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Allocating Patients to Rooms under Uncertainty: An MDP-Based Approach

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Abstract

Effective bed management in hospitals is becoming increasingly important due to rising demand and limited bed availability. Patient-to-room allocation is a challenging task influenced by (i) stochastic factors, such as the arrival for emergency patients and the variability in the length of stay; (ii) constraints like limited bed capacities in specific rooms and gender-based room-allocations; and (iii) the handling of overflow situations. Undesirable actions—such as patient transfers, overflow area allocations, or rejections—should be minimized to ensure high-quality patient care.

The existing literature often relies on deterministic approaches that either assume full prior knowledge or use dynamic rolling-horizon approaches, which iteratively solve deterministic problems while updating current states. In contrast, we propose a Markov Decision Process (MDP) formulation that incorporates explicitly stochastic influences within a finite planning horizon. The model considers allocating patients to regular rooms, the overflow area, or rejecting them, as well as transferring patients to a different room based on the current state. We present the MDP model and preliminary numerical results, highlighting the value of modeling uncertainty.