

Objective:

This project aims to develop an autonomous pilot for a Neatokart to successfully navigate a predefined parametric path (Rainbow Road) using Matlab. The goal is to implement an open-loop control system, where velocity commands are executed. This requires deriving a motion model for a Neato robot, computing tangent and normal vectors within the trajectory, and determining appropriate wheel velocities within predefined constraints. Additionally, the project involves using encoder data to reconstruct the actual path, comparing it with the theoretical trajectory to interpret real-life results.

Methodology:**1. Assumptions:**

- The robot follows a parametric trajectory given by:
 - $x(t) = 0.396 \cdot \cos(2.65t/10) + 1.4$
 - $y(t) = -0.99 \cdot \sin(t/10) + 1.4$
- The robot is a differential drive system with a wheelbase of $d=0.245$ meters.
- The parameter t represents time, while u is a scaled time variable, chosen as $u=1/10*t$ such that the Neato's speed is always less than or equal to 0.3 m/s.

2. Generating Left and Right Wheel Velocity Commands:

- Defined $u = (1/10)t$ (to accommodate Neato's wheel speeds)
- Forward Velocity: $v = \sqrt{(dx/dt)^2 + (dy/dt)^2}$
- Angular Velocity: $\omega = (dx/dt) \cdot (d^2y/dt^2) - (dy/dt) \cdot (d^2x/dt^2)$
- Wheel Velocities:
 - Left: $v_L = v - (d/2)\omega$
 - Right: $v_R = v + (d/2)\omega$

3. Path Reconstruction from Encoder Data:

- Linear Velocity: $v_{measured} = (v_L + v_R)/2$
- Angular Velocity: $v_{measured} = (v_R - v_L)/d$
- Orientation Over Time: $\theta(t) = \theta_0 + \sum \omega_{measured} \cdot \Delta t$
- Reconstruction of Path:
 - $x(t) = x_0 + \sum v_{measured} \cos(\theta) \cdot \Delta t$
 - $y(t) = y_0 + \sum v_{measured} \sin(\theta) \cdot \Delta t$

Neato Video:  Rainbow Road Video.mp4

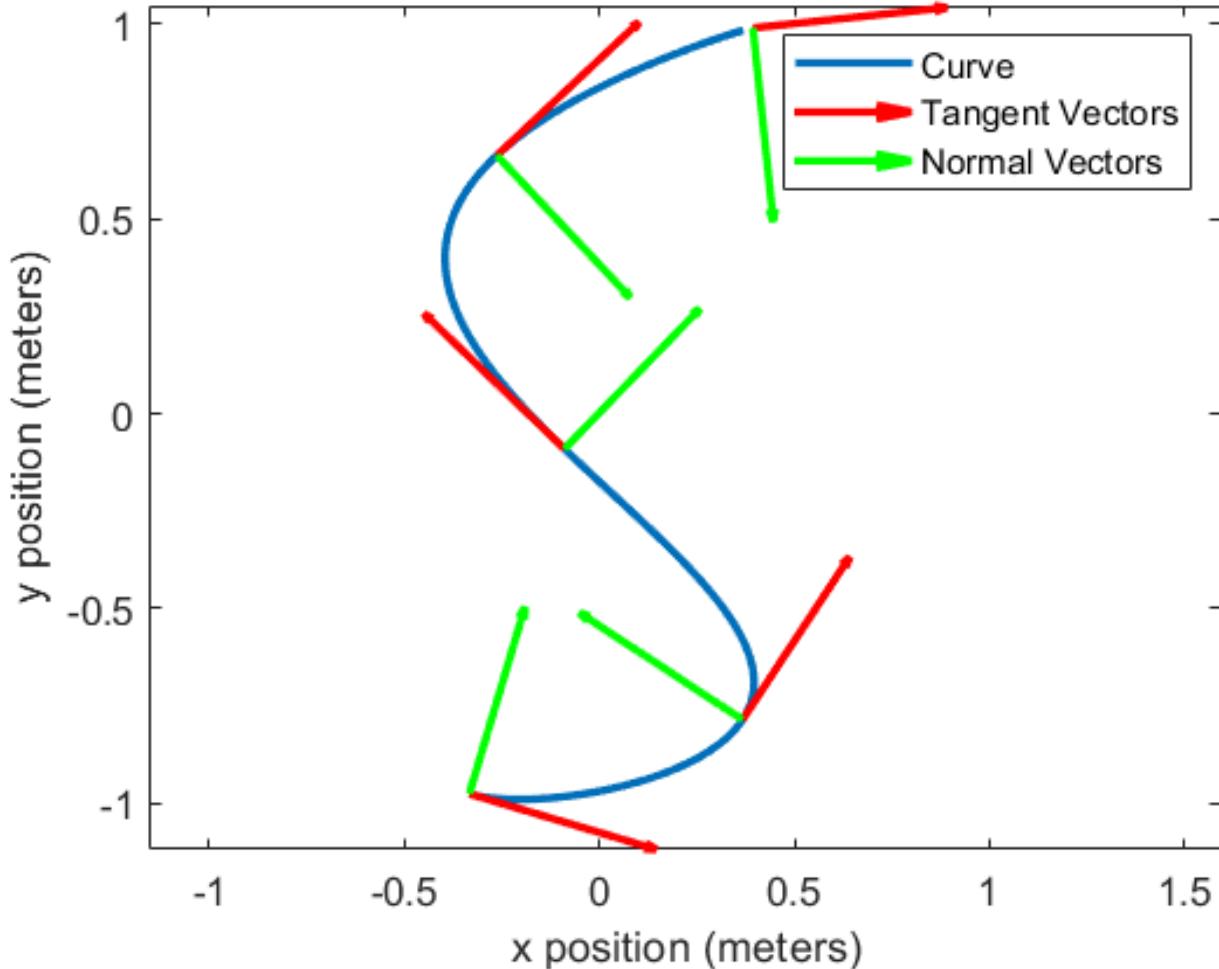
Graph 1: Parametric Curve Following Rainbow Road

Parametric Curve Following Rainbow Road

Theoretical path of Rainbow Road via the parametric equations:

$$x = 0.396 \cos(2.65((t/10)+1.4))$$

$$y = -0.99 \sin((t/10) + 1.4)$$

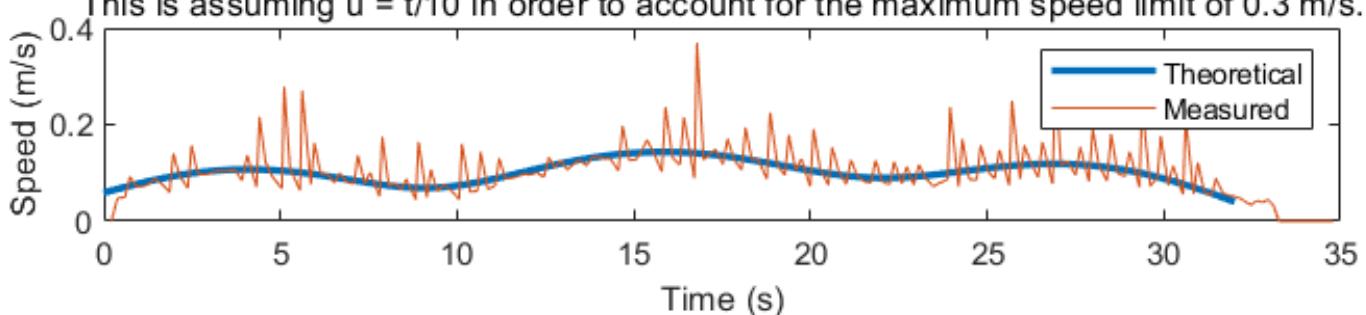


Graph 2: Theoretical versus Measured Speed & Angular Velocity of Neato Over Time

Comparison between Theoretical & Measured Speed of the Neato over Time

The following figure shows the theoretical speed of the Neato robot over time.

This is assuming $u = t/10$ in order to account for the maximum speed limit of 0.3 m/s.

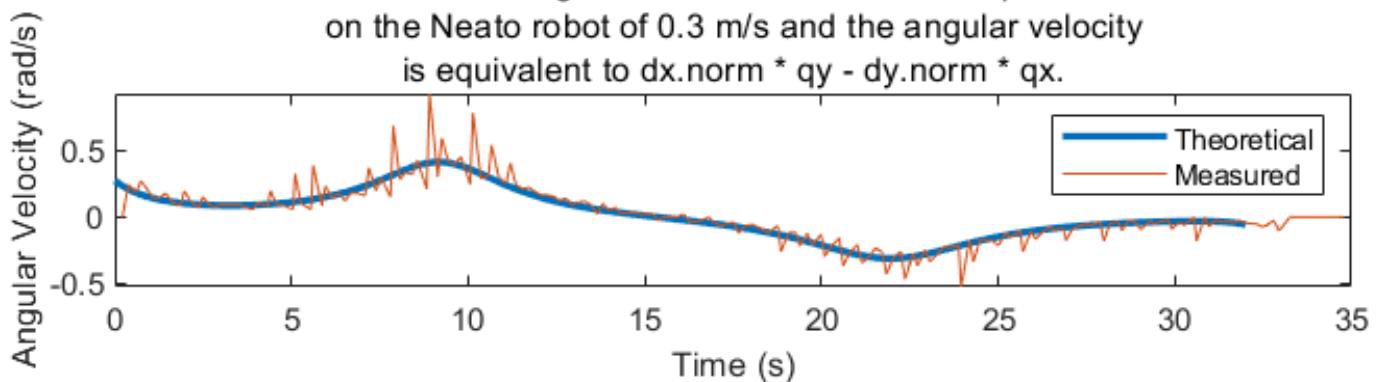


Comparison between Theoretical & Measured Angular Velocity of the Neato over Time

This is assuming $u = t/10$ to account for the speed limit

on the Neato robot of 0.3 m/s and the angular velocity

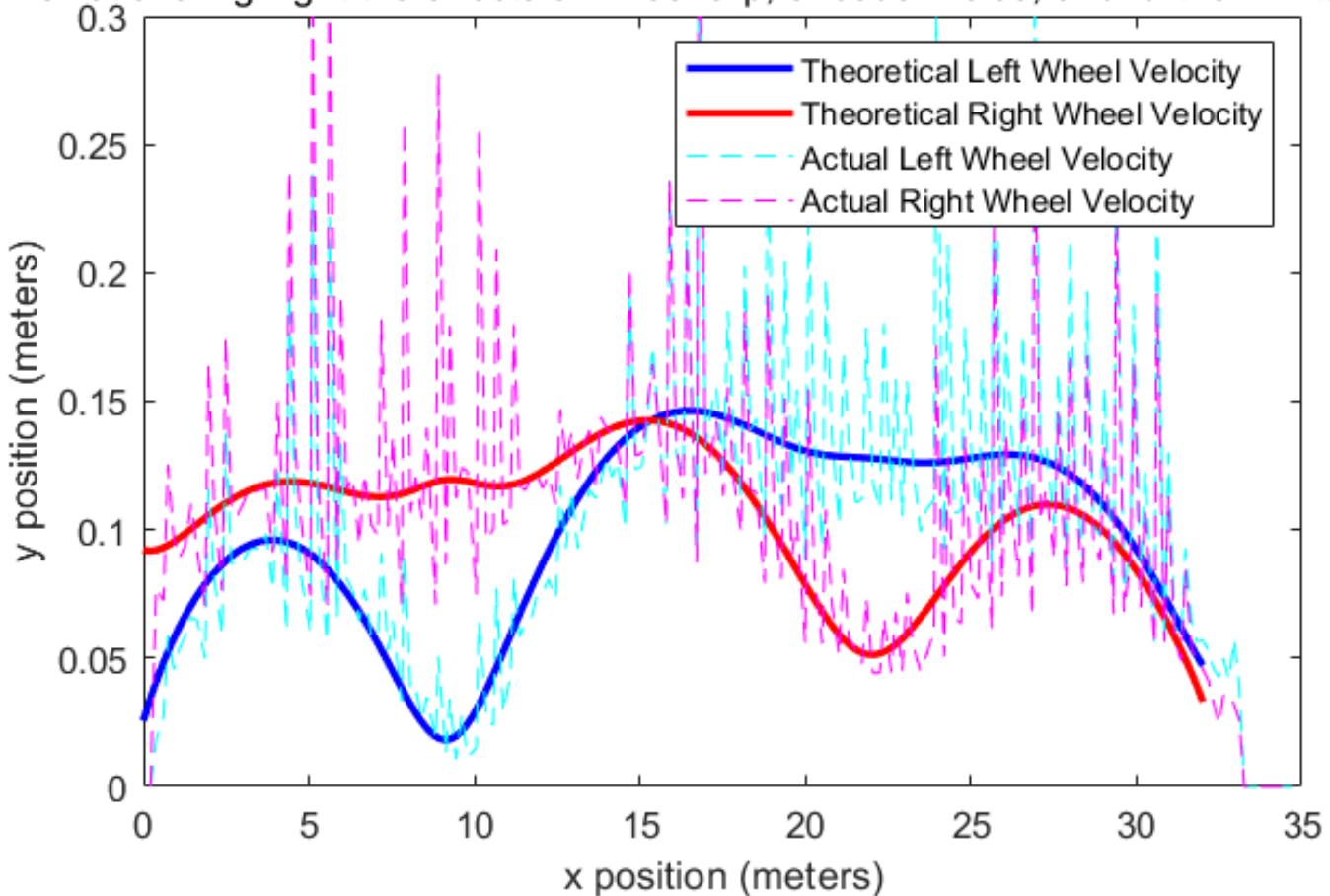
is equivalent to $dx.\text{norm} * qy - dy.\text{norm} * qx$.



Graph 3: Theoretical versus Measured Wheel Velocities of Neato Over Time

Comparison Between Theoretical & Measured Wheel Velocities of Neato

The solid lines represent the theoretical left and right wheel velocities, while the dashed lines show the actual recorded velocities from the encoders. Deviations highlight the effects of wheel slip, encoder noise, and further limitations.



Graph 4: Actual versus Theoretical Neato Path & Respective Tangent Vectors

