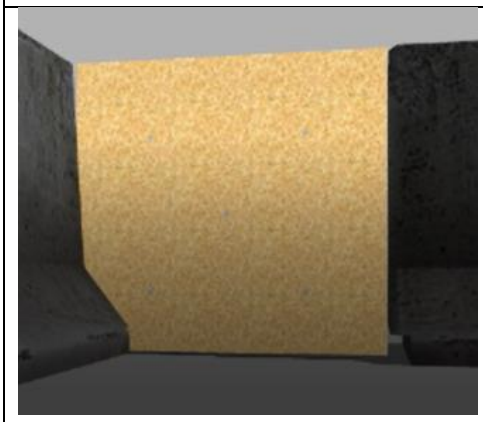
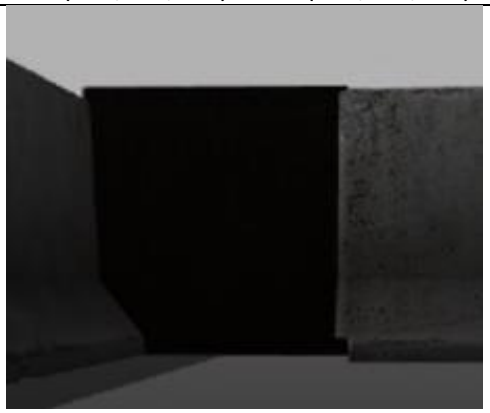


lval=(0,80,80) uval=(10,110,110)



lval=(0,0,0) uval=(20,20,20)

Figure 2: Color targets

3. Recording target achievement

After the robot has moved to within a close distance of the target (e.g., area=50 is a good measure), you must record some proof of reaching this goal. You should save the current image to a file. The file should be called goal0.jpg for the first target, goal1.jpg for the second, etc. You also need to add some information to the image. You should write

a. The goal number 0 through 3
b. The x and y location that the robot stopped at
c. The time that has elapsed since the task started

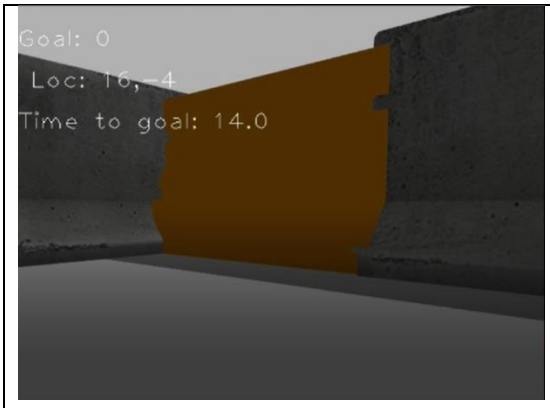
Figure 3 shows an example for each of the four color targets. You can use whatever color, font and scale you want to write on the image as long as you write this information (a through c above). White was used in Fig. 3, but it does not show up that well in my opinion.

4. Structure of the program

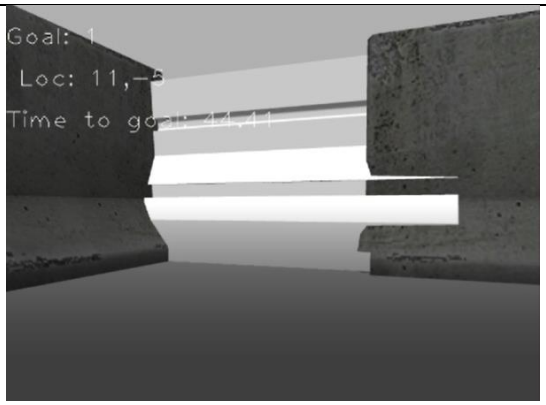
You must structure your program ***as two ROS nodes***. The first node accepts a Twist() message on a topic you get to name (e.g., safe_cmd_vel) and will pass this to the robot **if there are no obstacles detected** by

laser on the left hand side or the right hand side. If there are obstacles, then the angular velocity is *not* passed to the robot, instead -0.2 is passed if the obstacle is on the left and 0.2 if the obstacle is on the right. Furthermore, if there is a left or a right obstacle, the linear velocity passed to the robot is *one half of the linear velocity passed as a command* on the input topic. As you can see the purpose of this node is to separate any obstacle avoidance concerns from the color tracking concerns. Let's call this the OANode.

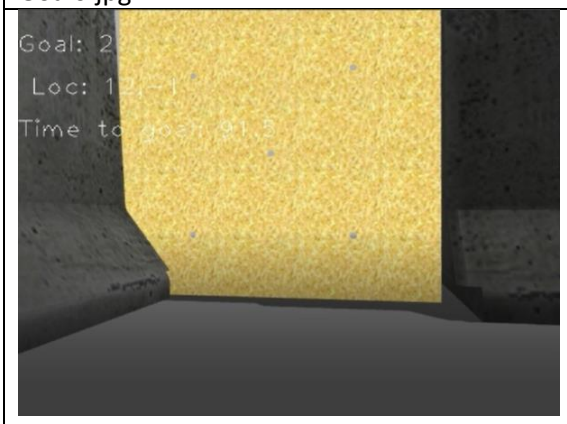
You may want to modify this behavior so that obstacle avoidance will only be triggered if a nonzero linear velocity was sent to the input topic. If the linear velocity is zero, then the robot may just be spinning, and no obstacle avoidance is needed.



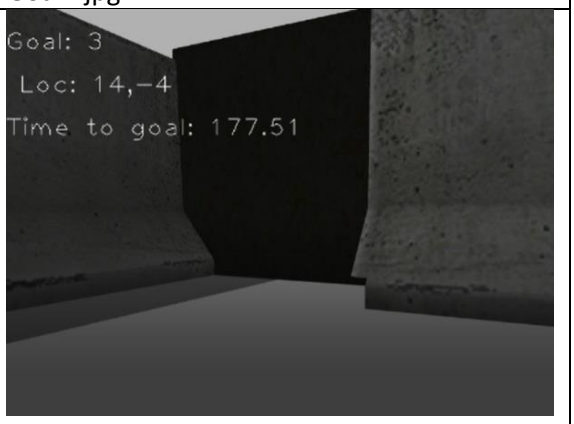
Goal0.jpg



Goal1.jpg



Goal2.jpg



Goal 3.jpg

Figure 3: Images saved for each target

The second ROS node is responsible for (1) searching for the color target and (2) when it is found, generating a linear and angular velocity to bring the robot close to the target. Let's call this the CTrackNode. The output Twist() message from the CTrackNodeNode should be written to the input topic of the OANode, which will then override the velocity on occasion to steer the robot away from obstacles.

5. Deliverables

Each student will need to write an individual report that includes all the details of the design, implementation and testing of the node they worked on, and then all the testing and results for the joint project with both nodes. You will work in teams to build and test the software. All the rules that related to lab reports related to this final document. Write it as well and as completely as you can. Your report

must be all your own work and unique to you. Your final system will be a group effort but each member will submit their code with their report.

Your team will also need to do a 10-minute presentation (on the final exam date) on your design explaining how your program works. You should USE as much ROS and robotics algorithms as you can from this class!! Don't reinvent the wheel. Each team member must participate in the presentation.

Finally, each team will be given a random initial location for the robot (close to the center of the enclosure) and must run their program and deliver their four images and times. The performance of all the team systems will be compared and a winner announced!