Master project

Dynamics of the Fractional Order Van der Pol Oscillator

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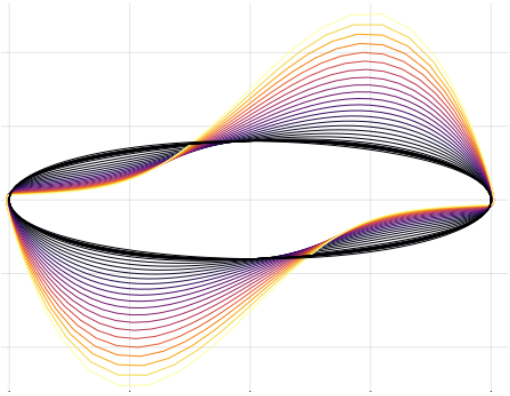
Background.



The van der Pol oscillator is a non-conservative oscillator with non-linear damping. Energy is dissipated at high amplitudes and generated at low amplitudes. As a result, there exist oscillations around a state at which energy generation and dissipation balance. Van der Pol himself came across the system as he was building electronic circuit models of the human heart. Due to the unique nature of the van der Pol oscillator, it has become the cornerstone for studying systems with limit cycle oscillations. In fact, the van der Pol equation has become a staple model for oscillatory processes in not only physics, but also biology, sociology and even economics.

Project description and methodology.

Originally, the van der Pol oscillator was described in terms of a second order ODE. Later the model was extended to the fractional-order setting in the Riemann-Liouville sense, known for its memory effects.

In this project you will:

1. Explore possible modifications of the Van der Pol oscillator, using the Hilfer fractional operator;
2. Analyse the obtained model(s);
3. Approximate its solutions using the Bernstein polynomials.

References.

[1] H. Jafari, C.M. Khalique, M. Nazari, *An algorithm for the numerical solution of nonlinear fractional-order Van der Pol oscillator equation*, Mathematical and Computer Modelling, **55**(5-6), 2012, 1782–1786.

[2] Z. Satmari, *Iterative Bernstein splines technique applied to fractional order differential equations*, Mathematical Foundations of Computing (2021), doi: 10.3934/mfc.2021039.

[3] Z. Tomovski, J. L. A. Dubbeldam, J. Korbel, *Applications of Hilfer-Prabhakar operator to option pricing financial model*, Fractional Calculus and Applied Analysis, **23**(4), 996-1012 (2020), doi: 10.1515/fca-2020-0052.