Practical Advanced Process Control & Dynamic Simulation, Selected slides from chapters (29 out of 137 slides)

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LEVEL OBJECTIVE

4B Global Optimisation

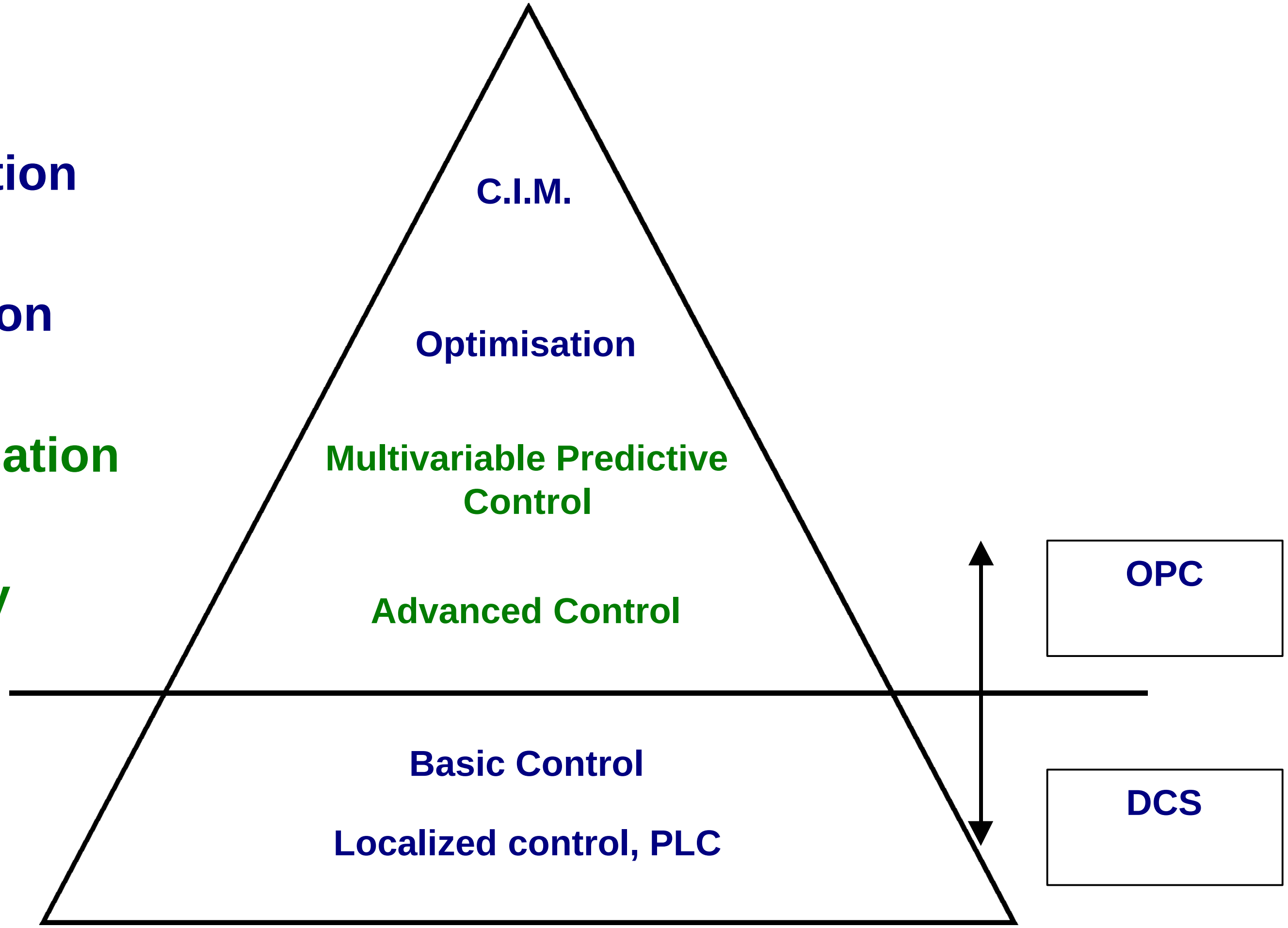
4A Local Optimisation

3B Quality / Optimisation

3A Stability / Quality

2 Stability / Safety

1 Stability / Safety



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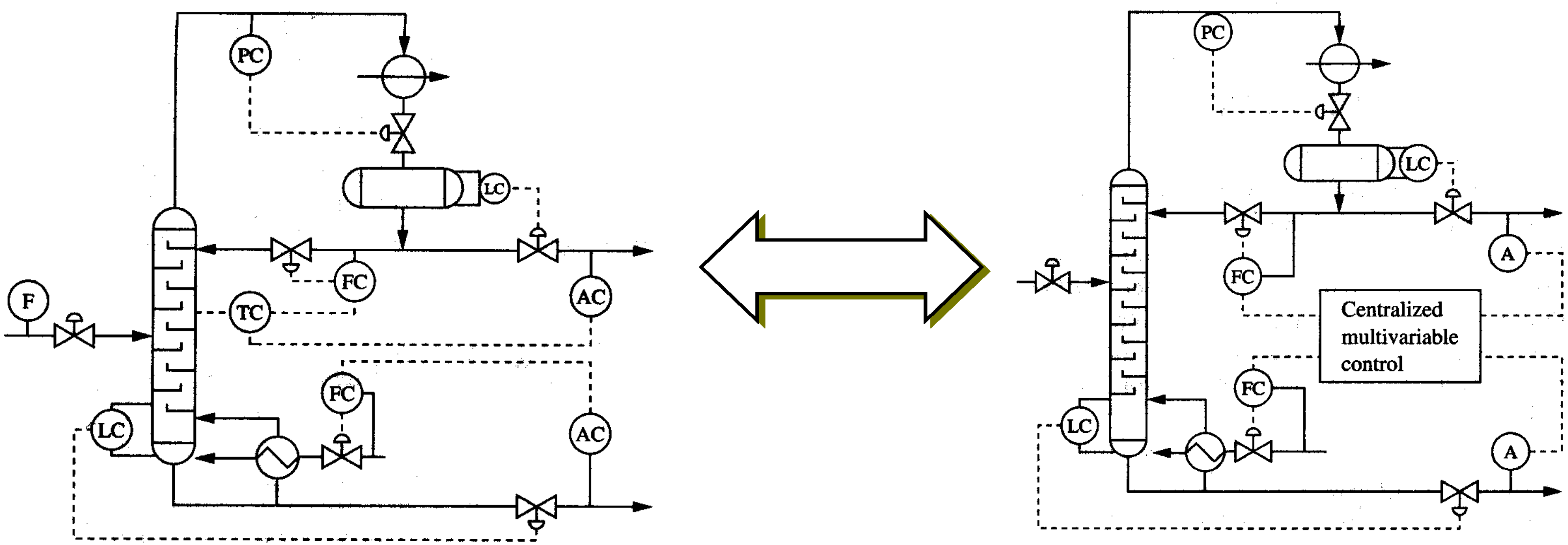
Classical Advanced Process Control / Predictive Control



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Classical Advanced Process Control

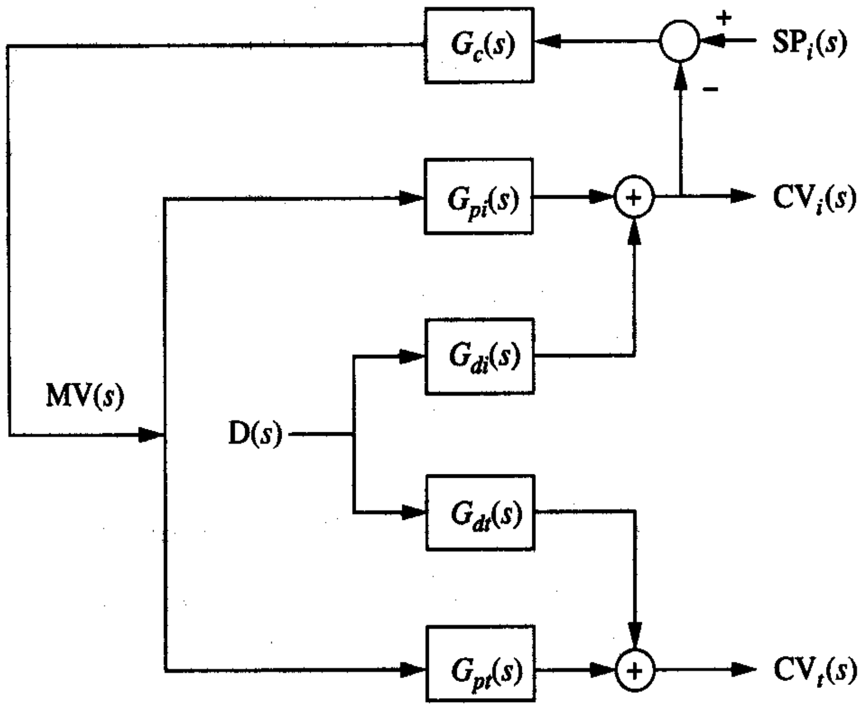
Techniques, Inferential Control

Sub index *i* corresponds to inferred variable and *t* corresponds to true variable

$$CV_t(s) = G_{dt}(s)D(s) + G_{pt}(s)MV(s) \qquad CV_t(s) = G_{dt}(s)D(s) - \frac{G_{pt}(s)G_c(s)G_{di}(s)}{1+G_{pi}(s)G_c(s)}D(s)$$

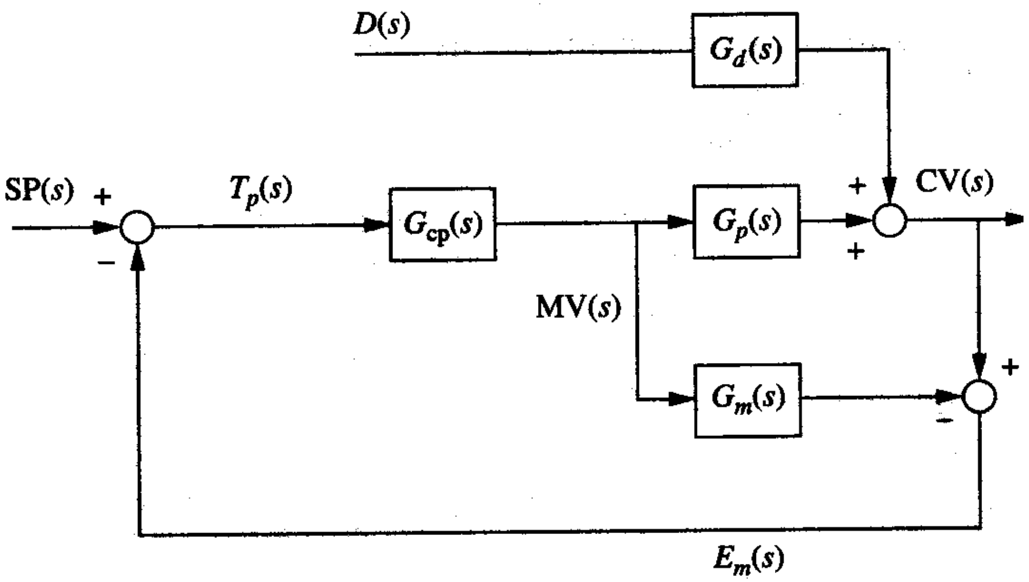
To maintain a zero state state deviation, the true and the infer variable should converge, thus it can be demonstrated that

$$\frac{K_{dt}}{K_{pt}} = \frac{K_{di}}{K_{pi}}$$



Techniques, Dead Time Compensation, Model Based Control

- Any predictive control algorithm has a feedback part processing and a process model part as shown



$$\frac{\mathrm{CV}(s)}{\mathrm{SP}(s)} = \frac{G_{\mathrm{cp}}(s)G_v(s)G'_p(s)}{1 + G_{\mathrm{cp}}(s)[G_v(s)G'_p(s)G_s(s) - G_m(s)]}$$

$$\approx \frac{G_{\mathrm{cp}}(s)G_p(s)}{1 + G_{\mathrm{cp}}(s)[G_p(s) - G_m(s)]}$$

$$\frac{\mathrm{CV}(s)}{D(s)} = \frac{[1 - G_{\mathrm{cp}}(s)G_m(s)]G_d(s)}{1 + G_{\mathrm{cp}}(s)[G_v(s)G'_p(s)G_s(s) - G_m(s)]}$$

$$\approx \frac{[1 - G_{\mathrm{cp}}(s)G_m(s)]G_d(s)}{1 + G_{\mathrm{cp}}(s)[G_p(s) - G_m(s)]}$$

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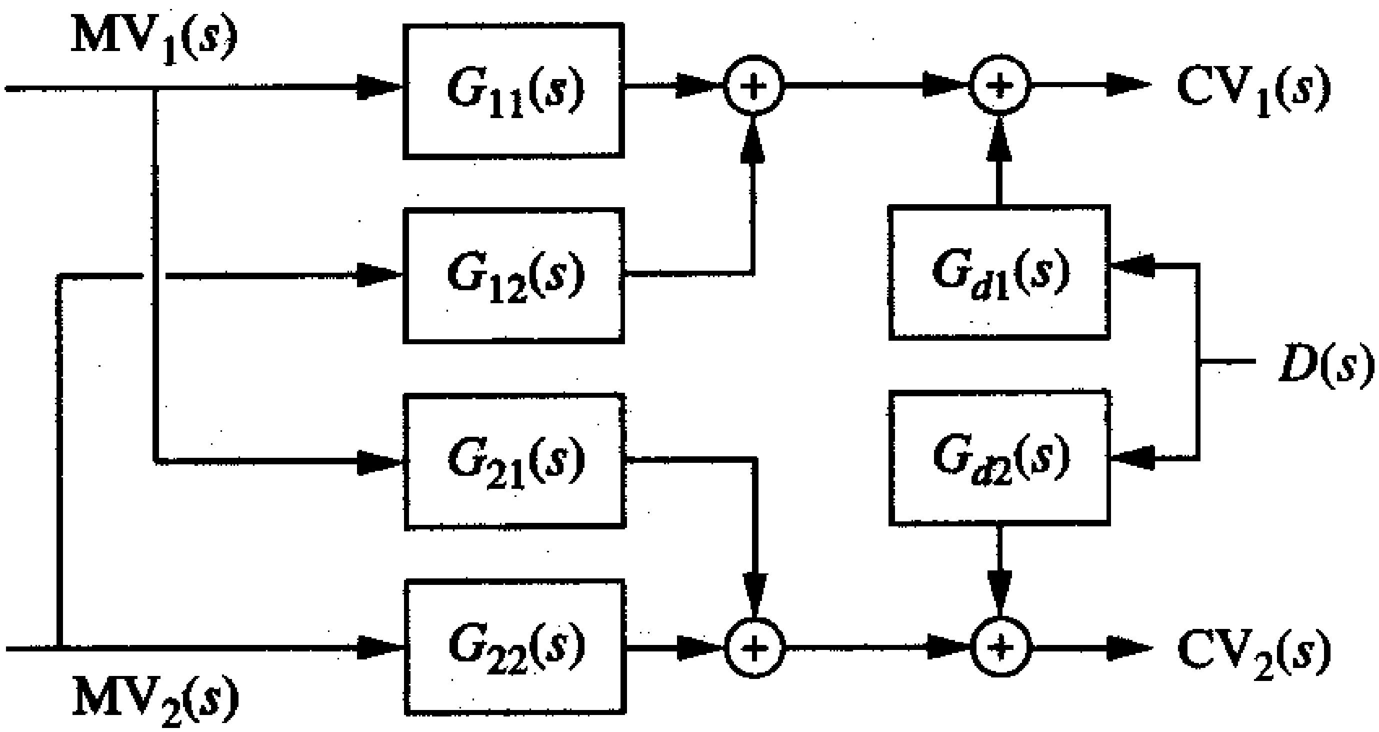
Interaction, Variable Coupling

Interaction, Variable Coupling, analytical example

In terms of block diagrams

$$\begin{bmatrix} CV_1(s) \\ CV_2(s) \end{bmatrix} = \begin{bmatrix} G_{11}(s) & G_{12}(s) \\ G_{21}(s) & G_{22}(s) \end{bmatrix} \begin{bmatrix} MV_1(s) \\ MV_2(s) \end{bmatrix} + \begin{bmatrix} G_{d1}(s) \\ G_{d2}(s) \end{bmatrix} D(s)$$



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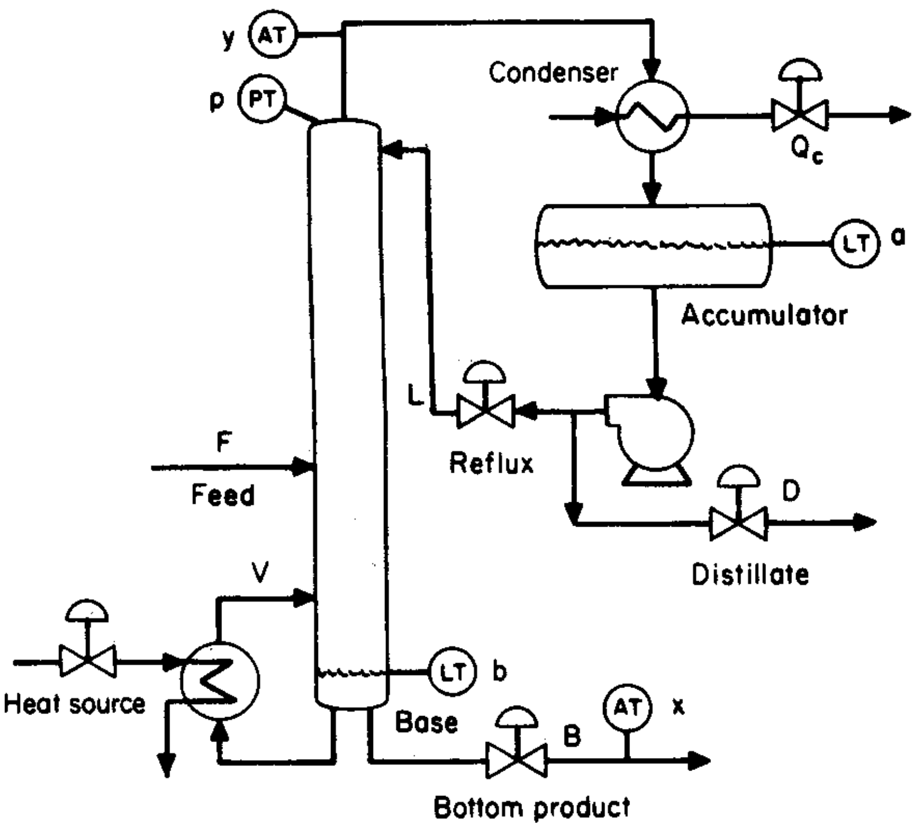
Distillation Advanced Control

Distillation Advanced Control, RGA



$$\lambda_{yD} = \frac{\left.\dfrac{\partial y}{\partial D}\right|_{V,\ L,\ B,\ Q_C}}{\left.\dfrac{\partial y}{\partial D}\right|_{x,\ a,\ b,\ p}}$$

c (controlled), m (manipulated)

c \ m	D	V	L	B	Q_C
Comp. y	0			0	
Comp. x	0			0	
Level a	1			0	
Level b	0			1	
Press. p	0			0	

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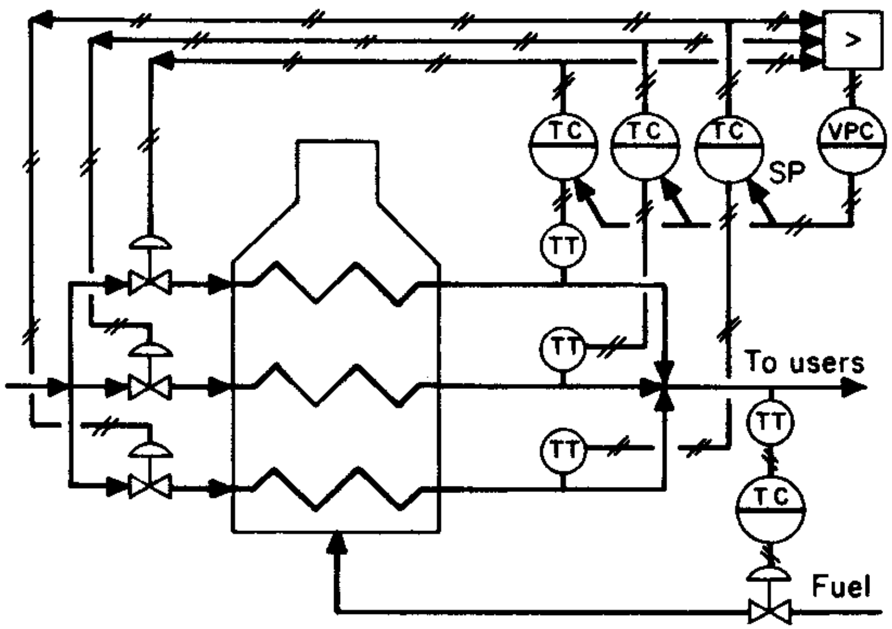
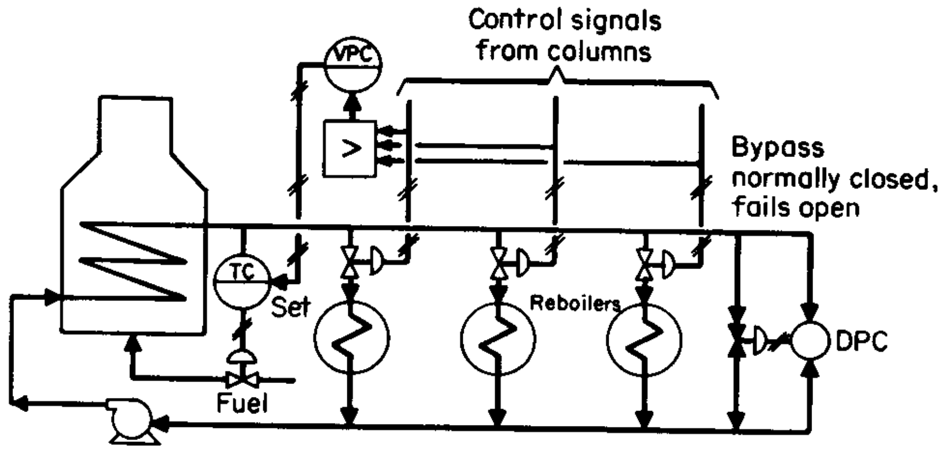
Furnace Advanced Control

Furnace Advanced Control, Furnace Pass Balancing





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“Advanced” Advanced Process Control

- What are we referring as “Advanced”?
- Process Models
  - Mechanistic models.
  - Black box models.
  - Qualitative models.
  - Statistical models.
- Model based modern automatic control
- Higher level operations
  - Process Optimization.
  - Process Monitoring.
  - Fault Detection, Location and Diagnosis.
  - Process Supervision via Artificial Intelligence Techniques

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Multivariable Predictive Controller

- A relative new way to copy the controller design
- Basic concept is that if we know who a CV variable is relate to a MV it should be a way to modify MV to move CV in a predicted way. This is why this technique is known as MPC
- MPC has being reinforce in Industry, but it has roots from Propoi (moving horizont controller, 1963), Lee and Marcus (1967)
- First application description, Richalet et al. (MPHC, IDCOM, 1976)
- Independently at Shell Oil, Cutler and Ramaker (DMC, 1979)
- DMC and IDCOM are first technology of MPC

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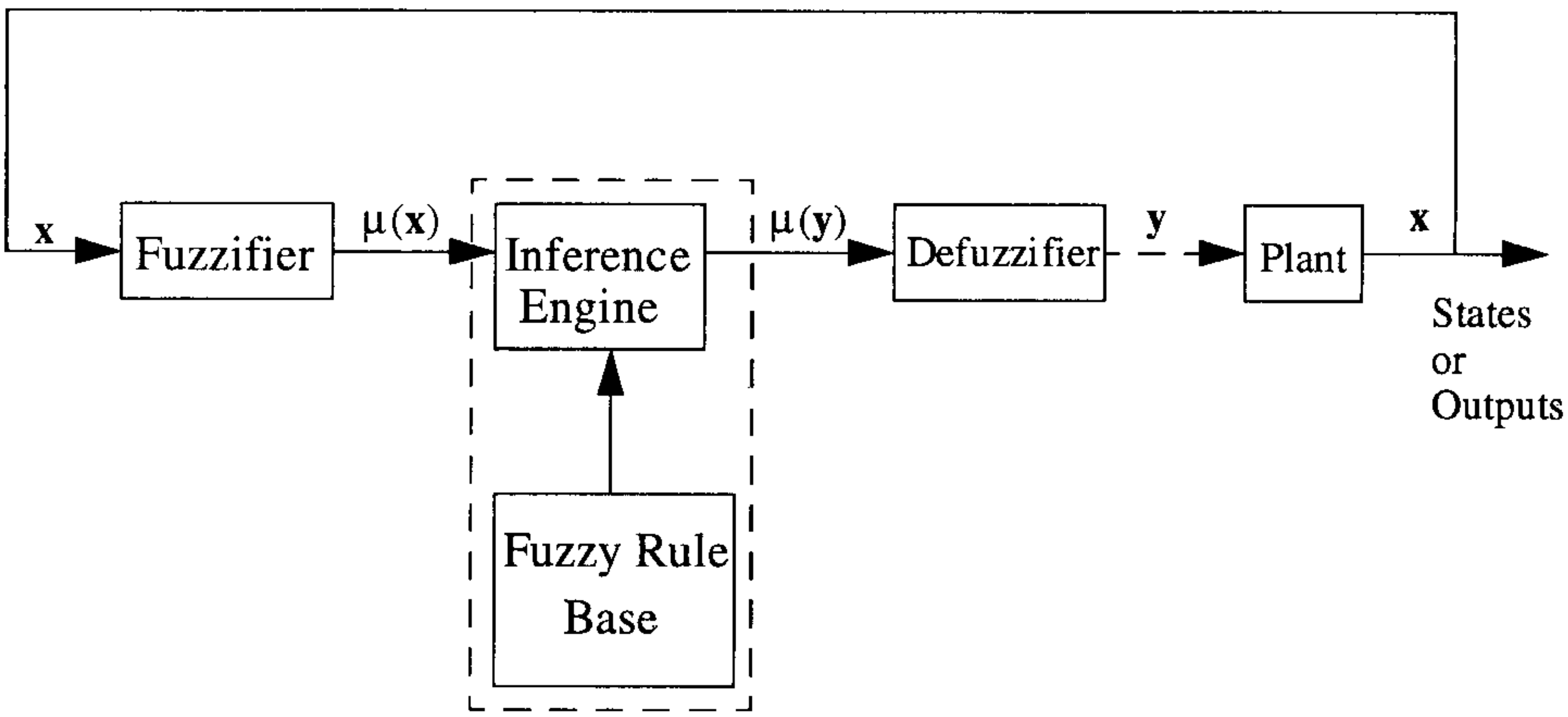
FUZZY LOGIC



Basic architecture of a fuzzy logic controller (FLC).

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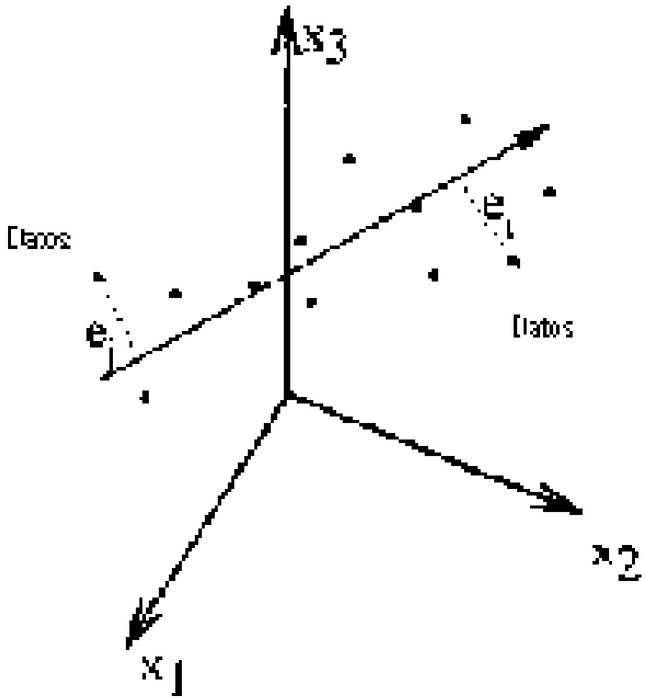
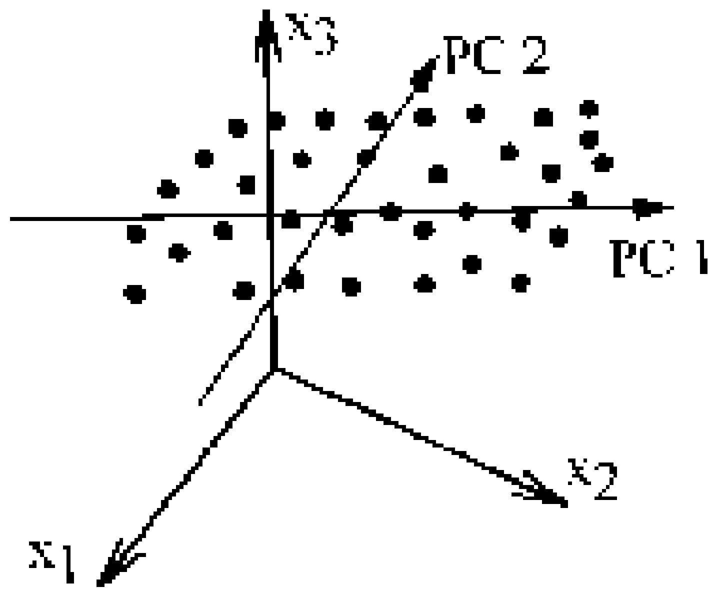
Multivariate Calibration Techniques

- PCA





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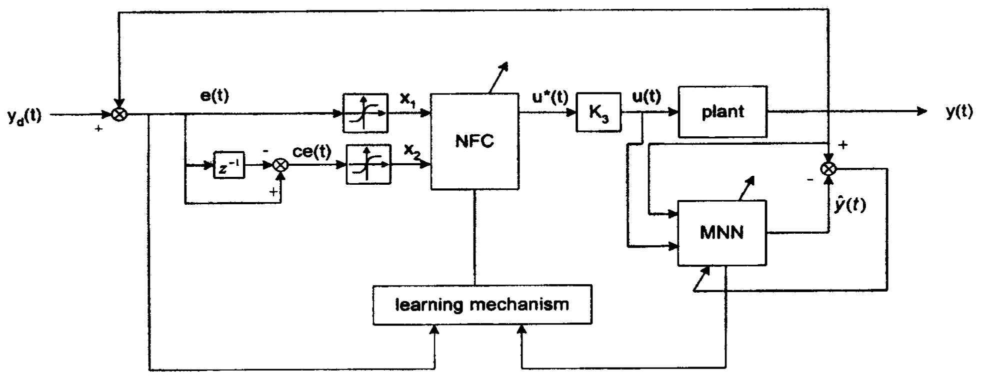
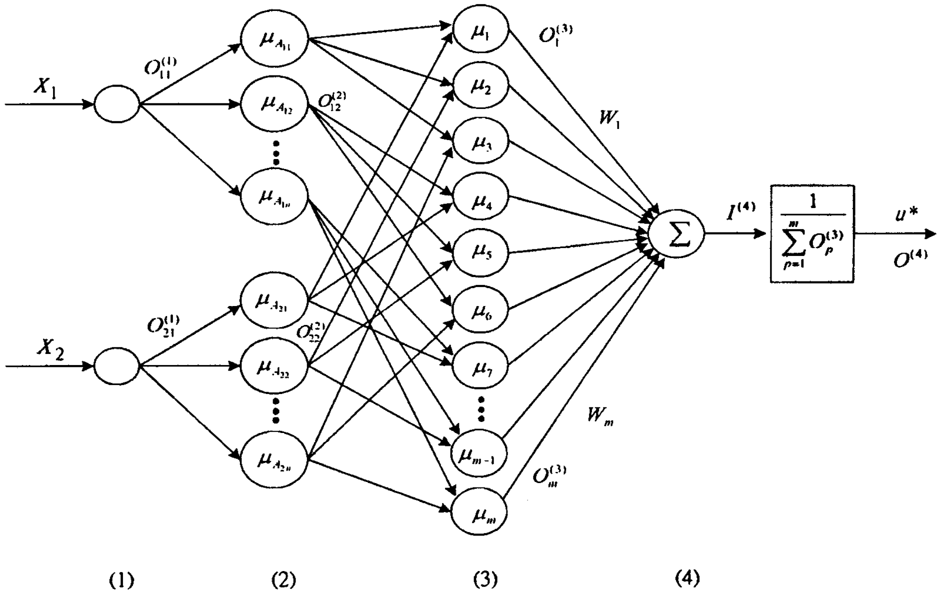
Artificial Neural Networks

Intelligent process control: neural fuzzy techniques.

C.-T. Chen, S.-T. Peng / Journal of Process Control 9 (1999) 493–503



The schematic diagram of the proposed neural fuzzy control system.



The structure of the proposed neural fuzzy controller.

Expert Systems

- Based on Rules, Facts and an inference engine
- Rule, element that show a cause-effect relationship
- Fact, specific state of a variable
- Inference engine, the technique to efficiently evaluate Rules against Facts
- Rules generates facts that give opportunities to new rule evaluation
- Execution is not sequential as in any conventional If-then procedures
- Several algorithm can process thousands of rules per second (RETE)

- Operator Advisory Systems
- Alarm Monitoring
- Scheduling
- Start Up and Shutdown procedures

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Optimization

- Above Advanced Control, it sets the most optimum CV for the process plant to achieve maximum economy
- Degrees of freedom
- Process Models
  - Rigorous steady state modeling
  - Simplified process models
  - Statistical Regression techniques
- Data availability
- Reconciliate and back reconciliate process data
- Steady state Optimization cycles, detection
- On line versus OFF line Optimization

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