Addressing uncertainty in health care with the cardinality-constrained approach: a tradeoff between accuracy, computational effort, and interaction with clinicians

Uncertainty is a fundamental aspect of several health care optimization problems, which cannot be neglected due to the significant impact it may have both on quality and feasibility of the problem solution. Indeed, high uncertainty is always related to patients' conditions and demands, and the solutions should guarantee a good quality of the service over a usually wide number of possible future realizations.

Different approaches have been proposed and applied in the literature to deal with uncertainty in health care problems, which can be mainly classified into stochastic programming, distributionally robust optimization, and robust optimization. Within the robust optimization approaches, the cardinality-constrained approach, introduced by Bertsimas and Sim about 10 years ago, represents a powerful tool that allows a trade-off between the level of robustness and the computational cost of the solution. Moreover, an intuitive modeling of the uncertainty set, which can be understood and tuned by clinicians and planners without any background in operations research, is another advantage of this approach. However, despite its potentialities, this approach has been only marginally applied in the health care sector.

Briefly, the cardinality-constrained approach assumes that all of the uncertain parameters belong to an interval around a nominal value, and concentrates the variability of the problem by assuming that in each constraint only a limited number of parameters deviate from the nominal to the maximum value.

The tutorial deals with the discussion of the robustness concept in health care optimization and with a detailed description of the cardinality-constrained approach: the methodology is presented and some examples of application to health care are given, e.g., to the assignment problem. Finally, an extension of the approach is outlined, and some remarks and drawbacks to take into account while implementing the approach in the practice are discussed.

SHORT BIO

Ettore Lanzarone was born in 1979, and he obtained the Master Degree in Biomedical Engineering and the Ph.D. in Bioengineering from Politecnico di Milano in 2004 and 2008, respectively

He is currently Researcher at the Institute of Applied Mathematics and Information Technology (IMATI) of the National Research Council of Italy (CNR), and Professor of Mathematical Analysis at the Politecnico di Milano. Moreover, he is co-founder and member of the β-Lab, joint laboratory among Università degli Studi di Pavia, CNR-IMATI and Policlinico San Donato.

His main research interests include: optimization and resource planning of healthcare facilities, with particular attention to the robustness of the plans; stochastic models for estimating the demand and planning the activities in healthcare structures; scheduling algorithms for the manufacturing industry; industrial bioengineering, with particular interest to the cardiovascular fluid-dynamics; parameter estimation and stochastic evolution of complex dynamic systems described by differential equations.

He is co-author of about 40 papers on international journals and conference proceedings.

He has been involved in several research projects, and among them he has been the Principal Investigator of the Project Fab@Hospital, funded by the Italian Ministry of Research and the National Research Council of Italy, dealing with methods and technologies for implementing prototyping services within the hospitals.

He is co-founder of the Bayesian Young Statisticians Meetings (BAYSM) and co-chair of two editions, and he was member of the committee of the first International Conference on Health Care Systems Engineering (HCSE).

He spent several visiting periods in international research centers, e.g., at the Jiao Tong University (Shanghai, China), at the G-SCOP Laboratory (Grenoble, France), and at the École des Hautes Études Commerciales (Montreal, Canada).

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