



RESEARCH

Inside IISE Journals

This month we highlight two articles in *IISE Transactions*. The first article contemplates what a medical decision-maker should do when there are multiple, conflicting estimates of a patient's risk. The authors propose a multimodel Markov decision process method to mitigate the ambiguity in medical treatments that could be caused by the conflicting estimates. The authors show a positive impact of the new approach, in terms of lower expected regret, in a case study of cardiovascular disease treatment. The second article looks into the issue of how to efficiently operate and coordinate thousands of overhead hoist transporters in a semiconductor fabrication. For this, the authors propose a cooperative zone-based rebalancing algorithm, which is to zone the semiconductor fabrication and then derive a decentralized rebalancing policy for each zone. They demonstrate a remarkably reduced retrieval time when the new research is applied to a semiconductor fabrication facility at SYNUS Tech, South Korea. These articles will appear in the October 2021 issue of *IISE Transactions* (Volume 53, No. 10).

Tackling the next level of uncertainty in medical decision-making

In the words of Sir William Osler, the Father of Modern Medicine: "Medicine is a science of uncertainty and an art of probability." Medical decision-making is a process that involves considering uncertainty in the consequences and trade-offs of decisions. For instance, when managing a patient's cardiovascular disease, doctors must consider uncertainty about whether the patient will have a heart attack or stroke in the future. While some medications may reduce the risk of a heart attack and a stroke, these medications cost money and can have side effects.

Fortunately, mathematical models like the Markov decisions process (MDP) can be used to synthesize all of this information to guide treatment decisions that are made sequentially over time. Given an estimate of the risk (i.e., probability) that the patient will have a cardiovascular event, MDPs can weigh the benefits and harms of many possible treatments to inform a strategy of whether and when to treat that makes the most sense for the patient.

But what should a modeler do when there are multiple, conflicting estimates of a patient's risk? In the case of cardiovascular disease, there are multiple, well-established risk calculators that use a patient's information to estimate their risk of a cardiovascular event, but different risk calculators can give conflicting estimates for the same patient profile. MDPs that rely on these conflicting estimates in turn give different treatment recommendations, leading to ambiguity in how the doctor should proceed to manage the patient's condition.

In their article "Multi-model Markov Decision Processes," Georgia Tech assistant professor Lauren N. Steimle, University of Michigan professor Brian Denton and University of Michigan-Dearborn assistant professor David Kaufman propose a new approach to mitigate this ambiguity. Their approach finds treatment strategies that work well across multiple plausible models of the probabilities while maintaining a similar level of complexity of strategies that are based on one model.

Using a case study of cardiovascular disease, the authors show that their approach recommends treatment strategies with lower expected regret compared to those based on a single model alone, as is typically done in practice. The study suggests that incorporating multiple plausible models into solution methods



Lauren N. Steimle



Brian Denton



David Kaufman

may be a promising way to mitigate the effects of ambiguity in medical decision-making and sequential decision-making more broadly.

In short, Steimle, Kaufman, and Denton propose a new take on Markov Decision Processes that pivot conflicting models from a dilemma to a feature, with applications to medicine and beyond.

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Operating multiple robot taxis to transport wafers in a semiconductor fabrication

Large-scale complex engineering systems are often composed of subsystems interacting with each other. Examples include wind turbines in a farm, robots or machines in a factory and energy systems in a smart grid. As the system becomes more complex, it becomes challenging to control such subsystems cooperatively to achieve system-level performance.

Multi-agent reinforcement learning, a multiagent extension of reinforcement learning, is an effective learning-based method that can learn the cooperative and decentralized control policy controlling subsystems to achieve system-level performance.



The authors of a paper on cooperative zone-based rebalancing of idle overhead hoist transportation stand in the Advanced Manufacturing Intelligence Innovation Center at KAIST. Pictured from left are professor Jinkyoo Park and doctoral student Kyuree Ahn.

In a semiconductor fabrication (FAB), thousands of overhead hoist transporters automatically transport a bundle of wafers from one machine to another while moving along a

Call for special issue submissions

Author submissions are being sought for two upcoming special issues of *IISE Transactions*.

Analytical methods for detecting, disrupting and dismantling illicit operations

This special issue will highlight analytical approaches that can help detect, disrupt and ultimately dismantle illicit operations. Its goal is to showcase the role of analytical methods in the fight against illicit operations by bringing together those within the industrial and systems engineering community and domain experts in distinct areas of fighting illicit operations. Of special interest are papers that integrate domain expertise and/or stakeholder engagement in their model formulation, analysis and validation.

The guest editors for the issue are Thomas Sharkey of Clemson University, Renata Konrad of Worcester Polytechnic Institute, Burcu Keskin of the University of Alabama and Maria Mayorga of North Carolina State University.

The deadline for abstract submissions is Oct. 31, 2021, with article submission due by Jan. 31, 2022. To learn more and provide a submission, visit think.taylorandfrancis.com/special_issues/analytical-methods-illicit-operations.

Modeling and optimization of supply chain resilience to pandemics and long-term crises

This issue aims to attract novel research dealing with supply chain resilience modeling and optimization in context of long-term crises motivated by the COVID-19 pandemic. The authors seek methodically rigor and practically relevant papers dealing with the settings when recovery/adaptation should be planned and deployed in the presence of disruptions and bouncing back to “old normal” is impossible or difficult on a short-term scale, and the only way to survive is to adapt. They encourage submissions that explicitly account for the context of epistemic and deep uncertainty (i.e., unknown-unknown) and supply chain viability.

The special issue editors are David Coit and Weiwei Chen, both of Rutgers University; Dmitry Ivanov of the Berlin School of Economics and Law; and Nezih Altay of DePaul University.

The deadline for submission is Feb. 28, 2022. To learn more and provide a submission, visit think.taylorandfrancis.com/special_issues/supply-chain-resilience-pandemics.