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Step-by-Step Formulation

1. Define the System Dynamics

Assuming a simple kinematic model for a differential drive robot:

$$\begin{cases} x(k+1) = x(k) + v(k)\cos(\theta(k))\Delta t \\ y(k+1) = y(k) + v(k)\sin(\theta(k))\Delta t \\ \theta(k+1) = \theta(k) + \omega(k)\Delta t \end{cases}$$

where:

- $x(k)$ and $y(k)$ are the coordinates.
- $\theta(k)$ is the orientation.
- $v(k)$ is the linear velocity.
- $\omega(k)$ is the angular velocity.
- Δt is the sampling time.

2. Define the Cost Function

The cost function J over the prediction horizon N is:

$$J = \sum_{k=0}^{N-1} \left((x(k) - x_{\text{ref}}(k))^2 + (y(k) - y_{\text{ref}}(k))^2 + (\theta(k) - \theta_{\text{ref}}(k))^2 \right)$$

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.