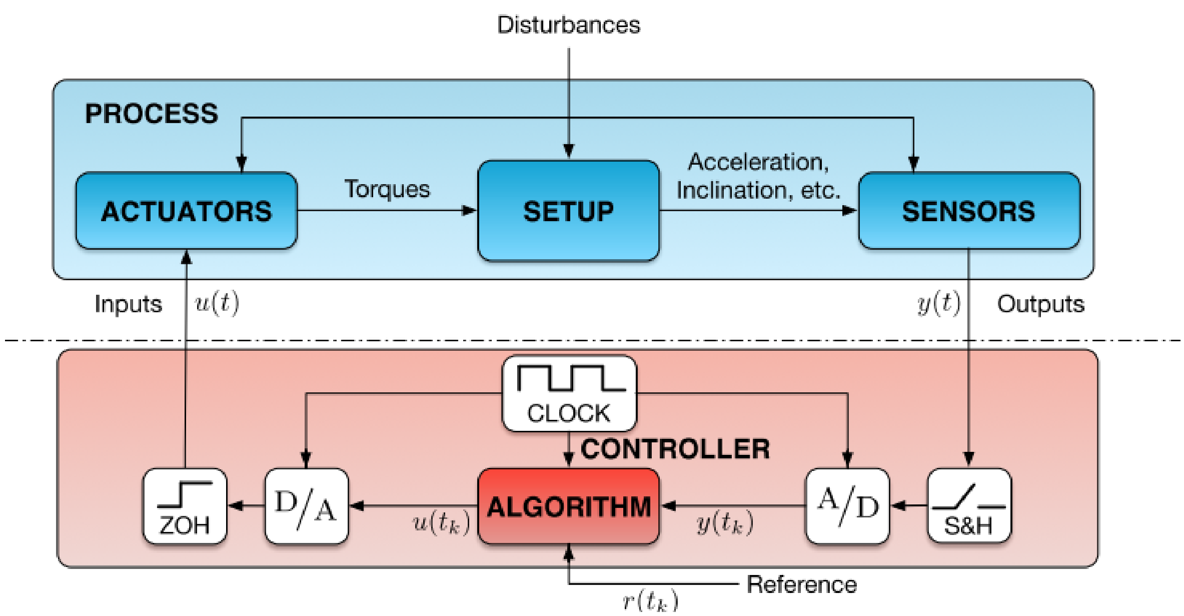
03_Control Techniques

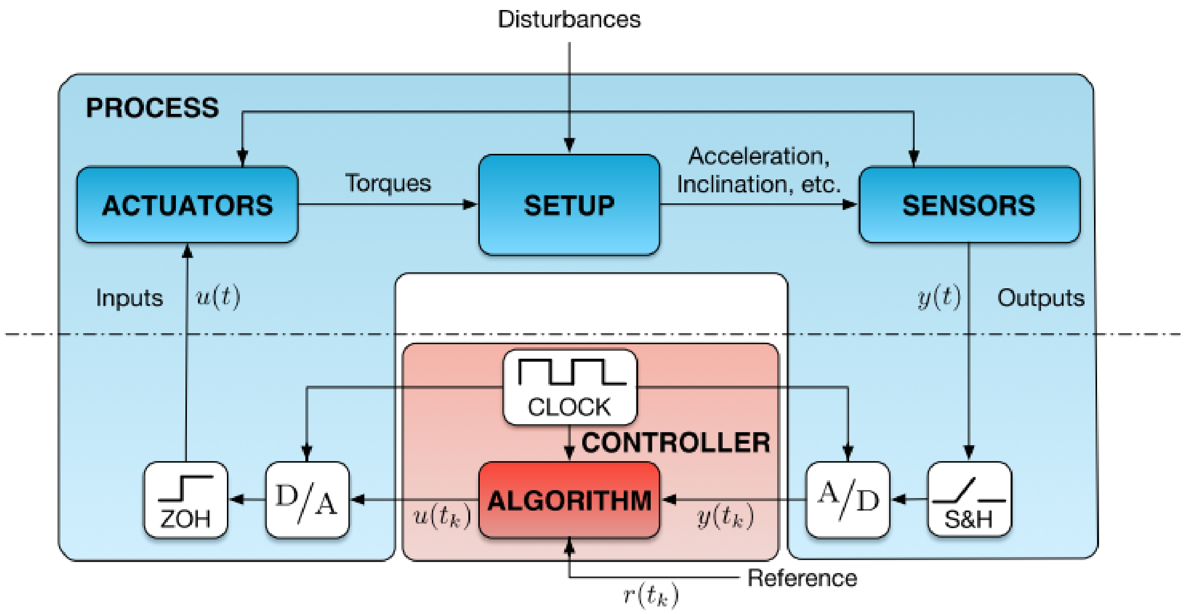
1. Digital Control Approaches

Approach 1



1. Design a **continuous-time controller**
2. Then make sure that the **(digital) computer** implementation **approximates the continuous-time controller** as precisely as possible.

Approach 2



1. **Describe** the system from the computer's **(digital) viewpoint** (i.e. discretise it)
2. then **design directly** a **discrete-time** controller

Useful MATLAB Commands

Useful basic MATLAB commands

```
G = ss(A,B,C,D);    % LTI continuous-time state-space model

h = 0.1;            % sampling period [s]

H = c2d(G,h);       % convert to discrete time (ZOH)

H = c2d(G,h,method);       % method = 'foh', 'matched', ...

G = d2c(H);         % convert to continuous time (ZOH)
```

2. State-Feedback Control, Observers

This part I have already learnt in other courses, so here, we will just do some keywords warm up

- State Feedback
- Poles Placement:
  - for controllable poles
  - choose poles method: use a continuous-time 2nd order model as a reference
- LQR
- Observer: Kalman Filter, Luenberger Observer
- Output Feedback
  - Separation Principle

3. PID Controllers

Basic structure of PID is known for us, so here only warm up some important part and some tuning method

The "textbook" version of a PID controller:

$$u(t) = K\left(e(t) + \frac{1}{T_i}\int^t e(s)ds + T_d\frac{de(t)}{dt}\right)$$

A more realistic PID controller (continuous case):

$$U(s) = K\left((R(s) - Y(s)) + \frac{1}{sT_i}(R(s) - Y(s)) - \frac{sT_d}{1 + sT_d/N}Y(s)\right)$$

- **Backward-difference** used to approximate the D-term

Tuning Method

- Pole Placement
- Root Locus
- Bode Diagram
- (Heuristic) Tuning rules (Ziegler-Nichols, λ−tuning)

$$G(s) = e^{-t_0 s}\frac{K_p}{(\tau s + 1)} \Rightarrow K_c = \frac{\tau}{K_p(\lambda + t_0)}, T_i = \tau, \quad T_d = \frac{t_0}{2}$$

Summary

- Digital Control Approaches

    - Continuous-model → Continuous controller → approximate by digital controller
    - Continuous model → discrete model → discrete controller
- State -Feedback Control, Observers
- PID Controller
    - Tuning Method