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SOFTWARE TOOLS FOR IDENTIFICATION NONLINEAR DYNAMIC SYSTEMS ON THE BASE VOLTERRA MODEL IN TIME DOMAIN

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ПРОГРАМНІ ЗАСОБИ ІДЕНТИФІКАЦІЇ НЕЛІНІЙНИХ ДИНАМІЧНИХ СИСТЕМ НА ОСНОВІ МОДЕЛІ ВОЛЬТЕРРА У ЧАСОВІЙ ОБЛАСТІ

Introduction. Mathematical modeling methods and experiments are the main tools of researching complex nonlinear dynamical systems (NDS). Integral-powered Volterra series [1] are often used to describe NDS. That way nonlinear and dynamical properties of these systems are completely characterized by a sequence of multidimensional weight functions – Volterra kernels. The problem of identification – construction of a model in the form of Volterra series – is the determination of Volterra kernels based on data of experimental exploration of "input-output" NDS.

Identification in essence is related to inverse problems, during the solving of which there are difficulties of computation kind, caused by ill-posed problems. Obtained solutions are unstable due to errors of input data – measurements of identifiable NDS's responses.

However, so far known applied identification algorithms of NDS based on Volterra series still do not allow to fully use a power of this mathematical tool. It is caused by several reasons, most important one being the absence of accounting of significant effect of measurements errors on result of identification in algorithms of experimental determination of Volterra kernels, that limits their use in the real world; insufficient elaborated software for identification of NDS based on Volterra series.

The aim is developing a set of efficient computational algorithms and software tools for estimation of Volterra kernels under incomplete a priori information about identifiable object.

1. **Identification methods and computational algorithms.** This work consists of methods of the theory of nonparametric identification based on Volterra model using test pulse and step signals: method for building approximation model; method of differentiation of responses by parameter-amplitude of test signals [2].

During implementation of identification methods such computational methods and numerical methods of processing empirical data were used: methods of wavelet-transformation [3]; regularization methods of ill-posed problems [4]. Throughout development of the tools and during the solving of tests and applied problems, methods of the theory of computational experiments were used for the analysis of accuracy and noise stability of Volterra kernels estimation. To verify the reliability of obtained theoretical results tools of imitation modeling in MATLAB/Simulink environment were used.

A built-in method for wavelet-transformation was used to denoise signals. The algorithms being non-perfect, they still worked fine, providing better results when regularization was used.

1. **Software tools.** In MATLAB/Simulink was developed the Identification Tools of Nonlinear Dynamical Objects – a kit for identification of NDS based on Volterra model in time domain, in which computational algorithms for model building were implemented. To simplify the management of modeling and identification processes a GUI that hides the details of computational processes was created in MATLAB. A block diagram is shown in fig. 1.

Structure hierarchy of interface's files is: *start.** – main executable file of interface; *config* – configurator; *denoise* – denoise modules; *models* – modeling module; *ident* – identification module; *results* – identification results; *utils* – helper functions.

Modeling window is used for selecting modeling parameters. Result is a file which consists of responses of a selected object on a selected input signal. One can set next parameters: type of test input signal for object; object; modeling time; modeling step; computational step; additional parameters for models, if specified.

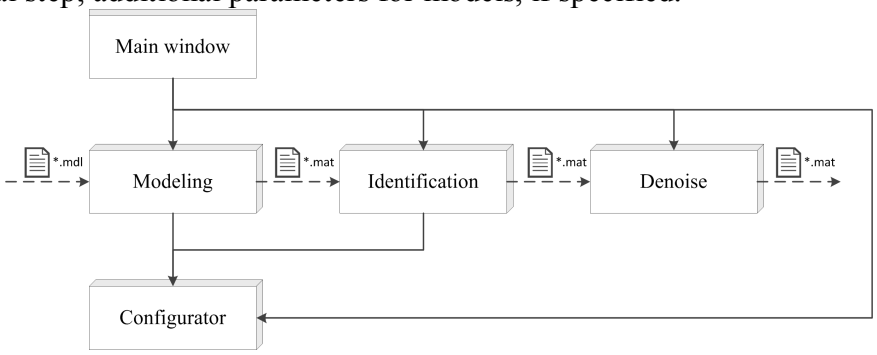

Figure 1. A block diagram of the kit

Identification window is used for evaluating of Volterra kernels' estimations of the object in research. Approximation and interpolation methods are used. One can set next parameters: name of file with responses of selected object; noise type and its value; identification method; order of evaluated object's kernel; etalon values of object's kernel.

Denoise window is used for denoise of signals with help of various denoising methods.

Configurator is used for setting default values of input signals, researched objects, noise types and identification methods. One can set parameters of object required for modeling: name of block, parameter name of block in Simulink, parameter name – alias for use, parameter value.

Conclusion. On the basis of theoretical and experimental researches new efficient computational algorithms for deterministic identification of nonlinear dynamical systems in time domain were developed, and the corresponding software tools, which provide a building of objects' models in a form of Volterra kernels' sequence based on experimental data of observations "input-output" with measurement errors taken into account. A GUI was created using MATLAB to simplify the processes of modeling and identifications.

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