International GUI for Oscillation and Stiction Detection (iStictionGUI)

Limited Trial Version (1.0)

User's Manual

Mohieddine Jelali

Introduction

This is a MATLAB graphical user interface (GUI) for oscillation and stiction detection in control loops. It was an outcome of a project initiated by *Mohieddine Jelali* during the writing of the book

M. Jelali, B. Huang (Eds.): *Detection and Diagnosis of Stiction in Control Loops: State of the Art and Advanced Methods*. Springer-Verlag London, 2010.

with contributions from different international Colleagues (called *Stiction Group*).

The Stiction Group has decided to publish this trial version (MATLAB p-code) of the GUI to enable other researchers working on the field to apply the methods involved to their own data, and possibly compare the results with their own code.

Installation

1. Copy the files to your directory.
2. Start MATLAB 7.5.0 (R2007b).
3. Run `iStictionGUI` from Matlab Command Window.
   `>> iStictionGUI`

Plant Data Format

Data has to be provided as mat-file containing the following structure elements:

data.Ts (sampling period)
data.PV (process variable)
data.SP (set point)
data.OP (controller output)
data.t (time axis [s])
data.BriefComments
data.Type (0: self-regulating; 1: integrating)
data.Kc (set to 9999 when not available)
data.Ti (set to 9999 when not available)

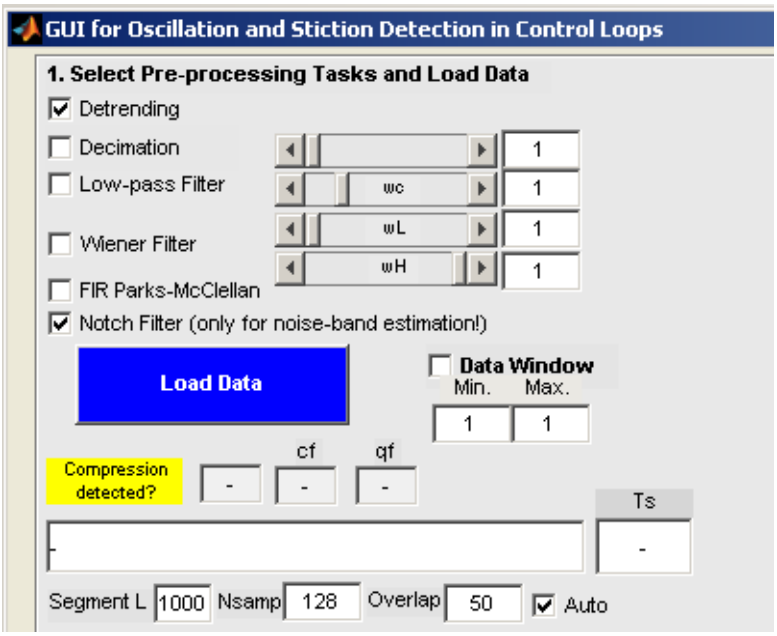
Example: Data from loop CHEM1 (see the ISDB), contained in the file *test_data.mat*

```
>> load test_data
>> data

data =

                Ts: 1
                PV: [1625x1 double]
                SP: [1625x1 double]
                OP: [1625x1 double]
                 t: [1x1625 double]
    BriefComments: 'Flow control (FC145); with stiction (A.
Horch)'
              Type: 0
                Kc: 9999
                Ti: 9999
```

This data set will be used below to demonstrate how the GUI works.

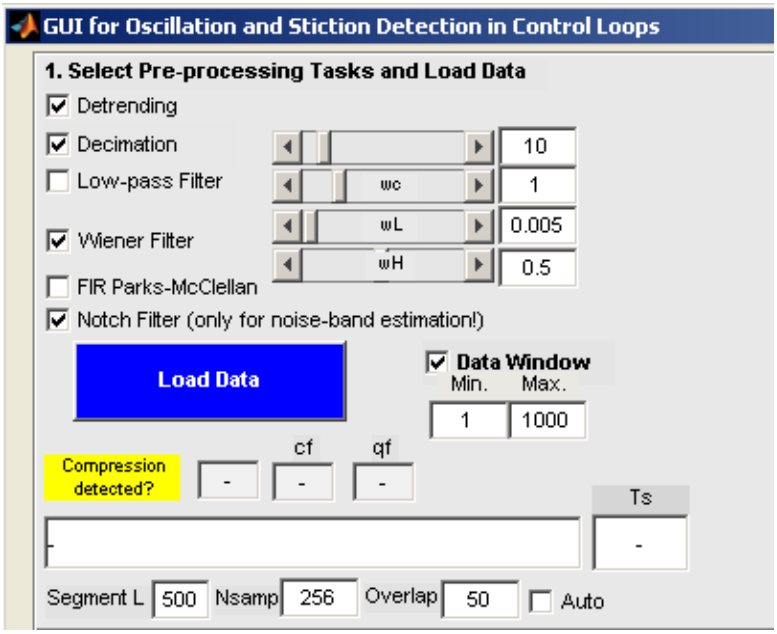
Use of the GUI / Case Study

1. Select pre-processing tasks (detrending, decimation, low-pass filtering, Wiener filtering, FIR, Notch filter) by clicking the corresponding checkbox and enter appropriate parameters, i.e. filter frequencies; select a data window, when desired; and load a data file by clicking the pushbutton “Load data”.

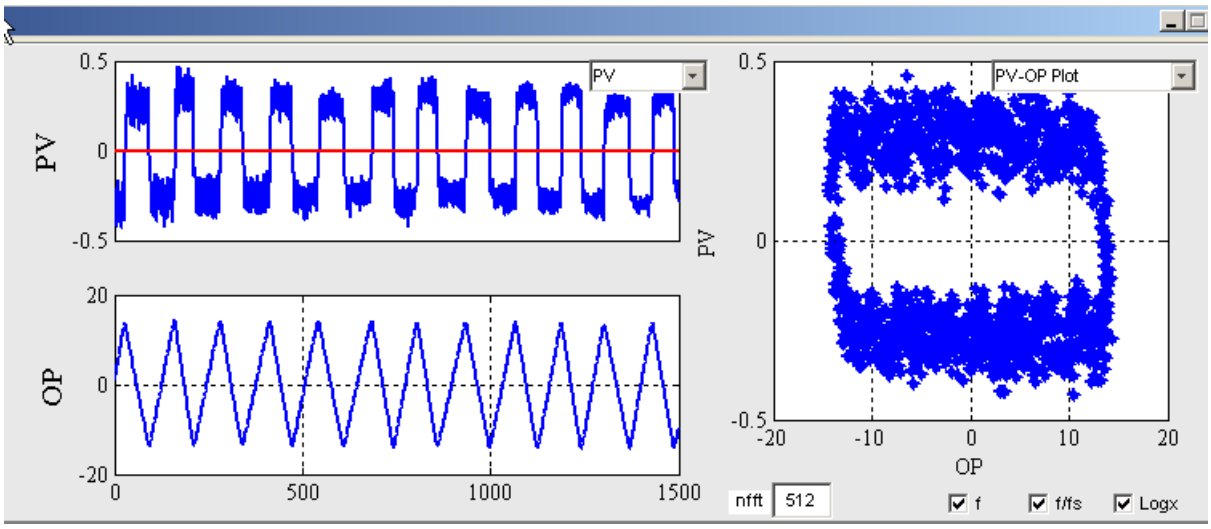


Note 1: “Detrending” and “Notch Filter” are (and should be) selected as default. “Notch Filter” is only used for the area-peak method.

Note 2: “Segment L”, “Nsamp” and “Overlap” are set automatically and only needed for the bicoherence method; disable the checkbox “Auto” to change the values.



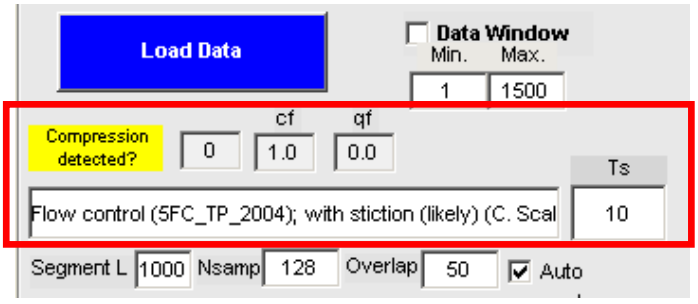
Data will then be displayed on the subplots.



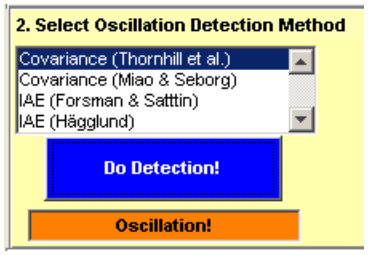
Observe the triangular shape of OP, the square shape of PV and the parallelogram shape of the PV-OP plot. All these are signatures of stiction.

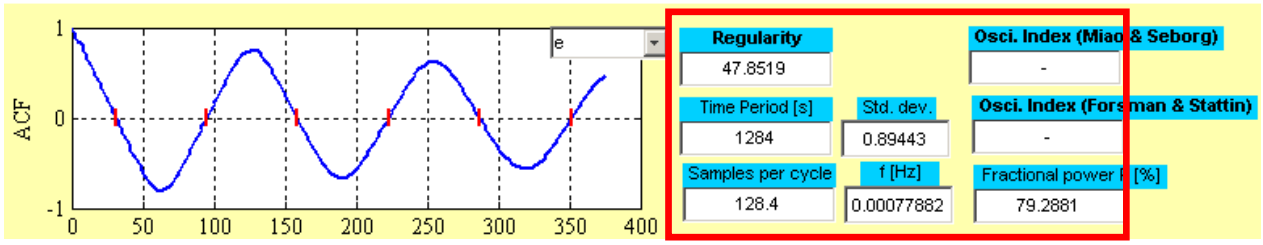
Different views can be selected by clicking the popupmenus “PV” and “PV-OP Plot”.

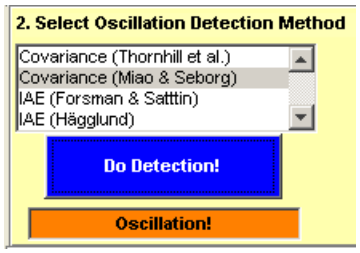
Also, the sampling period, comments and compression factors will appear.

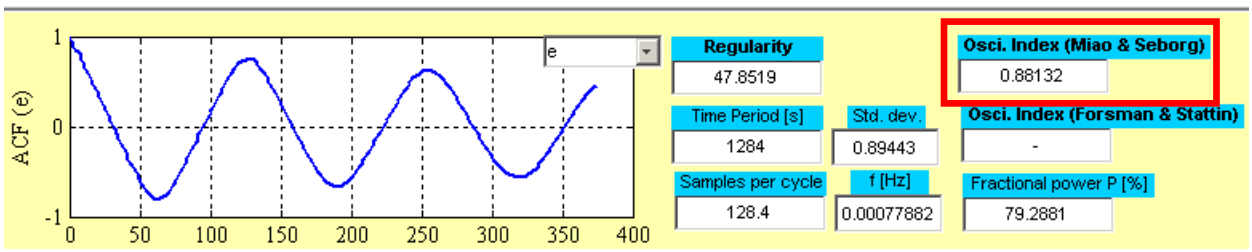


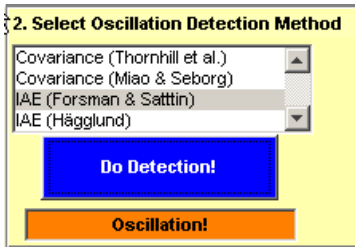
2. Select an oscillation detection method and click the pushbutton “Do Detection!”; observe the results in the subplots and the index values. The following figures (and contained) indices show that all methods indicate the presence of oscillation in the loop.

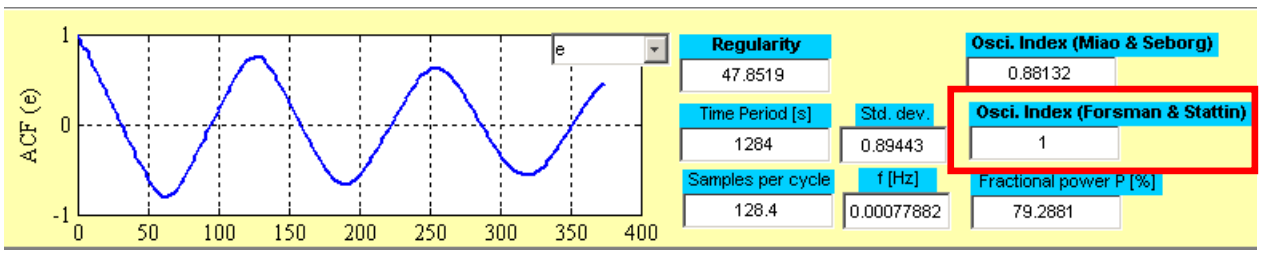


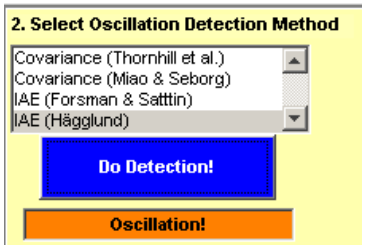


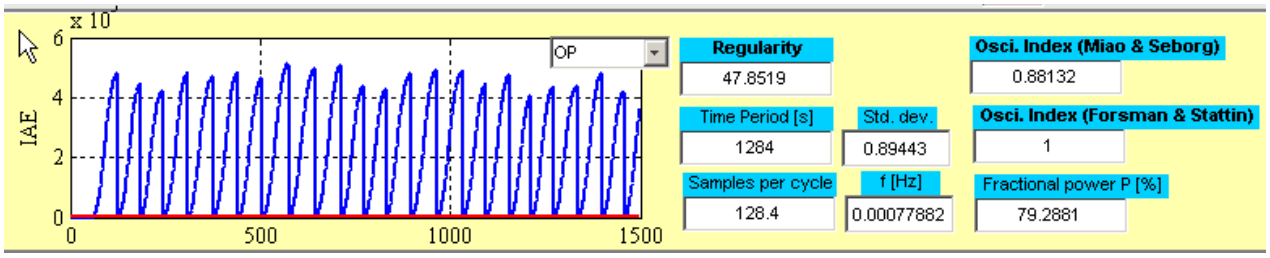






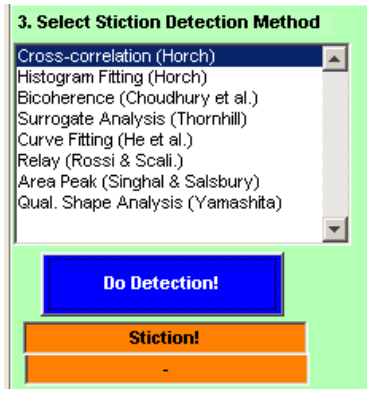


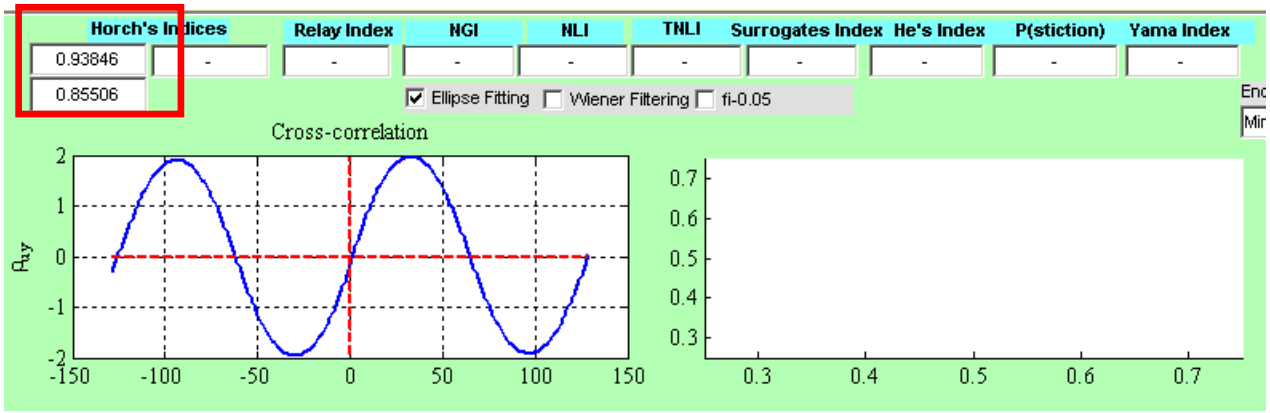




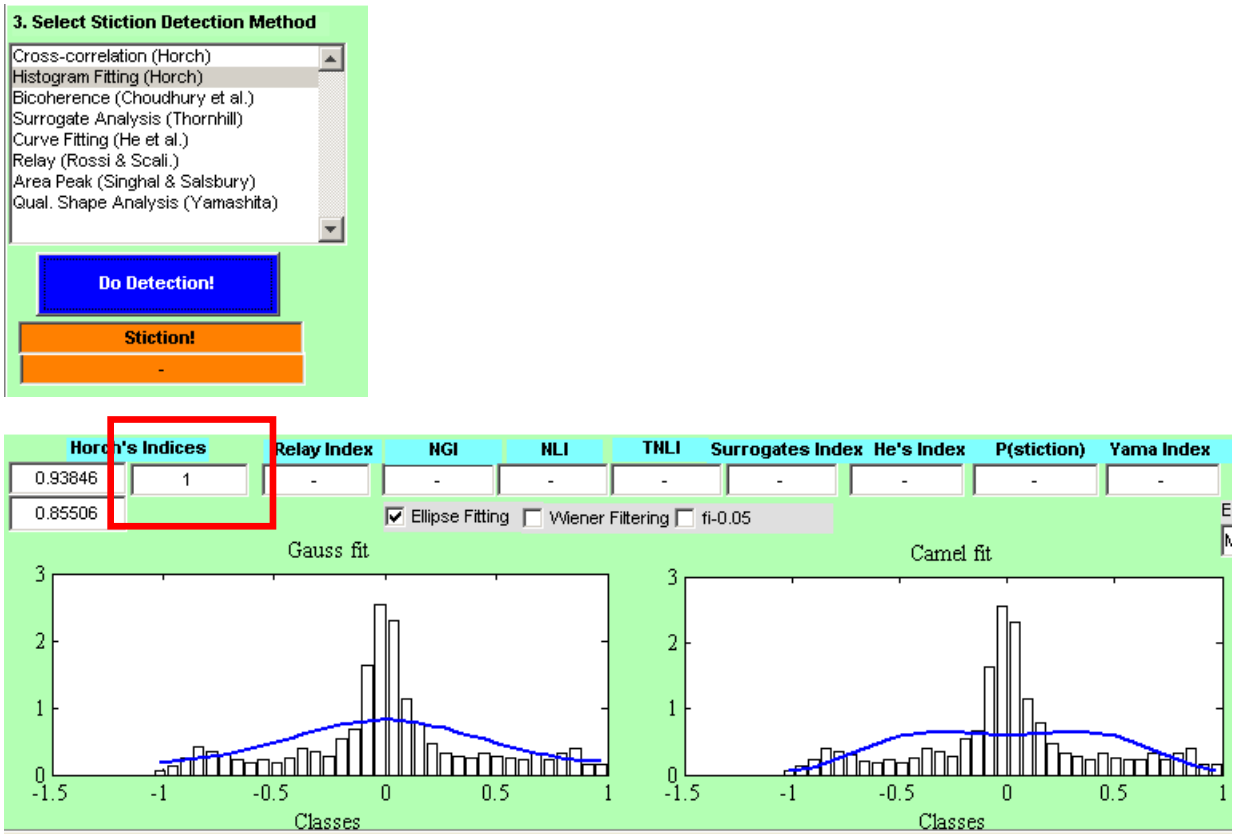
Note 3: Hägglund's method needs OP in %.

3. Select a stiction detection method and click the pushbutton "Do Detection!"; observe the results in the subplots and the index values.

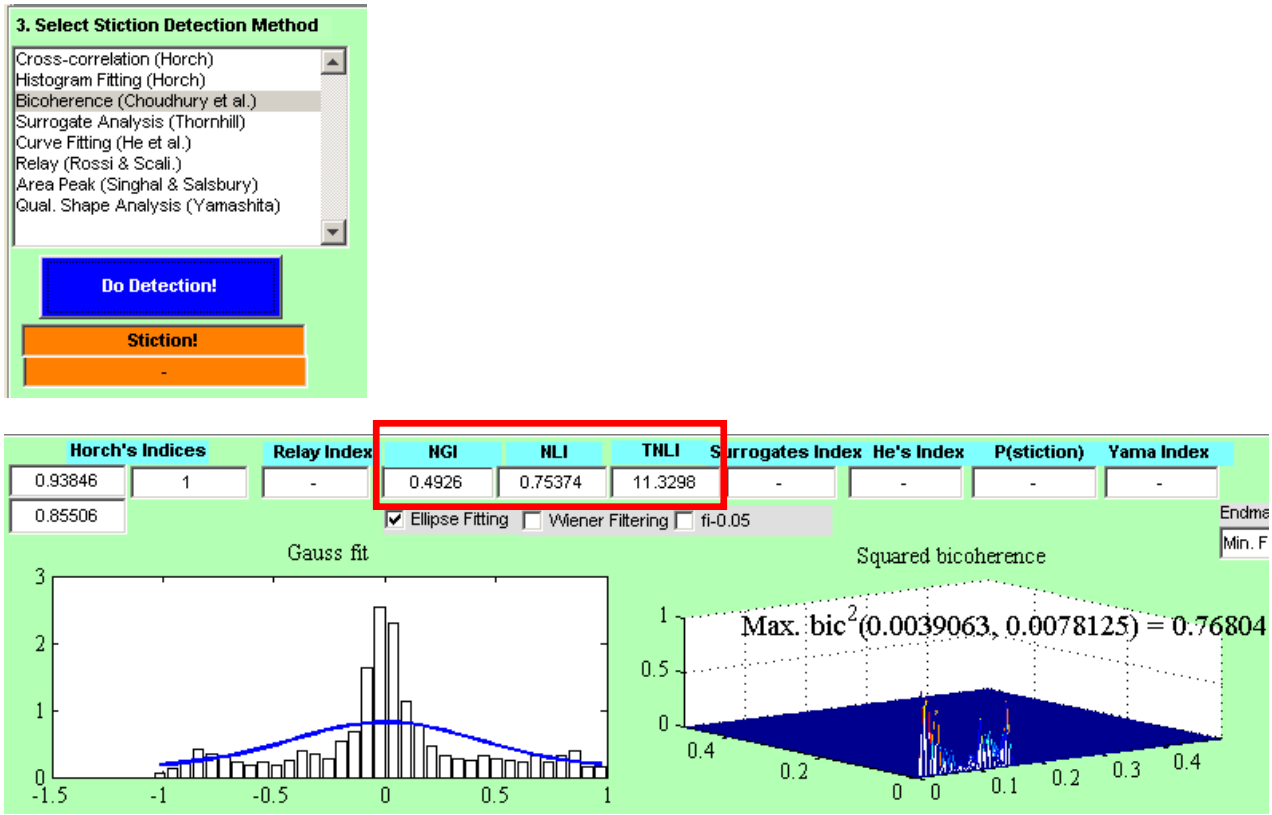




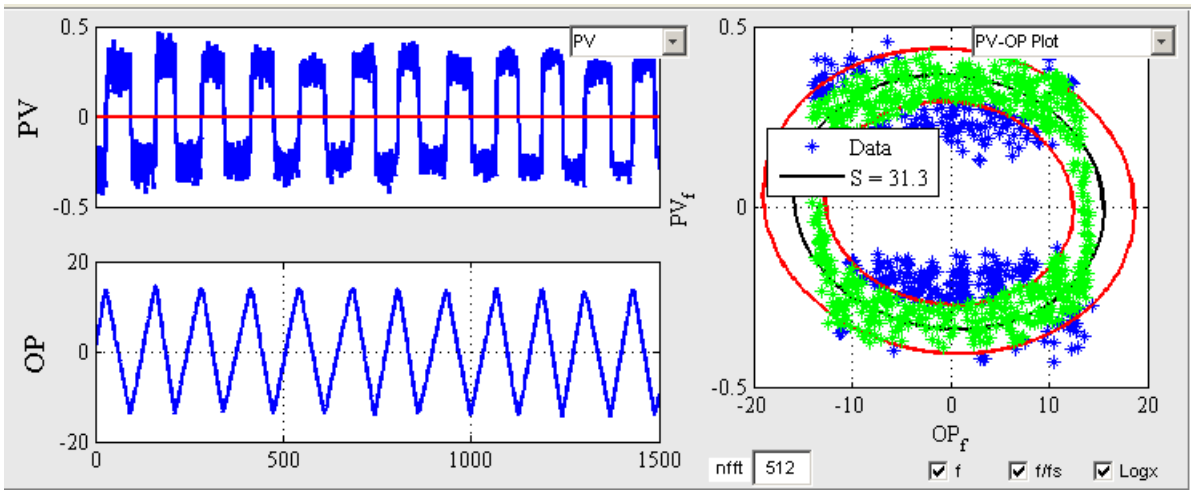
Horch's first method indicates stiction; the cross-correlation function is clearly odd.



The MSE for the Gaussian distribution is 1.81 compared to 9.78 for the camel distribution. It can be hence (correctly) concluded that the oscillation is due to stiction.

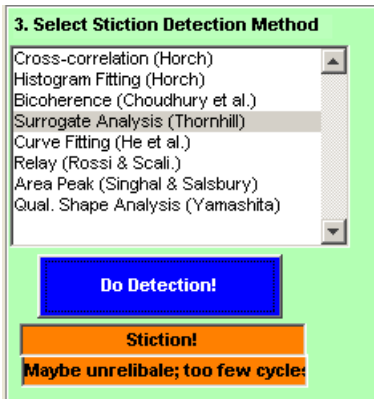


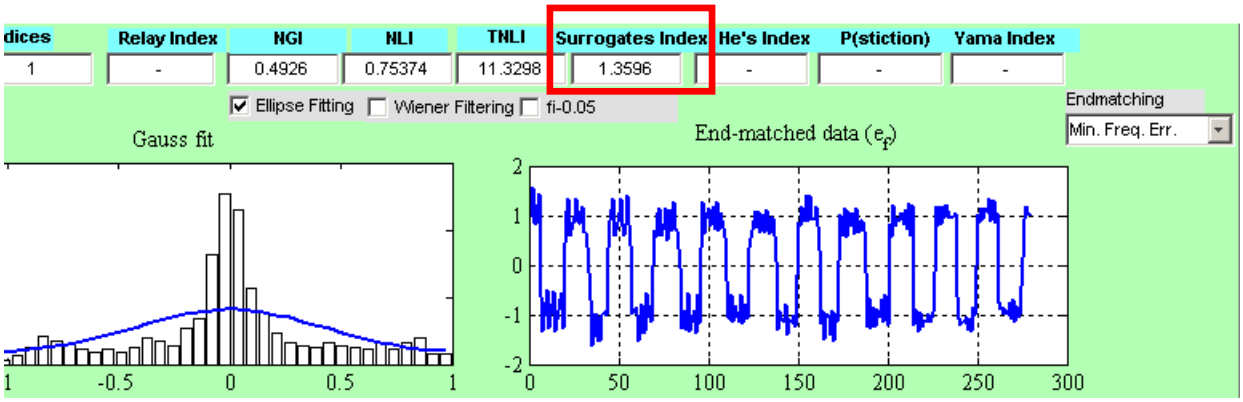
NGI > α = 0.05 indicates that the process is non-Gaussian; NLI > 0 that the process is non-linear (observe the non-flatness of the bicoherence plot). Also TNLI > 0 implies that the process is non-linear.



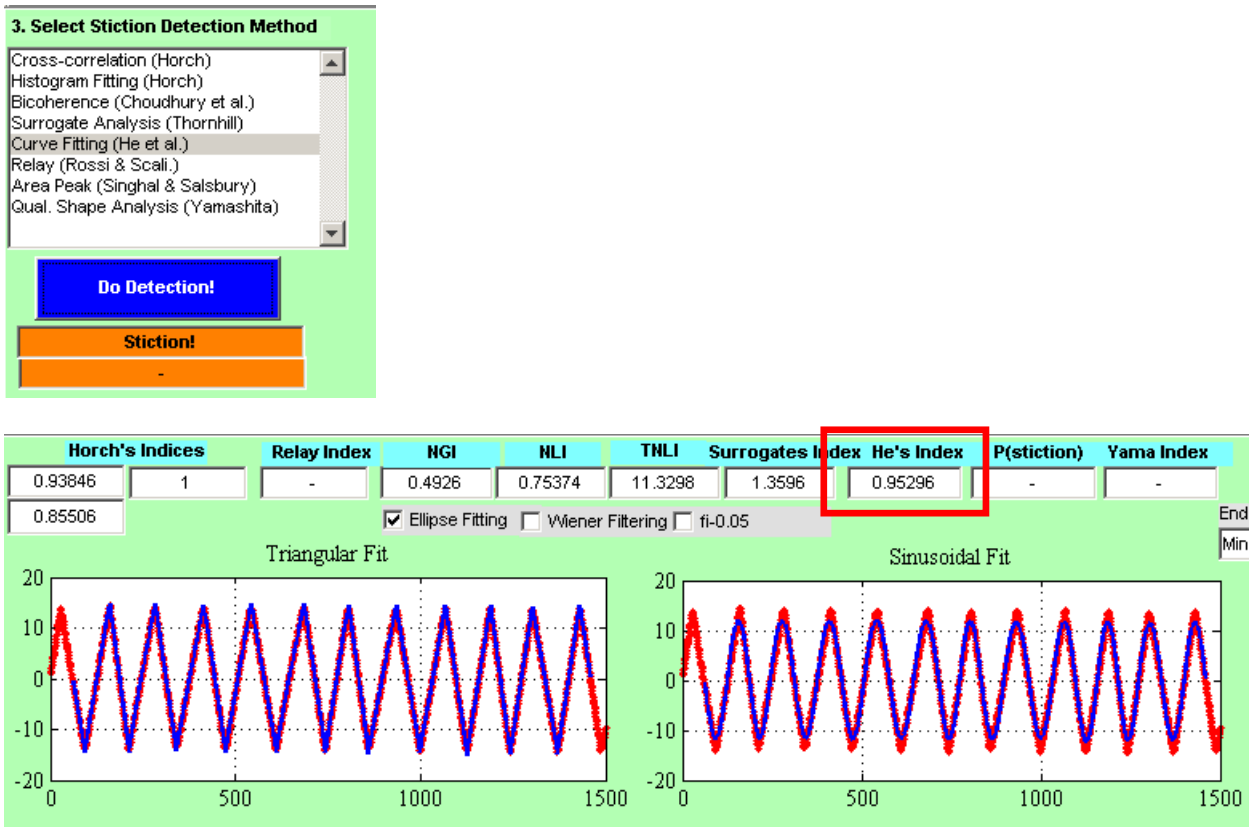
As an ellipse can be fitted to the PV-OP plot, the non-linearity is due stiction. The estimate of apparent stiction is S = 31.3.

Note 4: Default settings – threshold for ellipse fitness = 60%; confidence interval = 0.2 (confidence-limit ellipses).

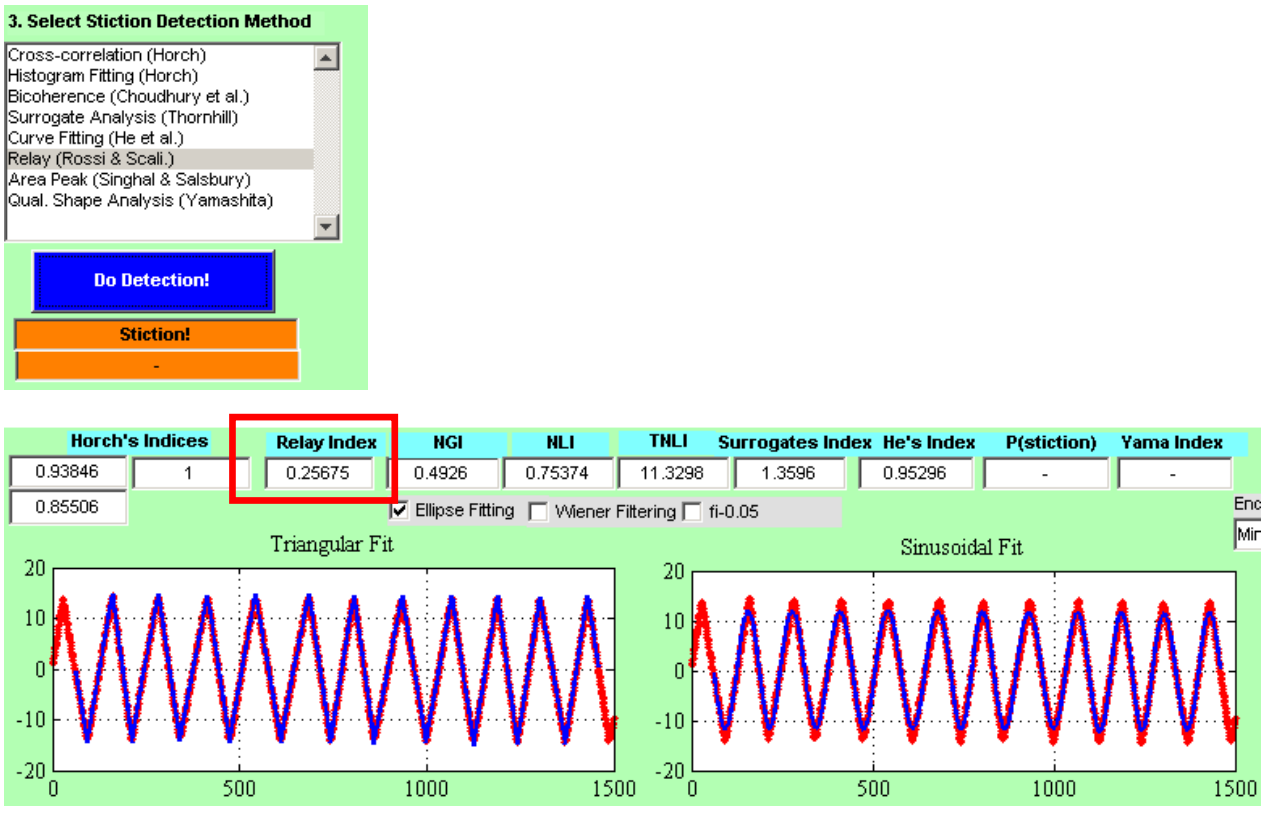




The NPI value 1.36 > 1.0 indicates that the loop signal (control error) is non-linear.

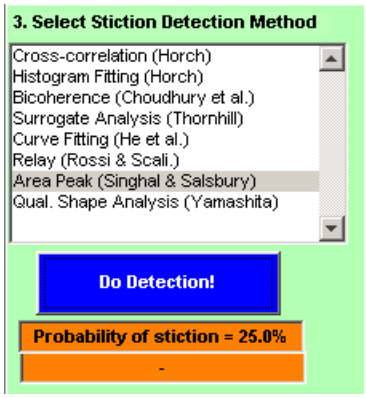


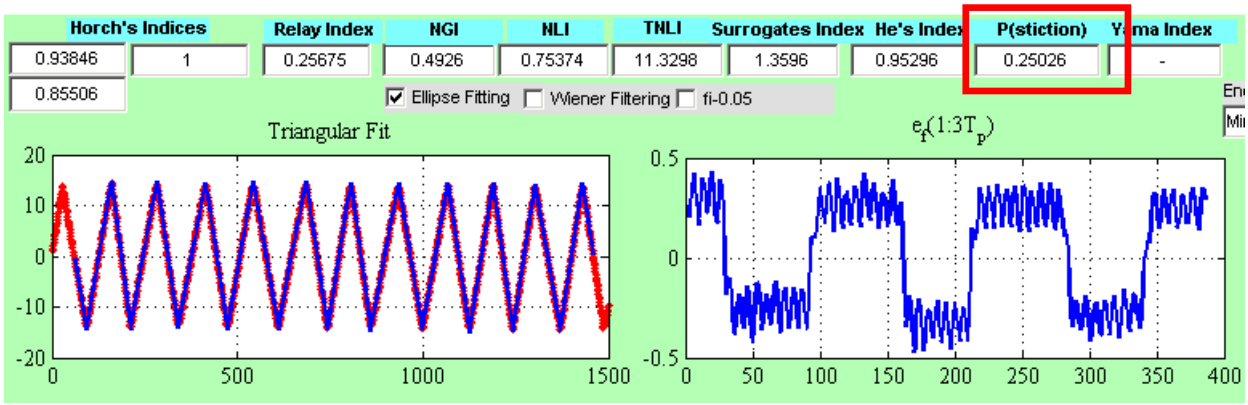
The stiction index value 0.95 > 0.6 indicates the presence of stiction. Observe that the triangular fit is better that the sinusoidal fit.



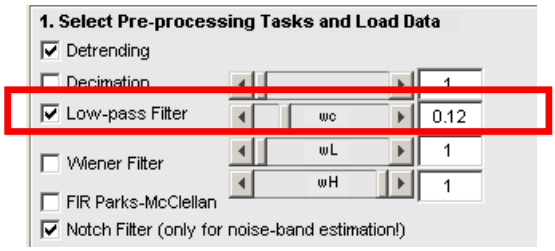
The relay method gives an index value 0.26 > 0.21, which implies that stiction is present in the loop.

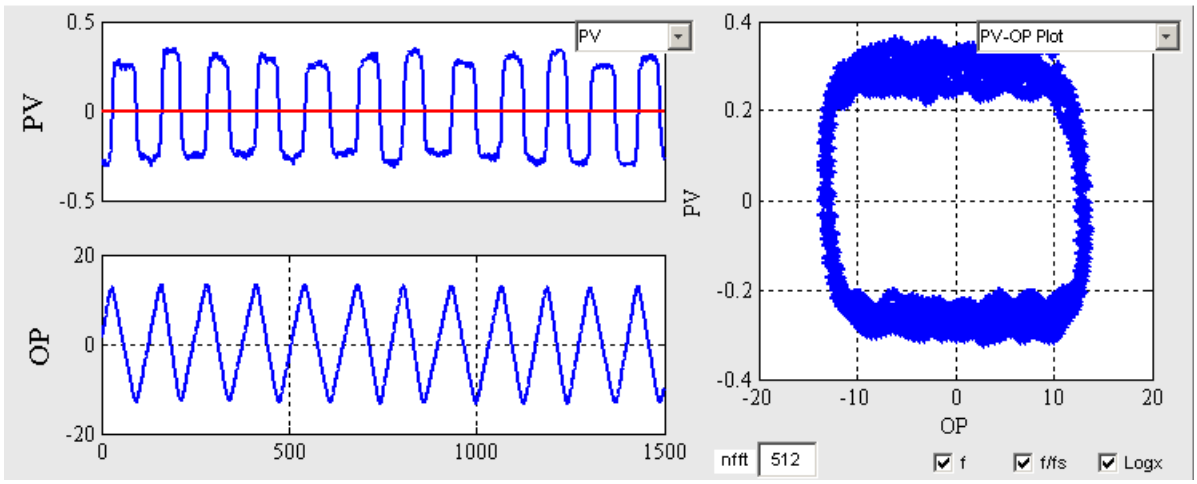
Note 5: This method is computationally demanding and thus may take some minutes for the calculation; so *be patient* after starting the detection!

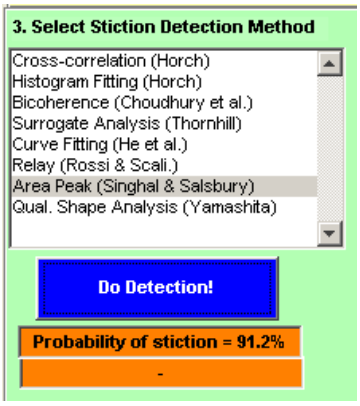


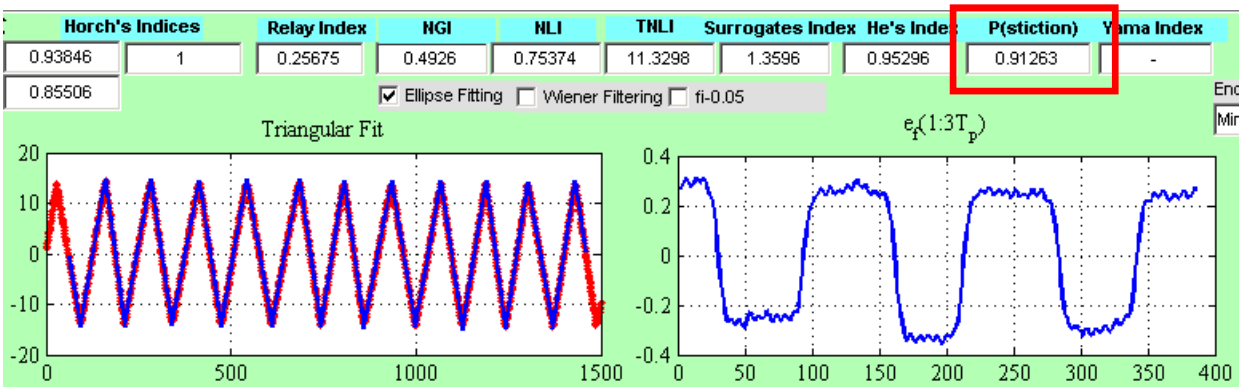


Without data filtering, the probability of stiction for the area-peak method is 25%. However, when low-pass filtering is applied to the data, …

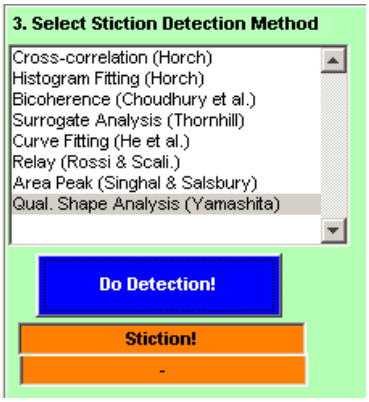


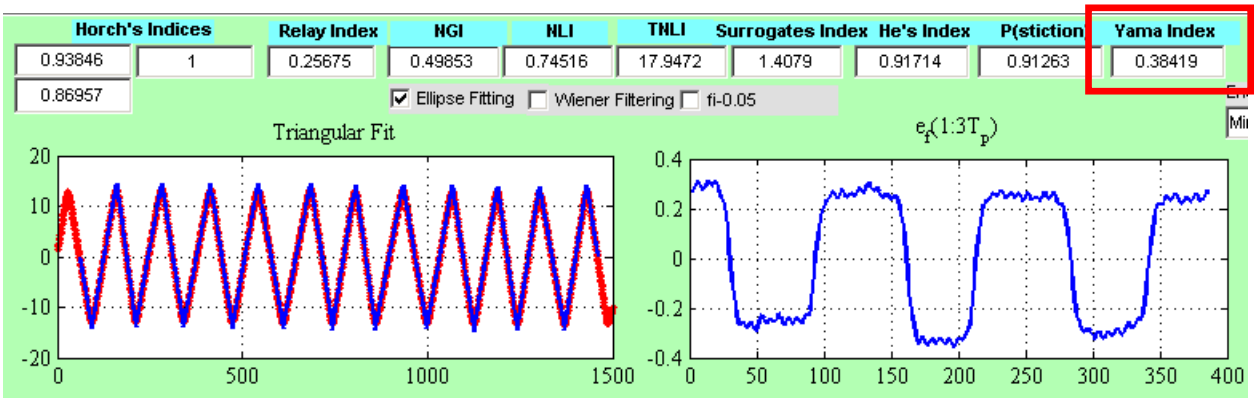






… the probability of stiction becomes 91%.





The Yama index value 0.38 > 0.25 clearly indicates the presence of stiction.

Note 6: Remember that the Yama method is only applicable for flow control loops.

Acknowledgements

Alexander Horch, Claudio Scali, Shoukat Choudhury, Timothy Salsbury and Peter He are acknowledged for providing software (either as m- or p-code), which has been included in this GUI.

Hints for the User

If you use the GUI, please refer to the above-mentioned book or its homepage. If you need any further help or details, or should you find any errors or inconsistencies, please contact the principle editor.