Advanced Fault Detection in Condition Monitoring: Combining Model-Based and Data-Driven Approaches

Part 4

Neural Networks for Fault Diagnosis

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References

Textbook (*suggested*)

• *Neural Networks for Identification, Prediction, and Control*, by Duc Truong Pham and Xing Liu. Springer Verlag; (December 1995). ISBN: 3540199594

• *Nonlinear Identification and Control: A Neural Network Approach*, by G. P. Liu. Springer Verlag; (October 2001). ISBN: 1852333421.

•*Multi-Objective Optimization using Evolutionary Algorithms*, by Deb Kalyanmoy. John Wiley & Sons, Ltd, Chichester, England, 2001.

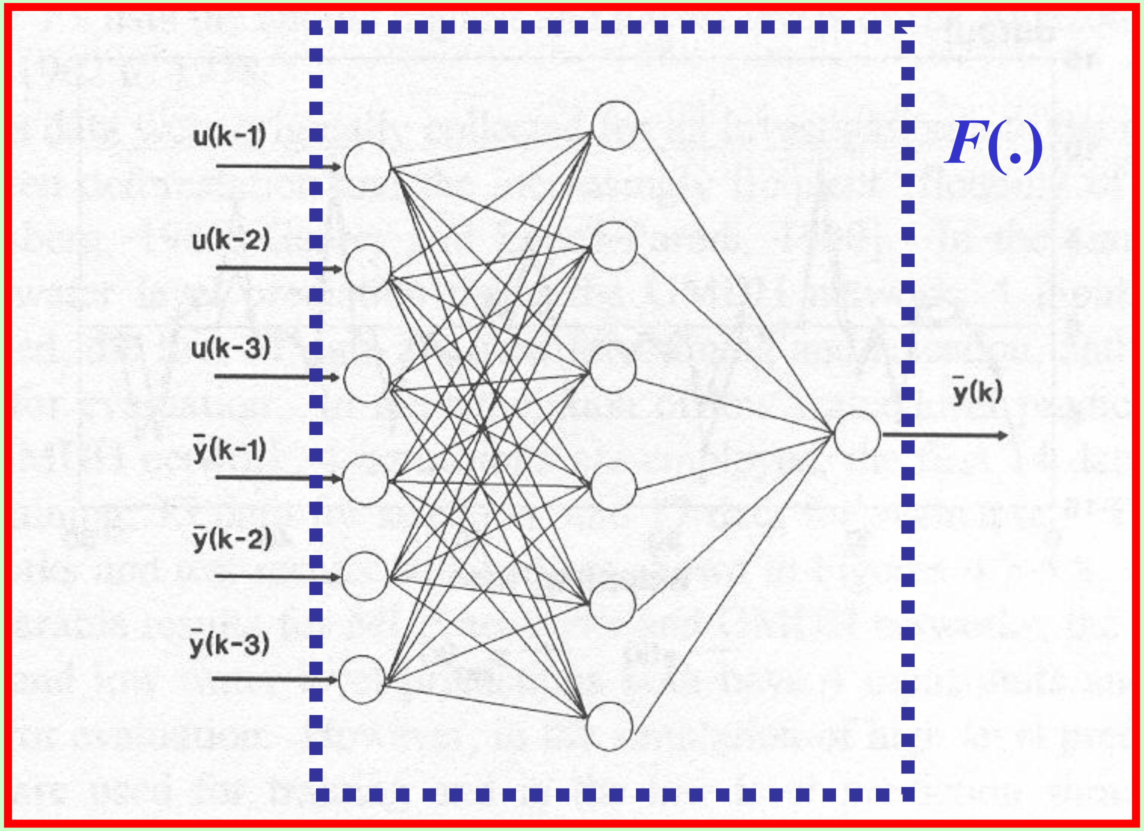
Application Examples

Neural Networks for

Fault Diagnosis of Nonlinear Processes

Nonlinear *Dynamic* System

- Take a static NN
- From static to dynamic NN
- "Quasi-static" NN
- Add inputs, outputs and delayed signals



$$\tilde{y}(k) = F\left(u(k-1), u(k-2), u(k-3), \tilde{y}(k-1), \tilde{y}(k-2), \tilde{y}(k-3)\right)$$

Example of Quasi-static NN with 3 delayed inputs and outputs

Nonlinear System Identification

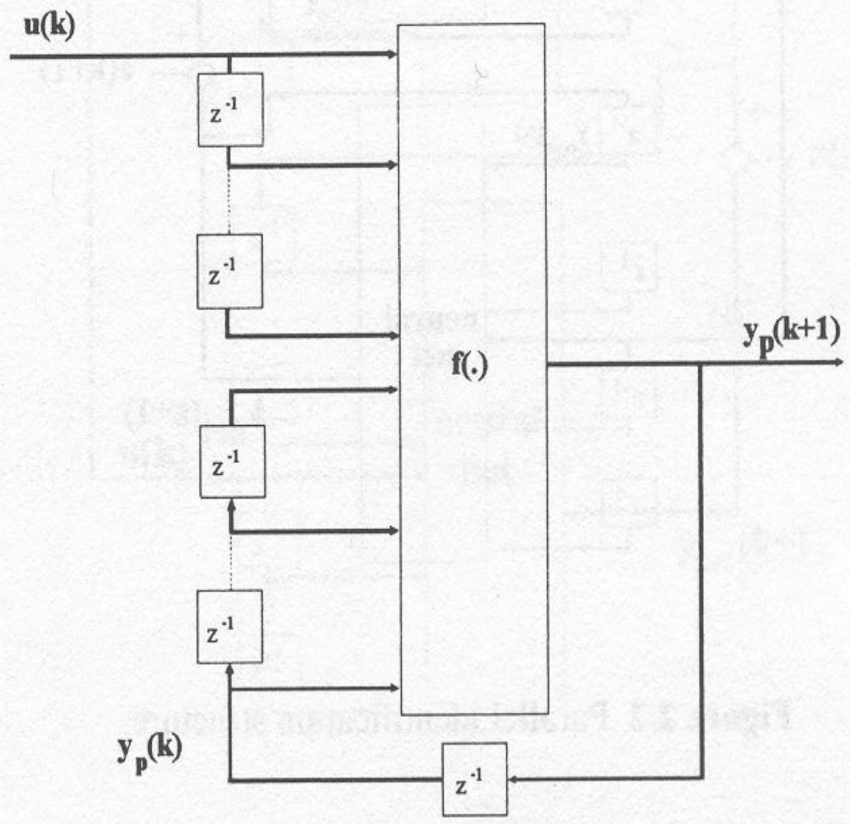


Figure 2.1 Input-output model

- f(.), unknown target function
- Nonlinear dynamic model
- Approximated via a quasi-static NN
- Nonlinear dynamic system identification
- Recall "*linear system identification*"

Nonlinear System Identification

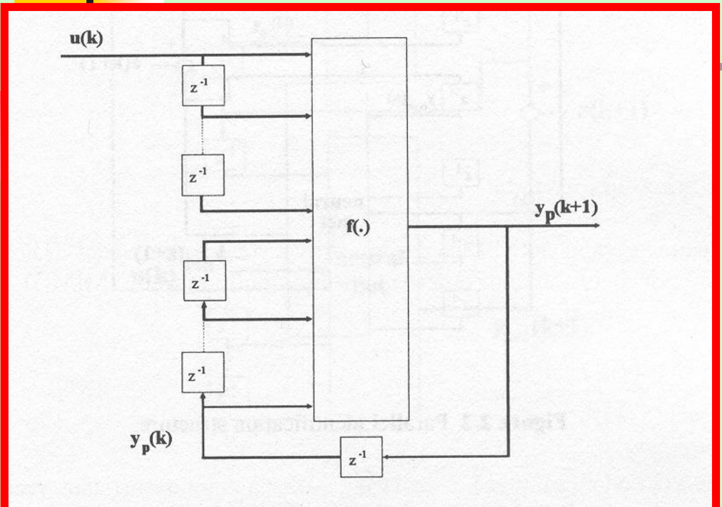
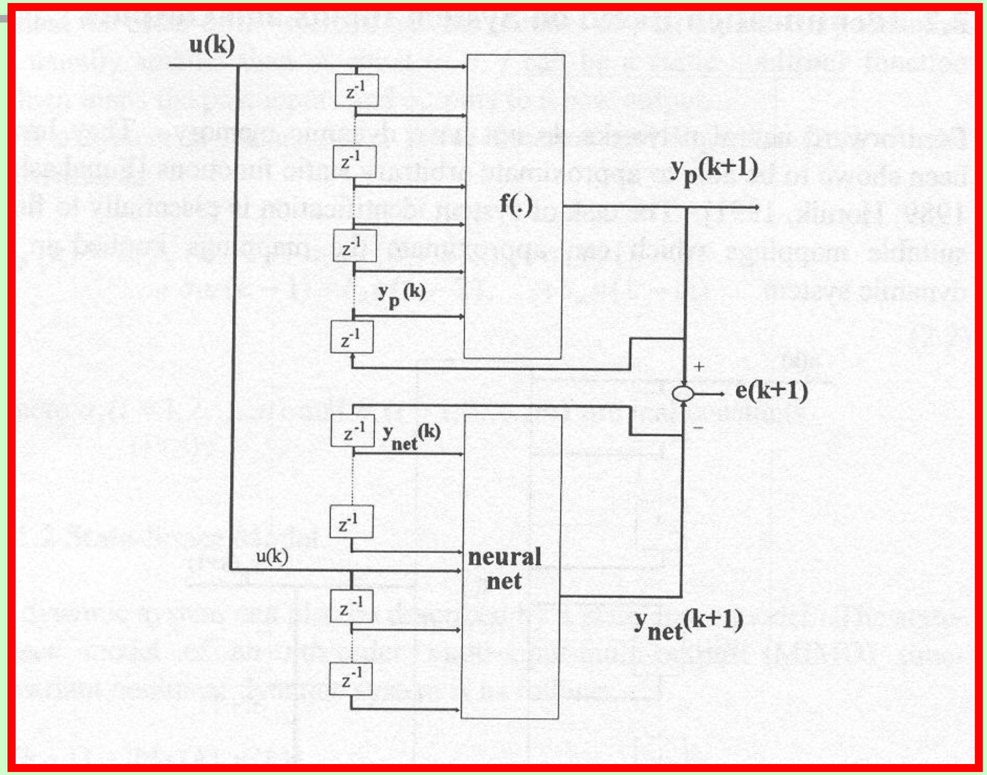
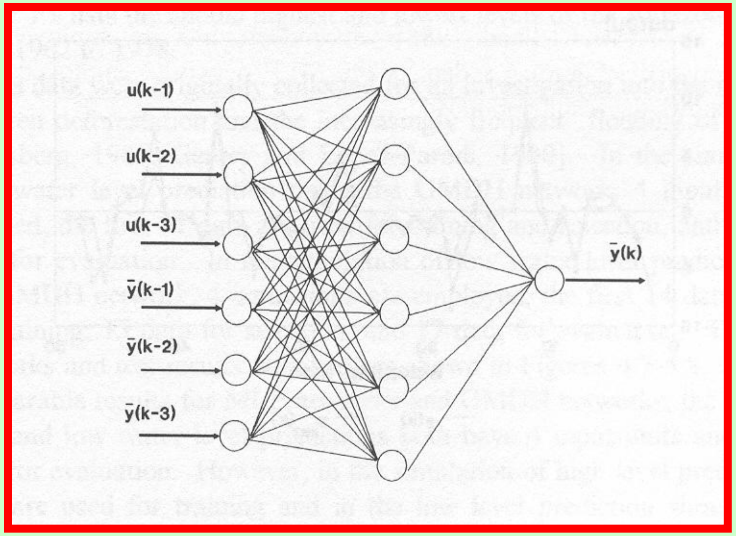


Figure 2.1 Input-output model



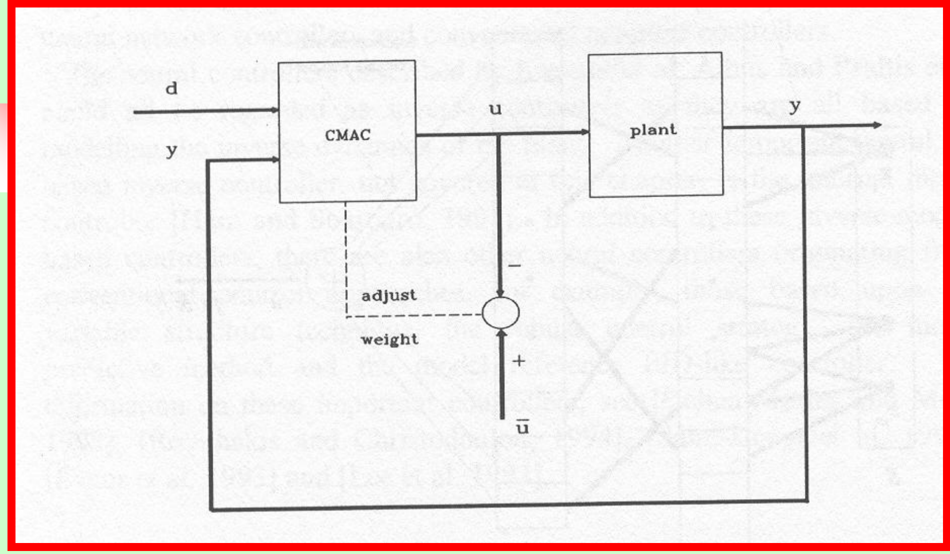


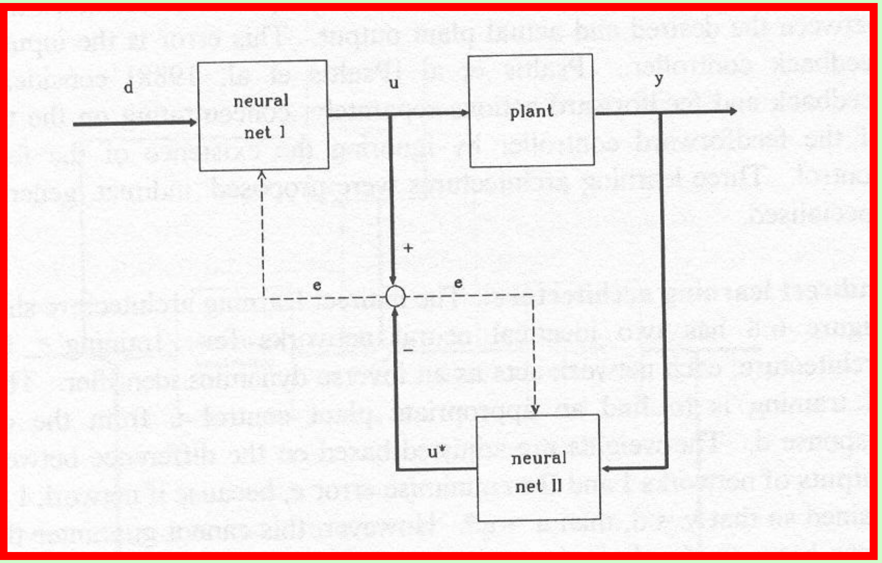
Target function: $y_p(k+1) = f(.)$

Identified function: $y_{NET}(k+1) = F(.)$

Estimation error: $e(k+1)$

Nonlinear System Neural Control





d: *reference/desired response*
y: *system output/desired output*
u: *system input/controller output*
ū: *desired controller input*
u^*: *NN output*
e: *controller/network error*

The goal of training is to find an appropriate plant control u from the desired response d. The weights are adjusted based on the difference between the outputs of the networks I & II to minimise e. If network I is trained so that y = d, then $u = u^*$. Networks act as inverse dynamics identifiers.