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Lab Group ✓

Lab 1 – starts Wednesday

Engineering Design Process (EDP)

Autonomous Vehicle

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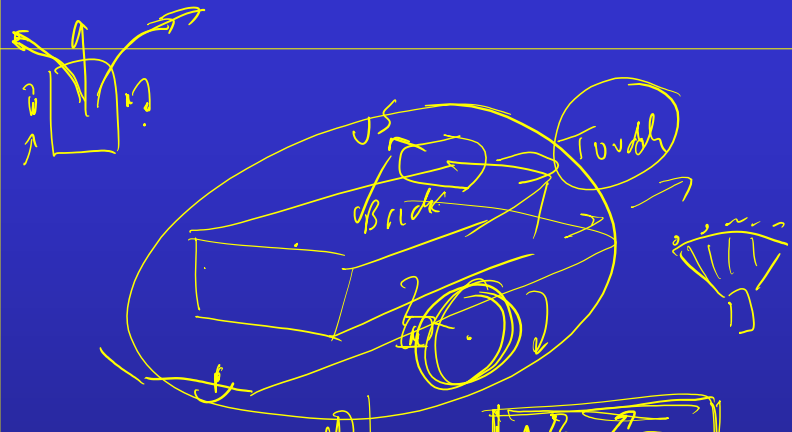

✓ US sensor

✓ Touch Sensor

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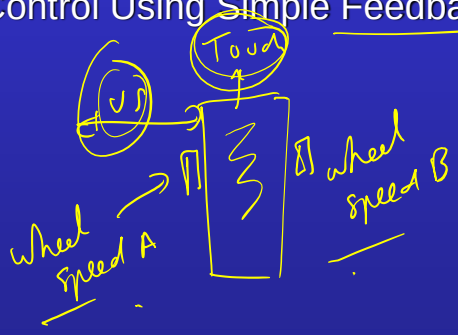
Control Using Simple Feedback



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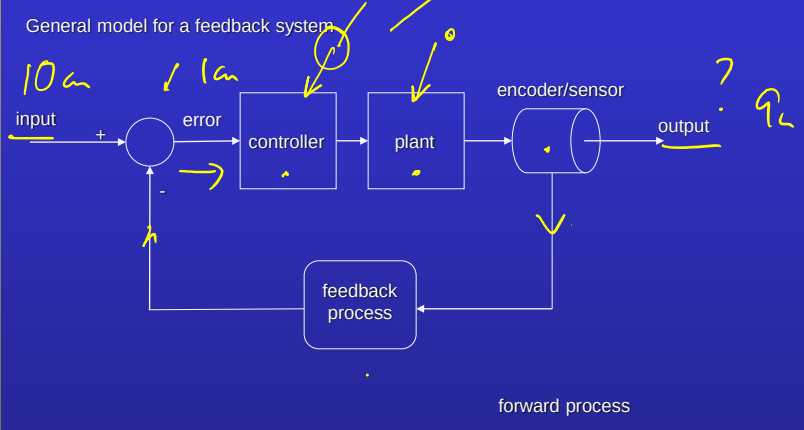
S&C - 1

General model for a feedback system



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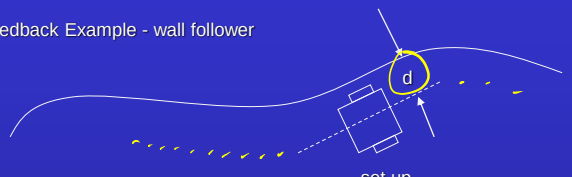
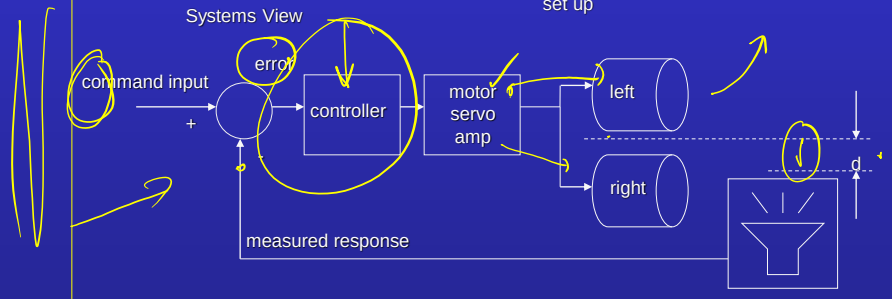
S&C - 2

Simple Feedback Example - wall follower



Systems View



• Difference in motor speeds controls lateral distance - d

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S&C - 3

Designing the Controller

• An intuitive view (you will study formal methods in ECSE 404, Control Systems)

Known Entities

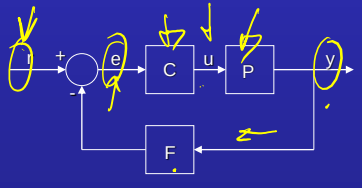
• The plant model can be measured and/or suitably approximated

• The range of inputs

• The desired response of the system to the inputs

Design Problem

• Figure out appropriate controller and feedback models to achieve the desired response



$$y = CPe$$

$$e = r - Fy$$

$$y = CP(r - Fy) = CPr - CPFy$$

$$y(1 + FCP) = CPr$$

$$y = \frac{CP}{(1 + FCP)} r$$

if CP large, then y ≈ r / F

$$y \approx \frac{r}{F}$$

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S&C - 4

Designing the Controller cont.

- C, P, and F can be arbitrarily complex functions
- Key aspects of their design include
  - Stability, the output must follow the input in a predictable manner
  - Fidelity, the output must be sufficiently responsive as a function of time
  - Control Theory deals with these and many other aspects of the design
- For the simple case considered here, the output is directly proportional to the input

Designing the Wall Follower

r = set offset distance in cm

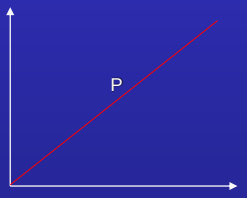
y = measured offset distance in cm

P = constant ∝ speed (deg/sec)

F = constant = 1 (error in cm)

What is C?

$d = 2\pi v_\theta t$



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S&C - 3

Designing the Controller

Design Problem

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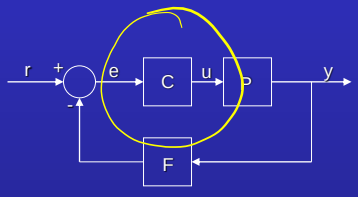

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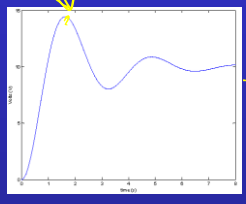
S&C - 5

Designing the Controller cont.

- C is a *gain* constant proportional to the error (r - y).
- Too large a value of C results in an *underdamped* system
- Too small a value of C results in an *overdamped* system
- A correct choice of C results in a *critically damped* system



under

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S&C - 5

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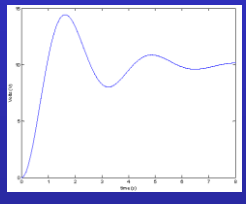
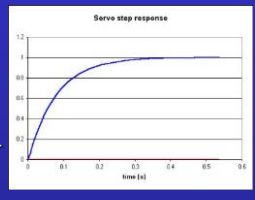


under

over



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S&C - 5

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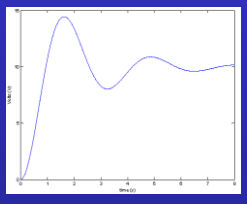

under

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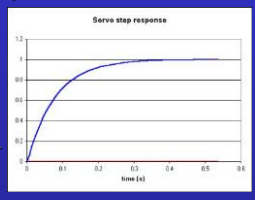

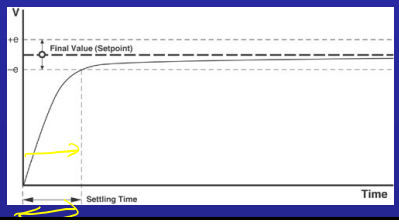

critical

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S&C - 6

Designing the Controller cont.

- Knowing the analytical forms of P and F, one can determine the proportional *gain*, C, that results in an appropriate response.

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S&C - 6

Designing the Controller cont.

- Knowing the analytical forms of P and F, one can determine the proportional *gain*, C, that results in an appropriate response.
- More often than not in simple designs such as this one, C can be adjusted by trial and error (so-called tweaking).

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S&C - 6

Designing the Controller cont.

- Knowing the analytical forms of P and F, one can determine the proportional *gain*, C, that results in an appropriate response.
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- An even more simplifed approach is possible, so-called BANG BANG Control.

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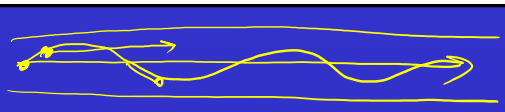

S&C - 6

Designing the Controller cont.

- Knowing the analytical forms of P and F, one can determine the proportional *gain*, C, that results in an appropriate response.
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- An even more simplifed approach is possible, so-called BANG BANG Control.

The BANG BANG Controller

- Consider a digital control loop that periodically samples the output at a rate S.
- At each sample interval, compute error, e, and apply a correction in the appropriate direction (+/-) using a fixed step.
- If the correction is applied often enough, the output will eventually catch up and follow the input as desired.
- At convergence, the controller will “hunt” about the zero error point applying successive +/- corrections.
- We eliminate hunting by suppressing any correction if | r – y | is less than threshold.