

Preface

Operator-splitting methods have been around for more than a century, starting with their common ancestor, the Lie scheme, introduced by Sophus Lie in the mid-1870s. It seems however that one had to wait after WW2 to see these methods joining the computational and applied mathematics mainstream, the driving force being their applicability to the solution of challenging problems from science and engineering modeled by partial differential equations. The main actors of this renewed interest in operator-splitting methods were mainly Douglas, Peaceman, Rachford, and Wachpress in the USA with the alternating direction implicit (ADI) methods and Dyakonov, Marchuk, and Yanenko in the USSR with the fractional step methods. These basic methodologies have known many variants and improvements and generated a quite important literature consisting of many articles and few books, of theoretical and applied natures, with computational mechanics and physics being the main sources of applications. In the mid-1970s, tight relationships between the augmented Lagrangian methods of Hestenes and Powell and ADI methods were identified, leading to the alternating direction methods of multipliers (ADMM). Albeit originating from problems from continuum mechanics modeled by partial differential equations and inequalities, it was quickly realized that the ADMM methodology applies to problems outside the realm of partial differential equations and inequalities, in information sciences in particular, an area where ADMM has enjoyed a very fast-growing popularity. The main reason of this popularity is that most often large-scale optimization problems have decomposition properties that ADMM can take advantage of, leading to modular algorithms, well suited to parallelization. Another factor explaining ADMM's growing popularity during the last decade was the discovery around 2007 of its many commonalities with the split-Bregman algorithm widely used first in image processing and then in compressed sensing, among other applications.

Late 2012, the three editors of this book were participating in a conference in Hong Kong, the main conference topics being scientific computing, image processing, and optimization. Since most lectures at the conference had some relations with operator splitting, ADMM, and split-Bregman algorithms, the idea of a book dedicated to these topics was explored, considering the following facts:

(i) The practitioners of the above methods have become quite specialized, forming subcommunities with very few interactions between them. (ii) New applications of operator-splitting and related algorithms appear on an almost daily basis. (iii) The diversification of the algorithms and their applications has become so large that a volume containing the contributions of a relatively large number of experts is necessary in order to interest a large audience; indeed, the last review publications on the above topics being quite specialized (as shown in Chapter 1), the editors did their very best to produce a large spectrum volume.

Following a Springer agreement to publish a book on operator splitting, ADMM, split-Bregman, and related algorithms, covering both theory and applications, experts were approached to contribute to this volume. We are pleased to say that most of them enthusiastically agreed to be part of the project.

This book is divided in chapters covering the history, foundations, applications, as well as recent developments of operator splitting, ADMM, split Bregman, and related algorithms. Due to size and time constraints, many relevant information could not be included in the book: the editors apologize to those authors whose contributions have been partially or totally overlooked.

Many thanks are in order:

- First, to the organizers of the December 2012 Hong Kong conference on *Advances in Scientific Computing, Imaging Sciences and Optimization*. Indeed, the inception of this project took place during this meeting.
- To Springer for accepting to publish this volume. The editors acknowledge in particular the assistance provided by Achi Dosanjh; she was involved with the project from day one and never lost her faith in it (and in the editors), despite the many (unavoidable) delays encountered during its completion.
- To the authors of the various chapters and to those colleagues who accepted to review them. They are really the ones who brought this book into existence.
- To Hengda Wen and Tsorng-Whay Pan for their assistance on many issues associated with the preparation of the “manuscript” (some of them L^AT_EX related). Both of them saved the day more than once.
- To the various institutions supporting the authors, the editors, and the reviewers.
- To Indhumathi at SPi Global for her leadership in transforming a complicated manuscript into a book

We would like to thank also all the scientists who contributed in their own way to operator-splitting and related methods; they made this book possible. Among them, we would like to give a special tribute to *Ernie Esser* and *Michèle Schatzman*; their untimely departure was a shock to their friends and colleagues. Both of them had outstanding contributions to various topics addressed in this book, for which we thank them and dedicate this book to their memory.

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 February 2016

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<http://www.springer.com/978-3-319-41587-1>

Splitting Methods in Communication, Imaging, Science,
and Engineering

Glowinski, R.; Osher, S.J.; Yin, W. (Eds.)

2016, XVIII, 820 p. 194 illus., 111 illus. in color.,

Hardcover

ISBN: 978-3-319-41587-1