Preface

This book is entirely devoted to numerical algorithms for optimization, their theoretical foundations and convergence properties, as well as their implementation, their use, and other practical aspects. The aim is to familiarize the reader with these numerical algorithms: understanding their behaviour in practice, properly using existing software libraries, adequately designing and implementing "home-made" methods, correctly diagnosing the causes of possible difficulties. Expected readers are engineers, Master or Ph.D. students, confirmed researchers, in applied mathematics or from various other disciplines where optimization is a need.

Our aim is therefore not to give most accurate results in optimization, nor to detail the latest refinements of such and such method. First of all, little is said concerning optimization theory itself (optimality conditions, constraint qualification, stability theory). As for algorithms, we limit ourselves most of the time to stable and well-established material. Throughout we keep as a leading thread the actual *practical value* of optimization methods, in terms of their efficiency to solve real-world problems. Nevertheless, serious attention is paid to the theoretical properties of optimization methods: this book is mainly based upon theorems. Besides, some new and promising results or approaches could not be completely discarded; they are also presented, generally in the form of special sections, mainly aimed at orienting the reader to the relevant bibliography.

An introductory chapter gives some generalities on optimization and iterative algorithms. It contains in particular motivating examples, ranking from meteorological forecast to power production management; they illustrate the large field of branches where optimization finds its applications. Then come four parts, rather independent of each other. The first one is devoted to algorithms for unconstrained optimization which, in addition to their direct usefulness, are a basis for more complex problems. The second part concerns rather special methods, applicable when the usual differentiability assumptions are not satisfied. Such methods appear in the decomposition of large-scale problems and the relaxation of combinatorial problems. Nonlinearly constrained optimization forms the third part, substantially more technical, as the subject is still in evolution. Finally, the fourth part gives a deep account of the more recent interior point methods, originally designed

for the simpler problems of linear and quadratic programming, and whose application to more general situations is the subject of active research.

This book is a translated and improved version of the monograph [43], written in French. The French monograph was used as the textbook of an intensive two week course given several times by the authors, both in France and abroad. Each topic was presented from a theoretical point of view in morning lectures. The afternoons were devoted to implementation issues and related computational work. The conception of such a course is due to J.-B. Hiriart-Urruty, to whom the authors are deeply indebted.

Finally, three of the authors express their warm gratitude to Claude Lemaréchal for having given the impetus to this new work by providing a first English version.

Notes on this revised edition. Besides minor corrections, the present version contains substantial changes with respect to the first edition. First of all, (simplified but) nontrivial application problems have been inserted. They involve the typical operations to be performed when one is faced with a real-life application: modelling, choice of methodology and some theoretical work to motivate it, computer implementation. Such computational exercises help getting a better understanding of optimization methods beyond their theoretical description, by addressing important features to be taken into account when passing to implementation of any numerical algorithm.

In addition, the theoretical background in Part I now includes a discussion on global convergence, and a section on the classical pivotal approach to quadratic programming. Part II has been completely reorganized and expanded. The introductory chapter, on basic subdifferential calculus and duality theory, has two examples of nonsmooth functions that appear often in practice and serve as motivation (pointwise maximum and dual functions). A new section on convergence results for bundle methods has been added. The chapter on applications of nonsmooth optimization, previously focusing on decomposition of complex problems via Lagrangian duality, describes also extensions of bundle methods for handling varying dimensions, for solving constrained problems, and for solving generalized equations. Also, a brief commented review of existing software for nonlinear optimization has been added in Part III.

Finally, the reader will find additional information at `http://www-rocq.inria.fr/~gilbert/bgls`. The page gathers the data for running the test problems, various optimization codes, including an SQP solver (in Matlab), and pieces of software that solve the computational exercises.

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