Making Decisions with Simulation

Christine S.M. Currie

University of Southampton, UK

Christine Currie is Professor of Operational Research within Mathematical Sciences at the University of Southampton and a member of the Centre for Operational Research, Management Sciences and Information Systems (CORMSIS), where she was Director from 2018 - 2020. She is Editor-in-Chief for the Journal of Simulation, has previously co-chaired the UK OR conference OR63 in 2021, UK Simulation Workshop in 2016 and 2018, and was a proceedings editor in 2023. Currently she chairs the Research Committee for the Operational Research Society. Her research interests include simulation optimization, applications of simulation in health care, optimal pricing, transportation and disaster management.

christine.currie@soton.ac.uk
https://www.southampton.ac.uk/people/5wzzxf/professor-christine-currie.

Abstract

Simulation models enable experimentation with different system settings and designs. This can be done much more quickly and cheaply than experimenting in real-life, and experimentation and optimisation of simulation models has been common practice for several decades. What has changed in recent years is the increased prominence of the idea of a digital twin. While the term digital twin has a variety of definitions dependent on the research area, within our community it gives the promise of using simulation for operational decision-making, returning recommendations within minutes. This leads into the idea of symbiotic simulation.

The term *symbiotic simulation* was first coined by Fujimoto et al. (2002) but Aydt et al. (2009) give a very useful definition: “a paradigm in which a simulation system and a physical system are closely associated with each other”. Typically, in a symbiotic simulation system, the simulation model is updated in real-time with data from the physical system and used to carry out an exploration of different possible system configurations. This gives the decision-maker information on the likely outcomes, allowing them to choose the best option.

We will use two examples, from manufacturing and healthcare, to describe advances in the use of simulation for real-time decision-making using symbiotic simulation. The manufacturing example draws on a collaboration with an engine manufacturer who were looking to optimise the repair processes on their production line; essentially their problem is one of determining the repair order of machines when more than one is broken simultaneously. The simulation model of the production line is relatively complex and, as a result, takes some time to run. As decisions are needed within

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minutes, this limits the number of simulations that can be run. We use a multi-fidelity simulation optimisation procedure, described in Cao et al. (2021) to find a good repair strategy quickly.

In the second example, which models a hospital emergency department (ED), we discuss how new data can be used to update a simulation model, including the use of process mining for determining the flow of patients through the ED and hence the logic of the simulation model. These ideas also contribute to the literature on the building of generalised simulation models (e.g. see Boyle et al. 2022). Our aim is to provide a decision-support tool for allocating staff to particular areas of the ED, going beyond previous work by Hoot et al. (2007) who use a discrete event simulation model for forecasting crowding in an ED.

These two examples will help to highlight open research questions in real-time decision making via simulation.

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