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3. Formulate the Optimization Problem

The optimization problem can be written as:

$$\min_{v,\omega} J$$

subject to the system dynamics and any constraints on v and ω.

4. Set Up the QP Matrices

Define the state vector and control vector:

$$\mathbf{x} = \begin{bmatrix} x \\ y \\ \theta \end{bmatrix}, \quad \mathbf{u} = \begin{bmatrix} v \\ \omega \end{bmatrix}$$

For a prediction horizon $N = 10$:

$$\mathbf{X}_{\text{pred}} = \begin{bmatrix} x(1) \\ y(1) \\ \theta(1) \\ \vdots \\ x(10) \\ y(10) \\ \theta(10) \end{bmatrix}, \quad \mathbf{U}_{\text{pred}} = \begin{bmatrix} v(0) \\ \omega(0) \\ \vdots \\ v(9) \\ \omega(9) \end{bmatrix}$$

5. Linearize the System Dynamics

For the purpose of QP, linearize the nonlinear dynamics around the current state. The linearized dynamics can be written as:

$$\mathbf{x}(k+1) = A\mathbf{x}(k) + B\mathbf{u}(k)$$

Where A and B are the Jacobian matrices evaluated at the current state.