

Tutorial GUI Matcont for maps

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1 Bugs

- Deleting systems or curves hangs matcontm or even matlab, work-around: restart, the deletion itself has been done.
- Branch switching at codim 2 bifurcations is not working.

2 Installation and Starting

Minimal Matlab 7.8 (R2009a) is required. Some familiarity with continuation and/or MATCONT (for ODE's) is expected.

Download from xxx and install to your favourite path. There you now have a directory MATCONTM. Start Matlab and change to the MATCONTM directory. Type 'matcontm' to start. You now see a diagram as in figure 2

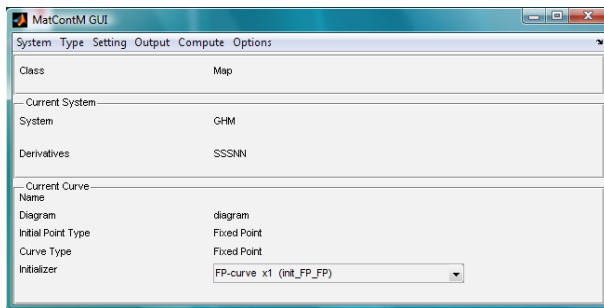


Figure 1: The main window of the graphical user interface

3 Data browser

The following general idea is applied. A system is map consisting of the name, the variables, the parameters and the equations. The equations are stored in a file in the directory Systems called system.m. For each system we have a diagram which can be found in the directory diagram. In this directory all curves computed so far are stored. For more details on the names of files see section 4.4.

All these data can be accessed via the Data browser, Figure 3. At the top level you can select a system. It shows the name, the variables, the parameters, the derivative options and the equations and, if applicable, the user functions. By double-clicking you can select a diagram. Within a diagram you have curves, see Figure 3.

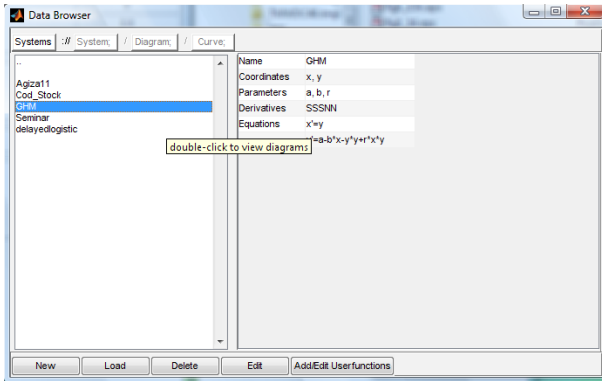


Figure 2: Browsing the data.

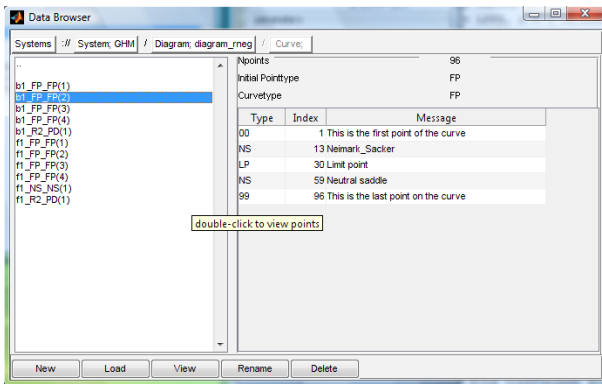


Figure 3: Browsing the data.

3.1 Defining a new system

Open the Data browser and select New. Now enter the name, the variables, the parameters and the equations. Choose the desired option for the derivatives. You may need to enlarge the window to see all text. From file means entering expressions for the derivatives manually. The option symbolic can only be chosen with the symbolic toolbox installed.

Figure 4: The window System definition is missing.

3.2 Using an existing system

- Load to use an existing system.
- Press Edit to make changes to the existing system. For details see section 3.1.
- Pressing Delete removes an existing system

4 Continuation

4.1 Initial point

There are several options to set an initial point:

- One can open the "Starter" window via "Setting" in the main window.
- Via the data browser one can select a curve and then a special point of this curve.
- One can select a curve which automatically sets an initial point.

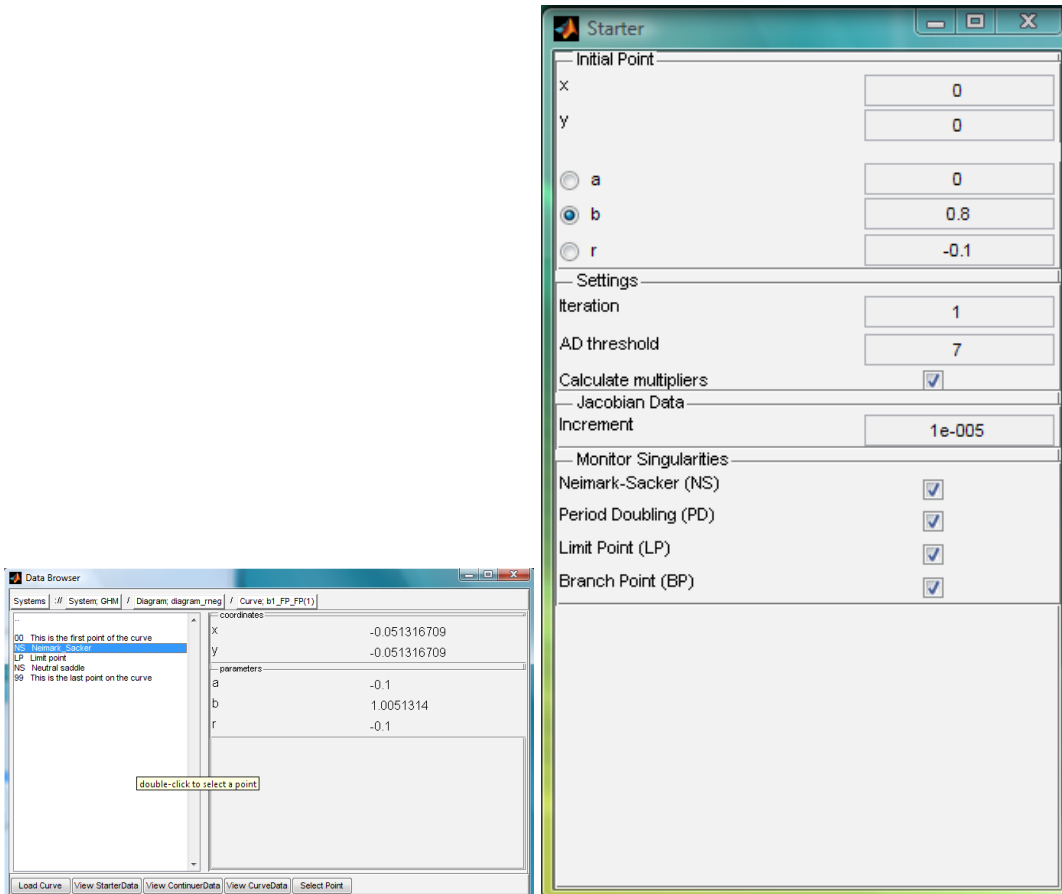


Figure 5: Ways to set an initial point

4.2 Curve type

Several possibilities depending on initial point type. In general see the diagram in W. Govaerts and Yu.A. Kuznetsov, *Interactive Continuation Tools*, pp. 51-75, in: "Numerical Continuation Methods for Dynamical Systems" (eds. B. Krauskopf, H.M. Osinga and J. Galán Vioque", Springer Complexity Series 2007 In the main window you can select the desired type out of all possible options. (Conditional means that it is not always possible. Matcontm will say so if it is not.) Note the presence of the field "AMPLITUDE" in some cases. It requires some experience...

4.3 Continuer settings

As the core of the continuer equals that of the ODE version we refer to the manual for MATCONT for ODE's.

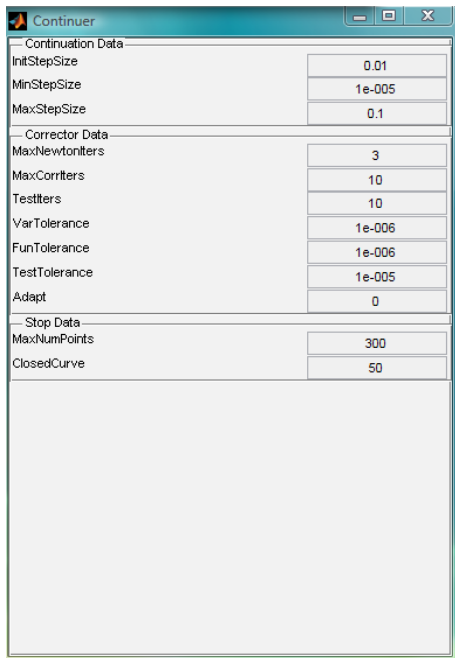


Figure 6: Options for the continuation

4.4 Continuation

The continuation can be started by selecting "Compute" and then "forward" or "backward". The windows "Starter" and "Continuer" are closed automatically and a window "Output" (Figure 5) with the buttons "Stop" and "Pause" appears. Any special messages are displayed here. At the end of the continuation the buttons "Stop" and "Pause" change into "View Curve" and "Close". If you press "View Curve" you automatically go to the Systembrowser at the level of the curve as in Figure 3. The computed data is stored a file that has the following name $xn_A_B(y).mat$ in the active diagram directory representing

- x = forward/backward continuation
- n = iteration number
- A = point type of the initial point (codim 0: FP, codim 1: LP,PD,NS or codim 2)
- B = curve type
- y = number of unnamed files, default maximum=4

Each curve contains the following fields

- x = continuation variables
- v =tangent vector
- h =test functions
- f =multipliers and special data
- s =singularities

5 Viewing data

There are several ways to access and visualize the computed data. The first option is the output window and is available during any continuation. In the "Output" window (Figure 5) special messages are shown including start, end, bifurcations and normal form coefficients. It has buttons "Stop" and "Pause" that change into "View Curve" and "Close" at the end of the continuation.

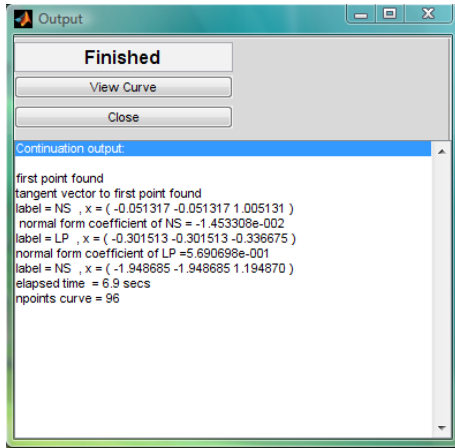


Figure 7: Display of special messages during continuation

Other options are the numeric and graphic windows. These can be opened by selecting "Output" in the main window. The numeric window shows all computed information that is selected via "Layout", default is everything. The graphic window is a normal Matlab figure with one extra option "MATCONTM". Here you can choose "Layout" to select variables, parameters, multipliers or testfunctions to be plotted and their range. Other options are self-explanatory.

The final option is to select "View CurveData" as in Figure 4.1 that loads an array view of the numerical values.

6 Miscellaneous

It is possible to define multiple diagrams. For instance, you may have a third parameter that you want to fix to particular values and for each of these you want a bifurcation diagram in two parameters. In the "System browser" at the diagram level you can create a new diagram by pressing new and enter a name for the new diagram, e.g. "mydiagram". It is then possible to assign computed curves to separate diagrams. For this select "System" in the "main" window and then "Organize diagrams". Select the diagrams and use the ">>" and "<<" buttons to move curves to other diagrams.

7 Exercises

7.1 Codim 2 bifurcations in extended Lorenz system

Before we consider maps, some experience with ODE's could be useful. Consider an extended version of the Lorenz-84 model

$$\begin{cases} \dot{X} &= -Y^2 - Z^2 - \alpha X + \alpha F - \gamma U^2 \\ \dot{Y} &= XY - \beta XZ - Y + G \\ \dot{Z} &= \beta XY + XZ - Z \\ \dot{U} &= -\delta U + \gamma UX + T \end{cases} \quad (1)$$

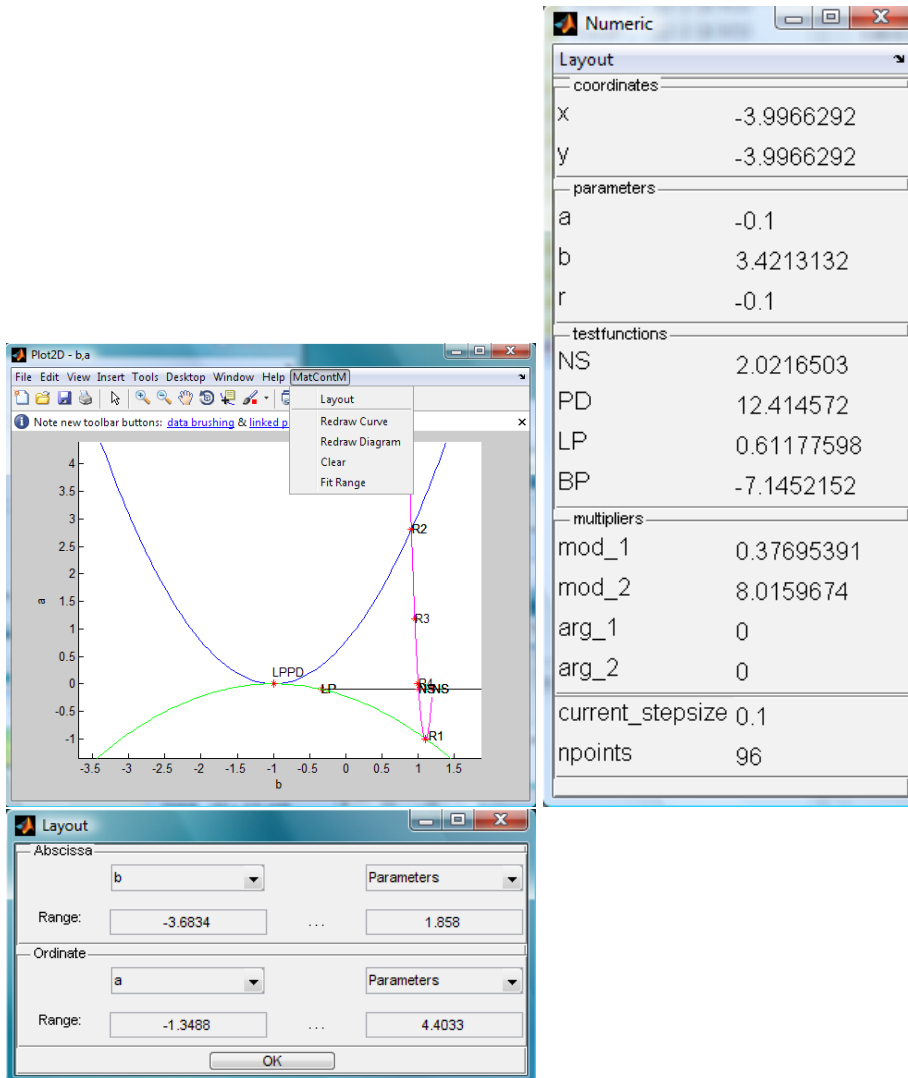


Figure 8: The numerical and graphical output windows

We fix $\alpha = .25, \beta = 1, G = .25, \delta = 1.04, \gamma = .987$. Determine the bifurcation diagram for the parameters F and T for equilibria. Near the codim 2 bifurcations find the curves that are rooted here.

7.2 Simulations

MatcontM does not yet simulate a map, for this use the following command line code:

```
nint=100;p=[.1,.8,-.1,0];x0=[-.1;-.2];
x=zeros(size(x0,1),nint);x(:,1)=x0;p=n2c(p);
func_handles = feval(@GHM);map=func_handles{2};
for i=2:nint x(:,i)=feval(map,0,x(:,i-1),p{:}); end
plot(x(1,:),x(2,:),'Marker','.', 'LineStyle',':');
```

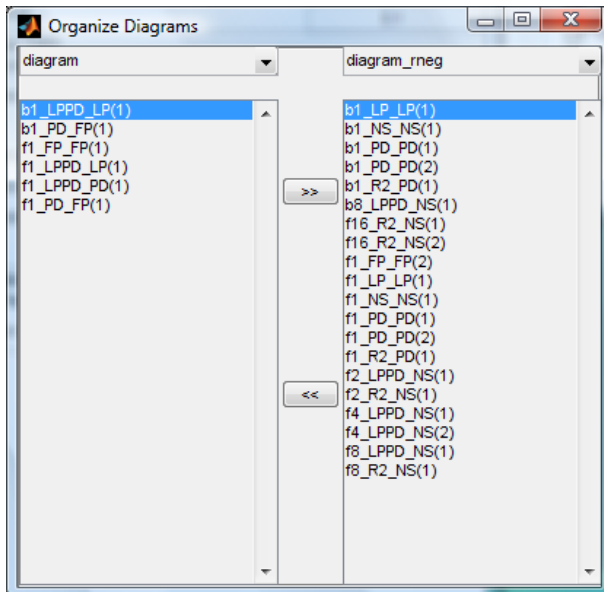


Figure 9: Grouping curves in separate diagrams

7.3 GHM

Enter GHM

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} a - b * x - y * y + r * x * y \\ y \end{pmatrix}$$

and determine the bifurcation diagram in two parameters (b, a) for $R = -3.0, -0.1, 0.1, 3.0$ In particular, do the following:

- for iteration number one: compute fold, flip and NS curves
- for iteration number two: compute flip and NS curves
- for iteration number three: compute fold and flip curves near 1:3 resonance
- for iteration number four: compute fold and flip curves near the 1:4 point, also from pd-cascade
- study the unfolding near the LPPD point for all four values of R .

In each case also provide characteristic phase portraits.

7.4 Adaptive control

Enter the adaptive control map and determine the bifurcation diagram in two parameters (b, k) for $c = .1$ and $c = .5$. In particular, do the following:

- for iteration number 1,2,4: compute flip and NS curves
- near the 1:4 resonance: compute all local bifurcation curves
- find a periodic orbit with $k = 5, 6, 7$ and compute fold bifurcation curves. Hint: monitor the multiplier to have an approximate idea of their location. Try to store these as we will use them in the next session.

In each case also provide characteristic phase portraits.

- 7.5 Chenciner bubbles in biology
- 7.6 High dimensional example from control
- 7.7 Handin project