The Gauntlet Challenge

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1 Introduction

In order to tackle The Gauntlet to the best of our abilities we chose to go for Level 2. Level 2 requires the use of LIDAR detection to map the pen and obstacles of The Gauntlet with known coordinates of the Bucket of Benevolence (BoB). Thus, in order to achieve these goals we first did random sample consensus (RANSAC) line fitting from the LIDAR scan of the pen, created artificial sources and sinks from this data, and finally applied gradient descent to find the best path to reach the BoB.

2 Methodology

2.1 RANSAC Fitting

The goal for our RANSAC algorithm focused on getting long line segments to define as much of the pen and the entire side of an obstacle in a single scan. This was accomplished by having a threshold value for the minimum expected length of a line segment which aided in getting a complete scan while also not creating false positives that go over random gaps in the pen.

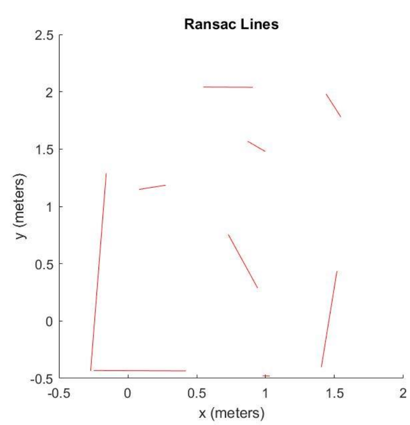

Figure 1: RANSAC Line Fit of Initial LIDAR Scan

As you can see in Figure 1 the fitting is not perfect as some gaps for the pen walls are missing. However, even with this incomplete map one can still find a proper path of gradient descent for the Neato to follow. This information was more than sufficient to create the scalar field so only one scan was necessary for completing the challenge.

2.2 Artificial Sources and Sinks

The purpose of creating an artificial source or sink in the contour plot of the pen is done to have the Neato follow the path of greatest decrease. Thus, creating an artificial source or sink guides the Neato away from the walls and obstacles and towards the BoB. First, sources were created based upon the lines generated by the RANSAC algorithm and and a single large sink was made at the known position of the BoB. Thus, in order to find the values for the sources in the z-direction we use the following equation:

$$\int_{p1}^{p2} \log \sqrt{(x_0 - x)^2 + (y_0 - (m * x + b))^2} \tag{1}$$

Where *p1* is the x component of the first endpoint of the line and *p2* is the x component of the second endpoint of the line. Also, m is the slope of the RANSAC fitted line and b is the y-intercept of the line. By using this equation a doctored contour plot to define the pen can be made to optimize the path for the Neato to follow.

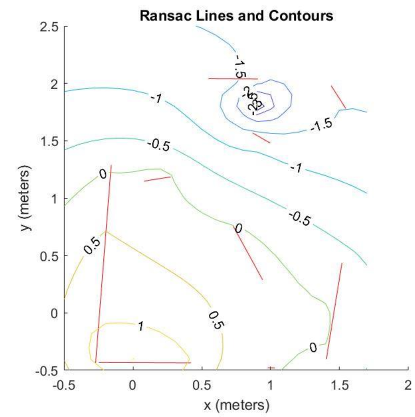

Figure 2: Contour Plot from Artificially Generated Sources and Sinks

2.3 Gradient Descent

In order to find the direction of greatest descent for a given position of the pen a symbolic equation of the entire gradient field was found. Therefore, we could recalculate the gradient at any point the Neato might find itself in the pen which enabled accurate directions towards the BoB. With the symbolic function to define the gradient field of the pen we are able to create the intended path seen in Figure 3.

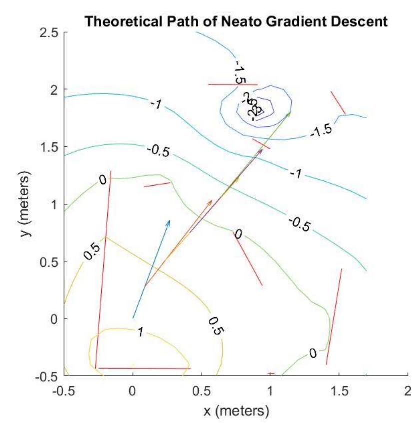

Figure 3: RANSAC Fitted Lines, Contour Plot, and Gradient Path of The Gauntlet

3 Tackling The Gauntlet

3.1 The Actual and Intended Path of the Neato

Finally, by applying our entire methodology we are able to create a proper procedure to directing the Neato towards the BoB. This intended path is translated into a script that directs the Neato to rotate and move linear a given amount based upon the calculated path. In the end, it took the Neato 11.06 seconds to complete the challenge with our approach. This time also includes the small pauses for collecting encoder data, so we still had the potential to do the challenge even faster. In the time taken to complete the challenge the Neato travelled a distance of 1.77 meters based upon wheel encoder data. The average percent error for the theoretical path versus the actual path is 3.19 percent. While this error metric if fairly low it is not totally representative of the accuracy of our Neato implementation. This is due to the fact that only six points are used to control the Neato.

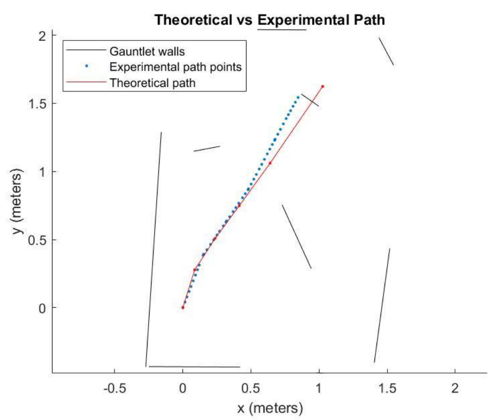

Figure 4: The Calculated Path and Actual Path of the Neato Based upon Wheel Encoder Data

3.2 Video Evidence of The Gauntlet Challenge

A video of one of the successful Gauntlet runs for Level 2 can be found **here**. The MATLAB code for our approach to The Gauntlet can be found **here**.