HomotopyContinuation.jl – a package for solving systems of polynomials in Julia

Paul Breiding and Sascha Timme

Technische Universität Berlin
breiding@math.tu-berlin.de, timme@math.tu-berlin.de

In many physical and engineering applications a key task is solving a system of polynomial equations. For example, in physics and chemistry, the geometry of molecules is modelled with a constraint on the distance or the angles between atoms. In robotics, connecting joints underlie constraints on distances or angles.

Traditionally, symbolic packages like `Macaulay2`, `Singular` and `CoCoA` were used to study the zero sets of such systems. Buchberger's Gröbner basis algorithm is underlying this approach. More recently, Numerical Nonlinear Algebra (NNA) has emerged. The computational paradigm in NNA is *numerical homotopy continuation*. The idea behind this is to generate a system of equations of which the solutions are known (a so called start system) and then to continue those solutions along a deformation of the start system towards the system one is interested in. The continuation leads to an ordinary differential equation, called Davidenko-differential equation, which is solved by a numerical predictor-corrector scheme.

With this presentation we would like to give a short introduction into the basic features of the software package `HomotopyContinuation.jl` [1]. The package is a modern and competitive implementation of numerical homotopy continuation in the programming language `Julia`. It provides the most commonly used strategies including multi-homogeneous total degree, polyhedral homotopy, and monodromy. In addition, the software makes use of modern CPUs by using all cores which provides significant speed-ups for large scale problems. The experiments in [2] demonstrate the robustness and performance of the package on several benchmark examples. Furthermore, we took great care of our website `juliahomotopycontinuation.org` and of the presentation of the software. Our goal is to set the hurdles for using `HomotopyContinuation.jl` as low as possible.

References

1. P. Breiding and S. Timme. HomotopyContinuation.jl: A Package for Homotopy Continuation in Julia. International Congress on Mathematical Software 2018.
2. S. Timme. Mixed Precision Path Tracking for Polynomial Homotopy Continuation *arXiv:1902.02968*.