Teknik Kontrol

Mairodi,ST.,MT.



Dosen : Mairodi, ST.,MT.
Semester : Genap
SKS : 3 sks
Buku Referensi : Programmable Logic Controller, Penulis: James A. Rehg dan Glenn J. Sartori
Jumlah Peserta Total : ……...

1. Pengantar Sistem Kontrol
2. Pengantar PLC
3. Field Devices
4. Hardware PLC
5. Driver Interface PLC
6. Mengkonfigurasi PLC
7. Software pemrograman PLC
8. Sistem Bilangan dan Sistem Memory dalam PLC
9. Logika Boolean dalam Pemrograman
10. Instruksi Bit
11. timer dan Counter
12. Instruksi Matematika
13. Instruksi Perbandingan/comparison
14. Pengontrolan Variabel Analog Menggunakan PLC



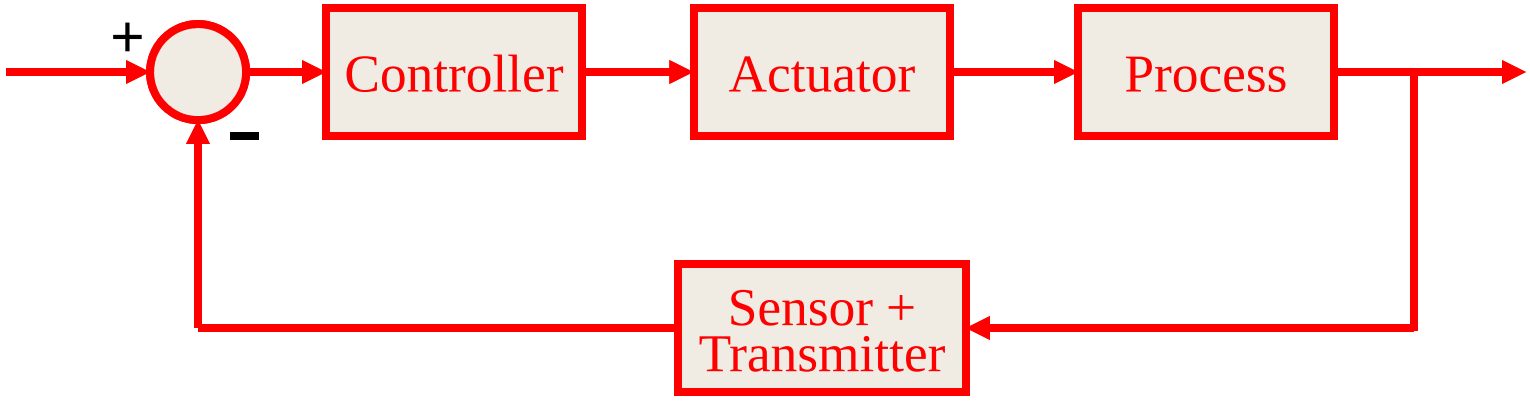


1. Pengantar Sistem Kontrol

Loop Kontrol

Jenis Pengontrol:

- Analog dan digital
- On-off dan PID
- Feedback, Feedforward dan Cascade Control



Tujuan Pengontrolan :

- Menjaga/mempertahankan nilai besaran pada referensi tertentu
- Mengatasi gangguan/efek perubahan pada sistem
- Meningkatkan performansi sistem

Contoh-contoh pengontrol yang sering dipakai dalam industri :

- ***Programmable logic controller (PLC)***
- **Microcontroller**
- **DCS (Distributed Control System)**
- **SCADA (Supervisory Control and Data Acquisition) System**



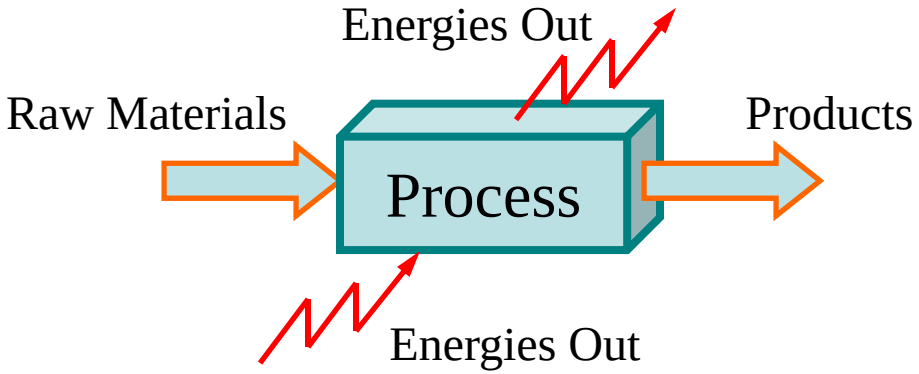
Definition (1)

- **Process**
  - A series of interrelated actions which transform material

    It covers all resources that are involved in the **process** and talks about

    process “inputs” (e.g. resources, raw material) and “outputs” (e.g.

    finished product)

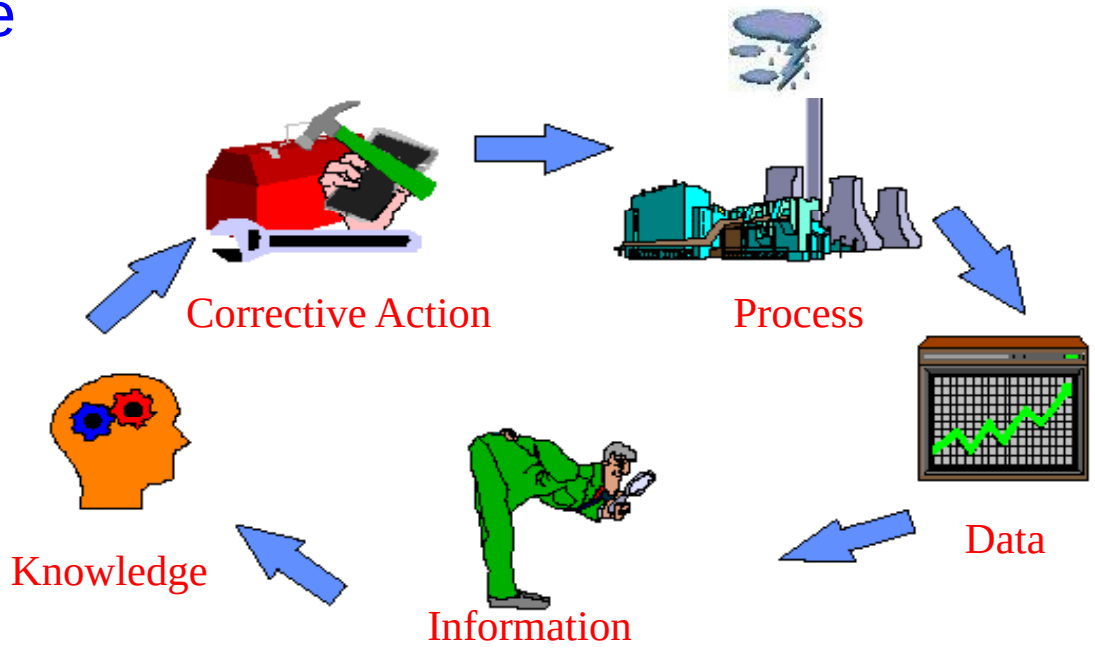


Control

- To maintain desired conditions in a physical system by adjusting selected variables in the system

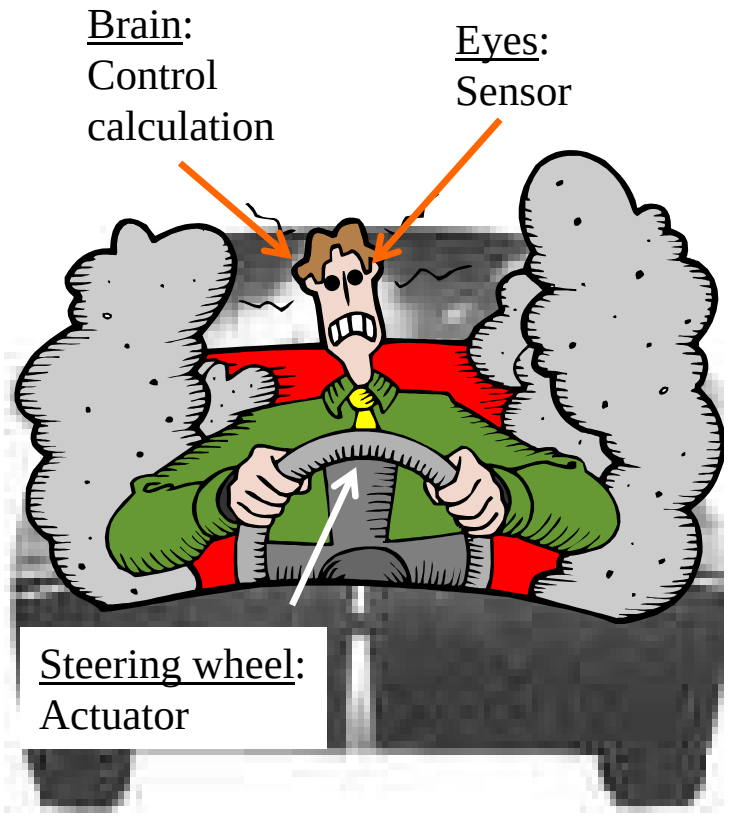
Definition (2)

- **Process Control**
  - To maintain desired conditions in a physical system by adjusting selected variables in the system in spite of disturbances affecting the system and observation noise



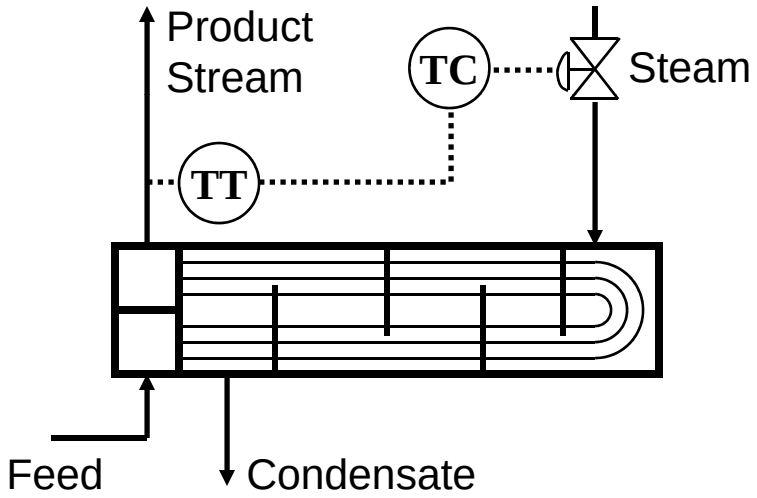
Daylife Example: Driving a Car

- Control Objective (Setpoint):
  Maintain car in proper lane
- Controlled variable:
  Location on the road
- Manipulated variable:
  Orientation of the front wheels
- Actuator:
  Steering wheel
- Sensor:
  Driver's eyes
- Controller:
  Driver
- Disturbance:
  Curve in road
- Noise:
  Rain, fog



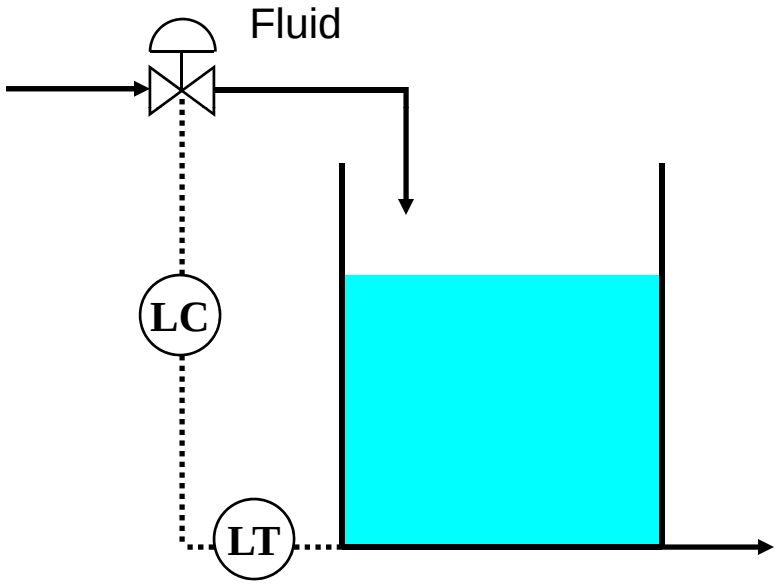
Industrial Example #1: Heat Exchanger

- Control Objective (Setpoint):
  Maintain temperature
- Controlled variable:
  Outlet temperature of product stream
- Manipulated variable:
  Steam flow
- Actuator:
  Control valve on steam line
- Sensor:
  Thermocouple on product stream
- Controller:
  Temperature controller
- Disturbance:
  Changes in the inlet feed temperature
- Noise:
  Measurement noise



Industrial Example #2: Liquid Level Control

- Control Objective (Setpoint):
  Maintain level
- Controlled variable:
  Fluid level in the tank
- Manipulated variable:
  Fluid flow
- Actuator:
  Control valve on fluid line
- Sensor:
  Level transmitter on the tank
- Controller:
  Level controller
- Disturbance:
  Changes in the inlet feed flow
- Noise:
  Measurement noise



Elements of Process Control Loop

- Sensor
  Measure process variable
- Transmitter
  Convert the measured process variable into standard signal
- Controller
  Drive actuator by giving an appropriate controller output signal
- Actuator
  Adjust manipulated variable based on the value of the controller output signal
- Process
  Physical system to be controlled

Istilah-istilah (I)

- Control Objective (Setpoint, *SP*)
- Controlled Variable (CV) or Process Variable (*PV*)
- Measured Process Variable (PV_m)
- Controller Output (*CO*)
- Manipulated Variable (*MV*)
- Final Control Element (Actuator)
- Sensor/Transmitter
- Controller
- Disturbance Variable (*DV*)
- Measurement Noise

Goal of Process Operation

- Safety & Reliability
- Product Specification
- Environmental Regulation
- Operating Constraint
- Efficiency
- Maximum profit



Safety and Reliability

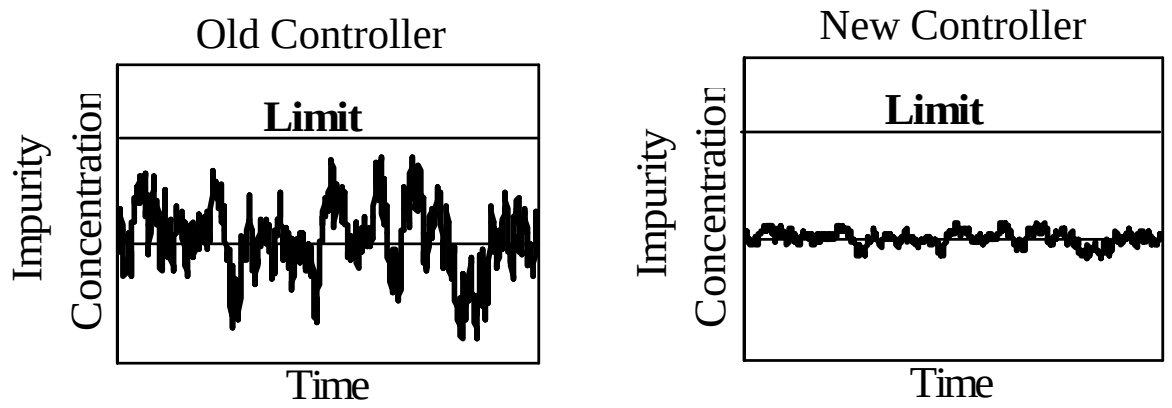
- The control system must provide safe operation
  - Alarms, safety constraint control, start-up and shutdown
- A control system must be able to “absorb” a variety of disturbances and keep the process in a good operating region
  - Feed composition upsets, temporary loss of utilities (e.g., steam supply), day to night variation in the process



Product Specification

- Quality
  - Products with reduced variability

    For many cases, reduced variability products are in high demand and have high value added (e.g. feedstocks for polymers)



- Product certification procedures (e.g., ISO 9000) are used to guarantee product quality and place a large emphasis on process control

Environmental Regulation

- Various government laws may specify that the temperatures, concentrations of chemicals, and flow rates of the effluents from a process be within certain limit

  Examples:

  – Regulations on the amounts of SO_2 that a process can eject to the atmosphere, and on the quality of water returned to a river or a lake

Operational Constraint

- All real process have constrained inherent to their operation which should be satisfied throughout the operation

  Examples:

  – Tank should not overflow or go dry
  – Distillation column should not be flooded
  – Catalytic reactor temperature should not exceed an upper limit since the catalyst will be destroyed

Efficiency

- The operation of a process should be as economical as possible in utilization of raw material, energy and capital



Maximizing the Profit of a Plant (1)

- The operation of a process may many times involves controlling against constraints
- The closer that you are able to operate to these constraints, the more profit you can make

  Example:

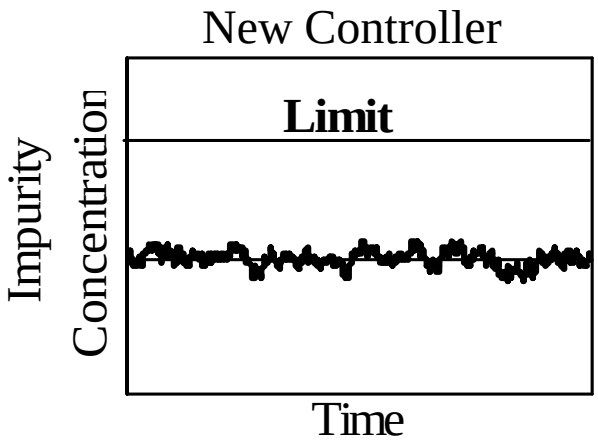
  – Maximizing the product production rate usually involving controlling the process against one or more process constraints

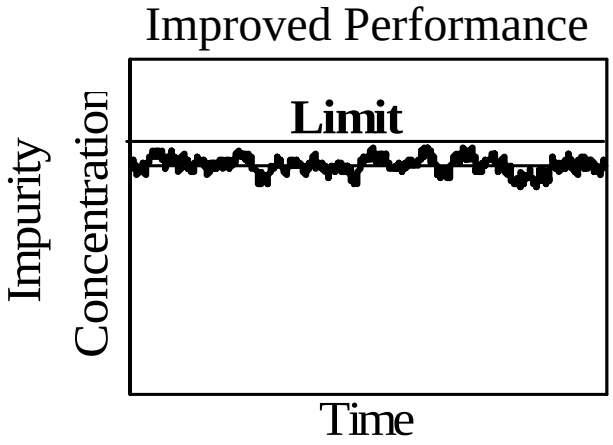


Maximizing the Profit of a Plant (2)

Constraint control example: A reactor temperature control

- At excessively high temperatures the reactor will experience a temperature runaway and explode
- But the higher the temperature the greater the product yield
- Therefore, better reactor temperature control allows safe operation at a higher reactor temperature and thus more profit





The History of Process Control

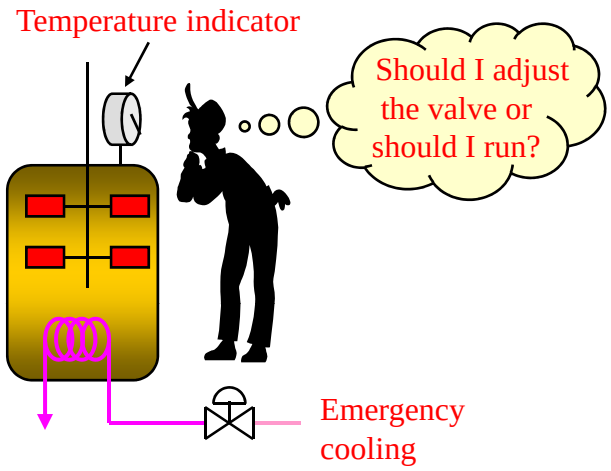
- **1960s** Pneumatic analog instrumentation, controllers, and computing modules
- **1970s** Electronic analog instrumentation, controllers, and computing modules
  - Direct digital control with special algorithms programmed in main frame computer
- **1980s** Electronic analog instrumentation and digital distributed control systems (DCS)
  - Supervisory and model predictive control configured in special purpose computers
- **1990s** Smart analog instrumentation, valves, and digital distributed control systems
  - Supervisory and model predictive control configured in special purpose computers
  - Neural networks, online diagnostics, and expert systems in special purpose computers
  - Real time optimization using model libraries in special purpose computers
- **2000s** Field bus based digital smart instrumentation, valves, and control systems
  - Digital bus takes full advantage of smartness and accuracy of instrumentation and valves
  - Some fast PID controllers such as flow and pressure go to the field transmitter or valve
  - Model predictive control, neural networks, online diagnostics, and expert systems are integrated into the graphically configurable field bus based control systems and move to PCs

Common Types of Control Strategy

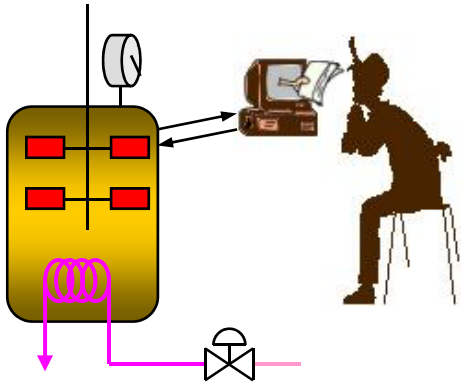
- Manual vs. Automatic
- Servo vs. Regulator
- Open-loop vs. Closed-loop
- Control strategies
  - Feedback Control
  - Feedforward Control
  - Cascade Control
- Single-Input Single-Output (SISO) vs. Multi-Input Multi-Output (MIMO, also known as multivariable)

Manual vs. Automatic

- Manual
  - Human has to adjust the MV to obtain the desired value of the PV based on observation and prior experiences



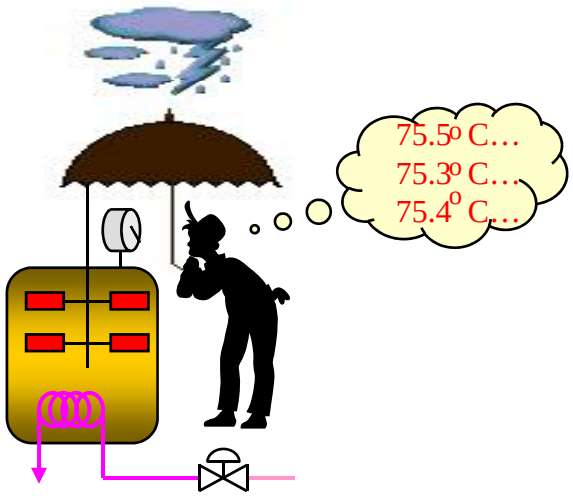
- Automatic
  - The computer (or other device) autonomously controls the process and may report status back to a operator



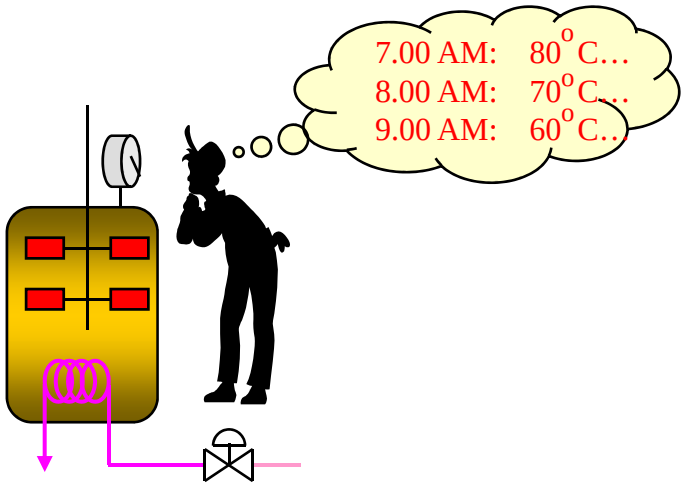
Question: Why manual override has to be included in every automatic control systems?

Regulator vs. Servo

- Regulatory control
  - Follow constant setpoint, overcoming the disturbance



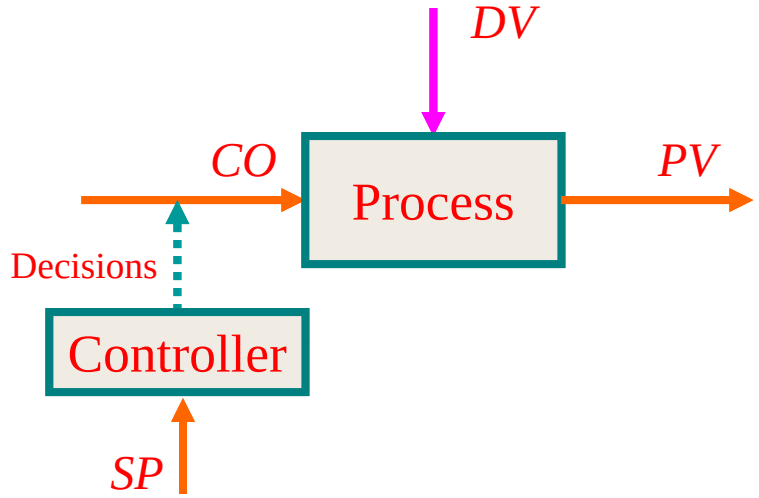
- Servo control
  - Follow the changing setpoint



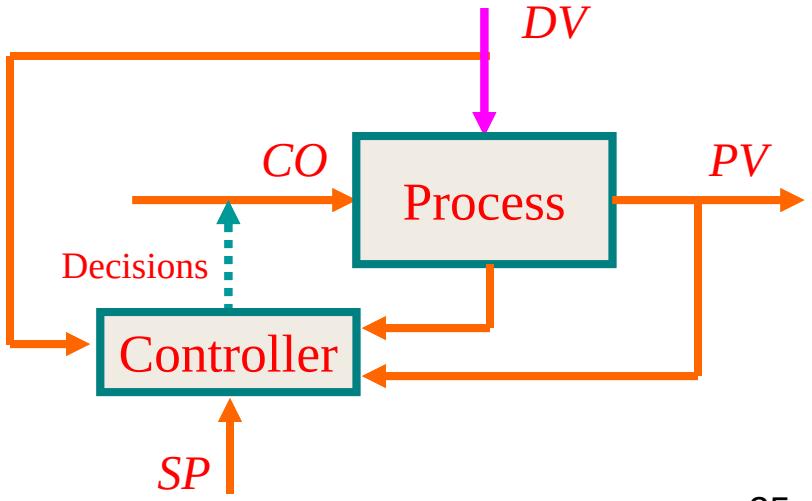
Open-loop vs. Closed-loop

- Open-loop
  - Process is controlled based on predetermined scenario

    Ex.: When food is done in an oven, timers on outdoor lights

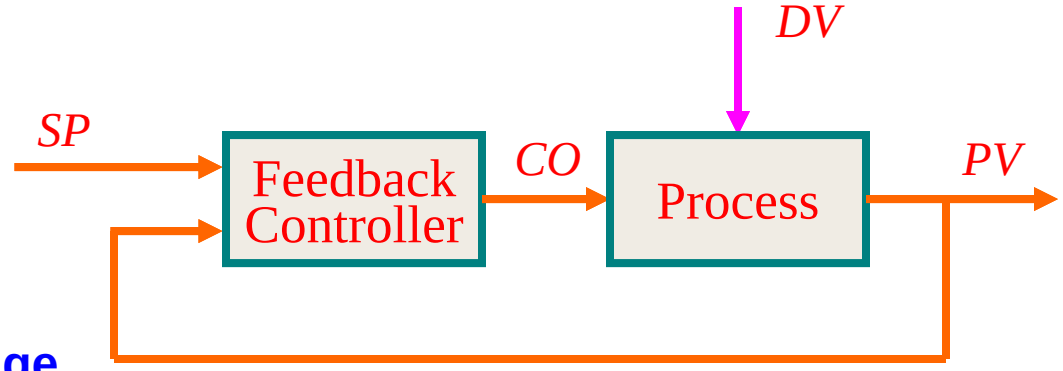


- Closed-loop
  - The information from sensor is used to adjust the MV to obtain the desired value of the PV



Control Strategies (1)

- Feedback Control
  - Corrective action based on process variable (PV)



Advantage

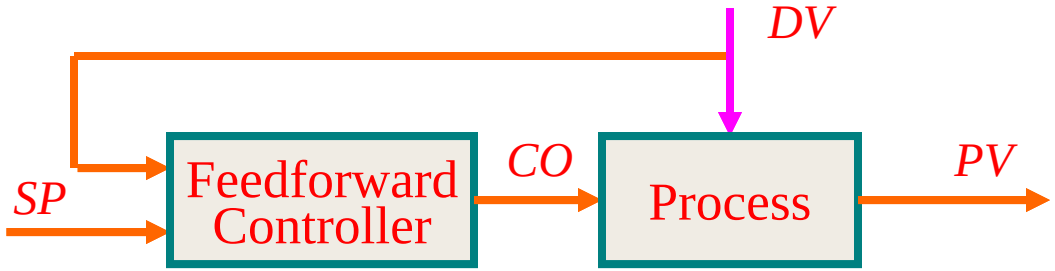
Requires no knowledge of the source or nature of disturbances, and minimal detailed information about how the process itself works

Disadvantage

Controller takes some corrective actions after some changes occurs in process variable PV

Control Strategies (2)

- Feedforward Control
  - Based on the measurement of disturbance (DV) → feedforward controller can respond even before any changes occurs in PV



Advantage

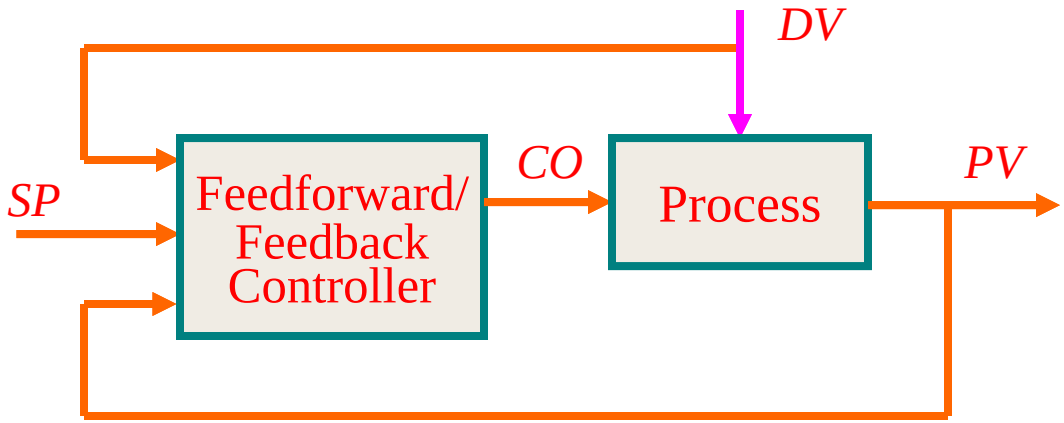
Controller takes some corrective actions before the process output is different from the setpoint → theoretically, perfect disturbance rejection is possible!

Disadvantage

- Requires process model which can predict the effect of disturbance on PV
- If there are some modeling error, feedforward control action will be erroneous (no corrective action)
- Feedforward controller can be quite complex

Control Strategies (3)

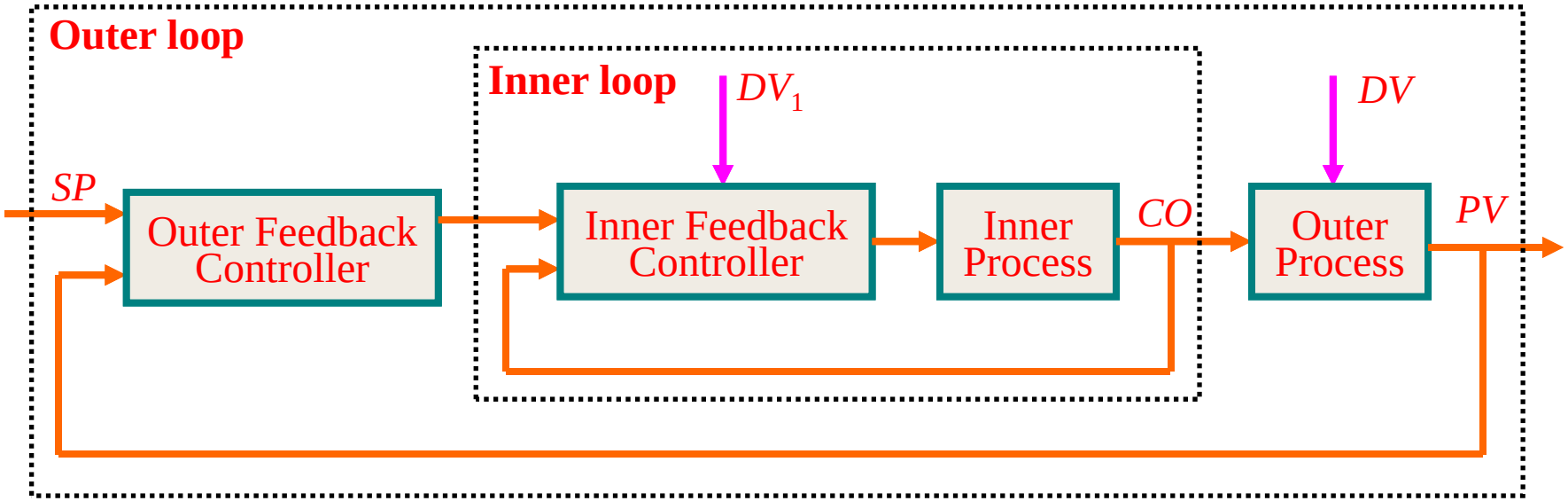
- Feedback/Feedforward Control
  - Feedforward controller will adjust CO as soon as the DV is detected
  - If the feedforward action is not enough due to model error, measurement error and etc., feedback controller will compensate the difference



Control Strategies (4)

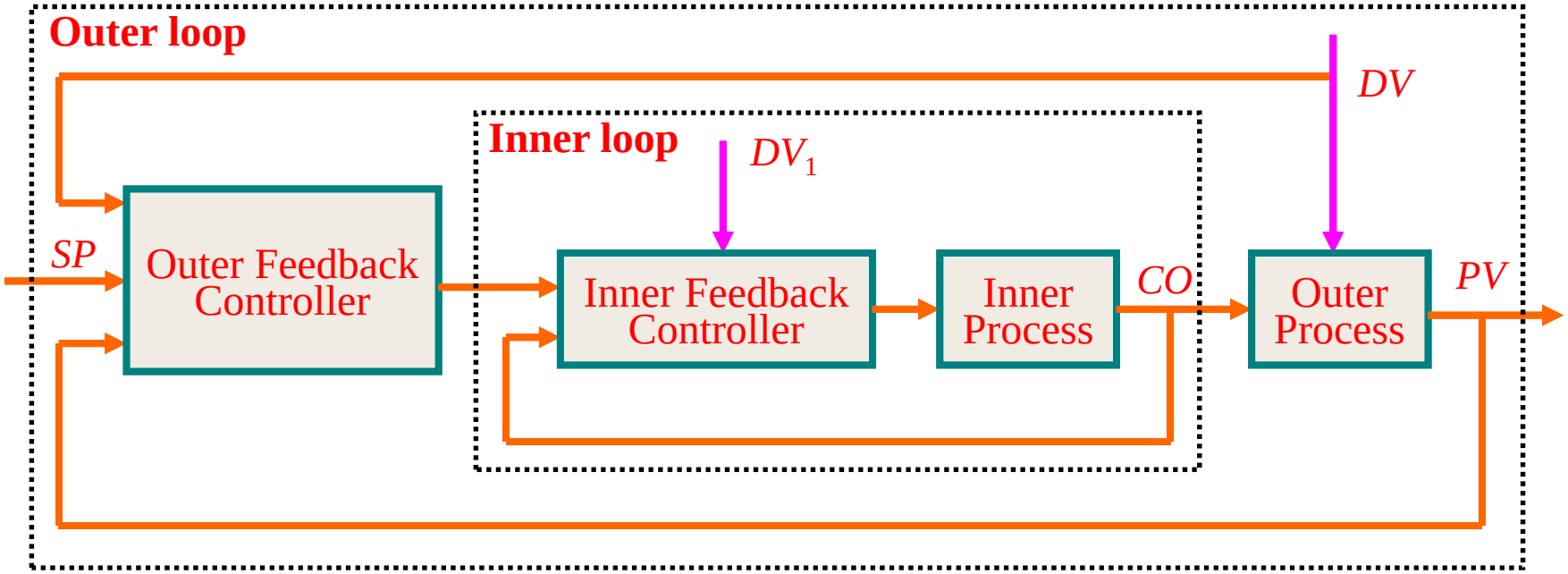
- Cascade Control
  - The disturbance DV1 arising within the inner loop are corrected by the inner controller before it can affects the PV of the outer one

    Example: Control valve + positioner



Control Strategies (5)

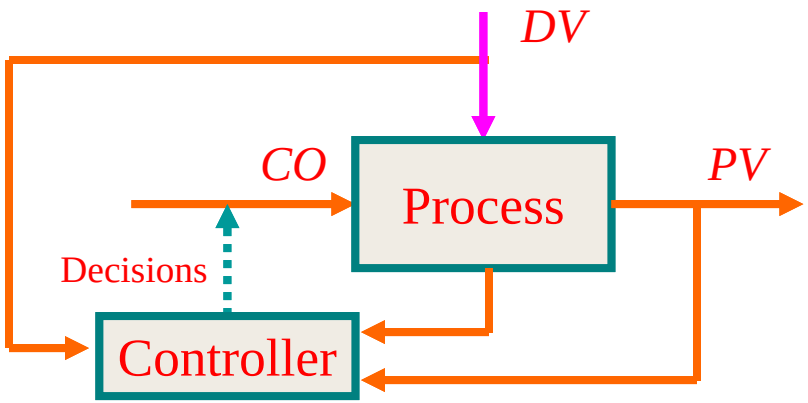
- Feedback/Feedforward + Cascade Control



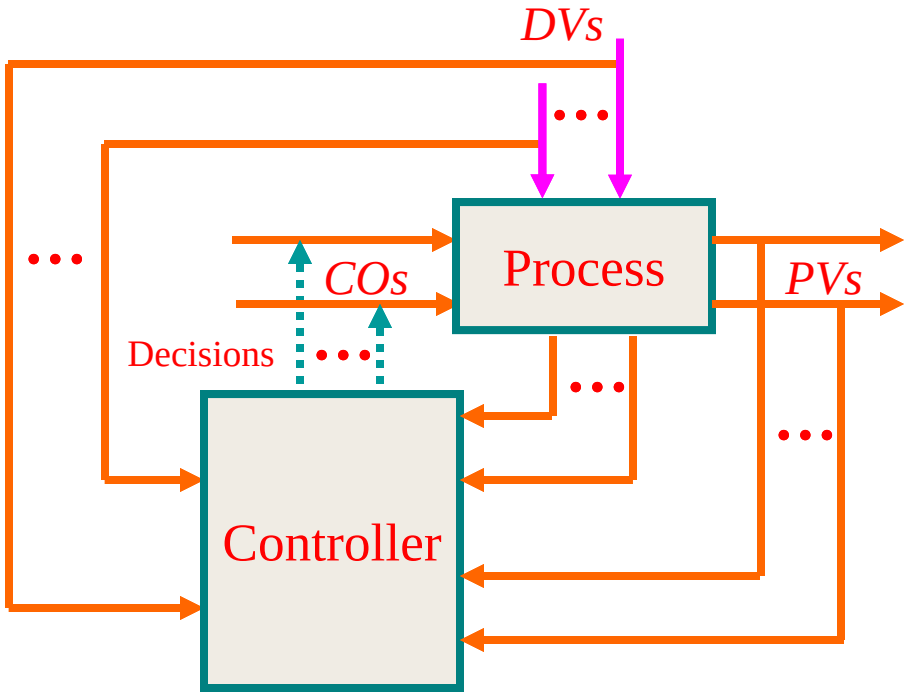
SISO vs. MIMO

- Based on how many *PV* and *MV* we have in a process

SISO



MIMO



Performances of Process Control System

- Closeness to setpoint[1]
- Short transient to one setpoint to other setpoint new [2]
- Smaller overshoot and less oscillation new [2]
- Smooth and minimum changes of variable manipulation new [1, 2]
- Minimum usage of raw materials and energy[1, 2]

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[1] Regulator

[2] Servo

Istilah-istilah (II)

- Manual control
- Automatic control
- Open-loop control
- Closed-loop control
- Feedback control
- Feedforward control
- Cascade control

- Servo control
- Regulatory control
- SISO control
- MIMO control
- Transient response
- Overshoot
- Oscillation

Ringkasan

- Control has to do with adjusting manipulated variables of the process to maintain controlled variables at desired values
- All control loops have a controller, an actuator, a process, and a sensor/transmitter
- Various controller strategies can be realized to achieve desired process objectives & product specifications