

## NOTE ON MULTIFUNCTIONS CONDENSING IN THE HYPERSPACE

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*Dedicated to the memory of Professor Francesco S. De Blasi*

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**Abstract.** We fill the gap in understanding the relationship between mappings which are condensing w.r.t. the measure of noncompactness defined on the hyperspace and multifunctions condensing in the ordinary sense.

**Key Words and Phrases:** Hyperspace, measure of noncompactness, condensing multifunction, hyper-condensing multifunction, strongly condensing multifunction, strongly hyper-condensing multifunction, Nadler contraction, h-compact multifunction.

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### REFERENCES

- [1] R.R. Akhmerov, M.I. Kamenskiĭ, A.S. Potapov, A.E. Rodkina, B.N. Sadovskiĭ, *Measures of Noncompactness and Condensing Operators*, Birkhäuser, Basel, 1992.
- [2] J. Andres, J. Fišer, *Metric and topological multivalued fractals*, Internat. J. Bifur. Chaos Appl. Sci. Engrg., **14**(2004), 1277–1289.
- [3] J. Andres, J. Fišer, G. Gabor, K. Leśniak, *Multivalued fractals*, Chaos Solitons Fractals, **24**(2005), no. 3, 665–700.
- [4] J. Andres, L. Górniewicz, *Topological Fixed Point Principles for Boundary Value Problems*, Kluwer, Dordrecht, 2003.
- [5] J. Andres, M. Rypka, *Multivalued fractals and hyperfractals*, Internat. J. Bifur. Chaos Appl. Sci. Engrg., **22**(2012), no. 1, 27 pp.
- [6] J. Andres, M. Väth, *Lefschetz and Nielsen number in hyperspaces for fractals and dynamical systems*, Proc. Amer. Math. Soc., **135**(2007), 479–487.
- [7] J.-P. Aubin, A. Cellina, *Differential Inclusions. Set-Valued Maps and Viability Theory*, Springer, Berlin, 1984.
- [8] J.M. Ayerbe Toledano, T. Domínguez Benavides, G. López Acedo, *Measures of Noncompactness in Metric Fixed Point Theory*, Birkhäuser, Basel, 1997.
- [9] J. Banaś, K. Goebel, *Measures of Noncompactness in Banach Spaces*, M. Dekker, New York-Basel, 1980.
- [10] M.F. Barnsley, A. Vince, *Real projective iterated function systems*, J. Geom. Anal., **22**(2012), no. 4, 1137–1172.
- [11] G. Beer, *Topologies on Closed and Convex Sets*, Kluwer, 1993.
- [12] C. Chifu, A. Petrușel, *Multivalued fractals and generalized multivalued contractions*, Chaos Solitons Fractals, **36**(2008), no. 2, 203–210.

- [13] G. Conti, V. Obukhovskii, P. Zecca, *On the topological structure of the solution set for a semilinear functional-differential inclusion in a Banach space*, Topology in Nonlinear Analysis, (Eds. K. Gęba, L. Górniewicz), Vol. 35, Banach Center Publications, Polish Acad. Sci. Inst. Math., Warszawa, 1996, 159–169.
- [14] A. Dawidowicz, *Méthodes homologiques dans la théorie des applications et des champs de vecteurs sphériques dans les espaces de Banach* (French), Dissertationes Math. (Rozprawy Mat.), **326**(1993), 50 pp.
- [15] F.S. De Blasi, P.Gr. Georgiev, *Hukuhara's topological degree for non compact valued multifunctions*, Publ. Res. Inst. Math. Sci., **39**(2003), no. 1, 183–203.
- [16] F.S. De Blasi, J. Myjak, *A remark on the definition of topological degree for set-valued mappings*, J. Math. Anal. Appl., **92**(1983), no. 2, 445–451.
- [17] S. Hu, N.S. Papageorgiou, *Handbook of Multivalued Analysis. Vol. I: Theory*, Kluwer, Dordrecht, 1997.
- [18] P.N. Ivanshin, *Properties of two selections in metric spaces of nonpositive curvature*, Asian-Eur. J. Math., **1**(2008), no. 3, 383–395.
- [19] L. Kapitanski, S. Živanović Gonzalez, *Attractors in hyperspace*, report no. 8, Preprint Series - Hamiltonians in Magnetic Fields, Institut Mittag-Leffler, Djursholm, 2012.
- [20] C. Kuratowski, *Topologie vol.I* (French), Polish Scientific Publishers, Warszawa, 1958.
- [21] A. Lasota, J. Myjak, *Attractors of multifunctions*, Bull. Pol. Ac. Sci. Math., **48**(2000), 319–334.
- [22] K. Leśniak, *Stability and invariance of multivalued iterated function systems*, Math. Slovaca, **53**(2003), no. 4, 393–405.
- [23] K. Leśniak, *Fixed points of the Barnsley-Hutchinson operators induced by hyper-condensing maps*, Matematiche (Catania), **60**(2005), no. 1, 67–80.
- [24] K. Leśniak, *Invariant sets and Knaster-Tarski principle*, Cent. Eur. J. Math., **10**(2012), no. 6, 2077–2087.
- [25] E.P. Klement, R. Mesiar, E. Pap, *A nonlinear integral which generalizes both the Choquet and the Sugeno integral*, Quantitative Logic and Soft Computing 2010. Vol. 2, (Eds. B.-Y. Cao, G.-J. Wang, S.-L. Chen, S.-Z. Guo), Springer, 39–52.
- [26] J.P. Moreno, R. Schneider, *Lipschitz selections of the diametric completion mapping in Minkowski spaces*, Adv. Math., **233**(2013), 248–267.
- [27] V. Šeda, *On condensing discrete dynamical systems*, Math. Bohem., **125**(2000), no. 3, 275–306.
- [28] P. Shvartsman, *Barycentric selectors and a Steiner-type point of a convex body in a Banach space*, J. Funct. Anal., **210**(2004), no. 1, 1–42.
- [29] M. Väth, *Topological analysis. From the basics to the triple degree for nonlinear Fredholm inclusions*, De Gruyter, Berlin, 2012.
- [30] A. Vince, *Möbius iterated function systems*, Trans. Amer. Math. Soc., **365**(2013), no. 1, 491–509.
- [31] J.-Z. Xiao, X.-H. Zhu, *The Chebyshev selections and fixed points of set-valued mappings in Banach spaces with some uniform convexity*, Math. Comput. Modelling, **54**(2011), no. 5–6, 1576–1583.

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