Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA
Published: February 18, 2025

DOI: 10.46254/AN15.20250231

Optimal Allocation of Resources for Epidemic Control using Stochastic Block Models and Multi-Armed Bandits

Muhammad Alfas ST and Shaurya Shriyam
Department of Mechanical Engineering
Indian Institute of Technology Delhi
New Delhi, India
mez208100@iitd.ac.in, shriyam@iitd.ac.in

Abstract

Effective distribution of resources such as testing kits and vaccines are crucial in epidemic control. However, these resources are often limited, necessitating their optimal allocation to maximize their impact on disease mitigation. This work proposes a resource allocation framework that integrates network epidemiology models and multi-armed bandits (MAB). The network epidemiology part consists of a stochastic block model network in which each block represents a population group, and each node represents an individual. Disease dynamics are simulated on this network, capturing the spread of infection across and within population groups. An empirical Bayesian model is used to estimate the prevalence of each block daily. The daily allocation of resources is modeled as an MAB problem in which prevalence is the deciding factor. Three widely used MAB algorithms -Upper Confidence Bound, Thompson Sampling, and Gittins Index - are implemented to solve the resource allocation problem and determine the optimal distribution of resources among the population blocks. Following each allocation decision, the disease dynamics are simulated for one day, and the resulting observations are used to update the prevalence estimates for the next day. This iterative process continues until the epidemic subsides. The disease evolution statistics such as peak infection numbers, total number of infections, and endemic states are used to evaluate the efficacy of the method. A comparative analysis is performed against three baseline methods - random allocation, uniform allocation, and demand-based allocation. The results demonstrate that the proposed method achieves superior performance across the selected evaluation metrics.

Keywords
Epidemic control, stochastic block model, multi-armed bandit, network epidemiology

Biographies
Muhammad Alfas ST is a PhD student at the Department of Mechanical Engineering, Indian Institute of Technology Delhi, India. He completed B Tech from Calicut University, Kerala, India and M Tech from APJ Abdul Kalam Technological University, Kerala, India. His research work focuses on modeling complex systems, resource allocation, and optimization using heuristics, as well as reinforcement learning.

Shaurya Shriyam is an Assistant Professor at the Department of Mechanical Engineering, Indian Institute of Technology Delhi, India. He completed his Ph.D. from the Department of Aerospace and Mechanical Engineering, University of Southern California, Los Angeles, CA, USA. His research interests lie in the application areas (robotics, logistics, healthcare, urban transport) of planning, inference, and learning algorithms aimed towards social good or industrial automation.