EXISTENCE AND UNIQUENESS RESULTS FOR A CLASS OF FRACTIONAL DIFFERENTIAL EQUATIONS WITH NONLOCAL BOUNDARY CONDITIONS

Mohammed Derhab* and Fatiha Meziane

Abstract. This study focuses on constructing solutions for a specific type of second order fractional differential equation involving nonlocal boundary conditions. We additionally provide exemplifications that demonstrate the application of our results.

Mathematics subject classification (2020): 34A08, 34B10.

Keywords and phrases: Fractional differential equations, upper and lower solutions, monotone iterative technique, nonlocal boundary conditions.

REFERENCES

- B. AHMAD, A. ALSAEDI AND A. ALSHARIF, Existence results for fractional-order differential equations with nonlocal multi-point-strip conditions involving Caputo derivative, Advances in Difference Equations 348 (2015), 11 pages.
- [2] B. AHMAD, J. HENDERSON AND R. LUCA, Boundary Value Problems for Fractional Differential Equations and Systems, Trends in Abstract and Applied Analysis Volume 9, World Scientific Publishing Co. Pte. Ltd. 2021.
- [3] B. AHMAD, J. J. NIETO AND A. ALSAEDI, Existence and uniqueness of solutions for nonlinear fractional differential equations with non-separated type integral boundary conditions, Acta Math. Sci. Ser. B Engl. Ed. 31 (2011), 2122–2130.
- [4] A. ALI, M. SARWAR, M. B. ZADA AND K. SHAH, Existence of solution to fractional differential equation with fractional integral type boundary conditions, Math. Methods Appl. Sci. 44 (2021), 1615–1627.
- [5] M. AL-REFAI, Basic results on nonlinear eigenvalue problems of fractional order, Electron. J. Differential Equations 2012 (2012), 1–12.
- [6] M. AL-REFAI, On the fractional derivatives at extreme points, Electron. J. Qual. Theory Differ. Equ. 2012 (2012), 1–5.
- [7] I. AREA AND JUAN J. NIETO, *On the fractional Allee logistic equation in the Caputo sense*, Examples and Counterexamples **4** (2023), 100121.
- [8] A. BOUCHERIF AND S. M. BOUGUIMA, Nonlocal multipoint boundary value problems, Comm. Appl. Nonlinear Anal. 8 (1998), 73–85.
- [9] Z. BAI, S. ZHANG, S. SUN AND C. YIN, Monotone iterative method for fractional differential equations, Electron. J. Differential Equations 2016 (2016), 1–8.
- [10] A. CABADA AND G. WANG, Positive solutions of nonlinear fractional differential equations with integral boundary value conditions, J. Math. Anal. Appl. 389 (2012), 403–411.
- [11] M. DERHAB AND M. S. IMAKHLAF, Existence of minimal and maximal solutions for a fractional differential equation on the half-line with nonlocal initial condition and without condition at infinity, PanAmer. Math. J. 31 (2021), 79–100.
- [12] M. DERHAB AND F. MEZIANE, Existence results and the monotone iterative technique for systems of nonlinear fractional differential equations with integral boundary conditions, J. Nonlinear Funct. Anal. 2018 (2018), 1–22.
- [13] M. DERHAB AND F. MEZIANE, Existence results for a class of first order fractional differential equation with a nonlocal initial condition, PanAmer. Math. J. **32** (2022), 1–16.



- [14] K. DIETHELM, *The Analysis of Fractional Differential Equations*, Lecture Notes in Mathematics, Springer, Berlin, 2010.
- [15] Y. JI, W. JIANG AND J. QIU, Solvability of fractional differential equation with integral boundary conditions at resonance, Topol. Methods Nonlinear Anal. 42 (2013), 461–479.
- [16] R. A. KHAN, M. U REHMAN AND J. HENDERSON, Existence and uniqueness of solutions for nonlinear fractional differential equations with integral boundary conditions, Fract. Differ. Calc. 1 (2011), 29–43.
- [17] A. A. KILBAS AND S. A. MARZAN, Cauchy problem for differential equation with Caputo derivative, Fract. Calc. Appl. Anal. 7 (2004), 297–321.
- [18] A. A. KILBAS, M. RIVERO, L. RODRÍGUEZ-GERMÁ AND J. J. TRUJILLO, *Caputo linear fractional differential equations*, Proceedings of the 2nd IFAC Workshop on Fractional Differentiation and its Applications Porto, Portugal, July 19–21, 2006.
- [19] A. A. KILBAS, H. M. SRIVASTAVA AND J. J. TRUJILLO, *Theory and Applications of Fractional Differential Equations*, North-Holland Mathematics Studies, 204, Elsevier Science B.V., Amsterdam, 2006.
- [20] X. LIU AND Y. LIU, Fractional differential equations with fractional non-separated integral boundary conditions, Electron. J. Differential Equations 25 (2013), 1–13.
- [21] R. L. MAGIN, Fractional Calculus in Bioengineering, Begell House Publishers, Inc. Connectitut, United States of America, 2006.
- [22] F. MAINARDI, Fractional Calculus and Waves in Linear Viscoelasticity, Imperial College Press, London, 2010.
- [23] C. V. PAO, Dynamics of reaction-diffusion equations with nonlocal boundary conditions, Quart. Appl. Math. 53 (1995), 173–186.
- [24] I. PODLUBNY, Fractional Differential Equations, Academic Press, San Diego, 1999.
- [25] J. D. RAMIREZ AND A. S. VATSALA, Monotone iterative technique for fractional differential equations with periodic boundary conditions, Opuscula Math. 29 (2009), 289–304.
- [26] S. G. SAMKO, A. A. KILBAS AND O. I. MARICHEV, Fractional Integrals and Derivatives. Theory and Applications, Gordon and Breach, Yverdon, 1993.
- [27] Z. SHUQIN, Monotone iterative method for initial value problem involving Riemann-Liouville fractional derivatives, Nonlinear Anal. 71 (2009), 2087–2093.
- [28] J. A. TENREIRO MACHADO, Fractional Calculus: Models, Algorithms, Technology, Discontinuity, Nonlinearity, and Complexity 4, (2015), 383–389.
- [29] O. K. WANASSI, R. BOURGUIBA AND D. F. M. TORRES, Existence and uniqueness of solution for fractional differential equations boundary conditions and the Adomian decomposition method, Math. Methods Appl. Sci. 44 (2022), 1–14.