Guest editorial

Special issue on hybrid simulation in construction

Simulation has proven to be a popular modelling method by enabling real-world systems to be represented in a virtual environment, allowing the impact of different managerial actions to be assessed in a risk-free environment. Simulation has experienced near-exponential growth in popularity in the last decade. In proposing this special section, we examined the journal papers published over the period of 2000 through to 2018 in each primary modelling and simulation technique including system dynamics (SD), agent-based modelling (ABM) and discrete event simulation (DES) with an application in construction projects. Using Scopus as the selected citation database, the total number of published journal papers that were identified from 2000 to 2018 which included DES, SD and ABM are 131, 115 and 60, respectively. In particular, there has been a rapid increase in the number of simulation papers in more recent years with more than 50% of these papers having been published from 2015 to 2018. This shows that simulation is a hot topic in construction management with a considerable number of published papers being devoted to the simulation tools and techniques and their applications.

In the past few years, there has been a new direction to use hybrid simulation (HS) to model highly dynamic and complex systems by combining two or more simulation tools. Construction systems are influenced by operational-level variables, interactions between agents and context-level variables. These variables can be modelled by DES, ABM and SD modelling methods, respectively. Using a single simulation paradigm, the dynamic behaviour of construction systems cannot be fully accounted for, as each of the alternative simulation tools can only consider some of the underlying influencing factors. However, a HS approach enables a wider range of underlying influencing factors to be taken into account when modelling complex construction systems. HS enables modellers to benefit from the capabilities of one simulation paradigm while compensating for the deficiencies of another simulation method.

A large proportion of the academic literature on HS is found in computer science and engineering journals. Leading academic journals in these fields have increasingly devoted significant attention to publishing the latest developments and findings on HS applications. However, the application of these contemporary concepts and methods within the construction industry has received scant academic attention.

This special section of *Construction Innovation* brings together four papers on HS-related topics. AbouRizk *et al.* (2021) propose a HS approach that combines DES with SD to improve microtunnelling construction planning. They use DES to model construction processes at the activity level and use SD to model the continuous flow of soil material in the system. Ahn *et al.* (2021) develop a SD-ABM HS approach for analysing worker policies. The authors introduce an agents-embedded SD modelling approach to incorporate individual attributes and interactions among individuals in an SD model representing the causality of group behaviour. Fayek *et al.* (2021) combine hybrid fuzzy Monte Carlo with ABM to simulate the behaviour of construction crews and predict their performance. The developed methodology allows ABM to simultaneously process all types of variables (i.e. deterministic, random and subjective) in the same simulation experiment while accounting for interactions between different agents. Taghaddos *et al.* (2021) use a HS approach combining SD and DES for site layout and material laydown planning in construction projects. In this research, dynamic features of project conditions and project operations are analysed by SD and DES,

respectively. Each of these papers demonstrates how HS can be used to provide advanced decision support for construction management and also increases our understanding of the use of HS in this area.

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