CS 369: Introduction to Robotics

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Spring 2026

HAVERFORD
COLLEGE

Admin

- Lab 2 due tonight

- Lab 3 posted (due next Tuesday)

Outline for today

- Controllers

- PID control

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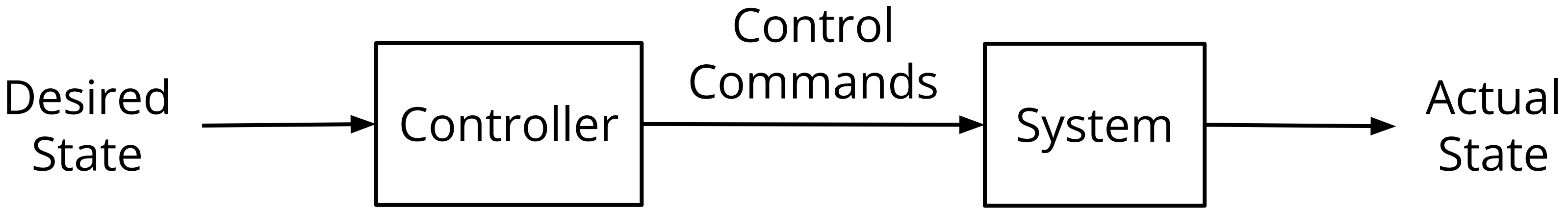
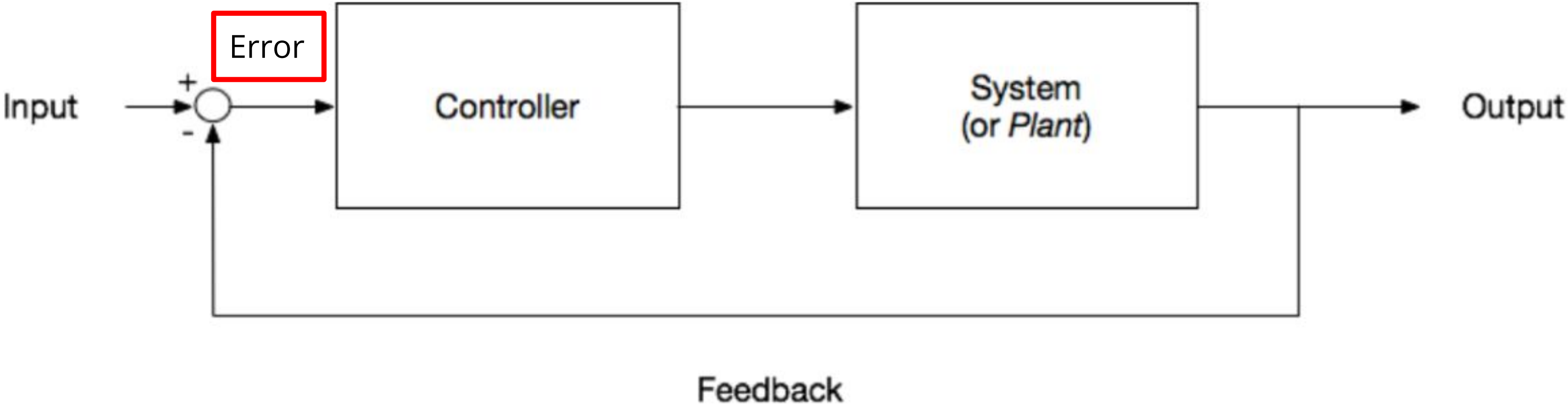
Controllers

Control the robot's movement by sending signals to the robot motors.

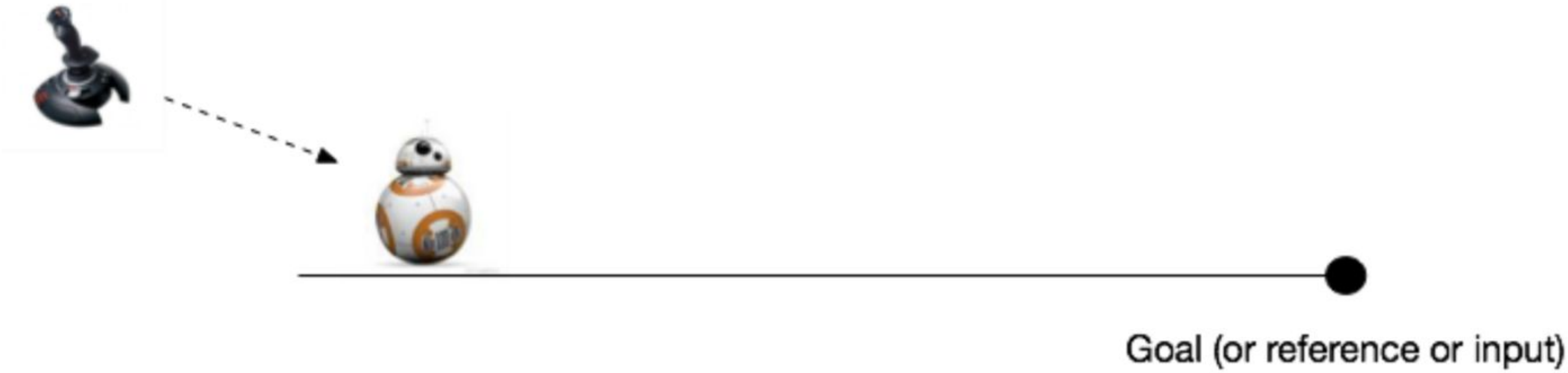


Open-loop controller

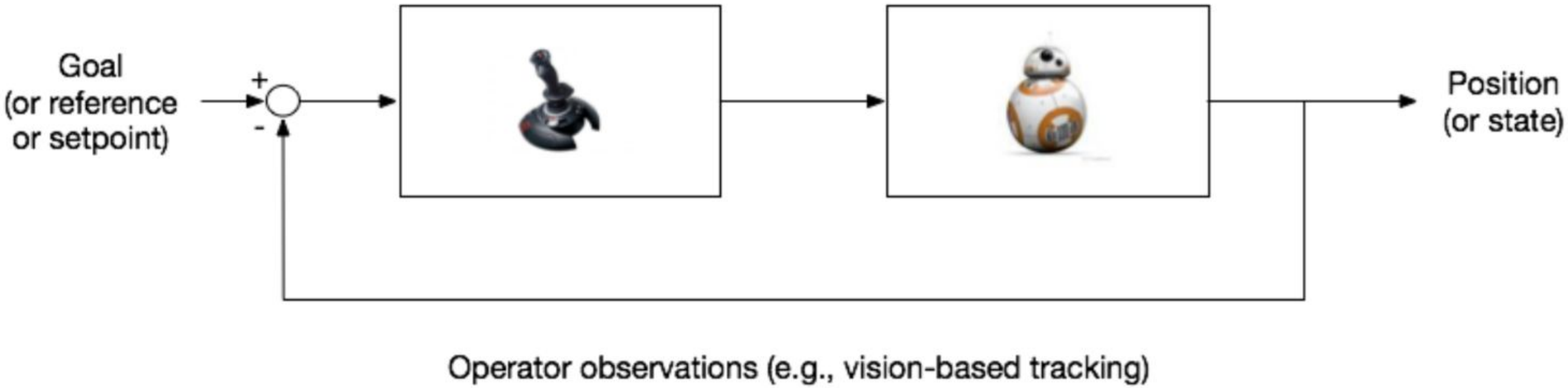
Feedback controller



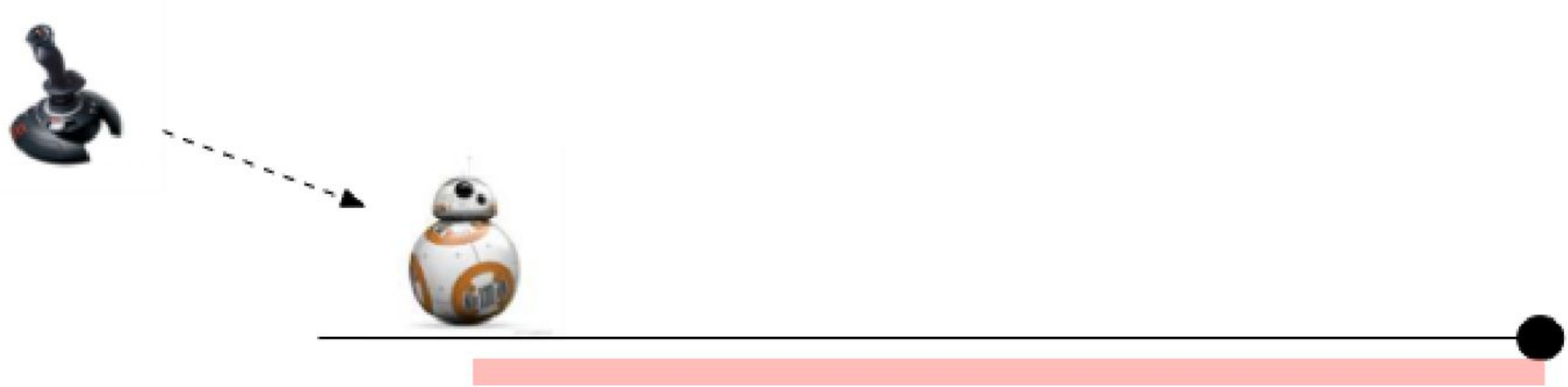
Feedback controller example



Feedback controller example

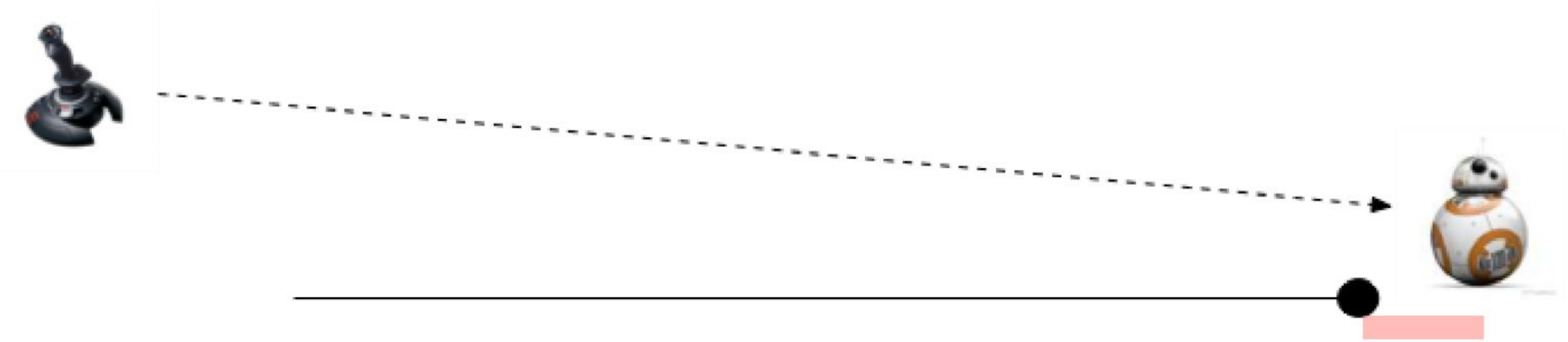


Feedback controller example



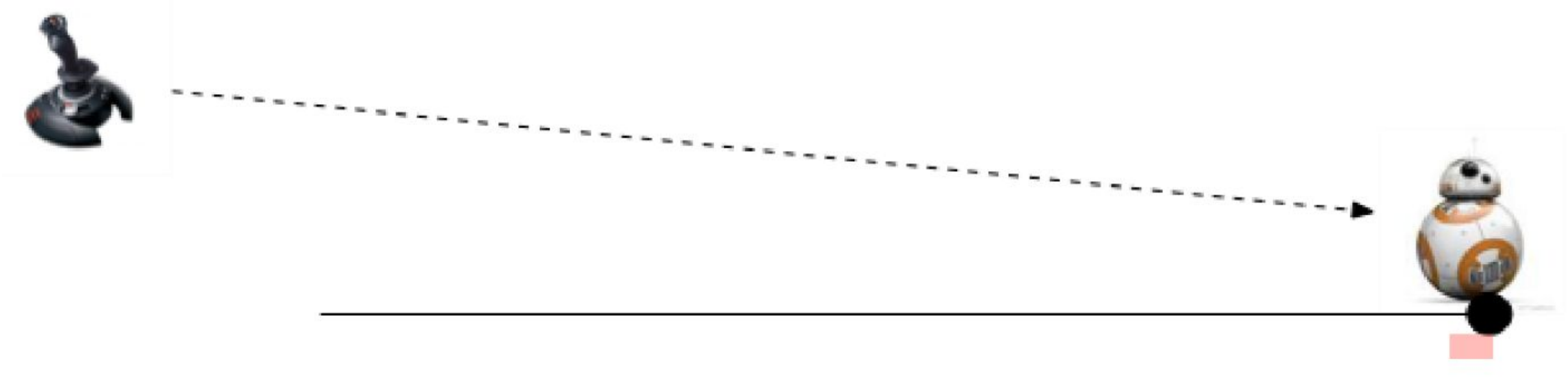
Error between current position and desired position (or goal)

Feedback controller example



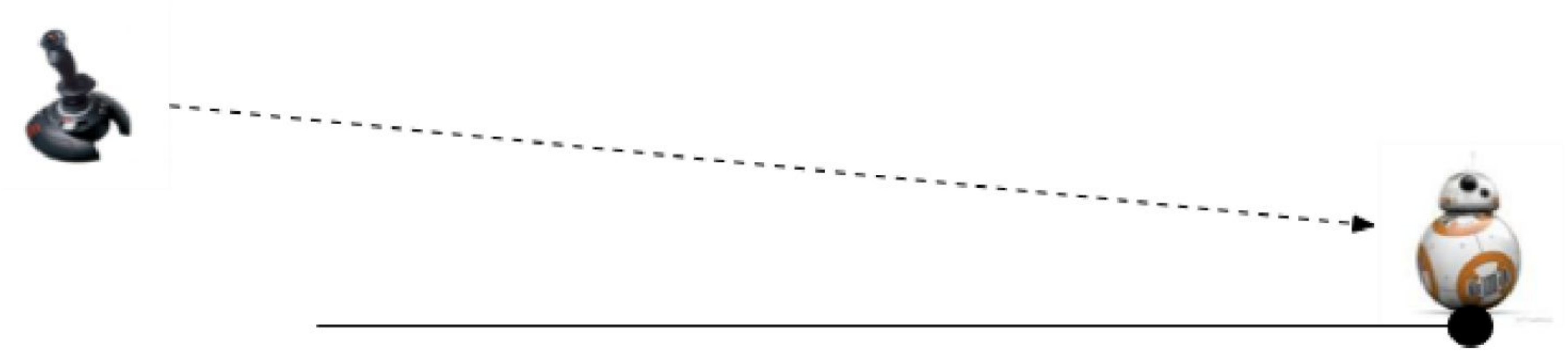
Error (overshoot)

Feedback controller example



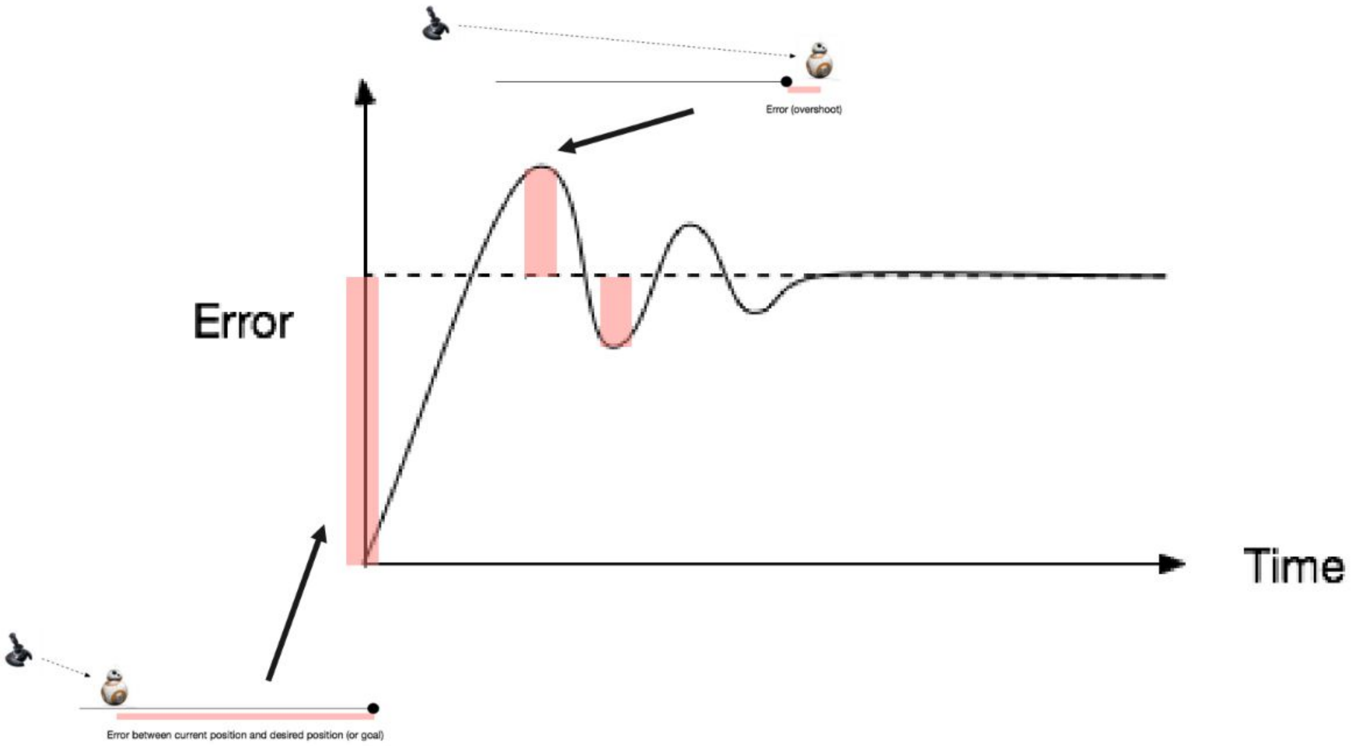
Error (undershoot)

Feedback controller example

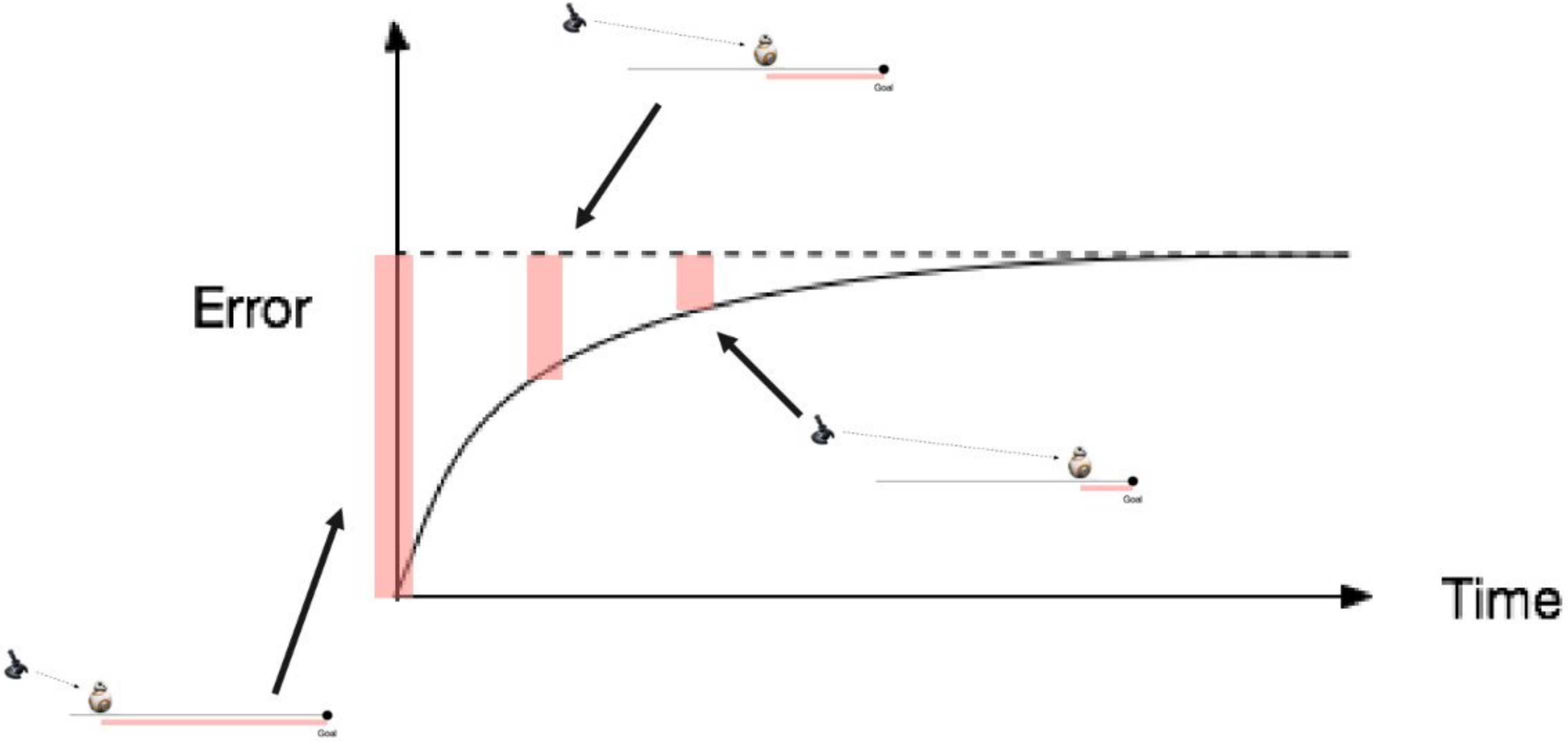


Converge to goal

Feedback controller example



Feedback controller example



Controller evaluation

- Rise time: time taken to reach (~90% of) goal
- Settling time: time for output to stay within a tolerance of the goal
- System stability
- Overshoot

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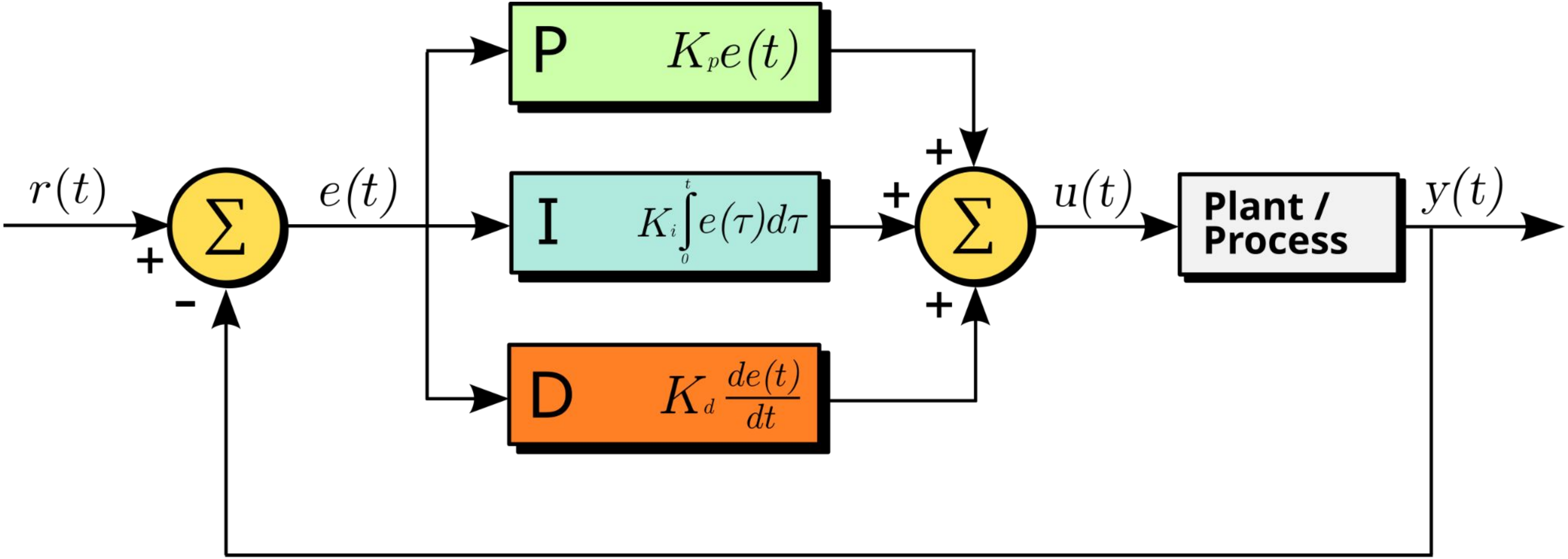
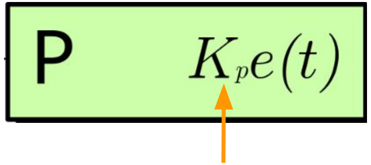
Proportional–integral–derivative controller



Wikipedia

Proportional term



P $K_p e(t)$

proportional gain

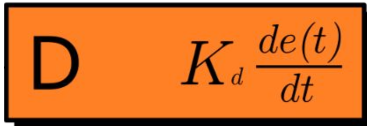
- Directly proportional to the current error
- Provides correction based on how far the system is from the goal
- ↑ K_p: ↓ rise time, ↑ overshoot

Integral term

I $K_i \int_0^t e(\tau)d\tau$

- Considers the cumulative sum of past errors
- Eliminates steady-state error
- ↑ K_i: ↑ overshoot

Derivative term



D $K_d \frac{de(t)}{dt}$

- Predicts future error by assessing the rate of change of the error
- Mitigates overshoot and enhances system stability

Tuning

- Parameters/gains must be adjusted for each control application

- Manual tuning:
  - set K_i and K_d values to zero
  - increase K_p until the output oscillates, then set K_p to half that value
  - increase K_i until any steady-state offset is corrected in sufficient time
  - increase Kd until the output stabilizes in sufficient time

Wikipedia