Preface

The goal of this book is to develop methodological principles of data correcting (DC) algorithms for solving NP-hard problems in combinatorial optimization. We consider two large classes of NP-hard problems defined either on the set of all subsets of a finite set (see the maximization of submodular functions, quadratic cost partition, and simple plant location problems) or on the set of all permutations of a finite set (see the Traveling Salesman Problem, TSP).

This book is organized as follows: in Chap. 1 we motivate the DC approach by its application to a single real-valued function defined on a continuous domain, which has a finite range, and describe how this approach might be applied to a general combinatorial optimization problem including its implementation for the asymmetric TSP (ATSP).

The first purpose of Chap. 2 is to make more accessible to the Western community some long-standing theoretical results about the structure of local and global maxima of submodular functions due to [29, 89] including Cherenin's excluding rules and his dichotomy algorithm (see [27, 28, 118]). We use Cherenin's dichotomy algorithm for determining a polynomially solvable class of submodular functions (*PP-functions*) and show that PP-functions contain precisely one component of strict local maxima. The second purpose of Chap. 2 is to present a generalization of Cherenin's excluding rules. This result is a base of DC algorithms for the maximization (minimization) of submodular (supermodular) functions presented in Chap. 3.

In Chap. 3 we present the DC algorithm for maximization of submodular functions; it is a recursive Branch-and-Bound (BnB)-type algorithm (see e.g., [6]). In the DC algorithm the values of a given submodular function are "heuristically" corrected at each branching step in such a way that the new (corrected) submodular function will be as close as possible to a polynomially solvable instance from the class of submodular PP-functions (instances), and the result satisfies a prescribed accuracy parameter. The working of the DC algorithm is illustrated by means of an instance of the simple plant location problem (SPLP). Computational results, obtained for the quadratic cost partition (QCP) problem, show that the computing results of the DC algorithm in general are better than the computational results known in the current literature (see, e.g., [8, 55, 102, 114, 115, 119, 120]), not only for sparse graphs but also for nonsparse graphs (with density more than 40 %) often with speeds 100 times faster. We further improve the DC algorithm for submodular functions by introducing an extended PP-function. Our computational experiments with the improved DC algorithm on QCP instances, similar to those in [102], allow us to solve QCP instances on dense graphs with number of vertices up to 500 within 10 min on a standard personal computer.

In Chap. 4 we deal with a pseudo-Boolean representation of the SPLP (see, e.g., [13, 38, 80]).

We improve the class of Branch and Peg algorithms (see [67, 68]) by using SPLP-specific bounds (suggested in [44]) and preprocessing rules (coined in [91]) in Chap. 4. We further incorporate a new reduction procedure based on data correcting, which is stronger than the preprocessing rules from [91], to reduce the original instance to a smaller "core" instance, and then solve it using a procedure based on DC algorithm developed in Chap. 3. Computational experiments with the DC algorithm adapted to the SPLP on benchmark instances suggest that the algorithm compares well with other algorithms known for the SPLP (see [69]).

In the summary of this book we discuss future research directions for DC approach based on the main results presented in the conclusions of the chapters.

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http://www.springer.com/978-1-4614-5285-0

Data Correcting Approaches in Combinatorial
Optimization
Goldengorin, B.; Pardalos, P.
2012, X, 114 p. 41 illus., Softcover
ISBN: 978-1-4614-5285-0