Introduction to Cognitive Robotics

Module 3: Mobile Robots

Lecture 6: The go-to-position problem; divide-and-conquer controller

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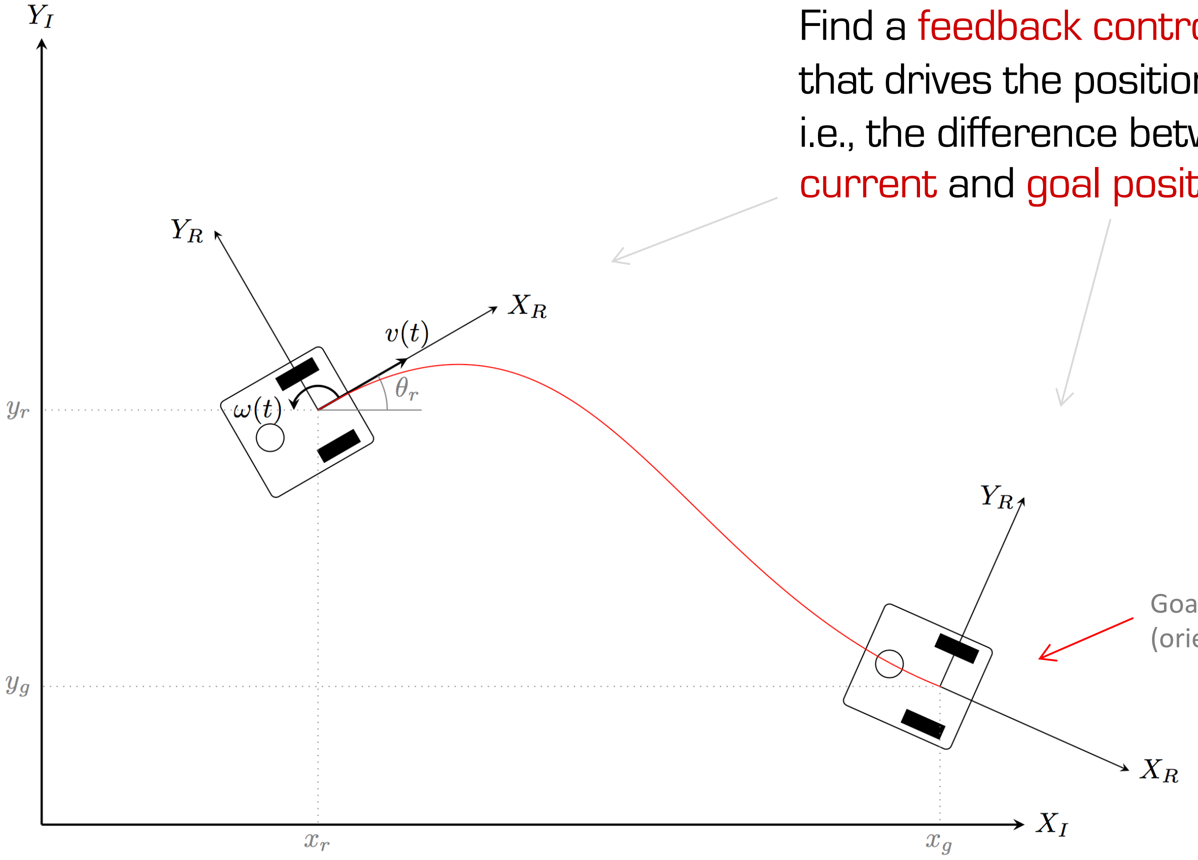
The Go-to-Position Problem



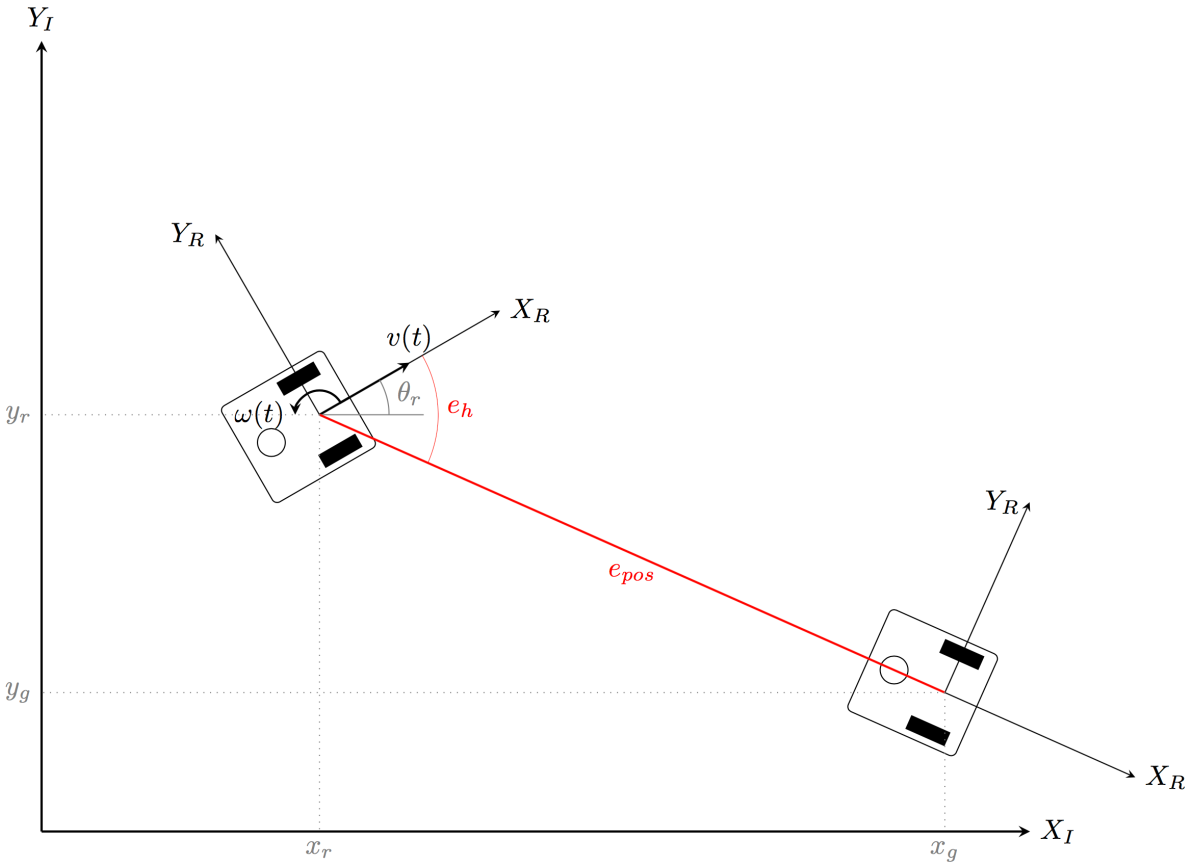
Find a feedback control equation that drives the positional error to zero, i.e., the difference between the current and goal position

Goal position
(orientation is the heading direction on arrival)

The Go-to-Position Problem

- The robot knows its own global current position
  - (x_r, y_r, θ_r)
- It knows the global position of the goal
  - (x_g, y_g)
- Compute error in position and heading
  - (e_{pos}, e_h)

The Go-to-Position Problem



The Go-to-Position Problem

- The robot knows its own global current position
  - (x_c, y_c, θ_c)
- It knows the global position of the goal
  - (x_g, y_g)
- Compute error in position and heading
  - (e_{pos}, e_h)
- Reduce both errors to zero
  - by generating the appropriate forward and angular velocities (v, ω) or, alternatively,
  - by generating the appropriate angular velocities of the wheels, (v_R, v_L) i.e. $(\dot{\phi}_1, \dot{\phi}_2)$

Go-to-Position as a Control Problem

Solution 1: Divide and Conquer

Decompose 2D problem into two 1D problems

- First, correct the heading:

  rotate to reduce the orientation error to zero

- Second, correct the position:

  translate straight ahead to reduce the position error to zero

Go-to-Position as a Control Problem

Solution 1: Divide and Conquer

Algorithm goto1(x_g, y_g) using proportional control

Global variables: the current robot position and orientation (x_r, y_r, θ_r)

Arguments: - the goal position of the robot (x_g, y_g)

- the proportional gains for controlling position and heading

$$K_p^{pos}$$
$$K_p^{h}$$

- the tolerances on position error Δ_{pos} and orientation error Δ_h

Go-to-Position as a Control Problem

Solution 1: Divide and Conquer

Version A: Control forward and angular velocities of the robot

Do

Compute the current position of the robot (x_r, y_r)

Compute the distances from the robot position to the target position (d_x, dy)

$d_x = x_g - x_r$

$d_y = y_g - y_r$

Compute the position and heading errors(e_{pos}, e_h)

$e_{pos} = \text{sqrt}\,(d_x^2 + d_y^2)$

$e_h = \text{atan2}\,(d_y, d_x) - \theta_r$

The difference between the desired heading and the current robot orientation

If not oriented correctly, correct heading

if $|e_h| > \Delta_h$

set forward velocity: $v = 0$

set angular velocity: $\omega = K_p^h\, e_h$

Otherwise, correct position

else

set forward velocity: $v = K_p^{pos}\, e_{pos}$

or some maximum velocity v_{max}

set angular velocity: $\omega = 0$

Send velocities (v, ω) to the robot

Pause some time

while $|e_{pos}| > \Delta_{pos}$

Send velocities $(0, 0)$ to the robot

Go-to-Position as a Control Problem

Solution 1: Divide and Conquer

Version B: Control angular velocities of the wheels

Do

Compute the current position of the robot (x_r, y_r)

Compute the distances from the robot position to the target position (d_x, dy)

$d_x = x_g - x_r$

$d_y = y_g - y_r$

Compute the position and heading errors(e_{pos}, e_θ)

$e_{pos} = \text{sqrt}\ (d_x^2 + d_y^2)$

$e_h = \text{atan2}\ (d_y, d_x) - \theta_r$

If not oriented correctly, correct heading

if $|e_h| > \Delta_h$

set right wheel angular velocity: $\dot{\phi}_1 = -K_p^h e_h$

set left wheel angular velocity: $\dot{\phi}_2 = -\dot{\phi}_1$

Rotate: left and right wheels go in opposite direction

Otherwise, correct position

else

or some maximum velocity

set right wheel angular velocity: $\dot{\phi}_1 = K_p^{pos} e_{pos}$

set left wheel angular velocity: $\dot{\phi}_2 = \dot{\phi}_1$

Translate: left and right wheels go in same direction

Send velocities ($\dot{\phi}_1$, $\dot{\phi}_2$) to the robot

Pause some time

while $|e_{pos}| > \Delta_{pos}$

Send velocities $(0, 0)$ to the robot