

HILFER AND HADAMARD COUPLED VOLTERRA FRACTIONAL INTEGRO-DIFFERENTIAL SYSTEMS WITH RANDOM EFFECTS

SAÏD ABBAS, RAVI P. AGARWAL, MOUFFAK BENCHOHRA
AND BOUALEM ATTOU SLIMANI

Abstract. This paper deals with some existence results for two classes of coupled systems of Hilfer and Hilfer-Hadamard random fractional integro-differential equations. The main tool used to carry out our results is Itoh's random fixed point theorem.

Mathematics subject classification (2010): 26A33.

Keywords and phrases: Fractional integro-differential equation, Riemann-Liouville integral of fractional order, Hadamard integral of fractional order, Hilfer fractional derivative, Hadamard fractional derivative, coupled system, random solution, existence, fixed point.

REFERENCES

- [1] S. ABBAS, W. ALBARAKATI AND M. BENCHOHRA, *Successive approximations for functional evolution equations and inclusions*, J. Nonlinear Funct. Anal., Vol. 2017 (2017), Article ID 39, pp. 1–13.
- [2] S. ABBAS, M. BENCHOHRA, J. GRAEF AND J. HENDERSON, *Implicit Fractional Differential and Integral Equations; Existence and Stability*, De Gruyter, Berlin, 2018.
- [3] S. ABBAS, M. BENCHOHRA AND J. HENDERSON, *Partial Hadamard-Stieltjes fractional integral equations in Banach spaces*, Manuscript for a chapter in the Banas, et al. Springer book, Advances in Nonlinear Analysis via the Concept of Measure of Noncompactness, Chapter 9, (2017), 375–391.
- [4] S. ABBAS, M. BENCHOHRA, J. HENDERSON AND J. E. LAZREG, *Measure of noncompactness and impulsive Hadamard fractional implicit differential equations in Banach spaces*, Math. Eng. Science Aerospace **8** (3) (2017), 1–19.
- [5] S. ABBAS, M. BENCHOHRA, J. E. LAZREG AND Y. ZHOU, *A Survey on Hadamard and Hilfer fractional differential equations: Analysis and Stability*, Chaos, Solitons Fractals **102** (2017), 47–71.
- [6] S. ABBAS, M. BENCHOHRA AND G. M. N'GUÉRÉKATA, *Topics in Fractional Differential Equations*, Springer, New York, 2012.
- [7] S. ABBAS, M. BENCHOHRA AND G. M. N'GUÉRÉKATA, *Advanced Fractional Differential and Integral Equations*, Nova Science Publishers, New York, 2015.
- [8] B. AHMAD, A. ALSAEDI, S. K. NTOUYAS, J. TARIBOON, *Hadamard-type Fractional Differential Equations, Inclusions and Inequalities*, Springer, Cham, 2017.
- [9] B. AHMAD, R. LUCA, *Existence of solutions for a sequential fractional integro-differential system with coupled integral boundary conditions*, Chaos Solitons Fractals **104** (2017), 378–388.
- [10] A. ALSAEDI, S. ALJOURDI, B. AHMAD, *Existence of solutions for Riemann-Liouville type coupled systems of fractional integro-differential equations and boundary conditions*, Electron. J. Differential Equations **2016**, paper no. 211, 14 pp.
- [11] S. ALJOURDI, B. AHMAD, J. J. NIETO, A. ALSAEDI, *A coupled system of Hadamard type sequential fractional differential equations with coupled strip conditions*, Chaos Solitons Fractals **91** (2016), 39–46.
- [12] A. T. BHARUCHA-REID, *Random Integral Equations*, Academic Press, New York, 1972.
- [13] J. M. CUSHING, *Forced asymptotically periodic solutions of predator-prey systems with or without hereditary effects*, Siam J. Appl. Math. **30** (1976), 665–674.
- [14] B. C. DHAGE, *Existence theory for first order functional random integrodifferential inclusions*, Nonlinear Stud. **24** (2017), 309–328.

- [15] B. C. DHAGE, R. G. METKAR, *Approximating monotonically the unique random solutions of second order periodic random boundary value problems*, Comm. Appl. Nonlinear Anal. **22** (2015), 34–44.
- [16] J. DIBLIK, E. SCHMEIDEL, M. RUZICKOVA, *Asymptotically periodic solutions of Volterra system of difference equations*, Comput. Math. Appl. **59** (2010), 2854–2867.
- [17] J. DIBLIK, E. SCHMEIDEL, M. RUZICKOVA, *Existence of asymptotically periodic solutions of system of Volterra difference equations*, J. Differ. Equ. Appl. **15** (2009), 1165–1177.
- [18] K. M. FURATI AND M. D. KASSIM, *Non-existence of global solutions for a differential equation involving Hilfer fractional derivative*, Electron. J. Differential Equations **2013**, no. 235, 10 pp.
- [19] K. M. FURATI, M. D. KASSIM, AND N. E. TATAR, *Existence and uniqueness for a problem involving Hilfer fractional derivative*, Comput. Math. Appl. **64** (2012), 1616–1626.
- [20] A. GRANAS AND J. DUGUNDJI, *Fixed Point Theory*, Springer-Verlag, New York, 2003.
- [21] X. Z. HE, K. GOPALSAMY, *Dynamics of Lotka-Volterra mutualism in changing environments*, Dynam. Systems Appl. **1** (1994), 173–185.
- [22] R. HILFER, *Applications of Fractional Calculus in Physics*, World Scientific, Singapore, 2000.
- [23] S. ITOH, *Random fixed point theorems with applications to random differential equations in Banach spaces*, J. Math. Anal. Appl. **67** (1979), 261–273.
- [24] V. K. JIRSA, H. HAKEN, *Field theory of electromagnetic brain activity*, Phys. Rev. Lett. **77** (1996), 960–963.
- [25] H. F. HUO, W. T. LI, *Oscillation criteria for certain two-dimensional differential systems*, Int. J. Appl. Math. **6** (2001), 253–261.
- [26] R. KAMOCKI AND C. OBCZŃSKI, *On fractional Cauchy-type problems containing Hilfer's derivative*, Electron. J. Qual. Theory Differ. Equ., 2016, no. 50, 1–12.
- [27] A. A. KILBAS, *Hadamard-type fractional calculus*, J. Korean Math. Soc. **38** (6) (2001), 1191–1204.
- [28] A. A. KILBAS, H. M. SRIVASTAVA AND J. J. TRUJILLO, *Theory and Applications of Fractional Differential Equations*, Elsevier Science B. V., Amsterdam, 2006.
- [29] G. S. LADDE AND V. LAKSHMIKANTHAM, *Random Differential Inequalities*, Academic Press, New York, 1980.
- [30] D. T. J. LILEY, P. J. CADUSCH, J. J. WRIGHT, *A continuum theory of electro-cortical activity*, Neurocomputing **26–27** (1999), 795–800.
- [31] V. LUPULESCU, D. O'REGAN, G. UR RAHMAN, GHAUS, *Existence results for random fractional differential equations*, Opuscula Math. **34** (2014), 813–825.
- [32] M. D. QASSIM, K. M. FURATI, AND N.-E. TATAR, *On a differential equation involving Hilfer-Hadamard fractional derivative*, Abstr. Appl. Anal., vol. 2012, Article ID 391062, 17 pages, 2012.
- [33] M. D. QASSIM AND N.-E. TATAR, *Well-posedness and stability for a differential problem with Hilfer-Hadamard fractional derivative*, Abstr. Appl. Anal., vol. 2013, Article ID 605029, 12 pages, 2013.
- [34] Y. N. RAFFOUL, *Classification of positive solutions of nonlinear systems of Volterra integral equations*, Ann. Funct. Anal. **2** (2011), 34–41.
- [35] S. G. SAMKO, A. A. KILBAS AND O. I. MARICHEV, *Fractional Integrals and Derivatives. Theory and Applications*, Gordon and Breach, Amsterdam, 1987, Engl. Trans. from the Russian.
- [36] V. E. TARASOV, *Fractional Dynamics: Application of Fractional Calculus to Dynamics of Particles, Fields and Media*, Springer, Heidelberg; Higher Education Press, Beijing, 2010.
- [37] Ž. TOMOVSKI, R. HILFER AND H. M. SRIVASTAVA, *Fractional and operational calculus with generalized fractional derivative operators and Mittag-Leffler type functions*, Integral Transforms Spec. Funct. **21** (11) (2010), 797–814.
- [38] C. P. TSOKOS AND W. J. PADGETT, *Random Integral Equations with Applications to Life Sciences and Engineering*, Academic Press, New York, 1974.
- [39] J.-R. WANG, AND Y. ZHANG, *Nonlocal initial value problems for differential equations with Hilfer fractional derivative*, Appl. Math. Comput. **266** (2015), 850–859.
- [40] H. R. WILSON, J. D. COWAN, *Excitatory and inhibitory interactions in localized populations of model neurons*, Biophys. J. **12** (1972), 1–24.
- [41] H. R. WILSON, J. D. COWAN, *A mathematical theory of the functional dynamics of cortical and thalamic nervous tissue*, Kybernetik **13** (1973), 55–80.
- [42] Y. ZHOU, *Basic Theory of Fractional Differential Equations*, World Scientific, Singapore, 2014.