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Bridge of Doom

Executive Summary

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1. Methodology

The first step to solving the Bridge of Doom Challenge was to plot the parametric curve defining the centerline for the path. To do so, the equation in terms of u

$$r(u) = 0.3690 * cos(2.65(u + 1.4))i - 0.99 * sin(u + 1.4)j \in [0, 3.2]$$

was converted to terms of timestep t with the function $u = \beta * t$ where $\beta = 3.2/20$ taking the upper bound of u - 3.2 - and dividing it by an assumed 20 seconds to run the Neato robot across the Bridge of Doom. In terms of t

$$r(t) = 0.3690 * cos(2.65(t + 1.4))i - 0.99 * sin(t + 1.4)j$$

This was then plotted in MATLAB and then the derivative of this equation was found to be

$$V = r'(t) = 0.396 *- sin(2.65 * (t + 1.4)) * 2.65 - 0.99 * cos(t + 1.4)$$

These equations were then used to plot the unit tangent and unit normal vector lines. The angular velocity then was found to be

$$\omega = T \times \frac{dT}{dt}$$

where T is the unit tangent vector, $\frac{dT}{dt}$ is the derivative of T. The linear and angular velocities were then used to calculate the velocities of the left and right wheel at any given time. The following equations were derived by dividing the difference in distance by the difference in time for the data.

$$V_L = V - \omega(\frac{0.245}{2}) \qquad V_R = V + \omega(\frac{0.245}{2})$$

These equations were then used to find the linear and angular velocity to recreate the path in the encoder, as well as the angle and position as a function of time.

$$V = \frac{V_L + V_R}{2} \qquad \theta(t + \Delta t) = \theta(t) + \omega(t)\Delta t$$

$$\omega = \frac{V_R - V_L}{0.245} \qquad r(t + \Delta t) = (x(t) + V(t)cos(\theta)\Delta t)i + (y(t) + V(t)sin((\theta)\Delta t)j$$

These equations were manipulated in MATLAB and were used to direct the Neato robot along the Bridge of Doom and produce the following visuals.

2. Visuals

2.1 Plot of Parametric Curve

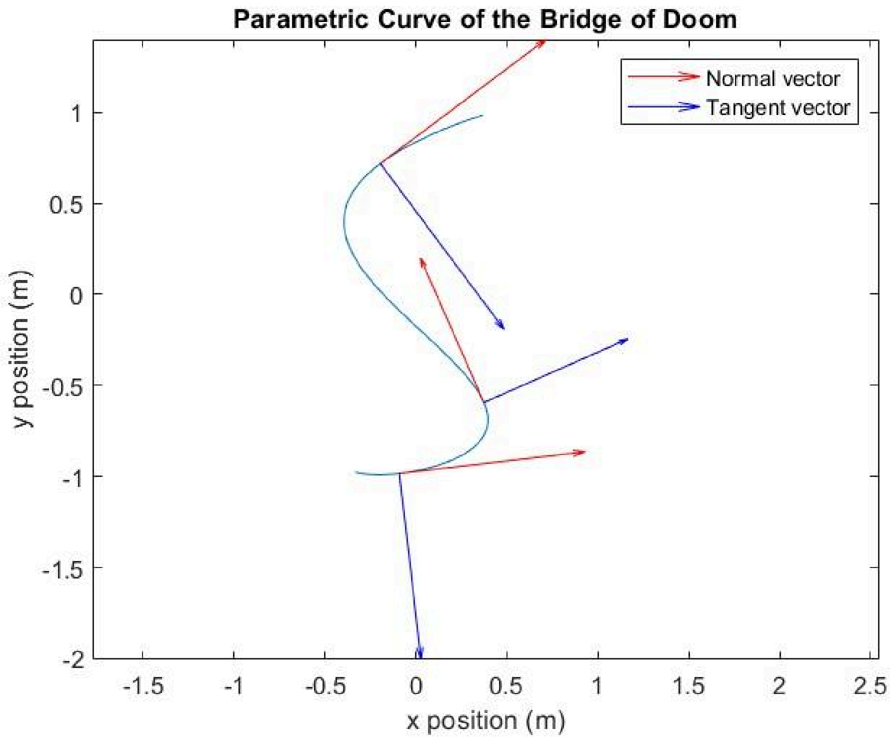

Figure 2.1.1: Plot of Parametric Curve

Figure 2.1.1 demonstrates the position of the robot path in the X/Y plane. The total path is approximately two meters long, and one meter wide. Select tangent vectors - lines that depict the slope of the Neato robot at that point - and select normal vectors - lines that depict the direction of acceleration - are also depicted in this plot.

2.2 Plot of Linear Speed

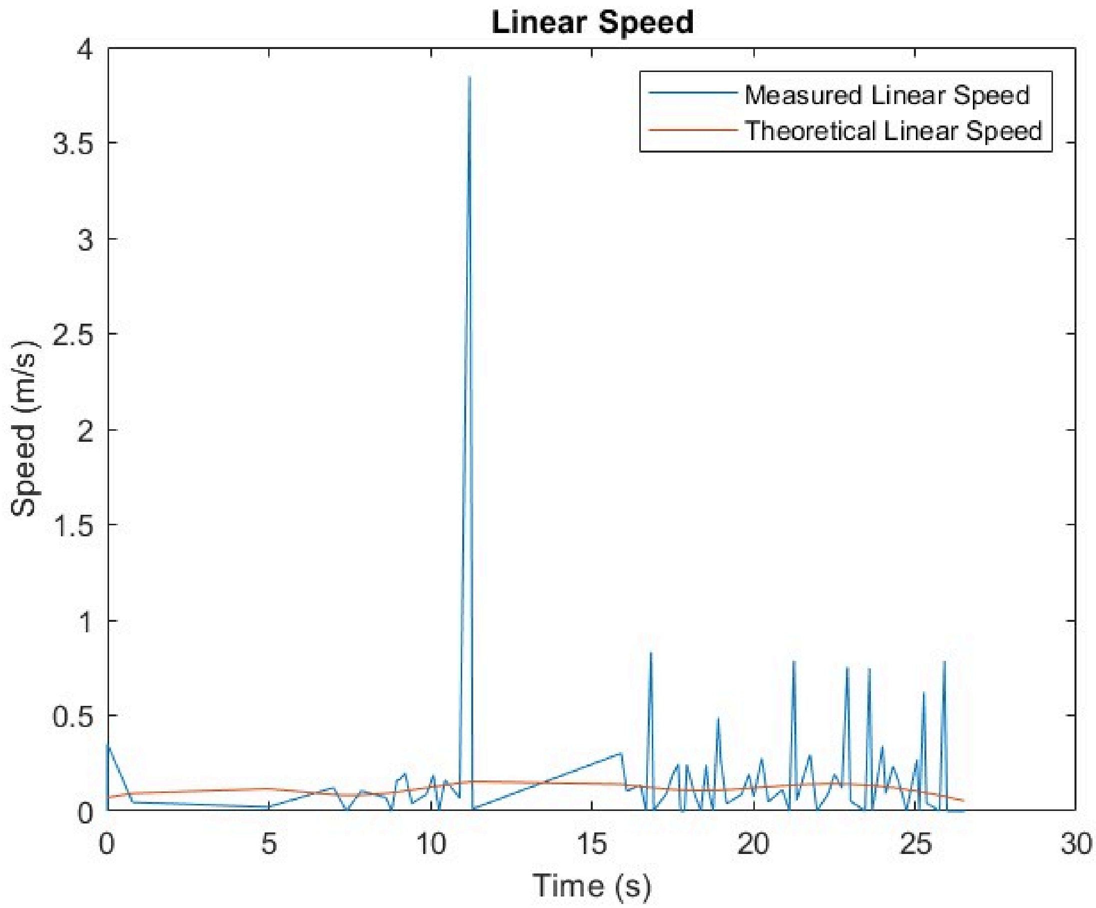

Figure 2.2.1: Plot of Linear Speed

Figure 2.2.1 demonstrates the predicted and measured plots of the linear speed of the center of mass of the Neato robot as a function of time. The Neato robot cannot and does not exceed a speed of 0.3 m/s. As it follows the near S-shaped path. The spikes in the measured data are due to simple discrepancies in the data; otherwise, the general shape holds to the shape that was predicted.

2.3 Plot of Angular Velocity

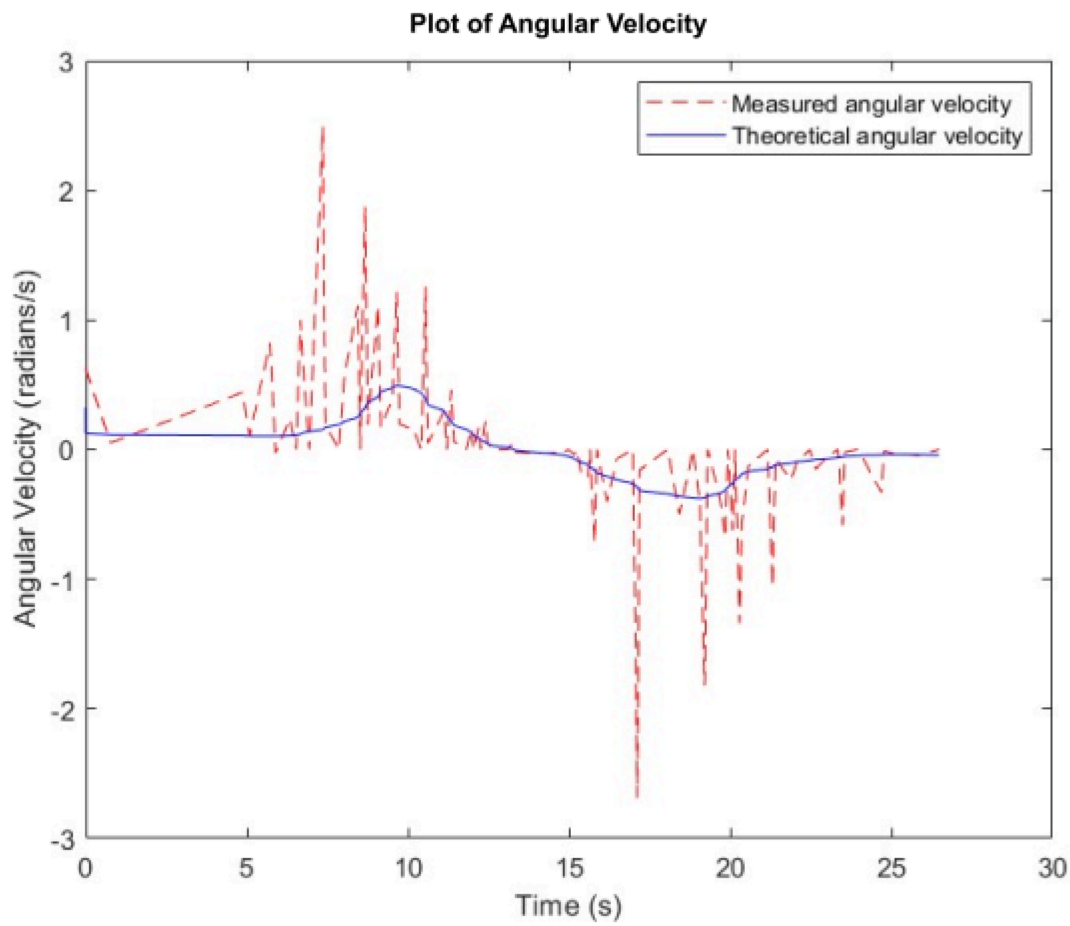

Figure 2.3.1: Plot of Robot Path

Figure 2.3.1 demonstrates the predicted and measured plots of the angular velocity of the center of mass of the Neato robot as a function of time. The near S-shaped path can be seen, as the magnitude of the angular velocity increases corresponding with the curves of the path. The spikes in the measured data are due to simple discrepancies in the data; otherwise, the general shape holds to the shape that was predicted.

2.4 Plot of Wheel Velocities

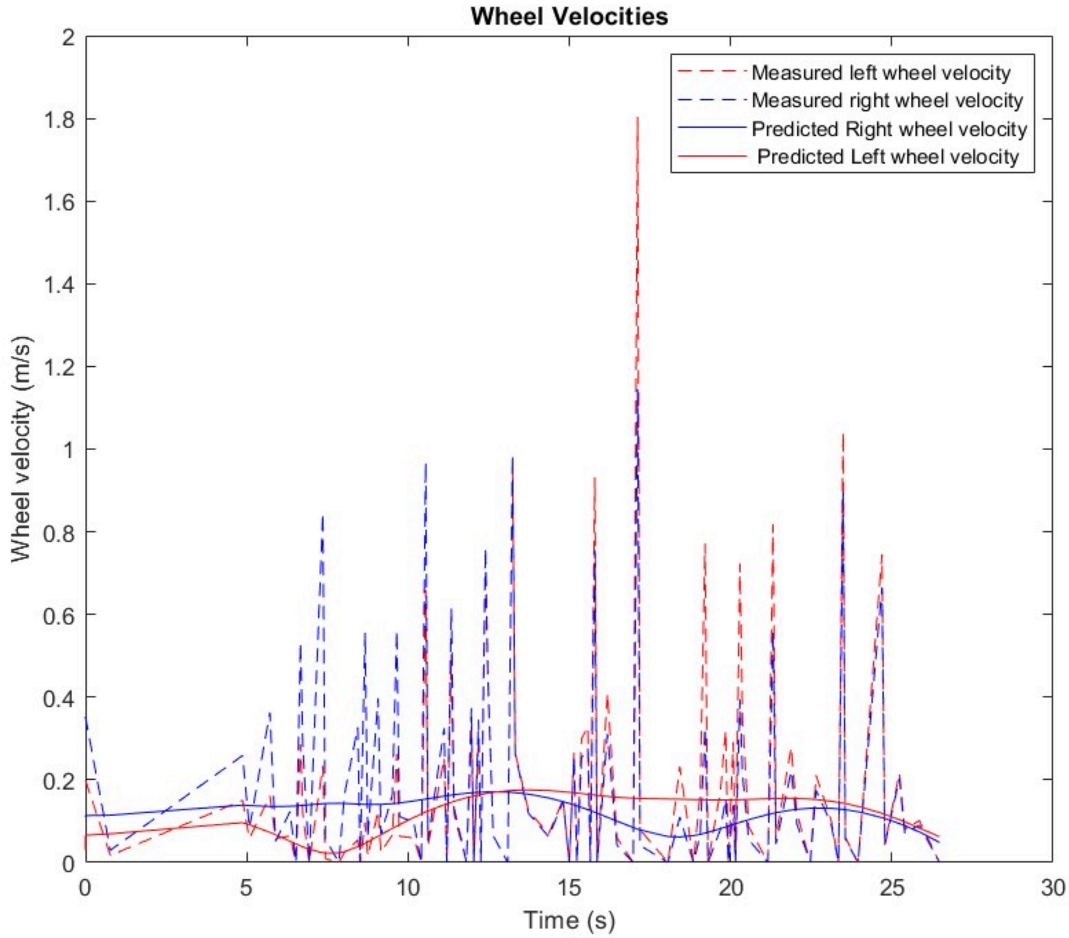

Figure 2.4.1: Plot of Robot Path

Figure 2.4.1 demonstrates the predicted and measured plots of the left and right wheels of the Neato robot as it traverses the Bridge of Doom. The Neato robot cannot and does not exceed a speed of 0.3 m/s. As it follows the near S-shaped path, the predicted left and right wheels would theoretically mirror each other over the course of the path; this is shown through the predicted data. The spikes in the measured data are due to simple discrepancies in the data.

2.5 Plot of Robot Path

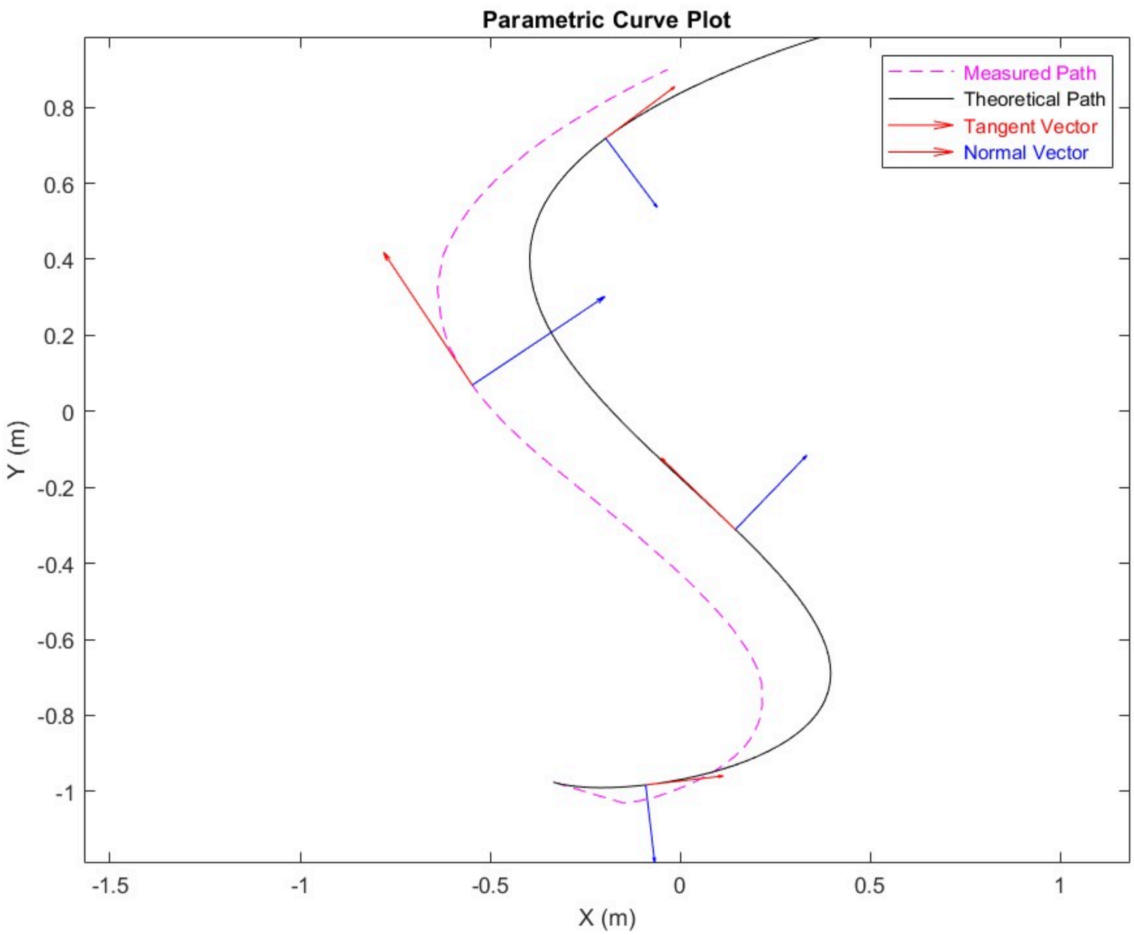

Figure 2.5.1: Plot of Robot Path

Figure 2.5.1 demonstrates the previous path of the robot path as shown in Figure 2.1.1 with the addition of the actual measured path of the Neato Robot on the Bridge of Doom. Select tangent vectors - lines that depict the slope of the Neato robot at that point - and select normal vectors - lines that depict the direction of acceleration - are also depicted in this plot.

3. Video

The following links lead to external sites containing a video of the Neato robot traversing the path of the Bridge of Doom.

https://youtu.be/uXDwSFOInvY

https://drive.google.com/file/d/14K21PL68v5q4juTnFQqimM7ZHUrJlk30/view?usp=sharing

4. Code

The following link leads to an external site containing the MATLAB code used to produce the prior visuals and demonstrations of the Neato robot traversing the Bridge of Doom.

https://github.com/SUCHETASUNDER/QEA2.git