Using the Graphical User Interface for Valve Monitoring 'GUI ValMon'

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1. Info

The Graphical User Interface for Valve Monitoring (GUI ValMon) was created as part of the project ICA4-CT-2002-10012 Efficient Operation of Urban Wastewater Treatment Plants, WP6 - Fault Detection and Isolation. The aim of the GUI is to evaluate a fault detection algorithm for monitoring faults in a flow control valve. The algorithm is based in a novel complementation to the conventional DPCA (Dynamic Principal Component Analysis) multivariate statistical tool which is able to deal with changes in the operating point.

2. Files

The GUI ValMon is integrated by the following files:

- DABLib.mdl
- OneHourTestData_ExampleII.mat
- val4masim.mdl
- FunSel_Val4.m
- Mod_Val4.m
- Mon1_Val4.m
- Mon2_Val4.m
- Val4_Mon.fig
- Val4_Mon.m
- Resongui_Val4.m

The **GUI ValMon** runs on MatLab 7.04.365/Simulink 6.2 environment or higher versions. To carry out simulations of the GUI ValMon install all the files in a specific folder.

3. Files Description

DABLib.mdl is the DAMADICS Actuator Benchmark Library developed by the DAMADICS[1] project and from which the valve has been taken to be evaluated. As emphasized by the DAMADICS developers, 'when using **DABLIB** components, please set the following solver options: Type / fixed-step, ode4 (Runge-Kutta), Fixed-step size / 0.0025s'[2].

OneHourTestData_ExampleII.mat is a file provided by the DAMADICS project which contains real input data useful to carry out tests in the valve.

val4masim.mdl is the Simulink model where the simulations of the Fault Detection algorithm are carried out. See Fig. 1.

The model shown in Fig. (1) is composed by the following blocks: Valve, Act; input data, From File (OneHourTestData_ExampleII.mat); changes in the input signal, In Chg; fault assignation, FGen and FSel; monitoring, Monitoring System; task selection, Sel Op; and results information, Results.

Internally the Monitoring System block, Fig. (2), is integrated mainly by a data conditioning block, Normalizer; and a block named Modeling/Monitoring which internally includes the call to a MatLab function (FunSel_Val4.m), Fig. (3), from which the modeling and monitoring tasks are carried out.

FunSel_Val4.m is a programmed MatLab function which internally runs specific functions depending on the task selected in Sel Op block. If Sel Op is 0 (modeling) the function Mod_Val4.m is executed, in case Sel Op is 1 (monitoring) the two functions Mon1_Val4.m and Mon2_Val4.m are executed.

[1] http://diag.mchtr.pw.edu.pl/damadics/
[2] Using Damadics Actuator Benchmark Library (DABLib) – DABLib Simulink Library Help File, ver. 1.22

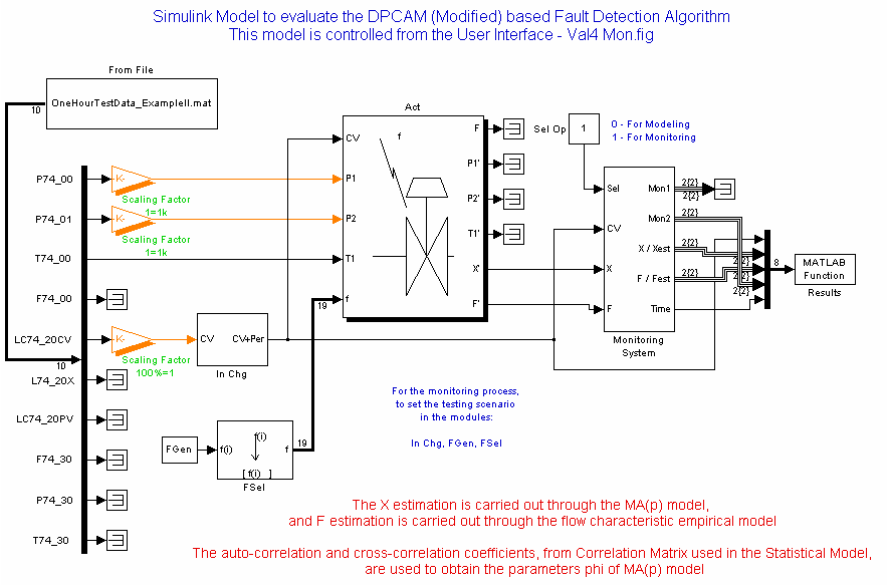

Fig. 1 Simulink Model to evaluate the modified DPCA based fault detection algorithm

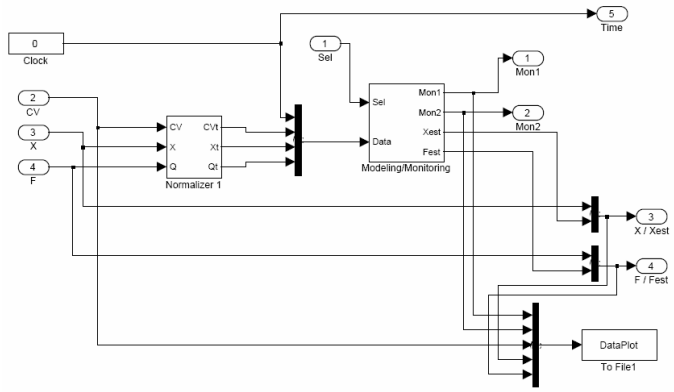

Fig. 2 Internal components of the Monitoring System block

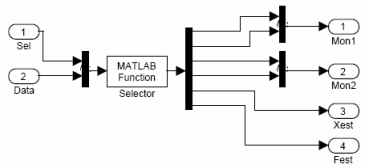

Fig. 3 Call to the MatLab function FunSel_Val4.m

Mod_Val4.m is a programmed MatLab function which carries out the DPCA based nominal statistical modeling of the valve and the identification of the nominal relation between CV (valve control signal) and X (stem displacement). The modeling and identification procedure are carried out from nominal historical data of the valve simulated during 110s. This function generates a set of modeling and identification parameters resumed in the file PARAM1_Val4.mat which are used in the monitoring task.

Mon1_Val4.m is a programmed MatLab function which carries out the fault detection in the valve based in a conventional DPCA algorithm. The detection performance of this function is not showed in the GUI; however, its detection results are available in the Monitoring System block in the output Mon1 for those who be interested in analyze them. This function makes use of the parameters PARAM1_Val4.mat.

Mon2_Val4.m is a programmed MatLab function which carries out the fault detection in the valve based in the modified DPCA algorithm proposed for this project. This function makes use of the parameters PARAM1_Val4.mat.

Val4_Mon.fig is the panel of the GUI, Fig. 4, from where an operator can evaluate, through simulations, the performance of the proposed fault detection algorithm for the valve.

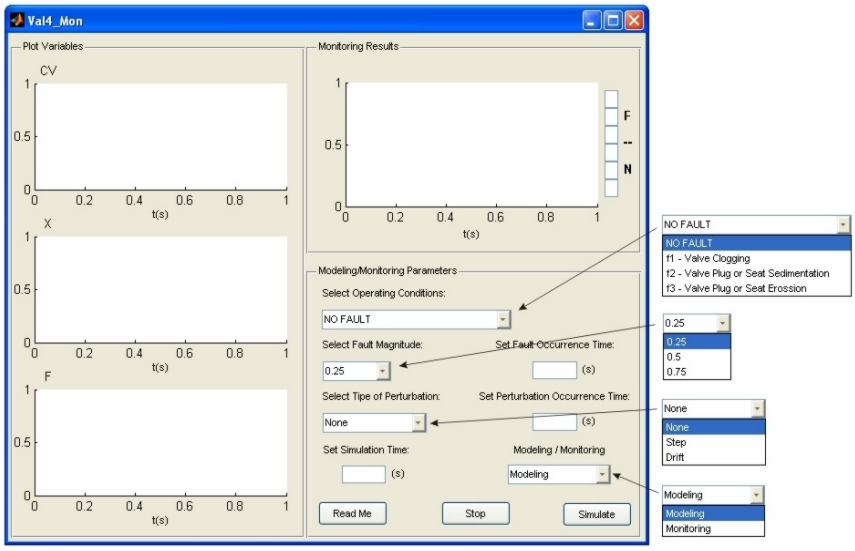

Fig. 4 GUI panel to carry out tests for fault detection in the valve

The different test scenarios can be defined from this panel, see the fields like Select Operating Conditions, Select Type of Perturbation, Modeling/Monitoring in Fig. 4. A test scenario defined in this panel will automatically change the corresponding parameters in the Simulink model val4masim.mdl. Pushing the Read Me button in this panel will display on the MatLab Command Window generic information of the GUI.

For those interested in view or carry out changes of the components in the GUI panel, it can be opened from the guide (Graphical User Interface Development Environment).

Val4_Mon.m is the M-file associated to the GUI panel. In this file is found the code for the definition of all the components in the panel, the code for the specific tasks carried out for each one of these components, and the code for the interaction between the panel components and the blocks parameters of the Simulink model val4masim.mdl.

Resongui_Val4.m is a programmed MatLab function found in the block Results of the Simulink model val4masim.mdl. This function mainly provides a communication of the actual results generated by val4masim.mdl to the axes in the GUI panel.

4. General Instructions for the use of GUI ValMon

To carry out simulations of fault detection in the valve first open the GUI panel (Val4_Mon.fig) typing Val4_Mon in the MatLab Command Window. The GUI panel will be displayed and the Simulink model val4masim.mdl will automatically be opened. It is necessary that the Simulink model be opened during simulations.

The GUI panel Val4_Mon.fig and the Simulink model val4masim.mdl are all that is needed in order to carry out simulations, the other programs or files are invisible to the user.

Before running monitoring simulations, this is, under fault conditions and/or perturbations in the input signal CV, it is necessary to carry out the modeling task. For the modeling task do not change the default values in the fields Select Operating Conditions (NO FAULT) and Select Type of Perturbation (None), just set a value greater than 100s in Set Simulation Time in order to store enough data for the modeling process, select Modeling in the Modeling/Monitoring field and finally click on the Simulate button. A file named PARAM1_Val4.mat will be generated.

In this case the modeling task has been previously run for a simulation time of 110s, so, additionally to the set of files (programs, models, etc.) is supplied the file PARAM1_Val4.mat in order to start directly with monitoring simulations.

For monitoring simulations just define a personal testing scenario in the GUI panel, set an appropriate simulation time, select Monitoring in the Modeling/Monitoring field and click on the Simulate button. The simulation can be stopped at any time if needed clicking on the Stop button, by clicking again on the Simulate button the simulation will restart from zero.

5. Examples of GUI ValMon

Example I

The valve is subject to change in the operating condition, this is, a step change in the input signal CV at 130s.

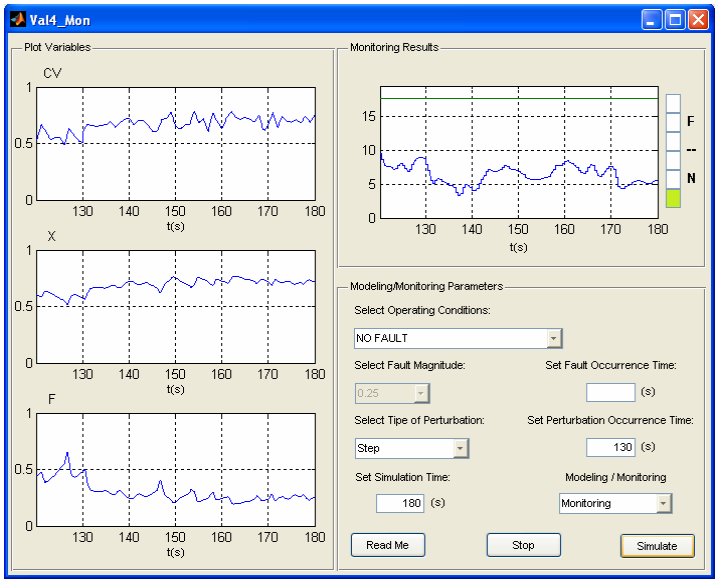

Fig. 5 Valve operating under Normal condition and subject to a step change in the CV control signal

As is shown in Fig. 5 in the Monitoring Results the symptom behavior stays under the normal condition threshold.

Example II

The valve is subject to both a step change in the operating condition and to the fault condition f3 at 130s and 150 s respectively:

As is shown in Fig. 6 in the Monitoring Results the symptom behavior stays under the normal condition threshold even before the step change in CV but indicates a fault only when the fault is present. This ability to distinguish between normal changes and changes due to faults is the main characteristic of the proposed algorithm.

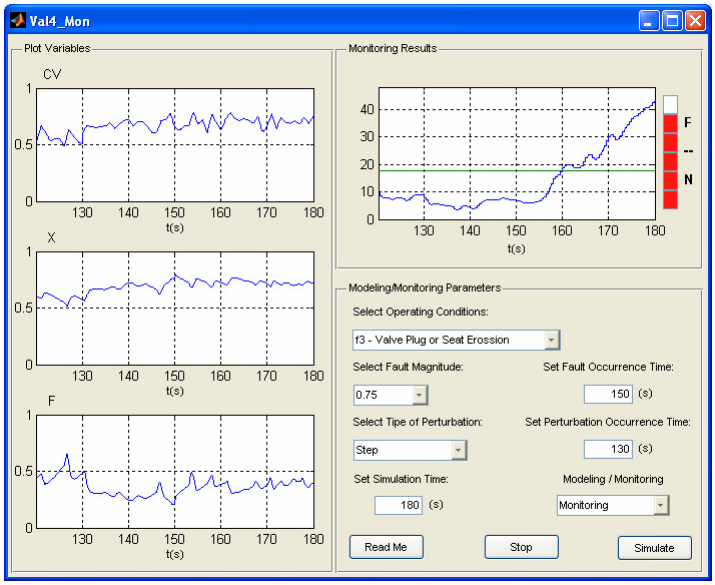

Fig. 6 Valve operating under Fault condition and subject to a step change in the CV control signal