

## TWO REMARKS ON THE MODIFIED HALPERN ITERATIONS IN CAT(0) SPACES

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**Abstract.** The purpose of this paper is to give a short and simple proof of a generalization of Suzuki's lemma [9] in metric spaces of hyperbolic type as well as to include some remarks on the strong convergence theorem of modified Halpern iteration in CAT(0) spaces, which is proved by Cuntavepanit and Panyanak [4].

**Key Words and Phrases:** Fixed point, strong convergence, CAT(0) space, metric space of hyperbolic type.

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### REFERENCES

- [1] K. Aoyama, Y. Kimura, W. Takahashi, M. Toyoda, *Approximation of common fixed points of a countable family of nonexpansive mappings in a Banach space*, *Nonlinear Anal.*, **67**(2007), 2350–2360.
- [2] M.R. Bridson, A. Haefliger, *Metric Spaces of Non-positive Curvature*, Grundlehren der Mathematischen Wissenschaften, 319. Springer-Verlag, Berlin, 1999.
- [3] D. Burago, Y. Burago, S. Ivanov, *A Course in Metric Geometry*, in Graduate Studies in Math. vol. 33, Amer. Math. Soc., Providence, RI, 2001.
- [4] A. Cuntavepanit, B. Panyanak, *Strong convergence of modified Halpern iterations in CAT(0) spaces*, *Fixed Point Theory Appl.* 2011, Art. ID 869458, 11 pp.
- [5] K. Goebel, S. Reich, *Uniform Convexity, Hyperbolic Geometry and Nonexpansive Mappings*, Marcel Dekker, Inc., New York, 1984.
- [6] W.A. Kirk, *Geodesic geometry and fixed point theory*, in: Seminar of Mathematical Analysis (Malaga/Seville, 2002/2003), pp. 195–225, Colecc. Abierta, 64, Univ. Sevilla Secr. Publ., Seville, 2003.
- [7] W.A. Kirk, *Geodesic geometry and fixed point theory II*, in: International Conference on Fixed Point Theory and Applications, Yokohama Publ., Yokohama, 2004, 113–142.
- [8] P.E. Maingé, *Strong convergence of projected subgradient methods for nonsmooth and non-strictly convex minimization*, *Set-Valued Anal.*, **16**(2008), no. 7-8, 899–912.
- [9] B. Panyanak, A. Cuntavepanit, *A generalization of Suzuki's lemma*, *Abstr. Appl. Anal.* 2011, Art. ID 824718, 14 pp.

- [10] S. Saejung, *Halpern's iteration in  $CAT(0)$  spaces*, Fixed Point Theory Appl. 2010, Art. ID 471781, 13 pp.
- [11] S. Saejung, *Halpern's iteration in Banach spaces*, Nonlinear Anal., **73**(2010), no. 10, 3431–3439.
- [12] T. Suzuki, *Strong convergence theorems for infinite families of nonexpansive mappings in general Banach spaces*, Fixed Point Theory Appl. 2005, no. 1, 103–123.
- [13] H.K. Xu, *An iterative approach to quadratic optimization*, J. Optim. Theory Appl., **116**(2003), no. 3, 659–678.

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