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An Agent-based Model for Quantitatively Analyzing and Predicting the Complex Behavior of Emergency Departments

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Abstract

Hospital based emergency departments (EDs) are highly integrated service units devoted primarily to handling the needs of patients arriving without prior appointment, and with uncertain conditions. In this context, analysis and management of patient flows play a key role in developing policies and decisions for overall performance improvement. However, patient flows in EDs are considered to be very complex because of the different pathways patients may take and the inherent uncertainty and variability of healthcare processes. The agent-based model provides a flexible platform for studying ED operations, as it predicts the system-level behavior from individual level interactions. In this way, policies such as staffing can be changed and the effect on system performance, such as waiting times and throughput, can be quantified. The overall goal of this study is to develop tools to better understand the complexity, evaluate policy and improve efficiencies of ED units. The main contribution of this paper includes: an agent-based model of ED, a flexible atomic data monitoring layer for agent state tracing, and a master/worker based framework for efficiently executing the model and analyzing simulation data. The presented model has been calibrated to imitate a real ED in Spain, the simulation results have proven the feasibility of using agent-based model to study ED system.

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Keywords: Emergency Department, Agent-Based Model, Complex Adaptive System, Decision Support System

1. Introduction and related work

1.1. Introduction and motivation

Nowadays, many of the healthcare systems are large, dynamic, complex environments, especially Emergency Departments (EDs). These EDs serve as the primary gateway to the acute healthcare system. They are struggling to provide care to a steadily increasing number of unscheduled visits [1]. In recent years, EDs are suffering from increasing stress due to a remarkable growth in demand, limited productivity, and reduced budgets which mostly lead to overcrowding in EDs [2]. As a consequence, patient congestion and long waiting times in EDs are one of the most common problems in public hospitals [3]. Moreover, patients expect that services are well organized from a *customer*

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