Feedback Control System Design

•••

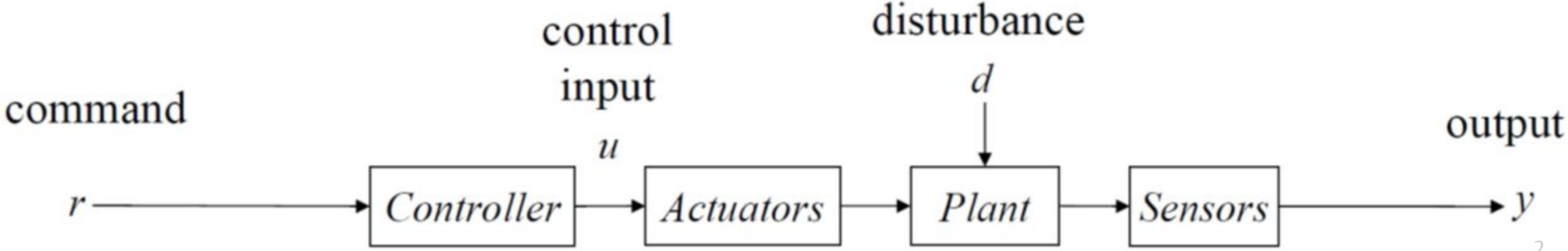
Nimal Skandhakumar

Faculty of Technology
University of Sri Jayewardenepura

2019

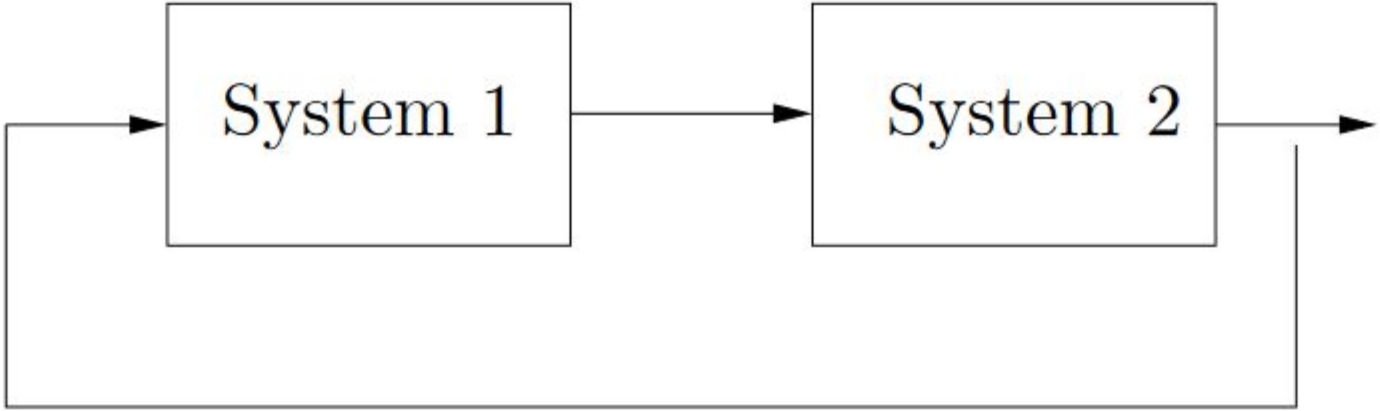
Types of Control Systems - Open loop

- The output variables do not affect the input variables
- The system will follow the desired reference commands if no unpredictable effects occur
- It can compensate for disturbances that are taken into account
- It does not change the system stability



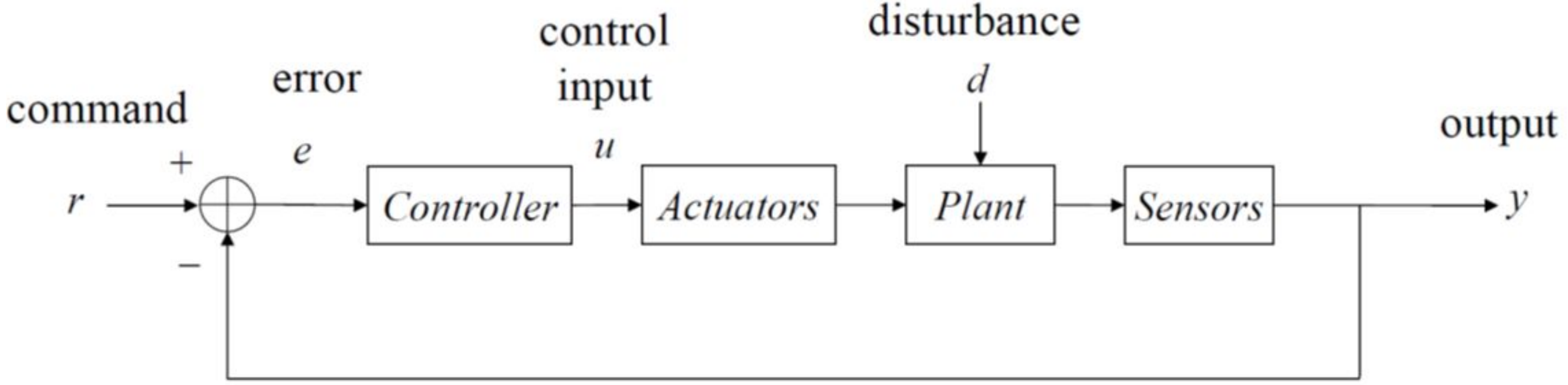
Types of Control Systems - Closed loop/Feedback

- The output variables do affect the input variables in order to maintain a desired system behaviour
- Requires measurement (controlled variables or other variables)
- Requires control errors computed as the difference between the controlled variable and the reference command



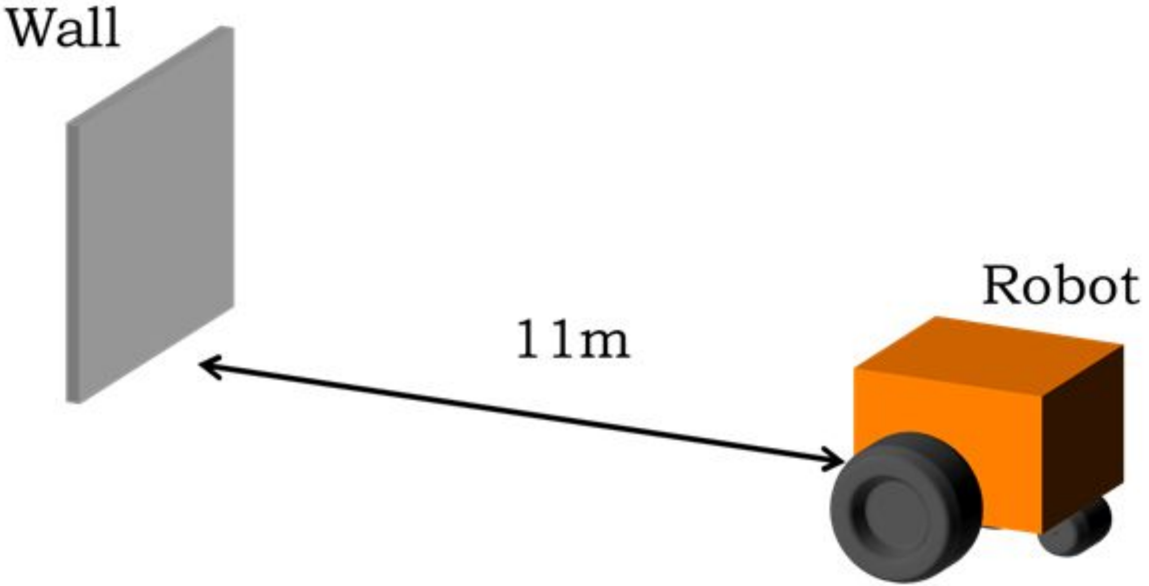
Types of Control Systems - Closed loop/Feedback

- Computes control inputs based on the control errors such that the control error is minimized
- Able to reject the effect of disturbances
- Can make the system unstable, where the controlled variables grow without bound



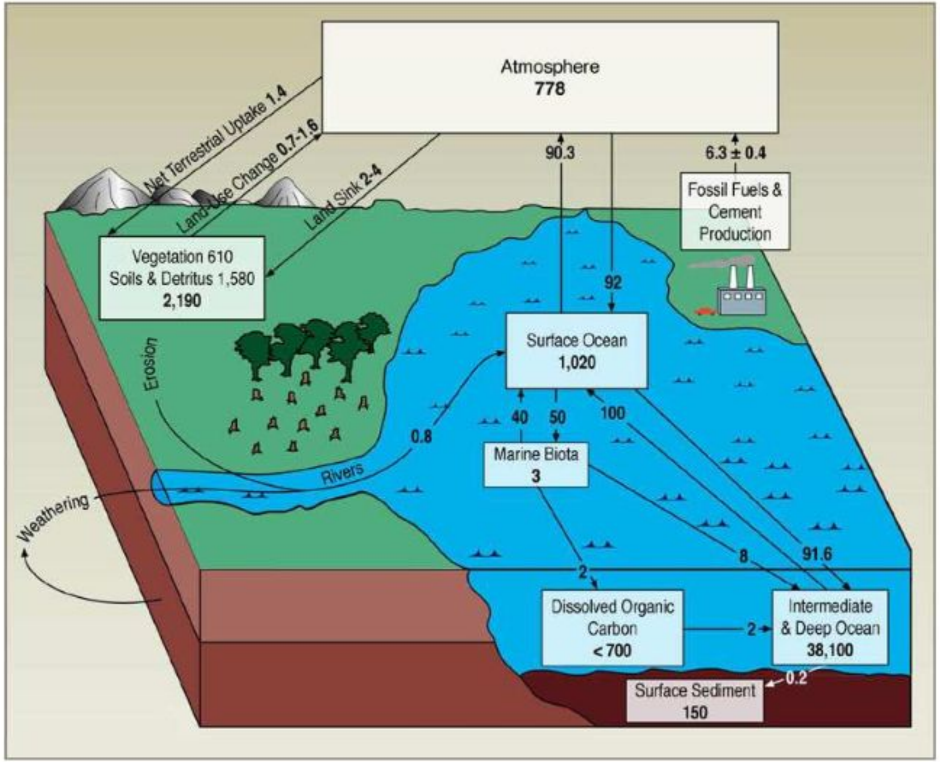
A Hitting the Wall Example

- A simple robot that moves forward when turned on.
- Task: Move from initial position to destination 1 meter from wall.
- Q? Give two control strategies, open loop and closed loop..



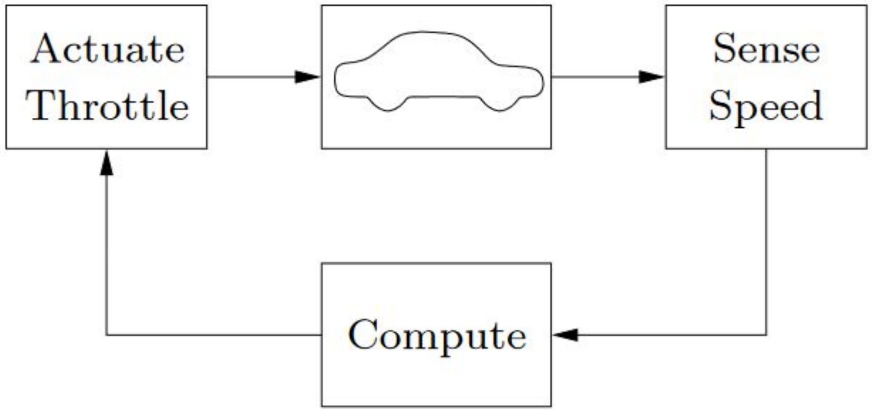
Example of a feedback system in nature

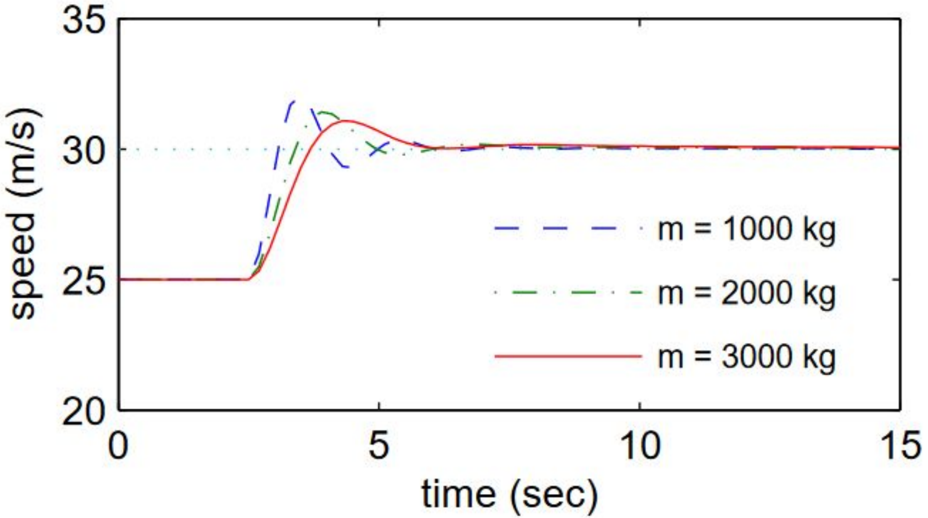
- Global carbon cycle



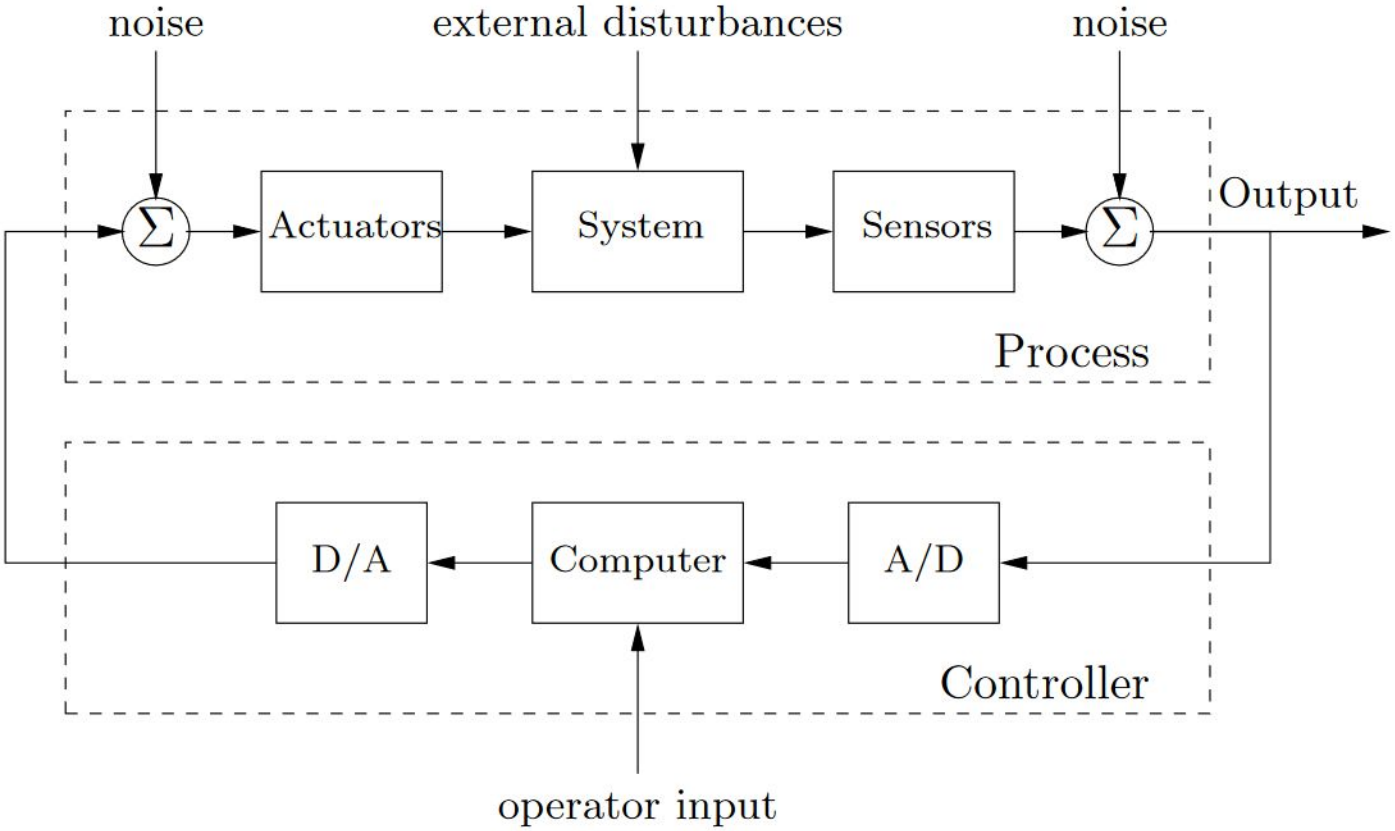
Example of feedback system using digital control

A simple feedback system for controlling the speed of a vehicle.

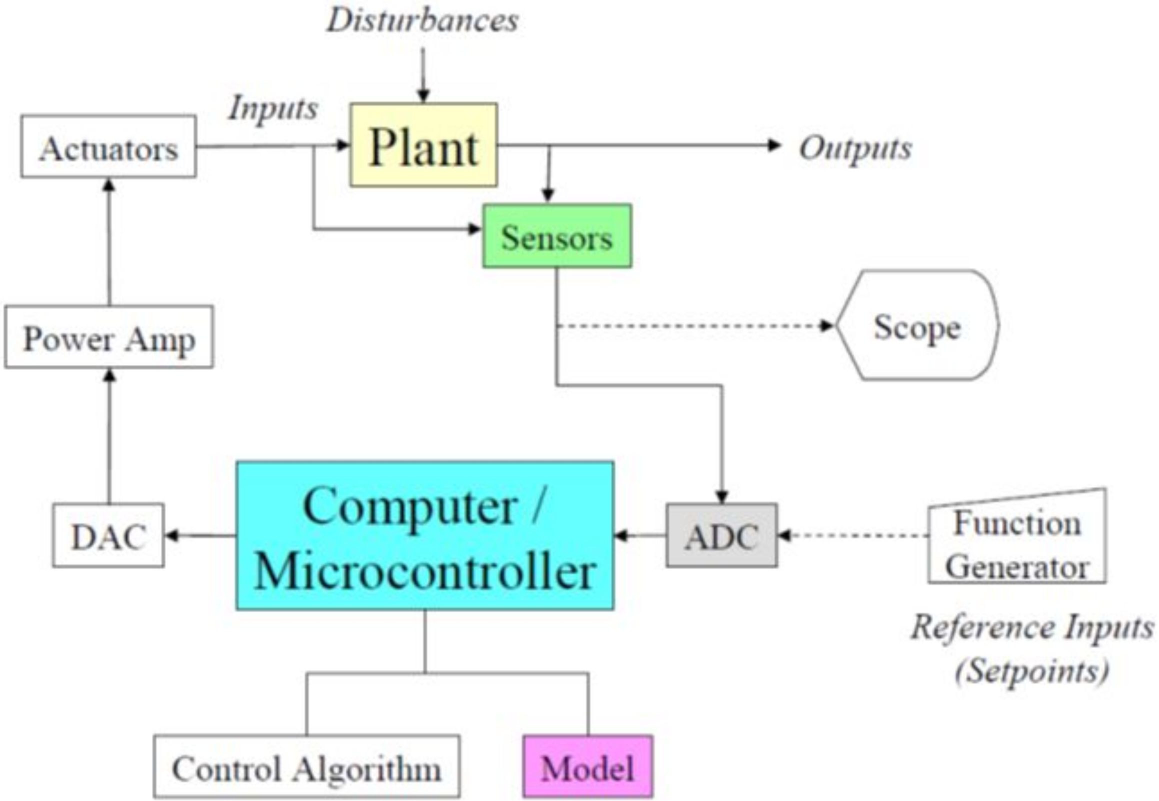




Components of a computer controlled system



Overview of Closed Loop Control Systems



Compensation

- What is system compensation?
    - Given the control plant, the procedure of controller design to satisfy the requirement is called system compensation.
- Why to compensate?
    - The closed-loop system has the function of self-tuning.
        - By selecting a particular gain value K, some single performance requirement may be met.
    - Is it possible to meet more than one performance requirement?
        - Sometimes, it is not possible.
    - Something new has to be done to the system in order to make it perform as required.

Compensation

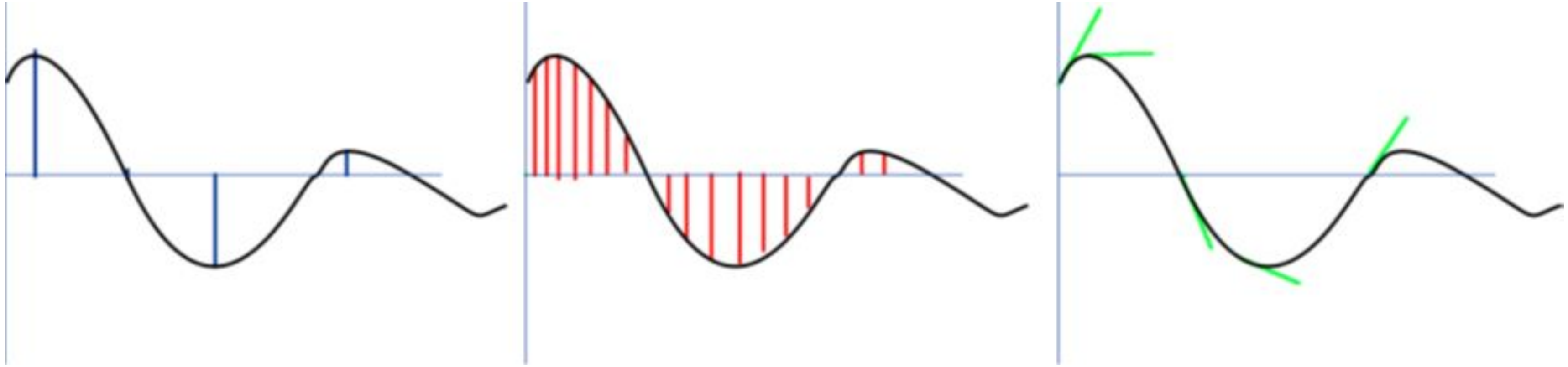
- The design of a control system is concerned with the arrangement of the system structure and the selection of a suitable components and parameters.
- A compensator is an additional component or circuit that is inserted into a control system to compensate for a deficient performance.
- Types of Compensation:
  - Cascade compensation
  - Feedback compensation
  - Output compensation
  - Input compensation

Compensation designs

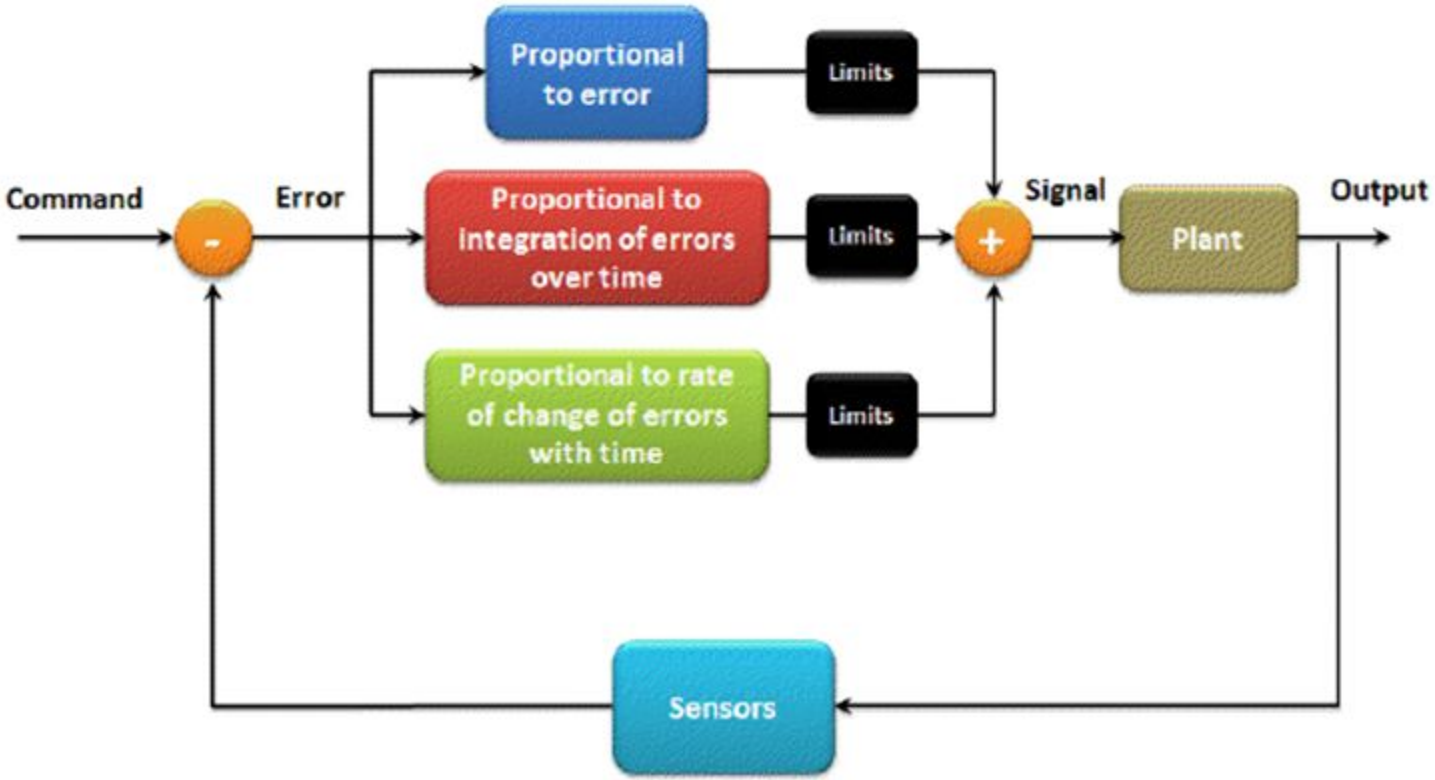
- PID Control
- Phase Lead Compensation
- Phase Lag Compensation
- Phase Lead-lag Compensation

PID Control

- Dynamic Systems controlled with a three term compensator known as PID:
  - P – Proportional Control
  - I – Integral Control
  - D – Derivative Control



PID Control

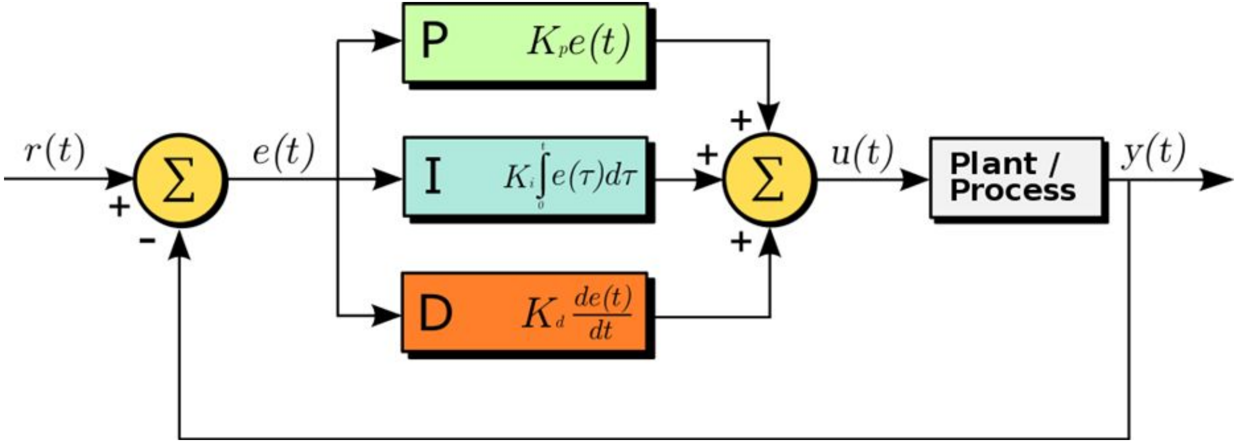


Command
-
Error
Proportional
to error
Proportional to
integration of errors
over time
Proportional to rate
of change of errors
with time
Limits
Limits
Limits
Signal
+
Plant
Output
Sensors

PID Control

$$u(t) = K_p\, e(t) + K_i \int e(t) + K_d\, e(t)/dt$$

- $u(t)$ - control input
- $e(t)$ - error
- K_p - proportional gain
- K_i - integral gain
- K_d - derivative gain



PID Control

Parameters	Advantage	Limitation
K_p	Adjustment of Controller output	May cause instability
K_i	Produces zero steady state error	Slow dynamic Response and Instability
K_d	Provides rapid system response	Sensitive to Noise and non-zero offset

Project Updates...