Fişa suspiciunii de plagiat / Sheet of plagiarism's suspicion	Indexat la: 0123/05

Opera suspicionată (OS)	Opera autentică (OA)
Suspicious work	Authentic work

OS	COLOŞI, Tiberiu, ABRUDEAN, Ioan Mihail, UNGUREŞAN, Mihaela Ligia, and MUREŞAN, Vlad. *Numerical Simulation of Distributed Parameter Processes*. Foreword: DRAGOMIR, Toma Leonida. Heidelberg: Springer Verlag. 2013.
OA	COLOŞI, T., UNGUREŞAN, M.L., DULF, E.H., CORDOŞ, R.C. *Introduction to analogical modelling and numerical simulation with (Mpdx) and Taylor series for distributed parameters processes.* Letter for the reader: DRAGOMIR, T.L. Târgu-Lăpuş: Galaxia Gutenberg. 2009.

Incidența minimă a suspiciunii / Minimum incidence of suspicion	
p.03:01 - p.197:14	p.21:01 – p.234:16
p.197:15 – p.198:02	p.241:01 – p.242:03
p.231:01 – p.281:00	p.243:01 – p.305:00
p.299:01 – p.332:00	p.306:01 – p.344:00

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Notă: p.36:00 semnifică întreaga pagină.

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Note: On page xi of suspicious work and on page 20 of the authentic work there is one mention where Coloşi Tiberiu claims to be the author of whole work. The other people that declare to be co-authors do not contradict this statement.

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Numerical Simulation of Distributed Parameter Processes

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ISBN 978-3-319-00013-8 ISBN 978-3-319-00014-5 (eBook)
DOI 10.1007/978-3-319-00014-5
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013931647

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Foreword

Generally, a scientific book represents a means of communication between the author and the reader, whereby the author introduces the reader to a specific field in the area of knowledge by presenting a range of concepts and approaches, of instruments and methods, of expertise and certainties structured in various ways, and—intentionally or unintentionally—raising questions to the reader, for which the book does not necessarily bring an answer.

After browsing through a book, the reader has a benefit if he retains the spirit of the book, if he manages to build on it a reference point, and to progress on the gradient of knowledge on the basis of the readings.

Which is the field in the area of knowledge addressed in this book? According to the title, the field it considers has two levels, one for those involved in the world of processes with distributed parameters and the other for those belonging to the domain of modeling and simulation techniques. Through these levels one gains access to a category of numerical methods that allow for the numerical solution of differential equations with partial derivates, used in various applied fields as models for the processes with distributed parameters.

This book presents the theoretical foundations of the methods that have the developments in the Taylor series as a starting point, the characteristics of the methods. It also develops examples and discusses practical applications.

Readers who are familiar with the processes with distributed parameters, who are, in my opinion, much closer to the real world—multidimensional, nonhomogeneous, nonisotropic—being used to the fact that multidimensional signals are propagated in distinct ways into different directions, know how difficult it is to estimate the way in which the phenomena occur in processes with distributed parameters and how hard it is to work with models based on differentiated equations with partial derivates. Therefore, they may be interested to use the first level and deepen their knowledge of the calculation method based on the principle of iterative local linearization presented in the first part of this book and to study the M_{pdx} method (the matrix of partial derivates of the state vector) which constitutes the subject of the main part of this book.

Readers having as a background the field of modeling and simulation techniques and who are interested in the processes with distributed parameters may find in the methods presented by the authors extremely advantageous alternatives for the numerical solution of the equations provided by the models with distributed parameters. Irrespective of the applicative justification, those interested in evaluations and estimates based on mathematical models will find in this book methods which are comparable to the methods of numerical integration known in the literature, which, in addition, allow for increasing the accuracy of calculations.

The large domain of application of the numerical modeling and simulation methods, which represent the focus of this book, render it interesting for multiple categories of researchers: engineers, physicist, biologists, chemical engineers, computer science engineers, having different levels of knowledge, from students to experienced specialists.

The multiple well-structured examples allow the reader to develop his own application models and calculation formulas, which can then be implemented by using usual computing software for engineers.

For those interested in applications in the field of automatic process control, the expression "process with distributed parameters" from the book's title requires a supplementary specification. For them "process" represents, in principle, the controlled part in an automatic system. In the general scientific terminology, which is used in the title, the process may also represent the entire automatic system. As a consequence, the methods presented in this book can be applied also for studying the control systems of plants with distributed parameters by means of simulation.

After having discussed with Professor Coloşi—the first author—about this new book, which is a remarkable work with a complex character, I realized that I had the chance, across time and during the many years we know each other, to witness the birth of the ideas comprised in this book. These ideas reflect the restless research efforts in fields such as energetic, chemistry, electrotechnique, which were finalized under his coordination and got materialized in numerous articles, doctoral theses, dissertations, and graduation theses, as well as in participations at conferences and published books.

I am convinced that you as a reader, after going through this book, will also be convinced of its value and utility.

Romania, 30 August 2009

Prof. dr. eng. Toma-Leonida Dragomir
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Preface

The following represents a revised and a complete form of the book [1] with the purpose to define, interpret, and use "**the matrix with partial derivatives of the state vector** ($\mathbf{M}_{pdx}$)", designed for some categories of processes with distributed and lumped parameters.

Within this frame, the work elaborates in a unitary systemized form:

- The analogical modeling through ($\mathbf{M}_{pdx}$)
- The numerical simulation through ($\mathbf{M}_{pdx}$) and Taylor Series.

Different stages of analyses and synthesis that are specific to the numerical calculus are included, for processes with distributed (and lumped) parameters such as: the local-iterative linearization, initial conditions for the beginning of the calculus, errors' propagation, case studies, the numerical integration's performances, usually with respect to time (t) obtained in the programs run on the computer, and others [2–14].

In order to ensure the beginning of the calculus for $t = t_0$, the ideal situation consists in knowing the state vector for the initial conditions $\mathbf{x}_{IC} = \mathbf{x}$ (t_0, p, q, r), where the spatial variables (p, q, r) can be associated or not to some coordinate axes (Cartesian, polar, cylindrical, etc.).

In many technical applications ($\mathbf{x}_{IC}$) cannot be precisely known, but there are some methods (for instance expert type) that can approximate the elements (or at least the first element of) the state vector ($\mathbf{x}_{IC}$) in a not very close to (t_0) vicinity. Within this frame, one of the usual variables for approximating the first element has been considered:

$$X_{0000}(\mathrm{t,p,q,r}) = \mathrm{K_y} \cdot \mathrm{F_{0T}(t)} \cdot \mathrm{F_{0P}(P)} \cdot \mathrm{F_{0Q}(q)} \cdot \mathrm{F_{0R}(r)} \cdot \mathrm{u_0(t)} \qquad \text{(A)}$$

with the ensurance of the continuity conditions for the functions $F_{0T}(t)$, $F_{0P}(p)$, $F_{0Q}(q)$, and $F_{0R}(r)$. The independent variable of the input signal was noted with $u_0(t)$ and (K_y) is a proportionality coefficient. In the composition of these functions there will be different levels of freedom (time and spatial constants) whose convenient choice might contribute to a better approximation for ($\mathbf{x}_{IC}$).

Chapter 13: "Numerical Simulation Using Partial Differential Equations, for Propagation and Control in Discontinuous Structures Processes" presents a possible study variant of propagation and control of some specific phenomena, in the areas with discontinuous structures. The numerical simulation is based on **"the matrix with partial derivatives of the state vector** ($\mathbf{M}_{pdx}$) **method**, **associated with Taylor series**". The theoretical preliminaries of this method with a general character are exposed in a compendious way, in order to be used in case studies, with heterogeneous applications, for example in chemistry, thermoenergetics, biomedical processes, etc.

Chapter 14: "Conclusions" presents the importance of studying the analogical modeling and numerical simulation through ($\mathbf{M}_{pdx}$) and Taylor Series.

Appendices AI, AII, and AIII help the reader to understand all material presented in Chaps. 1–14.

The entire work has been elaborated by Tiberiu Coloşi. This book could not be published without the very qualified and collegiate support of all authors.

Some examples and programs have been elaborated and included, throughout many years, in the projects and diploma papers of the students of the Faculty of Automation and Computer Science within the Technical University of Cluj-Napoca.

Chapter 4
Linear Processes with Distributed Parameters

4.1 Partial Derivative Equations

It is known that the usual analytical modeling of linear processes with distributed parameters can be expressed using equations or systems of equations with linear partial derivatives, homogeneous (without a free component) or non-homogeneous (with free component). The category of equations with linear partial derivative equations (PDE), to which this chapter refers to, is presented in the following examples:

$$a_{00}y + a_{10}\frac{\partial y}{\partial t} + a_{01}\frac{\partial y}{\partial p} = \varphi(t,p) \tag{4.1}$$

$$a_{000}y + a_{100}\frac{\partial y}{\partial t} + a_{010}\frac{\partial y}{\partial p} + a_{001}\frac{\partial y}{\partial q} = \varphi(t,p,q) \tag{4.2}$$

$$a_{00}y + a_{10} + \frac{\partial y}{\partial t} + a_{01}\frac{\partial y}{\partial p} + a_{20}\frac{\partial^2 y}{\partial t^2} + a_{11}\frac{\partial^2 y}{\partial t \partial p} + a_{02}\frac{\partial^2 y}{\partial p^2} = \varphi(t,p) \tag{4.3}$$

$$a_{000}y + a_{200}\frac{\partial^2 y}{\partial t^2} + a_{020}\frac{\partial^2 y}{\partial p^2} + a_{002}\frac{\partial^2 y}{\partial q^2} = \varphi(t,p,q) \tag{4.4}$$

$$\begin{aligned} a_{000}y &+ a_{100}\frac{\partial y}{\partial t} + a_{010}\frac{\partial y}{\partial p} + a_{001}\frac{\partial y}{\partial q} + a_{200}\frac{\partial^2 y}{\partial t^2} + a_{110}\frac{\partial^2 y}{\partial t \partial p} \\ &+ a_{020}\frac{\partial^2 y}{\partial p^2} + a_{011}\frac{\partial^2 y}{\partial p \partial q} + a_{002}\frac{\partial^2 y}{\partial q^2} + a_{101}\frac{\partial^2 y}{\partial t \partial q} = \varphi(t,p,q) \end{aligned} \tag{4.4'}$$

T. Coloşi et al., *Numerical Simulation of Distributed Parameter Processes*,
DOI: 10.1007/978-3-319-00014-5_4,

$$\begin{aligned} & a_{0000}y + a_{1000}\frac{\partial y}{\partial t} + a_{0100}\frac{\partial y}{\partial p} + a_{0010}\frac{\partial y}{\partial q} + a_{0001}\frac{\partial y}{\partial r} + a_{2000}\frac{\partial^2 y}{\partial t^2} \\ & \quad + a_{1100}\frac{\partial^2 y}{\partial t \partial p} + a_{0200}\frac{\partial^2 y}{\partial p^2} + a_{0110}\frac{\partial^2 y}{\partial p \partial q} + a_{0020}\frac{\partial^2 y}{\partial q^2} + a_{0011}\frac{\partial^2 y}{\partial q \partial r} \\ & \quad + a_{0002}\frac{\partial^2 y}{\partial r^2} + a_{1001}\frac{\partial^2 y}{\partial t \partial r} + a_{0101}\frac{\partial^2 y}{\partial p \partial r} + a_{1010}\frac{\partial^2 y}{\partial t \partial q} = \varphi(t,p,q,r) \end{aligned} \tag{4.4''}$$

$$a_{00}y + a_{30}\frac{\partial^3 y}{\partial t^3} + a_{03}\frac{\partial^3 y}{\partial p^3} = \varphi(t,p) \tag{4.5}$$

$$a_{000}y + a_{300}\frac{\partial^3 y}{\partial t^3} + a_{030}\frac{\partial^3 y}{\partial p^3} + a_{003}\frac{\partial^3 y}{\partial q^3} = \varphi(t,p,q) \tag{4.6}$$

$$a_{00}y + a_{40} + \frac{\partial^4 y}{\partial t^4} + a_{04}\frac{\partial^4 y}{\partial p^4} = \varphi(t,p) \tag{4.7}$$

$$a_{000}y + a_{400}\frac{\partial^4 y}{\partial t^4} + a_{040}\frac{\partial^4 y}{\partial p^4} + a_{004}\frac{\partial^4 y}{\partial q^4} = \varphi(t,p,q) \tag{4.8}$$

All coefficients $(a\ldots)$ are considered to be constant or variable, and $\varphi(t,p)$, $y(t,p)$, $\varphi(t,p,q)$, $y(t,p,q)$, $\varphi(t,p,q,r)$ and $y(t,p,q,r)$ fulfill the continuity conditions in the Cauchy sense. The independent variables (t), (p) and (q) could represent the time (t), respectively the spatial abscise (p) and (q) defined, for instance, in Cartesian coordinates.

The initial conditions (IC) are considered as being known, and other explanations could be added, from case to case, for boundary conditions (BC) and final conditions (FC).

4.2 State Variables, Initial Conditions and Final Conditions

Introducing the notations,

$$\mathbf{x}_{TP} = \frac{\partial^{T+P} y}{\partial t^T \partial p^P} \tag{4.9}$$

$$\mathbf{x}_{TPQ} = \frac{\partial^{T+P+Q} y}{\partial t^T \partial p^P \partial q^Q} \quad \text{or} \quad \mathbf{x}_{TPQR} = \frac{\partial^{T+P+Q+R} y}{\partial t^T \partial p^P \partial q^Q \partial r^R} \tag{4.10}$$

(for $T = 0, 1, 2, \ldots; P = 0, 1, 2, \ldots; Q = 0, 1, 2, \ldots; R = 0, 1, 2, \ldots$) the ten PDE, that is, (4.1–4.8) can be rewritten as

$$a_{00}x_{00} + a_{10}x_{10} + a_{01}x_{01} = \varphi_{00} \tag{4.11}$$

$$a_{000}x_{000} + a_{100}x_{100} + a_{010}x_{010} + a_{001}x_{001} = \varphi_{000} \tag{4.12}$$

$$a_{00}x_{00} + a_{10}x_{10} + a_{01}x_{01} + a_{20}x_{20} + a_{11}x_{11} + a_{02}x_{02} = \varphi_{00} \tag{4.13}$$

$$a_{000}x_{000} + a_{200}x_{200} + a_{020}x_{020} + a_{002}x_{002} = \varphi_{000} \tag{4.14}$$

$$\begin{aligned} a_{000}x_{000} + a_{100}x_{100} + a_{010}x_{010} + a_{001}x_{001} + a_{200}x_{200} + a_{110}x_{110} \\ + a_{020}x_{020} + a_{011}x_{011} + a_{002}x_{002} + a_{101}x_{101} = \varphi_{000} \end{aligned} \tag{4.14$'$}$$

$$\begin{aligned} a_{0000}x_{0000} &+ a_{1000}x_{1000} + a_{0100}x_{0100} + a_{0010}x_{0010} + a_{0001}x_{0001} \\ &+ a_{2000}x_{2000} + a_{1100}x_{1100} + a_{0200}x_{0200} + a_{0110}x_{0110} + a_{0020}x_{0020} \\ &+ a_{0011}x_{0011} + a_{0002}x_{0002} + a_{1001}x_{1001} + a_{0101}x_{0101} + a_{1010}x_{1010} = \varphi_{0000} \end{aligned} \tag{4.14$''$}$$

$$a_{00}x_{00} + a_{30}x_{30} + a_{03}x_{03} = \varphi_{00} \tag{4.15}$$

$$a_{000}x_{000} + a_{300}x_{300} + a_{030}x_{030} + a_{003}x_{003} = \varphi_{000} \tag{4.16}$$

$$a_{00}x_{00} + a_{40}x_{40} + a_{04}x_{04} = \varphi_{00} \tag{4.17}$$

$$a_{000}x_{000} + a_{400}x_{400} + a_{040}x_{040} + a_{004}x_{004} = \varphi_{000} \tag{4.18}$$

In the hypothesis of integration with respect to time (t), the elements of the state vector ($\mathbf{x}$), which correspond to the PDE (1), (2), …(8), are presented in Table 4.1.

The notation (n, υ) in line 2, Table 4.1, underlines by n = I, II, III and IV the order of PDE and by $\upsilon = 2$, 3 and 4 the number of variables, respectively 2 for (t, p), 3 for (t, p, q) and 4 for (t, p, q, r).

The state vector is presented in Table 4.2 for the IC ($\mathbf{x}_{\mathrm{IC}}$) and for some possible BC ($\mathbf{x}_{\mathrm{BC}}$), respectively the FC ($\mathbf{x}_{\mathrm{FC}}$), where (0) and (f) underline the initial and final values.

In order to exemplify the first line from Table 4.2, it is considered: $x(t, p) = F_{0\mathrm{T}}(t) \cdot F_{0\mathrm{P}}(p)$, where the exponentials $F_{0\mathrm{T}}(t)$ and $F_{0\mathrm{P}}(p)$ present increasing, respectively decreasing evolutions, as in Fig. 4.1. It can be noticed that $x_{\mathrm{IC}} = x(t_0, p) = 0$; $x_{\mathrm{FC}} = x(t_f, p)$; and the two BC are $x'_{\mathrm{BC}} = x(t, p_0)$ and $x''_{\mathrm{BC}} = x(t, p_f)$, where ($t_0$, p_0) and (t_f, p_f) correspond to the initial, respectively to the FC.

Table 4.1 Hypothesis of integration

PDE	4.1	4.2	4.3	4.4	4.4′	4.4″	4.5	4.6	4.7	4.8
Notation	I·2	I·3	II ·2	II·3	II·3	II·4	III·2	III·3	IV·2	IV·3
x State vector	x_{00}	x_{000}	x_{00}	x_{000}	x_{000}	x_{0000}	x_{00}	x_{000}	x_{00}	x_{000}
			x_{10}	x_{100}	x_{100}	x_{1000}	x_{10}	x_{100}	x_{10}	x_{100}
							x_{20}	x_{200}	x_{20}	x_{200}
									x_{30}	x_{300}

Table 4.2 State vector

$\mathbf{x}_{\mathbf{IC}}$	$\mathbf{x}_{\mathbf{BC}}$	$\mathbf{x}_{\mathbf{FC}}$
$\mathbf{x}(t_0, p)$	$\mathbf{x}(t, p_0)$; $\mathbf{x}(t, p_f)$	$\mathbf{x}(t_f, p)$
$\mathbf{x}(t_0, p, q)$	$\mathbf{x}(t, p_0, q)$ $\mathbf{x}(t, p, q_0)$ $\mathbf{x}(t, p_f, q)$ $\mathbf{x}(t, p, q_f)$	$\mathbf{x}(t_f, p, q)$
$\mathbf{x}(t_0, p, q, r)$	$\mathbf{x}(t, p_0, q, r)$ $\mathbf{x}(t, p, q_0, r)$ $\mathbf{x}(t, p_f, q, r)$ $\mathbf{x}(t, p, q_f, r)$	$\mathbf{x}(t_f, p, q, r)$

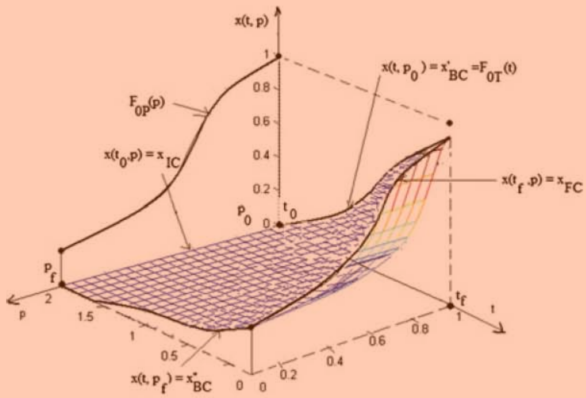

Fig. 4.1 The evolutions of $F_{OT}(t)$ and $F_{OP}(p)$

4.3 The Complete Method of the Taylor Series for the Approximation of the Vector (x_k): The Definition of the Matrix M_{pdx}

It is based on the iterative use of the Taylor series, included in a table structure, dependent on the form PDE.

For a more general case, having a temporal variable (t) and three variables, for example, spatial (p, q, r) on Cartesian axes, illustrated in Fig. 4.2, the table structure will be denoted with ($\mathbf{M}_{\mathrm{pdx}}$) and it will be called **"the matrix with partial derivatives of the state vector,"** having the form of