

HÖLDER AND MINKOWSKI TYPE INEQUALITIES FOR PSEUDO-FRACTIONAL INTEGRAL

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Abstract. We first introduce the concept of fractional operators and pseudo-analysis. Then we present new versions of Hölder, Minkowski and reverse Minkowski inequalities via ψ -Riemann-Liouville-Mittag-Leffler pseudo-fractional integral on a semiring $([a, b], \oplus, \odot)$.

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REFERENCES

- [1] S. ABBASZADEH, A. EBADIAN AND M. JADDI, *Hölder integral inequalities with different pseudo-operations*, Asian-Eur. J. Math. **12** 3 (2019) 1950032-1–1950032-15.
- [2] H. AGAHI AND M. ALIPOUR, *On pseudo-Mittag-Leffler functions and applications*, Fuzzy Sets Syst. **327** (2017) 21–30.
- [3] H. AGAHI, A. BABAKHANI AND R. MESIAR, *Pseudo-fractional integral inequality of Chebyshev type*, Inf. Sci. **301** (2015) 161–168.
- [4] H. AGAHI, Y. OUYANG, R. MESIAR, E. PAP AND M. ŠTRBOJA, *Hölder and Minkowski type inequalities for pseudo-integral*, Appl. Math. Comput. **217** (2011) 8630–8639.
- [5] T. A. ALJAAIDI AND D. B. PACHPATTE, *The Minkowski's inequalities via ψ -Riemann-Liouville fractional integral operators*, Rend. Circ. Mat. Palermo, II. Ser 70 (2021) 893–906.
- [6] A. BABAKHANI, *Minkowski's inequality for variational fractional integrals*, Kyungpook Math. J. **60** (2020) 289–295.
- [7] A. BABAKHANI, M. YADOLLAHZADEH AND A. NEAMATY, *Some properties of pseudo-fractional operators*, J. Pseudo-Differ. Oper. Appl. **9** (2018) 677–700.
- [8] A. BABAKHANI, H. AGAHI AND R. MESIAR, *A (\star, \star) -based Minkowski inequality for Sugeno fractional integral of order $\alpha > 0$* , Fract. Calc. Appl. Anal. **18** 4 (2015), 862–874.
- [9] Z. DAHMANI, *On Minkowski and Hermite-Hadamard integral inequalities via fractional integration*, Ann. Funct. Anal. **1** 1 (2010) 51–58.
- [10] B. DARABY, *Generalization of the Stolarsky type inequality for pseudo-integrals*, Fuzzy Sets Syst. **194** (2012) 90–96.
- [11] M. HOSSEINI, A. BABAKHANI, H. AGAHI AND S. H. RASOULI, *On pseudo-fractional integral inequalities related to Hermite-Hadamard type*, Soft Comp. **20** (2016) 2521–2529.
- [12] A. A. KILBAS, H. M. SRIVASTAVA AND J. TRUJILLO, *Theory and Applications of the Fractional Differential Equations*, vol. **204**, Elsevier Amsterdam (2006).
- [13] W. KUICH, *Semirings, Automata, Languages*, Springer, Berlin (1986).
- [14] D. Q. LI, X. Q. SONG, T. YUE, Y. Z. SONG, *Generalization of the Lyapunov type inequality for pseudo-integrals*, Appl. Math. Comput. **241** (2014) 64–69.
- [15] R. MESIAR AND J. RYBÁRIK, *Pseudo-arithmetic operations*, Tatra Mt. Math. Publ. **2** (1993) 185–192.
- [16] D. S. OLIVEIRA, *Properties of ψ -Mittag-Leffler fractional integrals*, Rend. Circ. Mat. Palermo, II. Ser (2021) 14 pages.
- [17] D. S. OLIVEIRA, *ψ -Mittag-Leffler pseudo-fractional operators*, J. Pseudo-Differ. Oper. Appl. **12** (2021) Article number: 40.

- [18] E. PAP, *g -calculus*, Univ. u Novom Sadu Zb. Rad. Prirod.-Mat. Fak. Ser. Mat. Ser. Mat. **23** (1993) 145–156.
- [19] E. PAP, *Pseudo-additive measures and their applications*, in: E. Pap (Ed.), Handbook of Measure Theory, 1403–1465, Elsevier, Amsterdam (2002).
- [20] E. PAP AND M. ŠTRBOJA, *Generalization of the Jensen inequality for pseudo-integral*, Infor. Sci. **180** (2010) 543–548.
- [21] E. PAP, M. ŠTRBOJA AND I. RUDAS, *Pseudo- L^p space and convergence*, Fuzzy Sets Syst., **238** (2014) 113–128.
- [22] W. RUDIN, *Real and Complex Analysis*, Third edition, McGraw-Hill, New York (1987).
- [23] S. G. SAMKO, A. A. KILBAS AND O. I. MARICHEV, *Fractional Integrals and Derivatives: Theory and Applications*, Gordon and Breach Science Publishers, Switzerland (1993).
- [24] J. F. TIAN AND M. H. HA, *Extensions of Hölder's inequality via pseudo-integral*, Math. Probl. Eng. **2018** (2018) Article ID 4080619.
- [25] F. USTA, H. BUDAK, F. ERTUGRAL AND M. Z. SARIKAYA, *The Minkowski's inequalities utilizing newly defined generalized fractional integral operators*, Commun. Fac. Sci. Univ. Ank. Ser. A1 Math. Stat. **68** 1 (2019) 686–701.
- [26] J. VANTERLER DA C. SOUSA AND E. CAPELAS DE OLIVEIRA, *The Minkowski's inequality by means of a generalized fractional integral*, AIMS Math. **3** 1 (2018) 131–147.
- [27] J. VANTERLER DA C. SOUSA, GASTÃO S. F. FREDERICO AND E. CAPELAS DE OLIVEIRA, *ψ -Hilfer pseudo-fractional operator: new results about fractional calculus*, Comput. Appl. Math. **39** (2020) Article number: 254.
- [28] M. YADOLLAHZADEH, A. BABAKHANI AND A. NEAMATY, *Hermite-Hadamard's inequality for pseudo-fractional integral operators*, Stoch. Anal. Appl. **37** 4 (2019) 620–635.
- [29] X. J. YANG, *General Fractional Derivatives: Theory, Methods and Applications*, CRC Press, Boca Raton (2019).
- [30] D. ZHANG AND E. PAP, *Fubini theorem and generalized Minkowski inequality for the pseudo-integral*, Int. J. Approx. Reason. **122** (2020) 9–23.
- [31] E. PAP, *Applications of the generated pseudo-analysis on nonlinear partial differential equations*, Litvinov GL, Maslov VP (eds.) Proceedings of the conference on idempotent mathematics and mathematical physics, contemporary mathematics 377, pp. 239–259, American Mathematical Society, Providence, RI.
- [32] V. P. MASLOV, S. N. SAMBORSKIJ (eds.), *Idempotent analysis*, Advances in soviet mathematics 13, American Mathematical Society, Providence (1992).
- [33] O. P. AGRAWAL, *Generalized Variational Problems and Euler Lagrange equations*, Computers and Mathematics with Applications **59** (2010) 1852–1864.
- [34] M. ŠTRBOJA, T. GRBIĆ, I. ŠTAJNER-PAPUGA, G. GRUJIĆ AND S. MEDIĆ, *Jensen and Chebyshev inequalities for pseudo-integrals of set-valued functions*, Fuzzy Sets Syst. **222** (2013) 18–32.