Fractional Initial and Boundary Value Problems: from Qualitative Analysis to Applications

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Abstract

In recent years fractional initial and boundary value problems have attracted much attention in the field of mathematical modeling due to the ability of fractional operators to capture non-local and memory effects. Such effects are relevant in many physical processes, thus making fractional differential equations (FDEs) a suitable modeling tool. Despite of the mentioned advantages of fractional operators, the inherent nonlocality of fractional calculus introduces several difficulties. Closed-form solutions to FDEs – particularly those encountered in engineering and applied sciences – are rarely available, especially when nonlinearities are involved. Traditional analytical methods tend to have limited applicability or require substantial adaptation to handle fractional formulations. In addition, the computational cost of numerical techniques for FDEs is typically higher than for classical integer-order models.

In my talk I will explain how a suitable parametrization technique and construction of functional sequences can not only ensure existence and uniqueness of solutions to the studied FDEs, but also enables approximation of these solutions with high precision. I will demonstrate efficiency of the presented approach on concrete examples of fractional initial and boundary value problems arising from applied sciences. The presented results will be based on the recent papers with Dona Pantova [1] and Niels Goedegebure [2].

References

[1] K. Marynets, D. Pantova, Fractional boundary value problems with parameter-dependent and asymptotic conditions, *Fractal and Fractional* (2025), 9 (7), 462; doi: 10.3390/fractalfract9070462.

[2] N. Goedegebure, K. Marynets, A numerical Bernstein splines approach for nonlinear initial value problems with Hilfer fractional derivative, *preprint* (2025), doi: 10.48550/arXiv.2503.22335.