# EXPID – Experimental Identification Toolbox

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**Abstract**

**This paper describes a MATLAB package EXPID for experimental identification. The package is based on step responses identification. The source codes are freely available at the package web page** `http://www.kirp.chtf.stuba.sk/~cirka/expid`**.**

## 1   Introduction

Processes in chemical technology can be modelled in various ways. The most natural representation is based on the state–space description resulting from material and energy balances. The models mostly used for control purposes are in form of linear differential or difference equations. We often assume that their parameters are known and constant. However, in experimental conditions it is often necessary to measure or estimate parameters from process input and output signals with carefully chosen input signal types. In this case we will speak about parameter estimation or system (experimental) identification.

This paper deals with the creation of a module for experimental identification. The module exists in three versions: a MATLAB toolbox, a MATLAB Web Server application, and a web interface written in the PHP language. Various deterministic methods are used for the experimental identification of systems (first order system, damped and underdamped second order system, Strejc and Broida methods for system of a higher order). Each of the module versions is simple in design, to allow use of this toolbox as a help in the study of deterministic identification methods.

## 2   EXPID Toolbox

EXPerimental IDentification toolbox (EXPID) is MATLAB GUI application that simplifies the process of transfer function identification from step responses based on measured data. The identification procedure in this case is as follows:

1. Measured data file is loaded. Data file is in CSV format without any headers.

2. Time, input, and output signals are assigned to respective columns (rows). To check correctness, plots of respective variables can be inspected.

3. If filtration of signals is required, the filter parameters are specified.

4. The desired transfer function structure is selected and identification procedure is started. The results are identified parameters and a plot with comparison of the original and the estimated systems.

Parameter estimation methods for identification of the following transfer function structures are used:

- first order system,

- damped and underdamped second order system,

- system of a higher order (using the Strejc and Broida method).

Figure 1: Load data box

Detailed theoretical foundations of respective methods can be found for example in [2].

The EXPID toolbox can be used under MATLAB 6.x and 7.x. The installation procedure is standard. It suffices to append to the standard MATLAB path the directory where all the files have been copied. GUI can be invoked by typing `expid` at the MATLAB command line.

**Working with EXPID**

1. Run EXPID;

2. Click on `Loading ≫` in `Load data` box (Fig. 1 left);

3. Choose the file name for processing and click `Open`[1] (Fig. 1 right);

4. Set the vector types (row or column (Fig. 2 left)) and time, input and output vectors (Fig. 2 right). The button `Data updating ≫` actualises the settings and plots. Then, it proceeds (Fig. 3) to continue with identification setup. The window heading contains information about the number of step responses;

5. Filtration settings. Fig. 4 (left) shows standard settings without any filtration and Fig. 4 (right) settings with low-pass filter characterised by its degree ($N$) and corner frequency ($W_n \in (0, 1)$);

6. Selection of identification method and its parameters (Fig. 5):

   - Setting `Step response` defines selection of respective step responses that will be used for identification. These can be defined as vectors (e.g. [5] – only the fifth, [3:7] – the third to the seventh, [2:7,10], etc). If this parameter is void all step responses will be taken into account.

   - Strejc or Broida methods show sometimes problems with the choice of times $t_u$ and $t_n$ and their ratio $t_u/t_n$ can be too large. In that case it is advantageous to divide $t_u$ into two parts: $t_u = t_{uf} + D_u$ where $D_u$ represents time delay. The overall time delay will then be given as sum of $D_u$ and calculated time delay.

   - If the first order transfer function is considered, two point on step response are needed (`Point 1` and `Point 2`) from range 0 to 100%. We assume here that output at step change time is zero and its new steady state value is 100%. Recommended values are between 10% and 40% for `Point 1` and between 70% and 90% for `Point 2`.

7. Finally, button `Identification ≫` starts the procedure. Results can be viewed in the `result of identification` part (Fig. 6). Comparison of step responses of the unknown process and estimated model is shown in Fig. 7.

**EXPID menu**

**Exit EXPID -** quit EXPID

**Exit Save as -** saves the last successful identification in form of structured data.

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[1]Text files saved in ASCII format containing only data meant for processing of row or column vectors. The files should not include headings
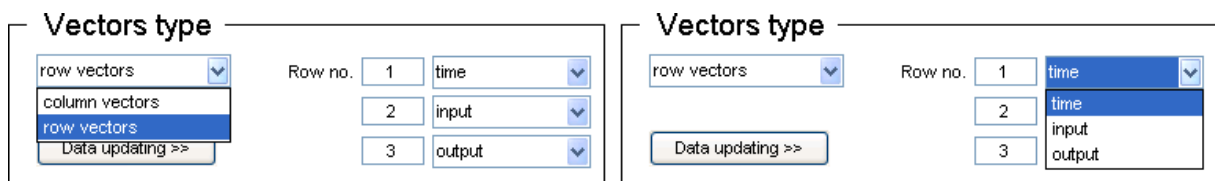
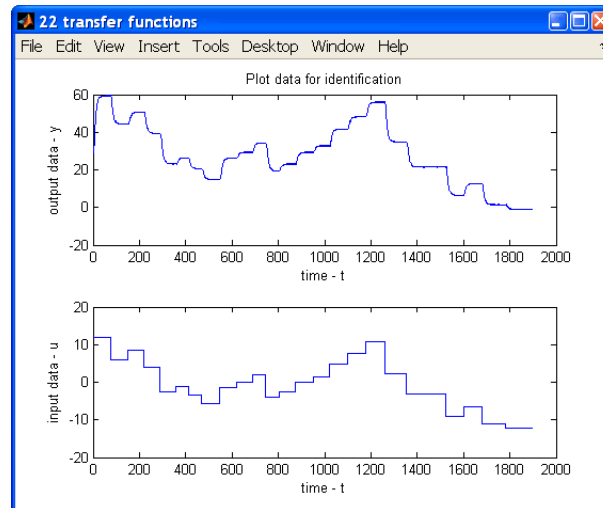Figure 2: Vectors type box



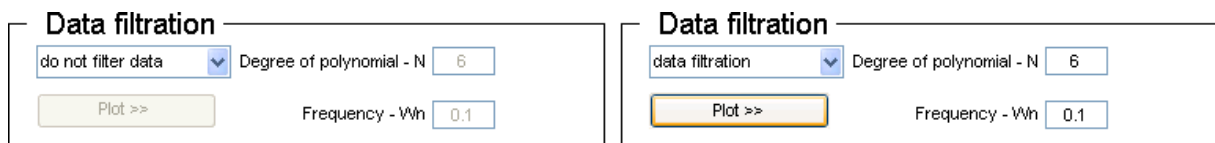Figure 3: Input and output data



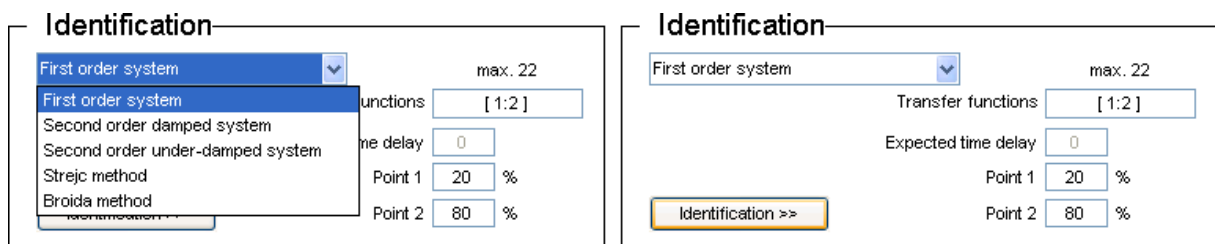Figure 4: Data filtration box
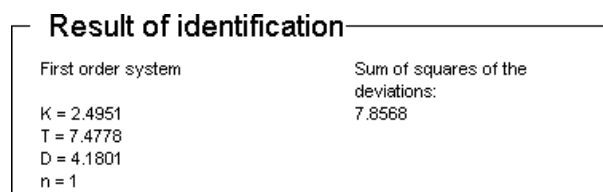


Figure 5: Identification box
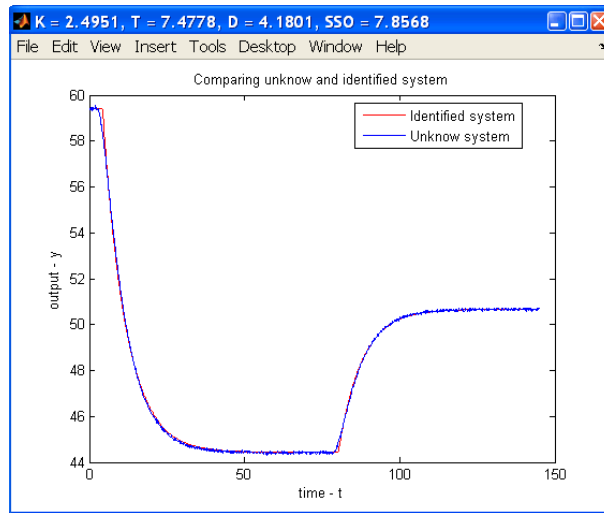


Figure 6: Result of identification box

Figure 7: Comparison of step responses of unknown process and estimated model

**Language -** changes the language (English (default) and Slovak language supported).

**Plot setting -** setting that allows you to draw the progress of the identification into one, two or no graph.

**Help -** shows the EXPID manual, web pages for support and information about EXPID.

**Change of default values**

Some changes of default values can be done directly in `expid.m` file:

- Slovak language setting (line 96):
  `expid_gendata.language == 'sk';`

- English language setting (line 96):
  `expid_gendata.language == 'en';`

- "Show no graph" setting (line 97):
  `expid_gendata.depicture == 0;`

- "Show only one graph" setting (line 97):
  `expid_gendata.depicture == 1;`

- "Show two graphs" setting (line 97):
  `expid_gendata.depicture == 2;`

# 3  EXPID modification

Two modifications of EXPID toolbox have been created that are suitable for Internet. The first one is based on the MATLAB Web Server (MWS) and the second one is implemented entirely in the scripting language PHP.

## 3.1  MWS Application of the EXPID

We have coupled the EXPID tool with Internet using MWS. To simplify the workflow for the user, the left part contains menu and the right part corresponding information (identification

Figure 8: MWS Application of the EXPID



Figure 9: PHP module of the EXPID

theory, forms for MWS, etc). Each method contains links to theoretical foundation of the methods and actual identification procedure (Fig. 8).

## 3.2 PHP module of the EXPID

This solution does not depend on MWS. Rather, it re-implements necessary elements directly using scripting language PHP. The web page is divided into three parts (Fig. 9):

- menu containing links to index and theory;
- specification of file and selection of identification method,
- results and graphs.

More information about both Internet applications can be found in [1].

# 4  Conclusions

Compared to the standard System Identification toolbox in MATLAB ([3]), our tool has narrowed focus and is used mainly by students in course Identification. Its Internet versions make it possible to used it anywhere.

Toolbox is based on the diploma thesis entitled E–learning Module for Experimental Identification ([1]).

The functions described in this paper are freely available for academic research. The EX-PID homepage can be found at `http://www.kirp.chtf.stuba.sk/~cirka/expid/`. A zipped file with the latest collection of MATLAB routines can be downloaded from there.

## Acknowledgments

# References

[1] P. Dováľ. E–learning Module for Experimental Identification (in Slovak). Master's thesis, FCHPT STU in Bratislava, 2007.

[2] M. Fikar and J. Mikleš. *System Identification (in Slovak)*. STU Press, 1999. 114 pp.

[3] Lennart L. *System Identification Toolbox for Use with MATLAB: User's Guide*. The Mathworks, Cochituate Place, 24 Prime Park Way, Natick, MA, USA, 1988.

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