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A Simulation-based Markov Decision Process for the Scheduling of Operating Theatres

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Scheduling of operating theatres is a recurrent problem in the literature on health care optimization and correspondingly appears in many different variations. In this study, we are concerned with the problem of scheduling patients for operation on a short-term basis. We consider a specific variation in which we only focus on the allocation of patients to days and rooms, and therefore omit the sequencing of the surgical procedures. Furthermore, we assume that requests for operation are postponed such that they are only scheduled at the end or early on each day, resulting in decision epochs that occur with discrete time-interval. We consider a rolling planning horizon of fixed length that is consequently overlapping for both previous and future decision epochs. Lastly, we account for a room setup-cost as well as a supplement payment for all procedures that stretch into overtime.

Our objective in this study is to test an approach for minimizing the long-term total expected cost of scheduling patients for operation. Our overall modeling approach is based on a Markov Decision Process (MDP), for which, due to the complexity of the problem, we derive a decision in an "on-line" manner by using a simulation-based framework, known as rollout [4, 2]. In our case, this framework is comprised of a Greedy Randomized Adaptive Search Procedure (GRASP) [1] that derives a scheduling of patient requests by considering the current known and future anticipative costs. The latter is evaluated by using a simulated annealing multiplicative weights algorithm [3].

We assess the MDP approach by conducting a number of numerical experiments using simulation, where the model performance is compared to both a close-to-manual and more advanced myopic scheduling method. In the first case, the MDP exercises a distinct improvement in performance on both total costs and patients that have to be outsourced due to capacity constraints. However, in comparison with the more advanced approach, experiments indicate that quite similar performance can be attained by aiming for a non-anticipative local optimum.

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