QEA Gauntlet Challenge: Starring Cha the NEATO

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1 Introduction

Our group decided to tackle level three of the Gauntlet Challenge. Given this level, we used LIDAR scans to identify and locate the walls, obstacles and the "Barrel of Benevolence" (BoB). After detecting all the significant objects' locations, we created a gradient field with the walls and obstacles being sources while the BoB was the sink. This allowed us to find the quickest path to the BoB using the method of gradient descent. To implement this in the NEATO simulation, we found the NEATO's position at different time steps and determined each wheels' velocities based on the direction of the gradient at that specific position.

2 Methodology

2.1 LIDAR Scan

We collected a LIDAR scan of the Gauntlet pen at the position (0,0) and the NEATO pointing in the positive i direction. We converted the polar coordinates into the global Cartesian frame with transformations matrices. Figure 1 below is a plot of the points of the LIDAR scan. The walls and the obstacles in the pen can clearly be seen with a small section of the BoB in the bottom right.

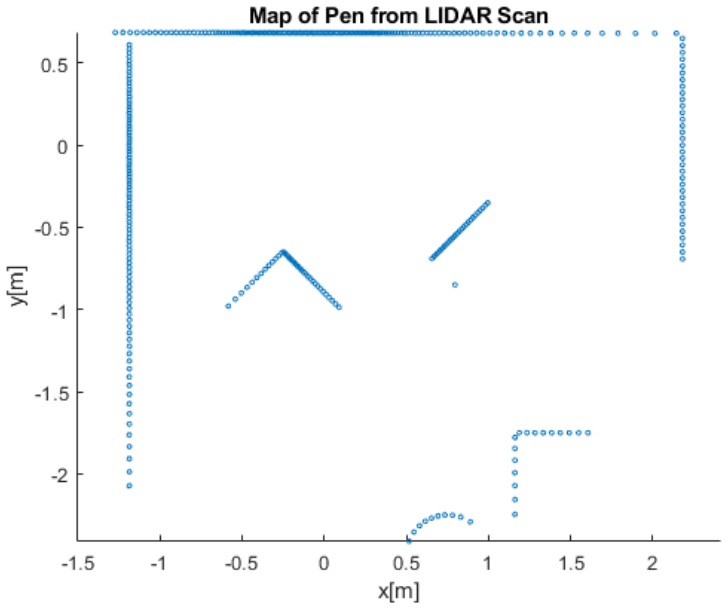

Figure 1: LIDAR scan of the Gauntlet

2.2 BoB Circle Fitting

Next, we determined an equation of a circle that represented the BoB. We isolated the LIDAR points that represented the BoB and performed linear regression on these points to create the best fit circle. After validating that this equation fit the data points, we had the center and the radius of the BoB, which we later used to create a sink in the gradient field.

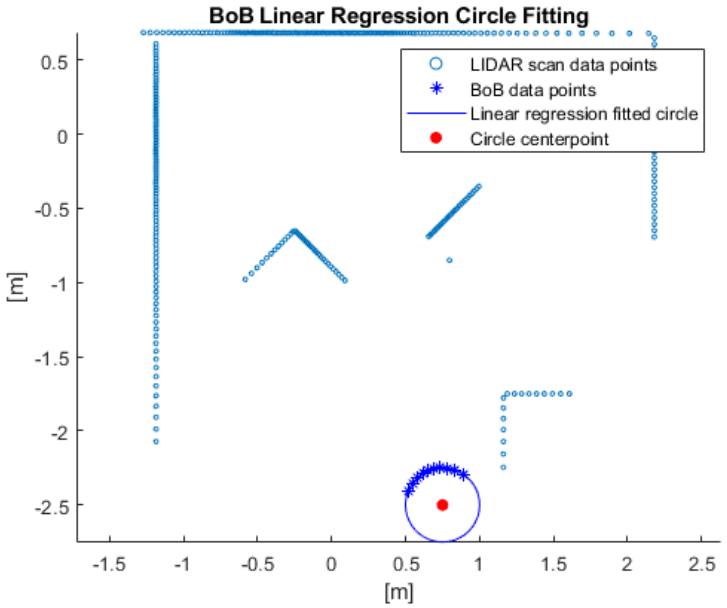

Figure 2: Visualization of BoB circle found through liner regression

2.3 Walls and Obstacles Line Fitting

Once we determined the equation and the position of the BoB, we performed RANSAC to find the equations of the lines that defined the walls and the obstacles. While finding the equation for each line, we also determined reasonable endpoints that represented each object. After completing this step, we had mathematical equations that represented everything inside of the pen.

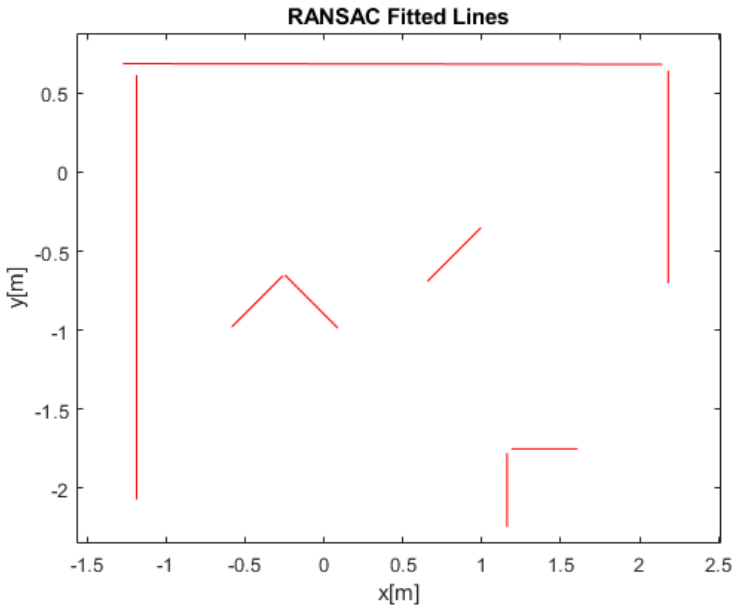

Figure 3: Lines representing the walls and obstacles found through RANSAC

2.4 Contours and Gradient Field

Using the equations we had of the BoB, walls, and obstacles, we created a gradient field with sources and sinks at the respective locations of each object. In Figure 4, it is clear that the BoB is at the lowest point while the point where the NEATO starts, (0,0), is at the highest.

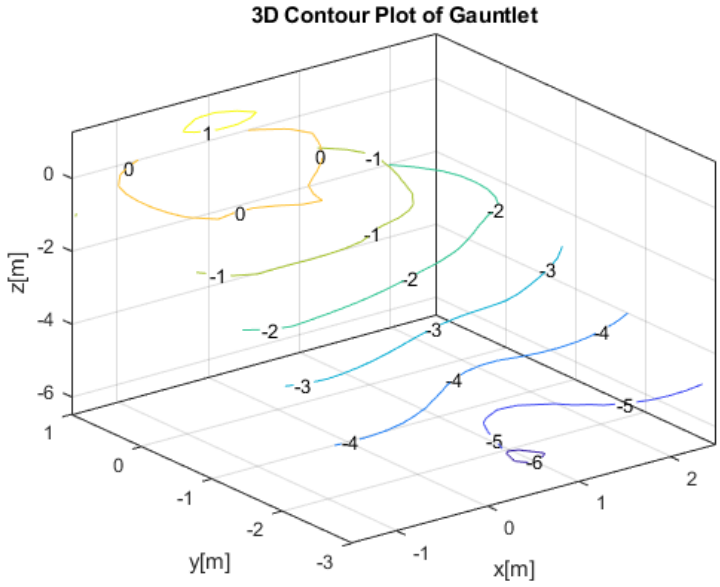

Figure 4: 3D Contour Plot with Gradient field of pen

The gradient field shown in Figure 5 indicates that all the gradient vectors are pointing from the NEATO's initial position to the BoB.

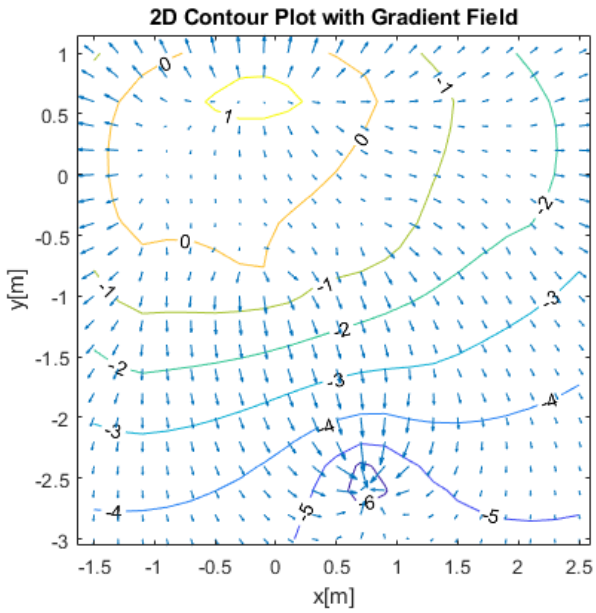

Figure 5: 2D Contour Plot with Gradient field of pen

2.5 Gradient Descent

For the NEATO to reach the BoB without hitting any walls or obstacles, we chose to implement gradient descent. At incremental time intervals, we found the position and the gradient at said position and moved the NEATO in the direction of the gradient. In Figure 6 our calculated path of the NEATO can be seen across the contours.

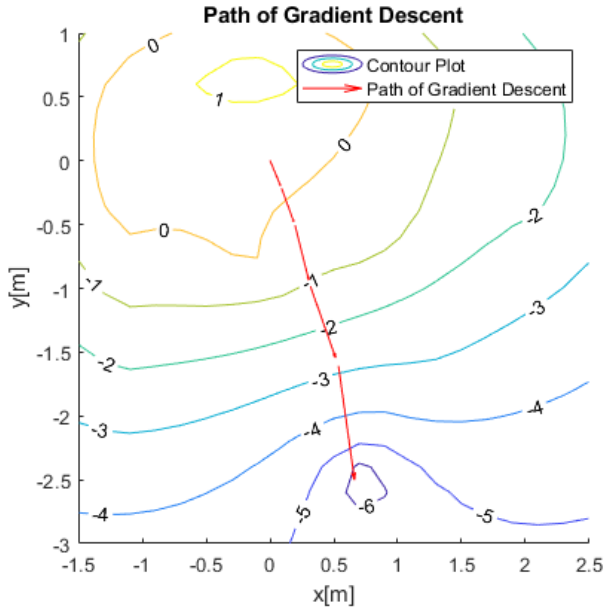

Figure 6: Path of the NEATO following the Gradient Descent

3 NEATO Simulation

While we ran the NEATO simulation on the Gauntlet map, we collected encoder data. We converted the data into Cartesian points and plotted the NEATO's measured path against our theoretical path. Although there is some discrepancy, this is likely due to errors in the simulation. With that said, the NEATO successfully avoided all obstacles and made its way to the Barrel of Benevolence.

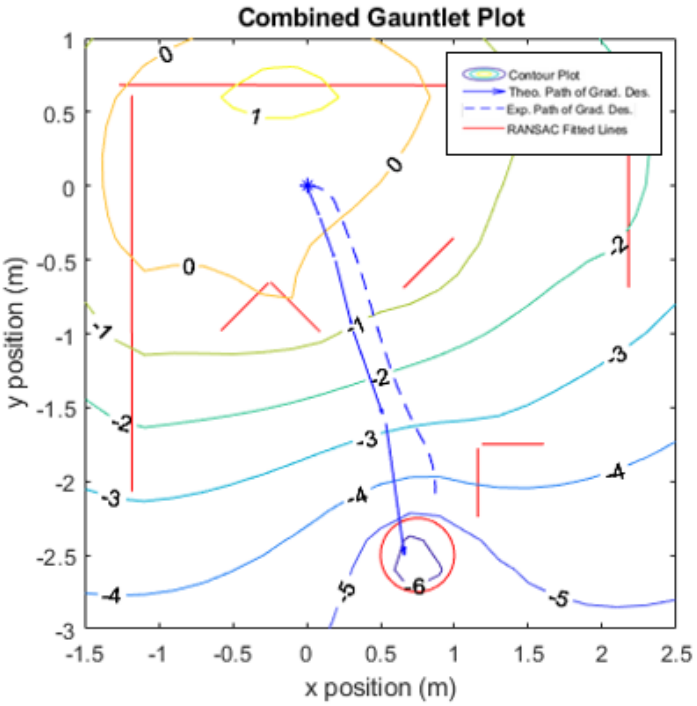

Figure 7: NEATOs Theoretical and Experimental Paths in the Pen

4 NEATO in Action

Click here to see a live action film of Cha navigating his way to the Barrel of Benevolence.

5 NEATO Code

Click here to access the code that was used to make Cha move.