Hierarchical Control

Laboratory

Exercise 7. Identification of complex systems.

During the laboratory, students use the sensitivity analysis for gradient estimation of non-linear dynamic systems parameters. As examples of such systems, the Hammerstein and Wiener models are used.

Students are supposed to know:

- how to construct an extended model in order to find the gradient for the given performance index,
- how to construct the sensitivity model for a non-linear dynamic system given in a structural form.

Students should be also familiar with the basic knowledge about gradient optimization methods.

Hammerstein and Wiener models

Hammerstein and Wiener models are often used in identification of real, non-linear dynamic objects/processes. They consist of two, serially connected, parts: a static, non-linear one, and a dynamic linear one. The models differ in order of those two parts, as can be seen in the Fig. 1.

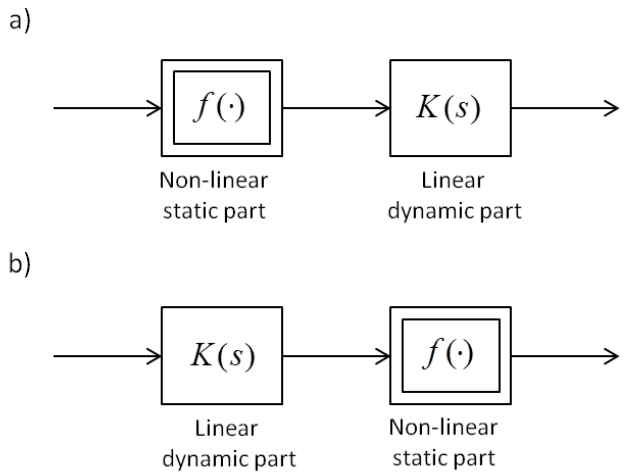

Fig 1. Hammerstein (a) and Wiener (b) models structure

The dynamic part can be either continuous (like in the Fig. 1) or discrete in time.

In order to identify the chosen model, it is necessary to identify parameters of both parts: the non-linear function $f(x)$ and the transfer function $K(s)$. When the only known values are the input and output signals, this task is not easy, since all the estimated parameters have to be found simultaneously (the tasks of each parameter estimation cannot be separated).

Plan of the laboratory exercise

1. Construct the extended model for the identification experiment scheme in the Fig. 2 and the following performance index:

$$J(t) = \frac{1}{2}e^2(t)$$

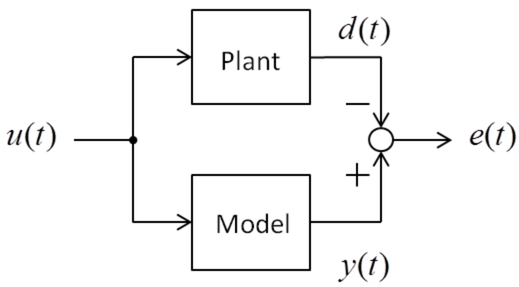

Fig. 2. Identification experiment scheme.

2. Construct the sensitivity models for all the estimated parameters.

3. Use the sensitivity models from the point 2 to generate the gradient of the performance index.

4. Implement the simple gradient descent minimizing algorithm that uses the gradients obtained in the point 3 to estimation (on-line adaptation) of the model's parameters.

5. Check the convergence of

    - the estimated parameters values to the values in the object,
    - model's output signal $y(t)$ to the object's output signal $d(t)$

    for various:

    - initial parameters of the model,
    - types and parameters (amplitude, frequency) of the input signal $u(t)$,
    - values of the learning coefficient in the gradient algorithm.