IDCON™ Nonlinear
Automatic Generation of Nonlinear Dynamic Simulation Models from Measured Data
Toolbox for use with MATLAB® and Microsoft EXCEL

Key Features

IDCON Nonlinear provides powerful and proven methods for automatic generation of nonlinear models for multi input-multi output systems from measured data (often known as: nonlinear system identification). Application areas include Hydraulic Systems, Electrical Systems, Mechanical Systems, Combustion and Diesel Engines, etc.

IDCON NL Application Areas

IDCON Nonlinear is ideally suited for:

- Identifying nonlinear model parameters for comprehensive system analysis with MATLAB and other toolboxes
- Calculating nonlinear model parameters for simulation purposes
- Calculating model parameters as a prerequisite for control systems design
- Determining system parameter changes

Highlights of IDCON Nonlinear

- May be used within MATLAB or EXCEL
- Easy to learn and easy to use
- Practice-proven method
- Only a few input samples are necessary
- Robust results, even with noisy data
- Direct parameter identification of nonlinear multi input-multi output systems

Prerequisites for Identification

The identification method is based on

1. A user defined model for the investigated system; and
2. Measured data taken from the real plant

Parameter Identification Steps

The necessary steps to calculate system parameters are:

1. Build a System Model

The user must generate the model structure containing known parameters and the parameters in question.
The investigated system with *m* inputs has to be described by a set of n nonlinear differential equations.

$$\dot{x}_i = \mathrm{f}_i(x_1, x_2, \ldots, x_n, u_1, u_2, \ldots, u_m) \qquad i = 1, \ldots, n$$

When working within the MATLAB environment, either a MATLAB M- or MEXfunction may be used to define the model. Within EXCEL, the model may be defined almost identical to a Matlab MEX-function.

2. ***Build the Jacobian Matrix***
The Jacobian matrix built from the set of nonlinear differential equations described above is necessary for system identification process.

$$\frac{\mathrm{d}f}{\mathrm{d}x} = \begin{bmatrix} \frac{\mathrm{d}f_1}{\mathrm{d}x_1} & \cdots & \frac{\mathrm{d}f_1}{\mathrm{d}x_n} \\ \vdots & & \vdots \\ \frac{\mathrm{d}f_n}{\mathrm{d}x_1} & & \frac{\mathrm{d}f_n}{\mathrm{d}x_n} \end{bmatrix}$$

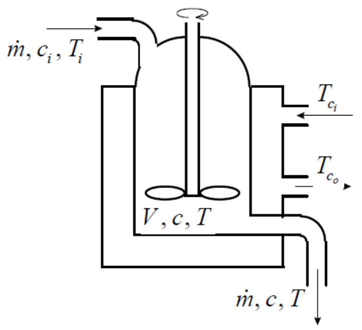
The Symbolic Math TB may be used to help simplify the generation of the Jacobian. Like the differential equations, the Jacobian matrix must be defined in an M- or MEXfunction if working within MATLAB. If working within EXCEL, the Jacobian needs to be defined in a function being almost identical to the Matlab MEX-function

3. ***Take measurements***
Experiments may now be performed with the plant under investigation, measuring the model I/O values.

4. ***Ready to go***
The parameter identification process may now be started with IDCON Nonlinear. The model parameters in question are directly returned by the identification process.

Example
The following example of a polymerization reaction in a stirring reactor demonstrates the capabilities of IDCON Nonlinear.

Using measurements of temperature *T(t)* and mass flow *m*(t) taken from the plant, IDCON Nonlinear is able to determine the following quantities:



Prerequisites
Independent of the tool landscape available MATLAB and/or EXCEL), IDCON Classic is required.

IDCON Nonlinear Functions
Within the Matlab environment IDCON Nonlinear provides all functionality to gain the desired model parameters which may be used for further analysis or simulation purposes.

These functions may be used interactively or be integrated into a user defined MATLAB application.
Similarly, a DLL may be accessed from within any other application to integrate the IDCON model generation capabilities. The EXCEL user interface is using this DLL access functionality.

$$\frac{\mathrm{d}T(t)}{\mathrm{d}t} = \frac{\dot{m}(t)}{V}\left(T_i - T(t)\right) + \frac{a \cdot A_c}{\rho \cdot C_p \cdot V}\left(T_c - T(t)\right) + \frac{\left(-dh_r\right)}{\rho \cdot C_p} \cdot k_2\, e^{E_2/T(t)} \cdot c(t)^{3/2}$$

$$\frac{\mathrm{d}c(t)}{\mathrm{d}t} = \frac{\dot{m}(t)}{V}\left(c_i - c(t)\right) + k_1\, e^{E_1/T(t)} \cdot c(t) - \left(k_2\, e^{E_2/T(t)} + k_3\, e^{E_3/T(t)}\right) c(t)^{3/2}$$

$$\text{where} \quad T_c = \frac{T_{c_i} - T_{c_o}}{2}$$

The dynamic behavior of the system may be described by the nonlinear differential equations shown below for temperature and concentration.

- polymer concentration *c(t)*
- heat transition parameter *a* (describing the complete transition from cooling water to fluid in reactor)
- energy for activating the reaction *E1*
- volume with active reaction *V* (due to non-ideal stirring, *V* is not equal to the entire fluid volume in the reactor)

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