

AVERAGING METHOD FOR FUNCTIONAL DIFFERENTIAL EQUATIONS

MUSTAPHA LAKRIB AND TEWFIK SARI

ABSTRACT. In this paper, the method of averaging which is well known for ordinary differential equations is extended, in a natural way, to functional differential equations. Our results are formulated in both classical mathematics and nonstandard analysis.

2000 Mathematics Subject Classification: 34C29, 34K25, 34K20, 03H05.

Key words and phrases: Averaging method, functional differential equations, exponential stability, nonstandard analysis.

1 INTRODUCTION

It is well known that the method of averaging is a powerful tool of investigation of many perturbation problems in nonlinear oscillations, and some in celestial mechanics. There is a rich literature for ordinary differential equations case ([2, 7, 11, 13, 15, 21, 22] and the references cited therein). The method is also extended to functional differential equations [8, 9, 10, 18, 24, 25] of the form

$$\dot{x}(t) = \varepsilon f(t, x_t) \quad (1)$$

where $\varepsilon > 0$ is a small parameter. Under suitable conditions, solutions of (1) can be approximated by those ones of the averaged ordinary differential equation

$$\dot{y}(t) = \varepsilon f^o(\bar{y}), \quad \bar{y}(\theta) = y \quad \text{for } \theta \in [-r, 0] \quad (2)$$

where

$$f^o(u) = \lim_{T \rightarrow \infty} \frac{1}{T} \int_0^T f(\tau, u) d\tau. \quad (3)$$

Notice that, if we let $t \longmapsto t/\varepsilon$ and $x(t/\varepsilon) = z(t)$, equation (1) becomes

$$\dot{z}(t) = f\left(\frac{t}{\varepsilon}, z_{t,\varepsilon}\right) \quad (4)$$

Method Of Averaging Functional Correctio

Anton ÍUř'evich Luchka



Method Of Averaging Functional Correctio:

Projection-iterative Methods for Solution of Operator Equations Nikolai Stepanovich Kurpel', 1976 *The Method of Averaging Functional Corrections* Anton Iur'evich Luchka, 1965 *An Analysis of the Method of Averaging Functional Corrections* Benson Jay King, 1967 **The Method of Averaging Functional Corrections; Theory and Applications. Translated from the Russian by Scripta Technica, Inc** Anton Iur'evich Luchka, **A Bibliography On: "Methods for Solving Integral Equations": Subject listing** Ben Noble, Benjamin Noble, 1971 **Scientific and Technical Aerospace Reports**, 1969 **Metod osrednenija funkcional'nykh popravok** Urij Dmitrievich Sokolov, 1967 *Iterative Methods for the Solution of a Linear Operator Equation in Hilbert Space* Walter Mead Patterson, 1974-07-22 In this expository work we shall conduct a survey of iterative techniques for solving the linear operator equations $Ax = y$ in a Hilbert space Whenever convenient these iterative schemes are given in the context of a complex Hilbert space Chapter II is devoted to those methods three in all which are given only for real Hilbert space Thus chapter III covers those methods which are valid in a complex Hilbert space except for the two methods which are singled out for special attention in the last two chapters Specifically the method of successive approximations is covered in Chapter IV and Chapter V consists of a discussion of gradient methods While examining these techniques our primary concern will be with the convergence of the sequence of approximate solutions However we shall often look at estimates of the error and the speed of convergence of a method **The Method of Averaging Functional Corrections** Anton Jur'jevic Lucka, 1965 **The Method of Averaging Functional Corrections. Theory and Applications. Translated ... by Scripta Technica, Inc** Anton Yur'evich LUCHKA, 1965 **Mathematical Reviews**, 1981 *On Sufficient Tests of Convergence of the Method of Averaging Functional Corrections* Yu D. Sokolov, JOHNS HOPKINS UNIV SILVER SPRING MD APPLIED PHYSICS LAB., 1969 In the iterative solution of the nonlinear functional equation $x^T x = \phi$ on a function space the author's method of averaging functional corrections is defined by the sequence $y_{n+1} = y_n + \alpha_n (Z\phi - y_n)$ where Z is a fixed function α_n is a scalar satisfying $L y_{n+1} \leq L y_n + \alpha_n L Z\phi$ and L is a fixed linear functional on the function space Sufficient conditions are obtained for the convergence of this method as applied to systems of integral equations of the Hammerstein type The results are related to the previous work of Kurpel Author [The Method of Averaging Functional Corrections](#) Anton Yur'yevich Luchka, 1965 [An Introductory Guide to EC Competition Law and Practice](#) Valentine Korah, 1994 **Soviet Mathematics (Iz. VUZ)**. Soviet Union. Ministerstvo vysshego i srednego spetsial'nogo obrazovaniia, 1974 **The Journal of Industrial and Engineering Chemistry**, 1920 **Solution Methods for Integral Equations** M. A. Goldberg, 1979-11 *Journal of the Institute of Actuaries*, 1906 [Notices of the American Mathematical Society](#) American Mathematical Society, 1976 Contains articles of significant interest to mathematicians including reports on current mathematical research *Australian Government Publications*, 1966

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