

Article

Hammerstein Nonlinear Integral Equations and Iterative Methods for the Computation of Common Fixed Points

María A. Navascués 

Department of Applied Mathematics, Universidad de Zaragoza, 50018 Zaragoza, Spain; manavas@unizar.es

Abstract: In the first part of this article, a special type of Hammerstein nonlinear integral equation is studied. A theorem of the existence of solutions is given in the framework of \mathcal{L}^2 -spaces. Afterwards, an iterative method for the resolution of this kind of equations is considered, and the convergence of this algorithm towards a solution of the equation is proved. The rest of the paper considers two modifications of the algorithm. The first one is devoted to the sought of common fixed points of a family of nearly asymptotically nonexpansive mappings. The second variant focuses on the search of common fixed points of a finite number of nonexpansive operators. The characteristics of convergence of these methods are studied in the context of uniformly convex Banach spaces. The iterative scheme is applied to approach the common solution of three nonlinear integral equations of Hammerstein type.

Keywords: Hammerstein integral equations; common fixed points; nonexpansive maps; nearly asymptotically nonexpansive mappings; iterative methods

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1. Introduction

A. Hammerstein introduced, in the reference [1], a new type of nonlinear integral equation, given by the expression:

$$f(x) + \int_a^b k(x, y)\varphi(y, f(y))dy = 0,$$

for $x \in [a, b]$ and $k(x, y)$ and $\varphi(x, y)$ given functions. Equations of this kind appear in a great number of fields of physics, especially in electro-magnetic fluid dynamics. Similar to almost every integral equation, it can be reformulated in terms of a problem of ordinary or partial differential equations.

Hammerstein considered as hypotheses that the operator associated to k is symmetric and positive, and φ is such that

$$|\varphi(x, y)| \leq C_1|y| + C_2,$$

where $C_1, C_2 \geq 0$. He proved that, if $C_1 < \lambda$, where λ is the first eigenvalue of the kernel, and k and φ are continuous functions, then the equation has a continuous solution. If, in addition, the mapping $\varphi(x, \cdot)$ is non-decreasing for any $x \in (a, b)$, the solution is unique. Brézis and Browder gave in the reference [2] sufficient conditions for the existence and uniqueness of solution of Hammerstein equations in \mathcal{L}^p -spaces. For instance, they proved that, if $k(x, y)$ and $\varphi(x, y)$ are such that

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