
Preface

Optimization has become pervasive in medicine. The application of computing to medical applications has opened many challenging issues and problems for both the medical computing field and the mathematical community. Mathematical techniques (continuous and discrete) are playing a key role with increasing importance in understanding several fundamental problems in medicine. Naturally, optimization is a fundamentally important tool due to the limitation of the resources involved and the need for better decision making.

The book starts with two papers on Intensity Modulated Radiation Therapy (IMRT). The first paper, by R. Acosta, M. Ehrgott, A. Holder, D. Nevin, J. Reese, and B. Salter, discusses an important subproblem in the design of radiation plans, the selection of beam directions. The manuscript compares different heuristic methods for beam selection on a clinical case and studies the effect of various dose calculation grid resolutions. The next paper, by M. Ehrgott, H. W. Hamacher, and M. Nußbaum, reviews several contributions on the decomposition of matrices as a model for rearranging leaves on a multi-leaf collimator. Such a process is essential for block radiation in IMRT in order to achieve desirable intensity profiles. Additionally, they present a new approach for minimizing the number of decomposition segments by sequentially solving this problem in polynomial time with respect to fixed decomposition times.

The book continues with a paper by G. Deng and M. Ferris on the formulation of the day-to-day radiation therapy treatment planning problem as a dynamic program. The authors consider errors due to variations in the positioning of the patient and apply neuro-dynamic programming to compute approximate solutions for the dynamic optimization problems. The fourth paper, by H. Fohlin, L. Kliemann, and A. Srivastav, considers the seed reconstruction problem in brachytherapy as a minimum-weight perfect matching problem in a hypergraph. The problem is modeled as an integer linear program for which the authors develop an algorithm based on a randomized rounding scheme and a greedy approach.

The book also covers other types of medical applications. For instance, in the paper by S. Sabesan, N. Chakravarthy, L. Good, K. Tsakalis, P. Pardalos, and L. Iasemidis, the authors propose an application of global optimization in the selection of critical brain sites prior to an epileptic seizure. The paper shows the advantages of using optimization (in particular nonconvex quadratic programming) in combination with measures of EEG dynamics, such as Lyapunov exponents, phase and energy, for long-term prediction of epileptic seizures.

E. K. Lee presents the optimization-classification models within discriminant analysis, to develop predictive rules for large heterogeneous biological and medical data sets. As mentioned by the author, classification models are critical to medical advances as they can be used in genomic, cell molecular, and system level analysis to assist in early prediction, diagnosis and detection of diseases, as well as for intervention and monitoring. A wide range of applications are described in the paper.

This book also includes two papers on inverse problems with applications to medical imaging. The paper by A. K. Louis presents an overview of several techniques that lead to robust algorithms for imaging reconstruction from the measured data. In particular, the inversion of the Radon transform is considered as a model case of inversion. In this paper, a reconstruction of the inside of a *surprise egg* is presented as a numerical example for 3D X-Ray reconstruction from real data. In the paper by M. Malinen, T. Huttunen, and J. Kaipio, an inverse problem related to ultrasound surgery is considered in an optimization framework that aims to control the optimal thermal dose to apply, for instance, in the treatment of breast cancer. Two alternative procedures (a scanning path optimization algorithm and a feedforward-feedback control method) are discussed in detail with numerical examples in 2D and 3D.

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