IMPROVING PERFORMANCE OF THE ON-LINE NEURAL NETWORK IDENTIFICATION USING SELECTION OF PATTERNS IN THE TRAINING SET

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ABSTRACT

The many identification algorithms based on the artificial neural networks is known. If the identification is running on-line the training set with the limited number of training patterns have to be created. This paper deals with on-line system identification for Self-Tuning controller construction. The problem of an increasing of training set during the on-line identification using the patter selection method is solved.

1. INTRODUCTION

As the system identification is performed on-line, the number of measurements is increasing continuously, and thus the training set for neural network is growing. The problem is that the size of the training set is limited [1, 3]. The problem of selection training patterns in each sampling step must be solved. We have next two main requirements for the training patterns:

- the most recent data,
- high level of diversity.

The first point is important for adaptability on changes of the system. The second point leads to increasing performance of neural network identification. If the standard way for creation of training set is used (FIFO stack) the requirement of age of training patterns is guaranteed. However the FIFO stack leads to the problem with diversity in the training set. For example when the input of the identified system isn't persistently excited then no new information about system dynamics is available. In these situations the new data represents mainly the noise of the sensor.

2. ON-LINE SYSTEM IDENTIFICATION USING NEURAL NETWORK

On-line identification algorithms are very widely used methods in many applications. For example on-line identification is the most important part of the Self-tuning controller [4]. In many applications the identification methods based on the artificial neural networks are used.

For computing the identified system output we can use the linear ARX model [2]

$$F_M = \frac{b_1 z^{-1} + b_2 z^{-1} + \ldots + b_{m-1} z^{-1} + b_m z^{-1}}{1 + a_1 z^{-1} + a_2 z^{-1} + \ldots + a_{n-1} z^{-1} + a_n z^{-1}} \tag{1}$$

where $a_1 \ldots a_m$ and $b_1 \ldots b_n$ are the model parameters.

The ARX model can be written in vector form as follows:

$$y(k) = \varphi^T(k)\phi(k), \tag{2}$$

where

$$\varphi(k) = \left[u(k-1)\ \ldots\ u(k-1-m) - y(k-1)\ \ldots\ -y(k-1-n)\right]^T \tag{3}$$

is the vector of measured inputs and outputs and

$$\theta(k) = \left[b_1(k)\ \ldots\ b_m(k)\ a_1(k)\ \ldots\ a_n(k)\right]^T \tag{4}$$

is the vector of estimated system parameters [2].

The training pattern that represents the behavior of identified system can be defined:

$$\upsilon(k) = [\varphi(k), y(k)] \tag{5}$$

Collection of all training patterns is called training set and could be written as follows:

$$M = \sum_{k=1}^{N} \upsilon(k) \tag{6}$$

where N is number of patterns in training set.

3. TRAINING SET

Training of the neural networks is performing with the all training patterns in the training set. As it was mention above the character of training data is very important for performance of training process. In [1] was developed algorithm for training pattern selection. This algorithm was improved using the time penalization [5]. The main idea is to eliminate the training pattern that is evaluated as useless for training. The algorithm can be described as follows:

- measure of the new pattern,
- computing distances between all patters,
- modification of distances in accordance to age of compared patterns,
- elimination of older pattern from two the nearest pattern
- replacement of eliminated pattern with the new one.

The distance between two patterns (input vectors of the neural network) can be computed using transformation R which transforms input vector φ to the new space:

$$\varphi' = R\varphi \, . \tag{7}$$

Then the distance between two vectors is defined as follows:

$$\left\|\varphi_i' - \varphi_j'\right\| = \left\|R\varphi_i - R\varphi_j\right\| = \left\|R\Delta\varphi\right\| = \sqrt{\Delta\varphi^T R^T R \Delta\varphi} \, , \tag{8}$$

where expression $R^T R$ is the transformation matrix. In the basic case it can be equal to the identity matrix. All distances between patterns are multiplied by variable γ defined as follows:

$$\gamma = e^{(1-\lambda)\max(t_1, t_2)} \, , \tag{9}$$

where t1 and t2 denote the age of two training patterns which are compared.

4. SIMULATION EXPERIMENS

Described algorithm for the construction of the Self-Tuning LQ controller was used [4, 6]. The set point was set to values [2, 4, -1, 2] and the number of training patterns was limited to 25. From the viewpoint of control the obtaining of control system output to the set-point is required. When the set-point is reached and the system is in the steady state no new information about system dynamics is available. For the identification, on the contrary, system excitation is required. If the system is excited than the training vectors are able to cover bigger part of the state space. If the mathematical model is 1st order, it is possible to paint training vectors in the two-dimensional chart. Figures 1 and 3 show training vectors after 200s of simulation. On the first figure one can see the comparison of coverage of space with the training vectors. Figure 2 shows the variance of training patterns during the control process. It is obvious that in case of standard FIFO stack are training data in the steady states practically identical.

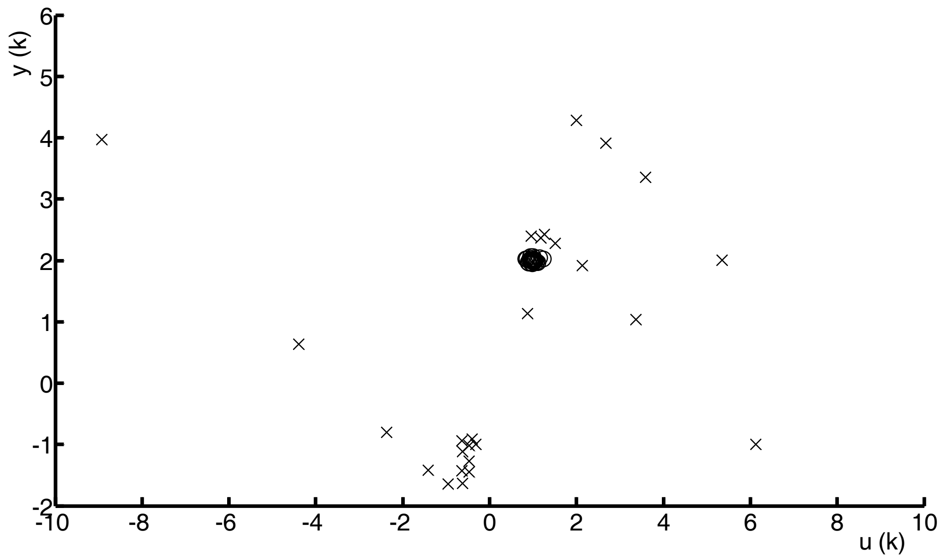

Fig. 1 Training set after 200s , identification with (x) and without the training pattern selection (o).

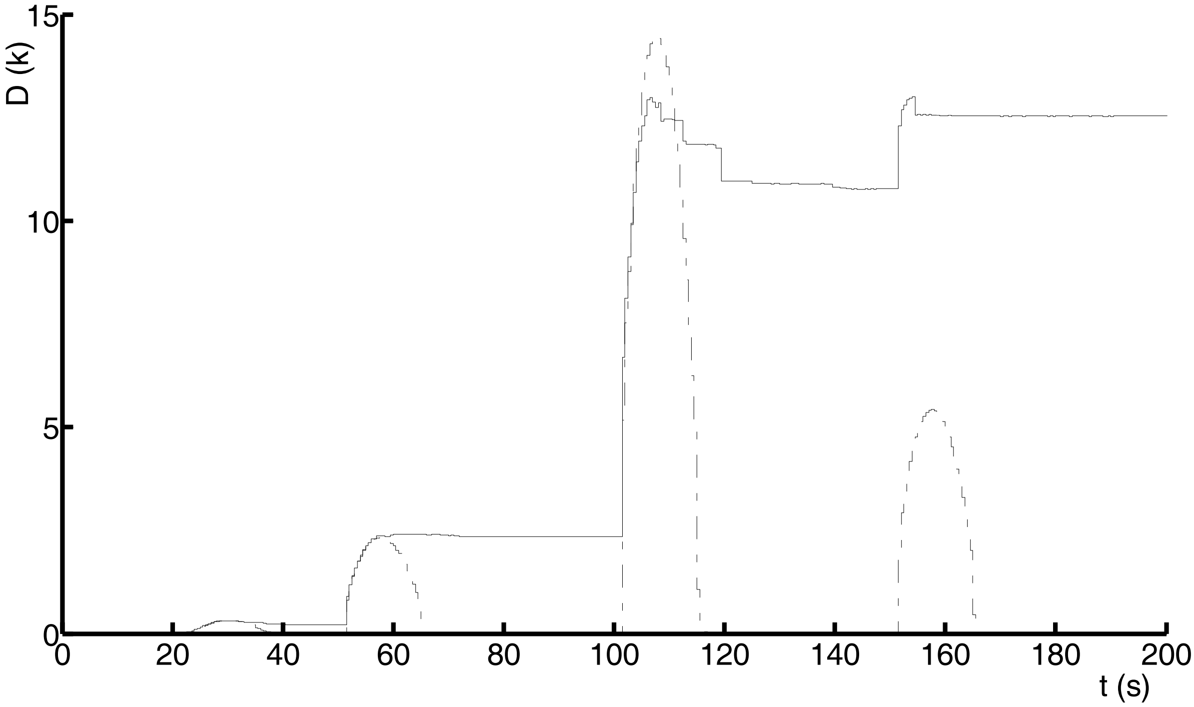

Fig. 2 Trace of covariance matrix, identification with (solid line) and without the training pattern selection (dashed line).

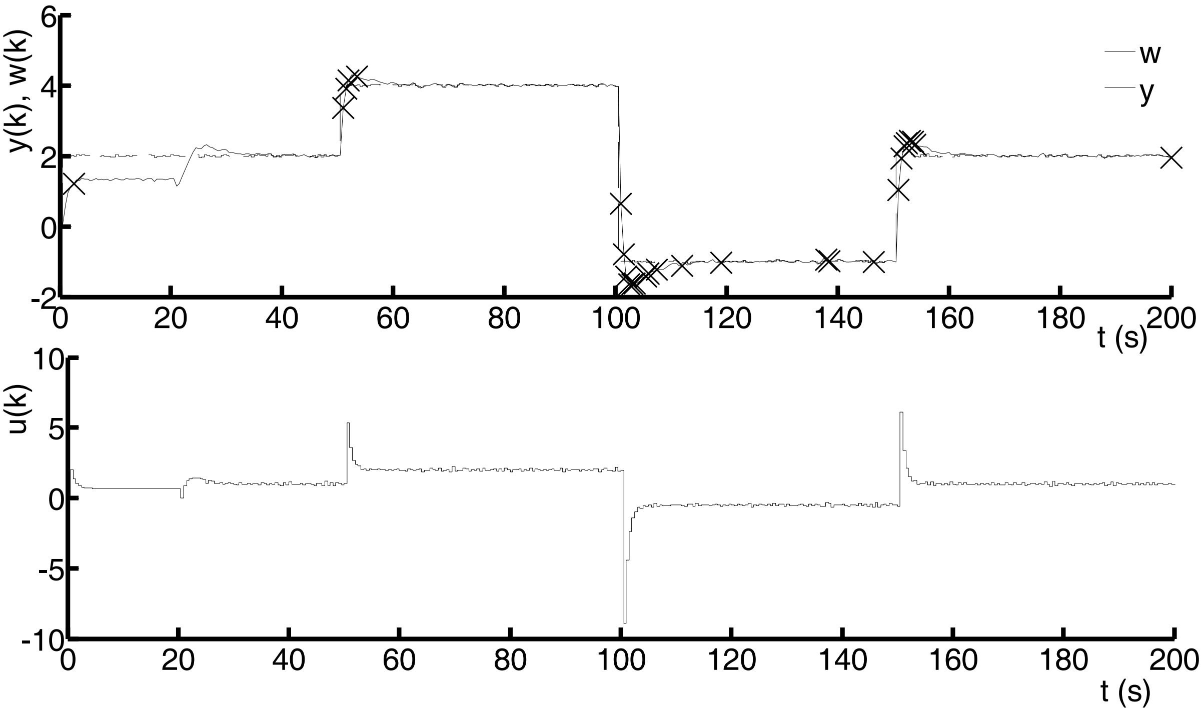

Fig. 3 Training set after 200s displayed in the time response.

5. CONCLUSION

The algorithm for neural network training with pattern selection based on computing euclidean distances between all training vectors was presented. This algorithm for the construction of the Self-Tuning controller was used. The simulation experiment shows that described algorithm is able to solve the problem of limited number of training patterns for on-line identification. It was shown that in the steady state was saved training data from situations when the system was more excited and data carried more information about system dynamics.

Modification of the training set offers potential for next work and improvements. Using the training data preprocessing could be possible to discard training data that are statistically evaluated as disturbance. Other point for next work can be development of supervisor algorithm that solves switching off the identification procedure in situations when data in the training set aren't changing. Start condition for identification can be number of new patterns in the training set.

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