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EXTENSION FOR THE FREQUENCY DOMAIN SYSTEM IDENTIFICATION TOOLBOX: GRAPHICAL USER INTERFACE, OBJECTS, IMPROVED NUMERICAL STABILITY

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Abstract: An Extension to the Frequency Domain System Identification Toolbox for MATLAB has been developed. It adds a simple-to-use Graphical User Interface to the existing toolbox. It increases numerical stability by using orthogonal polynomials. Both periodic and nonperiodic excitation signals can be used by proper modeling in the frequency domain. Systems in closed loop can also be identified. Objects allow simple use of the toolbox functions, and smooth transition to the Control Systems Toolbox for MATLAB.

Keywords: graphical user interface, GUI, MATLAB, system identification, frequency domain, transfer function, arbitrary excitation signal, objects, numerical stability, conditioning of equations.

1. INTRODUCTION

The Frequency Domain System Identification Toolbox for MATLAB has been distributed by The MathWorks since 1994.

Already from the first release of the toolbox, there has been a continuous demand for simpler use, possibly for a Graphical User Interface. Moreover, recent advances in the field made it possible to improve numerical stability, and by this, it became possible to process data of relatively high-order resonant systems, of orders up to 50-100.

This extension, running on top of the existing toolbox, meets these demands. Its first version was presented at Sysid'97. Now it is fully functional, and it is available as shareware from the Developers' Page (Fdident, 1999).

MAIN FEATURES OF THE EXTENSION

There is a fully functional *Graphical User Interface* which guides the inexperienced user through the whole identification process.

Extensive on-line help and several demonstrations implemented within the GUI offer an easy introduction to the possibilities. The basic chart is a flow graph where the boxes represent data processing, and the connecting arrows represent data (Fig. 1). The measured data need to be read into one of the input blocks, and the procedure needs to be followed along the arrows to the right end.

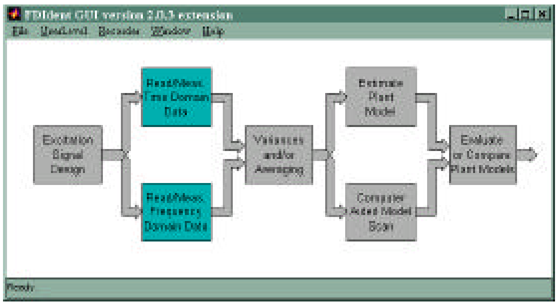

Fig. 1. Starting window of the Graphical User Interface

One of the most important functionalities a user may desire is on-line help everywhere. Such a possibility is provided in Matlab by the so-called tooltipstrings (pop-up or balloon helps, Fig. 2).

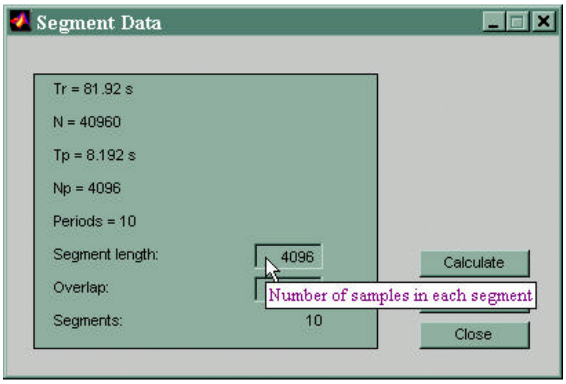

Fig. 2. Pop-up help on a uicontrol

Another way of providing information is the possibility of asking for *help on objects* (Fig. 3).

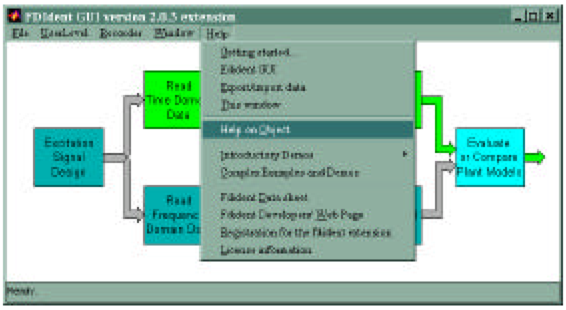

Fig. 3. Help on Object: possibility to get information of any object (uicontrol, menu item, graphics object)

The new data structures of MATLAB allow *simpler command-line call forms* than before. The functions dig out the properties of a data set or of a model themselves, and execute a reasonable default procedure.

Data and model objects allow to treat all the related properties of data or of a model consistently, e.g. perform the desired user action on a given object, represented by an arrow (Fig. 4).

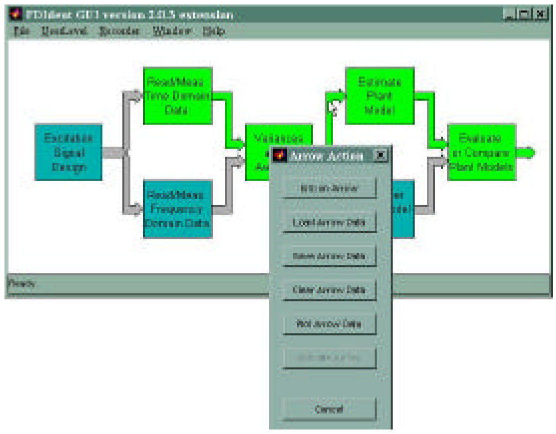

Fig. 4. Action window which pops up when clicking on an arrow

An experiment has several important circumstances which may influence the way of processing: the type of the excitation (periodic or nonperiodic), frequency content, type of the experiment (zero-order hold or excitation signal reconstruction filter), state of the system during measurement (steady-state or transient), sampling frequency, anti-aliasing filter on or off, delays, names and physical units of channel signals, date and time, etc. Even a small arithmetic is built around the objects: e.g. data2/model3 means to compensate for the given partial model in the data. Smooth transition to the control toolboxes is achieved e.g. by simply executing tf(model3).

The possibility of the use of an *orthogonal polynomial basis* (Rolain et al, 1995) makes it possible to handle large resonant systems (orders up to 50-100). The model objects hide this representation from the user who may only consider the model object as a single entity.

A modified algorithm allows the *processing of transient data*, a novelty in frequency domain system identification (Pintelon and Schoukens, 1997; Pintelon et al., 1997).

The extension runs under MATLAB versions 5.2 or newer. Since it consists exclusively of MATLAB function M-files, it runs on any platform where MATLAB also runs. A detailed description of the toolbox extension is available on the WEB (Kollár et al, 1999).

EXAMPLES FOR THE USAGE

The Frequency Domain System Identification Toolbox follows the whole identification procedure:

- design of periodic excitation signals
- preprocessing of data

- identification of continuous-time or discrete-time systems with fractional delay
- model order selection
- calculation of confidence intervals of magnitude, phase, and poles/zeros
- model validation, residual analysis
- simulation
- model saving as Control Toolbox object

At each step there are easy-to-use possibilities for user interaction. Some examples are as follows.

Preprocessing of time domain data is offered by a "sub-flowchart". The main steps of the preparation for frequency domain processing are offered (Fig. 5).

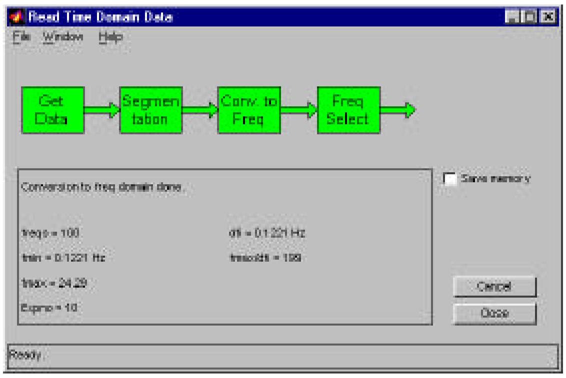

Fig. 5. Preprocessing of time series

A common task is to select the best combination of numerator/denominator orders of the transfer function. An automatic scan makes this search easier (Fig. 6).

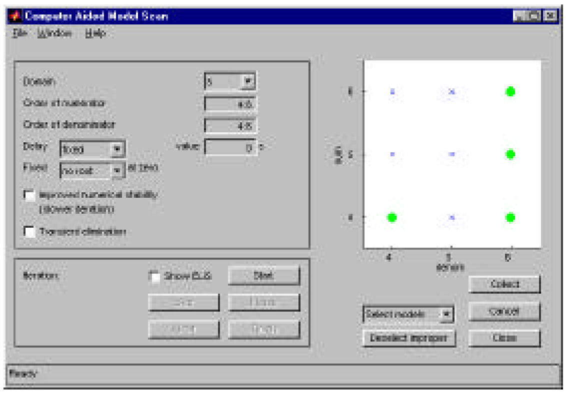

Fig. 6. Automatic scan of several model orders

The results of identification are usually complex. Therefore, a special window illustrates the main features of the result: the magnitude response along with the frequency response function, the phase difference, and the pole-zero plot (Fig. 7).

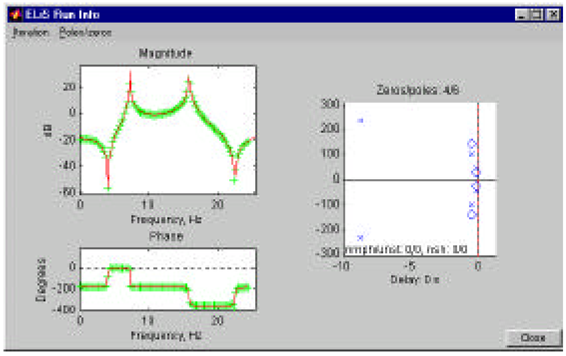

Fig. 7. Informative plot of the result of identification

However, model validation and comparison need even more specialized tools. The graphical user interface offers several possibilities for user interaction. A sample window with explanations is shown in Fig. 8.

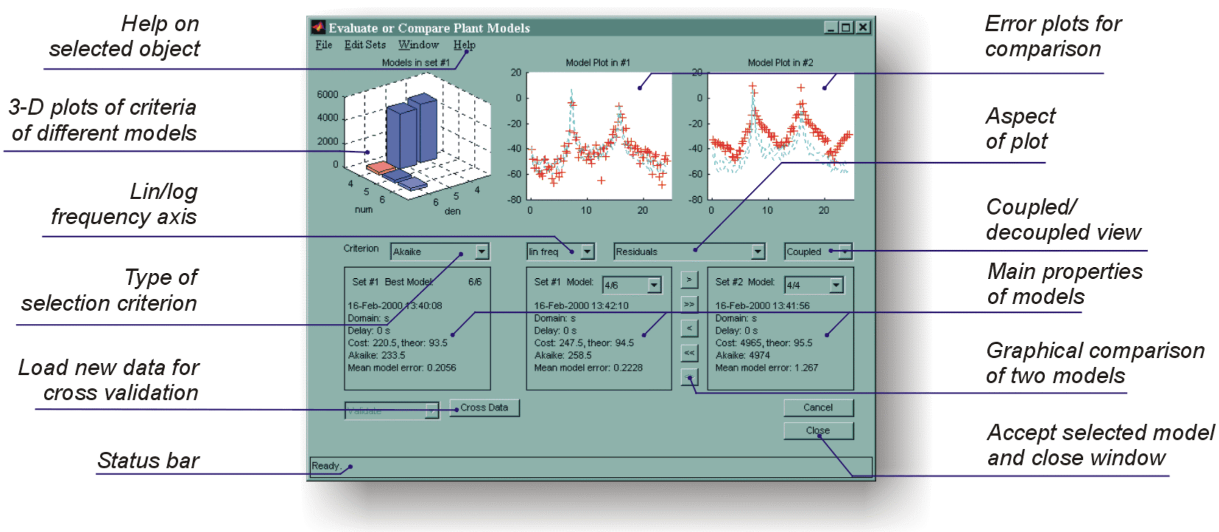

Fig. 8. The window for the evaluation and comparison of models

The graphical user interface is a complex tool which may need repetitions of user actions. This is implemented as an *Action Recorder*. This “recorder” can compile an action sequence from the user actions, and replay them with different data, or perform demonstration, using the actions of the previous processing.

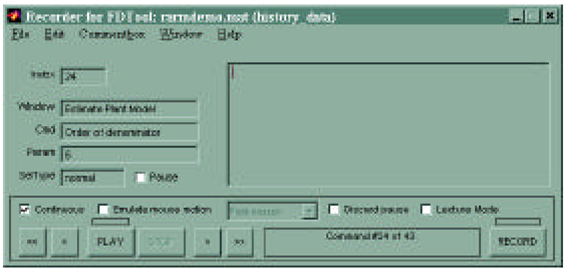

Fig. 9. The Action Recorder

SUMMARY

The extension for the fdident toolbox is a flexible tool. Years of usability test assure that it is user-friendly and effective. We sincerely hope that it will increase the number of identification fans.

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