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Also available as Python thesis!

Project Thesis: Implementation of the basin stability concept in programming language Julia

The Dynamics Group is currently working on an open-source software package for computing the **basin stability** [1] of nonlinear dynamical systems. The basin stability is a very recent, yet very general concept that can be applied to dynamical systems ranging from the Amazon rainforest, neural networks and electrical powergrids to mechanical oscillators such as turbine blades. Hence, the computation of the basin stability is highly interesting for many scientific disciplines. A Matlab-based implementation is already available at the Dynamics Group. However, as the computations involve a very high number of time integrations, we are looking for higher computational performance through faster programming concept and other programming languages.

Julia (https://julialang.org/) is an open-source project devoted to high performance computing, parallelization, dynamic typesetting and is as easy to use as Python, but as fast as C (https://devblogs.nvidia.com/gpu-computing-julia-programming-language/) Hence, the objective of this thesis is to implement the existing code in Julia and to perform benchmark studies w.r.t computation time, efficiency and accuracy. The following work packages constitute the project thesis:

- Getting familiar with Julia (programming style, data formats, …), implementing time integrations for dynamical systems and basic operations like looping through arrays
- Implementing approaches for parallelization and GPU-acceleration through CUDA
- Realization of canonical test cases:
  - Mechanical pendulum
  - Turbine blade in air stream
  - Friction oscillator
- Benchmarking against existing Matlab implementation (performance, accuracy)
- Documentation (Thesis work, user manual)

Required skills:

- Demonstrated programming experience in at least one of the following languages: C++ / Matlab / Python, (optimally in Julia)
- General knowledge about dynamical systems and their vibrational behavior
- Interest in open-source and collaborative (Git) software development
- Curiosity, excellent skills in working independently, strong communication skills

Please contact Mr. Merten Stender (m.stender@tuhh.de) when you are interested (please indicate your programming skills and knowledge about dynamical systems)!

[1] Menck, P. J., Heitzig, J., Marwan, N., & Kurths, J. (2013). How basin stability complements the linear-stability paradigm. Nature physics, 9(2), 89-92.