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Matlab software for ODEs and maps: presentation

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Abstract

We give a presentation of the Matlab software packages CL_MATCONT, its GUI version MATCONT and its version for maps CL_MATCONTM. They were and are being developed in collaboration with Yuri A. Kuznetsov (Utrecht) and several PhD students at Ghent and Utrecht, in particular Annick Dhooge, Bart Sautois, Hil Meijer and Reza Khoshsiar Ghaziani, with the kind assistance and advice of Eusebius Doedel in all stages of development. More recently, Mark Friedman (Huntsville, Alabama, USA) joined the effort by working in particular on a version called MATCONTL for large systems The current versions are available at http://matcont.ugent.be/. These are continuation packages, developed in the spirit of AUTO and incorporating many ideas from AUTO. In particular, they use the same collocation methods for periodic and homoclinic orbits.

At present, these packages are not competitive with AUTO with respect to speed for intensive computations. For problems that involve such computations they are rather complementary because they have many functionalities not provided by AUTO such as normal form coefficients and branch switching. Advanced features include the use of automatic differentiation for the accurate computation of normal form coefficients of codimension 1 bifurcations of cycles of maps.

On the other hand, the additional functionalities of these packages make them ideally suited for a detailed analysis of the dynamical features of continuous and discrete dynamical systems. This applies in particular to the GUI-version which is also a nice tool for teaching. The non-GUI versions are less user-friendly but offer additional possibilities for more experienced users. For example, CL_MATCONT has been used for inverse bifurcation computations.

Depending on time, we envisage to show some or all of the following examples:

- An ODE model from systems biology for the biochemical base of the development of flowers in the plant Arabidopsis. We will show that the model has bistability, contrary to the expectation of biologists based on simulation. More precisely, we will compute the domain of bistability in a two-parameter situation.

- An ODE model for root development in the same plant. We will show how periodic orbits can be studied under parameter variation.

- An ODE model from biological engineering: birth of periodic orbits in a synthetic oscillatory network in *Eschericia coli* by Elowitz and Leibler.

- An ODE model of a genetic toggle switch in *Eschericia coli*; bistability and pitchfork bifurcation in a model of Gardner, Cantor and Collins.

- A standard ODE model for infectious diseases (SIR with vertical transmission): transcritical bifurcation of the disease-free and the endemic steady states.

- The Morris-Lecar model of the barnacle muscle fiber: a Generalized Hopf point on a branch of Hopf points and a branch of limit points of cycles that converge to the Generalized Hopf point.

- A Leslie-Gower map model for the competition of two species of flour beetles: a flip curve, a Generalized Period Doubling Point, branch switching to the fold curve of the second iterate and regions of multistability.

- A map model for Cournot duopoly: a branch of Neimark-Sacker points, a resonance 1:4 point, branches of fold and flip curves of the fourth iterate, multistability.