Practical numerical aspects of MatCont and a model for cell cycle control

Like other continuation and bifurcation packages (AUTO, CONTENT), MatCont uses specific numerical algorithms for finding initial points, for continuation, detection of bifurcations, location of bifurcations, branch switching etc. These algorithms are published in the technical literature, though unfortunately not yet collected in book form.

In most cases, the user manual provides enough information but intensive users soon discover that there are typical situations where the outcome of MatCont computations is puzzling. We will discuss several such issues in cases where there is a close relation with the numerical aspects of the code (i.e. when they are not due to problems with compilation, incompatible Matlab or MatCont versions, operating systems, or simply bugs).

In such cases it helps to understand why the code fails and what can (sometimes) be done to remedy the situation. This may involve changing the continuation parameters such as convergence thresholds, initial amplitude, discretization, adaptation of the defining system, or simply maximal stepsize. It may also involve doing previous computations in a different way, or approach the problem in a different way, e.g. starting a continuation of periodic orbits by time integration instead of from a Hopf point.

Not all computational parameters are easily accessible but source code is always provided with MatCont and can be adapted by an experienced person. Also, MatCont is by no means a closed system. The outcome of all computations is archived in the form of Matlab data files which can be inspected, handled directly from the Matlab command window, or introduced in other programs.

As an application of this discussion and an illustration of the use of MatCont we study numerically a dynamical systems model for the control of the budding yeast cell cycle as proposed by J.J. Tyson and B. Novak. This model has many interesting features and relates slow-fast systems, boundary value problems and fixed points of maps. Several new observations are highlighted, in particular an unexpected branch of stable equilibria and a relation between the growth rate of the cells and cell size at division, which leads to a better understanding of the controllability of the process.