NOT PARAMETRIC IDENTIFICATION AND CONTROL WITH NEURAL NETWORK OF DYNAMIC SYSTEMS

Jan PĚNIČKA, Master Degree Programme (5)
Technical university of Liberec
E-mail: hop@volny.cz

Supervised by: Dr. Osvald Modrlák

ABSTRACT

Abstract: In this work we present an approach to the identification and control with uncertainty by using not parametric neural network identification and control. The base of the method is the NNARX neural network.

1 INTRODUCTION

We use the neural networks for their ability to learn of system dynamics from measured data. And also in cases when a system is non-linear this can be done. In next step we use obtained model in Nonlinear Predictive Controller to compute output prediction.

2 NEURAL NETWORKS

The neural network usually consists from several layers (usually two) and each layer is build up from server neurons. On Fig. 1 is show example of two layer neural network, two neurons in first layer and one neuron in second (output) layer.

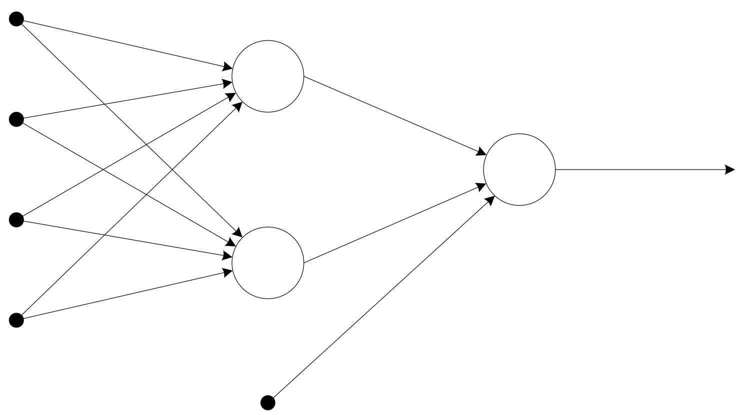

Fig. 1: *Feed forward neural network example*

Where output from network on Fig. 1 is given by

$$y = f\left(\sum_{i=1}^{2}\left[W_i \cdot f_i\left(\sum_{j=1}^{3}\left[w_{i,j} \cdot u_j\right] + w_{i,0}\right)\right] + W_0\right) \qquad (1)$$

where activation function f can take any form but most often it is monotonic. Hyperbolic tangent function can be used for example. Learning of network is done by adjusting weight $w_{i,j}$. Adjusting is done by minimization of criterion.

3 DYNAMIC SYSTEM

For experiments we use dynamic system on Fig. 2 which consists from DC motor and tachometer which are together connected with elastic clutch, which makes system strongly nonlinear. To conduct experiments on real system we use Simulink and real time toolbox from MATLAB.

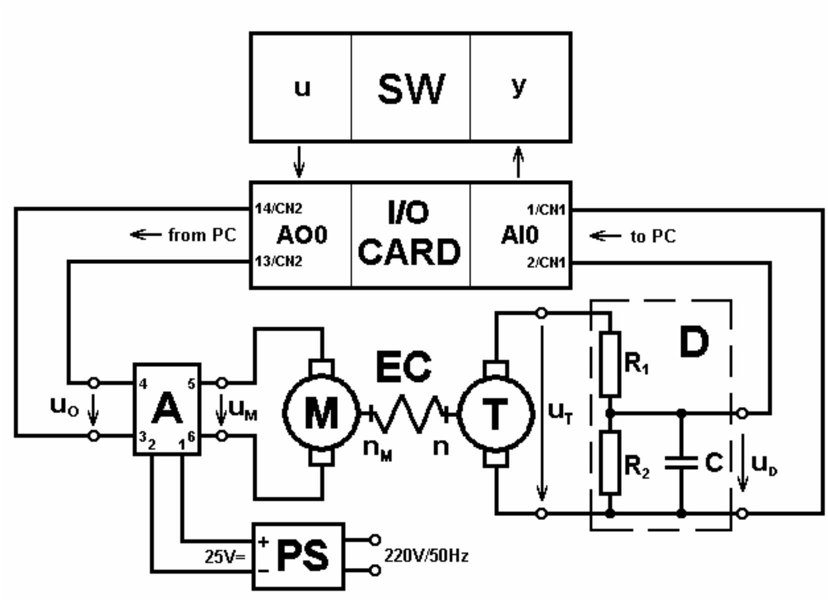

Fig. 2: *DC-motor with tachometer and an elastic clutch*

M	DC motor	$\mathbf{R_1}$	resistance 33kΩ	**u**	input
T	tachometer (dynamo)	$\mathbf{R_2}$	resistance 8kΩ	$\mathbf{u_o}$	output voltage from PC
EC	elastic clutch	**C**	capacitor of filer	$\mathbf{u_M}$	supply voltage of Motor
A	amplifying and power element			**I/O CARD**	PC-Lab Card in PC
$\mathbf{u_T}$	voltage of tachometer	**PS**	supply unit		
AO0	Analog Output of I/O card			$\mathbf{u_D}$	input voltage in PC
SW	PC and used software	**AI0**	Analog Input of I/O card	**y**	output of system

4 IDENTIFICATION AND CONTROL

For model we select NNARX structure which is shown on Fig. 3. To obtain model Levenberg-Marquardt minimization algorithm is used, which minimize differences between output from model and output from real system. Data for identification are obtained from experiment with real system.

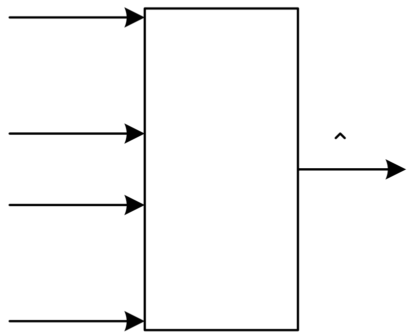

Fig. 3: *NNARX model structure*

The results of the suggested identification are shown in the Fig. 4. You can compare the dynamics of the NNARX model with the well-known model of BJ (Box-Jenkins). It is obvious that the NNARX model gives the best approximation of the dynamic behavior of the DC-motor system

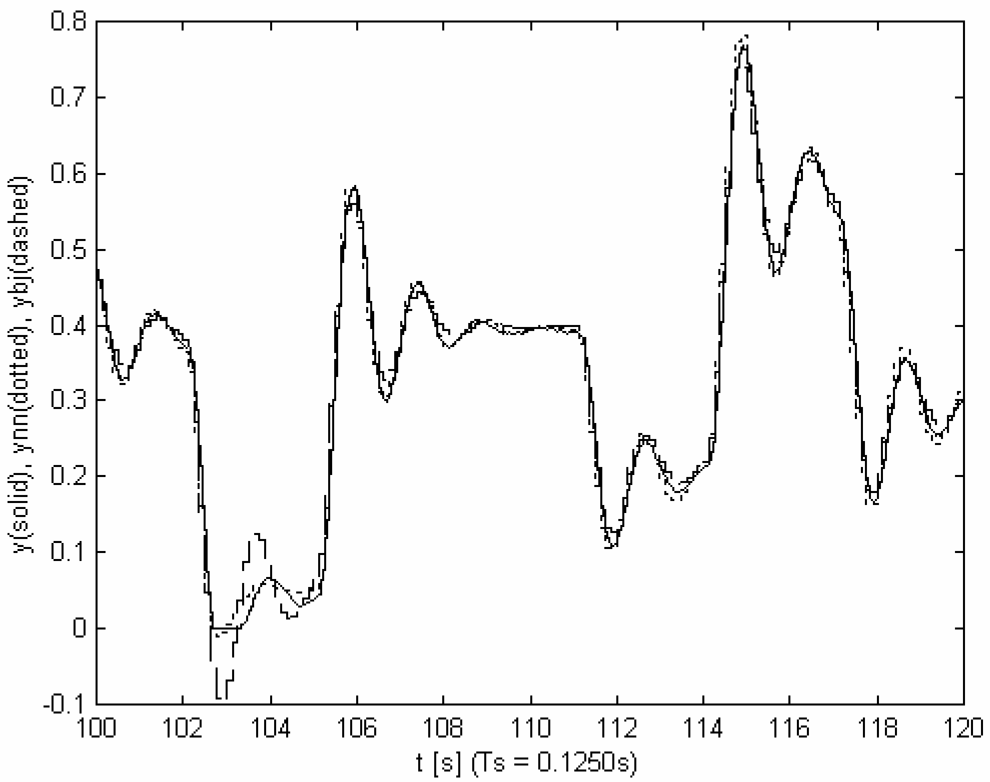

Fig. 4: *Model outputs of NNARX (ynn) and Box-Jenkins (ybj) compared to real data (y)*

5 CONTROL

For control of our dynamics system we use Nonlinear Predictive Controller (NPC) which internally uses our model of system (NNARX) to compute k-steps ahead of output from system. Control signal is computed from minimization of following criterion

$$J = \sum_{k=N1}^{N2} \left(w(t+k) - \hat{y}(t+k)\right)^2 + \rho \sum_{k=1}^{Nu} \left(u(t+k-1) - u(t+k-2)\right)^2 \qquad (2)$$

where $\hat{y}$ is prediction of output obtained from model which depends on control signal u. This minimization is done at each time sample.

Result of suggested control by Nonlinear Predictive Controller is shown on Fig. 5.

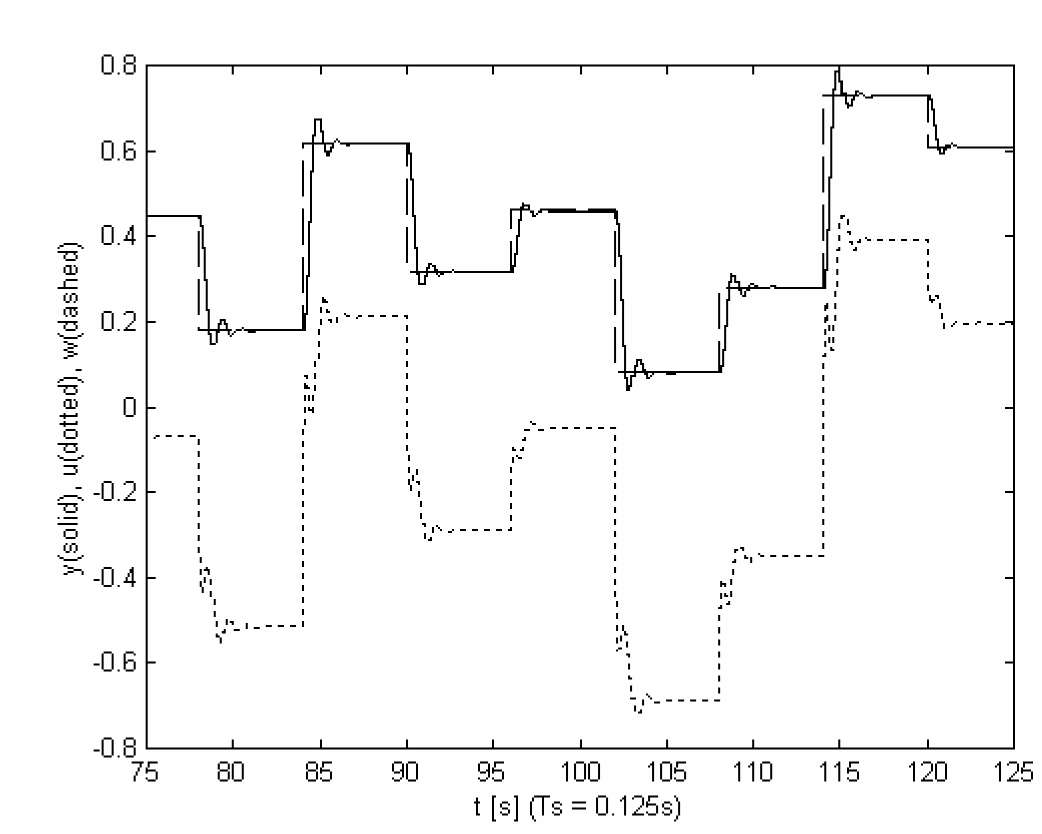

Fig. 5: *Control of system with NPC (request - w)*

6 CONCLUSIONS AND RESULTS

1) The not parametric identification of real systems with uncertainty offers very good dynamic behavior.
2) The approach shows the ability of very quickly adaptation to parameter changing.
3) The comparison with classic identification methods was made.
4) Disadvantage of the approach is that the computing methods are time consuming
5) Real time control in SIMULINK is possible.

REFERENCES

[1] Nørgaard M. et al. Neural networks for modeling and control of dynamic systems. London: Springer, 2000. ISBN 1-85233-227-1.

[2] Nørgaard M. et al. Home page for the Book: Neural networks for modeling and control of dynamic systems [on-line]. Available at URL: http://www.iau.dtu.dk/nnspringer.html (February 2003).