Jackie Scanlon
Algorithmic Robotics - PA2
Due: 2/21/19

Part 1: Turtlesim Trajectory Planning

1. What parts of the twist message cause the turtle to move?
The twist message has 6 components: 3 linear velocity components in the x, y, and z directions, and 3 rotational velocity components in the x, y, and z directions. In the bike model, only the linear x-component and rotational z-component are used and cause the turtle to move.

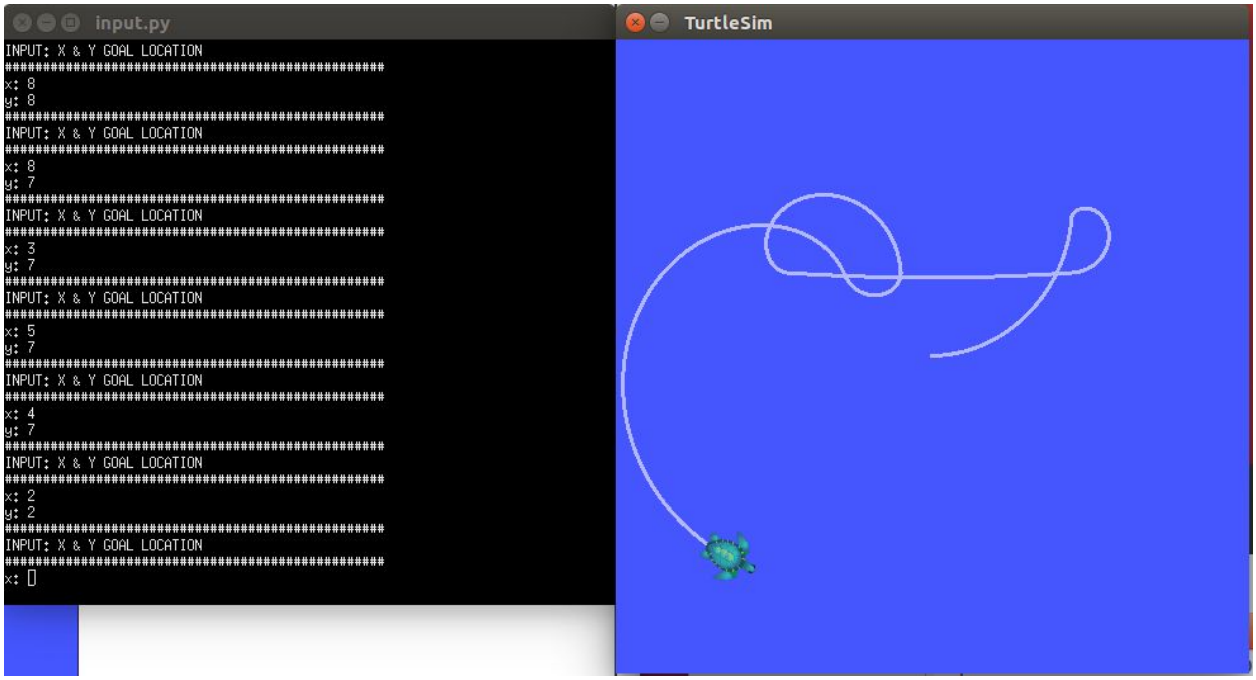
2. Let ωz be the twist component that causes the turtle to rotate. If ωz is positive, which way does the turtle rotate?
$+w_z$ -> rotate counterclockwise
$-w_z$ -> rotate clockwise

3. Why is python's math.tan2() better than math.tan() for this assignment?
It determines the exact quadrant of the angle, whereas tan only calculates for quadrant pairs.

4. How do the values of the proportional gains affect the quality of the turtle's trajectory?
Higher gains cause the turtle to move faster but also may cause the turtle to overshoot the goal. Lower gains cause the turtle to move more slower but more accurately.

5. Does turtle execute the twist messages that it hears in the world frame or the turtle frame. How do you know?
Turtle frame. In the world frame, the turtle has velocity in the x and y directions, whereas in the turtle frame, the turtle has velocity only in the x direction. Since we are commanding velocity only in the x direction, the twist messages must be in the turtle frame.

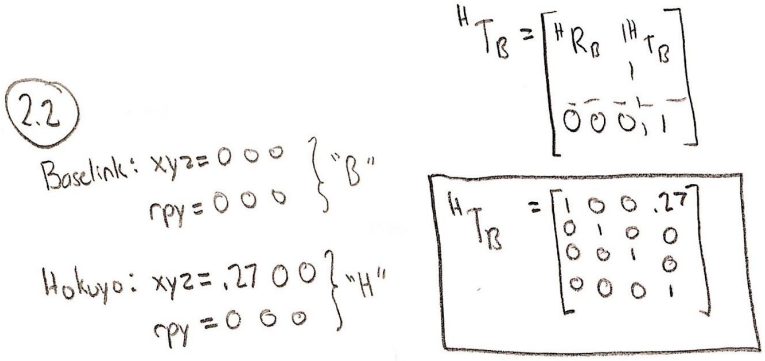
Demonstration:
Inputs are [(8,8), (8,7), (3, 7), (5, 7), (4, 7), (2,2)]



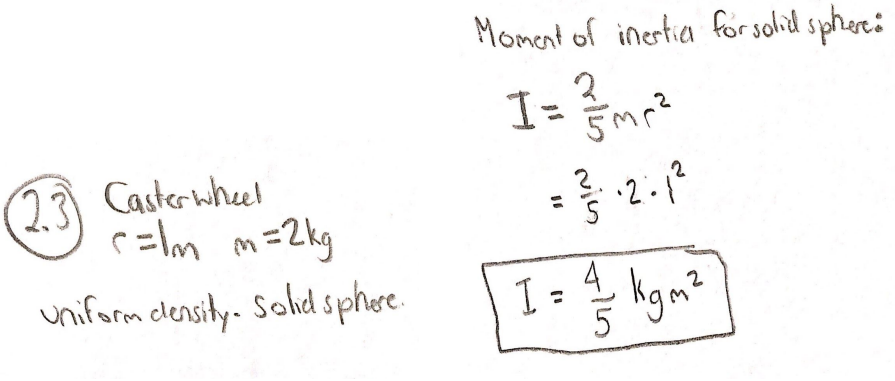
Part 2: R2D2 in Gazebo and Rviz

1. Gazebo only needs a <collision> and <inertial> tag in order to simulate the system. What is the purpose of adding the <visual> tag?
The visual tag allows us to see the item in the gazebo simulation.

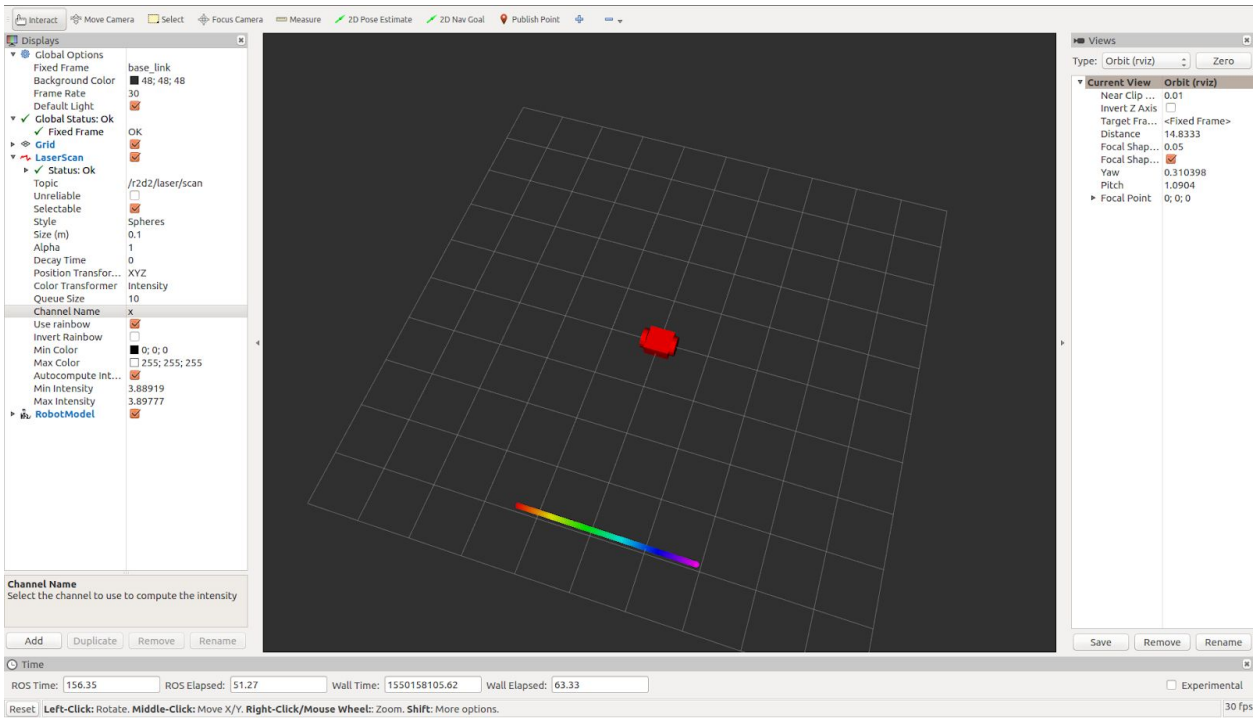
2. Both wheel links have the same starting pose. When viewing the model in Gazebo, they are obviously not in the same place. Where in the r2d2.gazebo file do we specify the actual wheel locations? Use this information to determine the homogeneous transformation matrix between the base link and the hokuyo link (sensor).
The actual wheel locations are in the right/left wheel joint specifications- lines 89 and 124.



3. Determine the moment of inertia for a caster wheel of radius 1m with mass 2kg and uniform density. Note that a caster wheel is a solid sphere (be sure to show your work).



4. In Rviz change the following under LaserScan and add a screenshot to your document: set Style to spheres, set Size to 0.1, and set Channel Name to x.



Part 3: R2D2 Trajectory Planning

1. What topic does R2D2's right wheel subscribe to?
/r2d2/right_velocity_controller/command
2. What topic does R2D2's left wheel subscribe to?
/r2d2/left_velocity_controller/command
3. What is the purpose of drive.py?
drive.py converts the the linear and angular velocity calculated by the bike model into the diff drive model with velocities for the right and left wheels.

Part 4: R2D2 Wall Detection

1. What topic does the planar lidar publish to?
/r2d2/laser/scan

2. What is the x, y, z offset of the planar lidar and how does it affect its range detection?
It is offset .27m in the x direction - it will be able to objects in a circle that is offset 0.27m from the center of the robot. Thus, the CollisionNode needs to account for that fact when setting the distance of the robot from objects, to avoid them in a 1m radius.

3. How would you get a list of thetas that correspond to each range detected by the lidar?
To do this in collision_avoidance.py, I used

```
angles = np.linspace(scan_msg.angle_min, scan_msg.angle_max,
len(scan_msg.ranges))
```

It creates an array starting from the minimum angle, going to the maximum angle, incrementing such that there is one angle for each range measurement, spaced evenly.

Additional Information

- The gravity in Gazebo works very well - the robot was off balance causing it to wobble a bit, and is also what I think is causing it spin for a bit at the beginning.
- I learned how to do conditional indexing in python, which is more complex than in Matlab.