Section 07: Modelisation and Simulation	Poster number 24

Modelling of Non-linear Dynamic Systems by Volterra Series Approach (VSA): Identification and Applications

Denis N. Sidorov, Department of Applied Mathematics, Melent'ev Institute of Energy Systems of Siberian Brach of Russian Academy of Sciences (ISEM SB RAS), Irkutsk, Russia.

ABSTRACT

The universal tool for modelling of non-linear input-output dynamic systems — Volterra functional series

$$y(t) = \sum_{p=1}^{q} \sum_{1 \le i_1 \le \ldots \le i_p \le m} f_{i_1, \ldots, i_p}(t), \tag{1}$$

where $f_{i_1, \ldots, i_p}(t) = \int_0^t \ldots \int_0^t K_{i_1 \ldots i_p}(t, \nu_1, \ldots, \nu_p) x_{i_1}(\nu_1) \ldots x_{i_p}(\nu_p) d\nu_1 \ldots d\nu_p$, $\qquad t \in [0, T]$,
giving of the system response to exterior perturbation as an integral-power series was used. Here n is some natural number, T is the time of a transient, $x_{i_j}(t)$ and $y(t)$ are deviations values of input and output signals from stationary values respectively, so that $y(0) = 0$. The functions $K_{i_1 \ldots i_p}$ are called the Volterra kernels (transfer functions) and should be identified by the known responses of a system to special sets of test perturbations. There are many non-universal algorithms for identification of the Volterra kernels. The original universal algorithm for identification of the Volterra kernels by reducing of this problem to the problem of the solution of multidimensional linear Volterra integral equations of the 1st kind was considered. Selfregularizing properties of some discretization's procedures of such equations are considered. Theorems (existence and uniqueness) for these equations were proved. The explained technique was tested on the problem of construction of an integral model of the heat exchange process, proceeding in a working medium of the steamgenerator.

The full-scale experiments to obtain arrays of the responses, ensuring both identification of the Volterra kernels and verification of constructed models were carried out on the high-temperature outline plant [2], [3].

The software package for construction of a cubic segment of the Volterra series, and also for synthesis of quadratic models, will improve accuracy of modelling by adjusting the Volterra kernels to a series of stationary values the input data is being developed.

References

1. Volterra V. The theory of the functional, integral and integro-differential equations. Moscow, Nauka. 1982.

2. Sidorov D.N. About integral model of nonlinear dynamic systems, The 4th International Congress on Industrial and Applied Mathematics (ICIAM-99), Book of Abstracts, Edinburg, 1999. p. 310.

3. Apartsyn A.S, Sidorov D.N., Solodusha S.V. To Identification of Integral Models of Nonlinear Models of Nonlinear Dynamic Systems, Proceedings of the 3rd International Conference "Identification of Dynamical systems and Inverse problems", Moscow-St.Petersburg, 1998. pp. 167–175.