Meta-Model Optimization of Simulated EMS Systems: A Case of Statistical Engineering

Matthew Snyder[1]; Byran Smucker[1]

[1] Department of Statistics, Miami University, Oxford, OH USA

Abstract:

Emergency Medical Services (EMS) systems often develop haphazardly over time based upon perceived need or availability of resources in a region or community. However, as data becomes more abundant and analytical modeling more available, data-driven planning can be done in order to reduce response times and save lives. EMS systems can be modeled using discrete event simulators (DES) that allow for modifications to the geographic station configurations and resource allocation, but optimization of such simulators is computationally challenging. This work uses an example of an EMS system from northern St. Louis County, Minnesota to study the effectiveness of fitting and optimizing a metamodel based on data generated from a DES, with the goal of finding improved station configurations. We begin by modeling a single station within the system, and then examine increasingly complex settings culminating with consideration of all 12 stations in the system which have ambulances. As part of our analysis, we use a decade of call data from the EMS system under study, which informs the development of a realistic stochastic DES, facilitates calibration of OpenStreetMap estimates of driving times, and supports the estimation of the spatial distributions of calls which guides the random selection of station configurations that train the metamodel. Overall, we found that the metamodel approach produced improved configurations for the one- and two-station cases, but the amount of data required to produce effective metamodels for the five- and twelve-station versions of the system was computationally infeasible given our current DES and optimization implementations.

Keywords:

Emergency medical services; Discrete event simulation; Metamodeling; Particle swarm optimization; Random forest