Takahashi's minimization theorem and some related results in quasi-metric spaces

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Abstract

We establish Takahashis minimization theorem in the setting of quasi-metric spaces and provide its equivalence with Ekelands variational principle. We present an equilibrium version of Ekelands variational principle and extended Takahashis minimization theorem in the setting of quasi-metric spaces but without using the triangle inequality of the involved bifunction. We establish an equivalent chain of theorems containing Takahashis minimization theorem, Ekelands variational principle, the equilibrium version of Ekelands variational principle and Caristi-Kirks fixed point theorem for set-valued maps in the setting of quasi-metric spaces. As applications, we give an error bound for the solution set of the equilibrium problems and provide sufficient conditions for the existence of weak sharp solutions of equilibrium problems.