Proceedings of the 2022 Winter Simulation Conference
B. Feng, G. Pedrielli, Y. Peng, S. Shashaani, E. Song, C.G. Corlu, L.H. Lee, E.P. Chew, T. Roeder, and P. Lendermann, eds.

SIMULATION AND ARTIFICIAL INTELLIGENCE IN MANUFACTURING

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ABSTRACT

Simulation has been used as a strategic decision support tool for a long time now. The technologies like Machine Learning and Artificial Intelligence have proven to be a strong contender for decision making as well. Simulation can provide data for training an AI policy in industrial areas where data availability and scenarios can pose a challenge. We introduce use cases in the field of manufacturing where simulation-based AI policies can serve the purpose better, considering the dynamic nature of the system.

1. INTRODUCTION

The manufacturing industry has undergone major transformations in the last two decades, from mass production to just-in-time production to lean manufacturing. The customer driven business has motivated us to adopt higher product variability to provide customized solutions specific to the customer. Discrete Event Simulation (DES) and Artificial Intelligence (AI) have demonstrated that it can change the way decisions are made inside manufacturing environments.

2. WHY AI IN SIMULATION?

The first and most crucial step in the implementation of Artificial Intelligence is to obtain enough data for training the AI model, which is also one of the major obstacles in its implementation. Most times it is not an easy task to obtain the required data from the actual system. Even if data is collected successfully, the validity and reliability of data is still at stake.

Simulation can act as a perfect tool to gather this data for Artificial Intelligence. The data generated from simulation model is validated with the actual system. Hence, we can rely on the data and can use it for training AI models. Once the AI models are trained to a certain level, the next step is to test the trained AI model. On the already developed simulation model, the qualified AI model can be tested for its accuracy. The results can be compared with the original simulation model results and the accuracy of the AI can be judged. In a way, AI model implementation strategy can be first virtually commissioned on simulation model and thereafter can be implemented at actual system.

3. REINFORCEMENT LEARNING

Reinforcement learning has an environment and an agent, which interact with each other to formulate a decision policy. The agent performs action in the environment, which may change the state of the environment. It receives a reward or penalty based on the action it has taken and the state of the environment. The goal is to train the algorithm, to decide what action should be taken, based on a certain state of the system, that will lead to maximum cumulative reward. The reinforcement learning algorithms learn by exploring and exploiting the actions it takes, over multiple episodes of training. Simulation models can be used to train reinforcement learning algorithms in an efficient way. The system in simulation model can be configured to be environment, and any entity in the simulation model can be the agent, for reinforcement learning algorithms. The algorithm communicates with simulation model to exchange actions and rewards/penalties in each episode, for training the optimal policy.

4. USE CASES IN MANUFACTURING INDUSTRY

Artificial intelligence technologies can be implemented in manufacturing factories and processes to improve productivity and reduce operating costs. We propose two unique applications of this technology in the automobile manufacturing industry.

- **Defining Material Delivery Policy to Point of Use:** Artificial Intelligence in confluence with discrete event simulation can be used to define policies of material delivery to the point of use. Data generated from simulation model can be used to train the Reinforcement Learning Algorithm which will be used to take decisions considering delivery at the right time and optimal utilization for the material handling equipment's (MHEs). The simulation model can consider but is not limited to reducing the travel of material handlers to drop parts at stations, reducing number of replenishment calls and delays due to part unavailability and dynamic shifts for MHEs based on utilization.
- **Dynamic product sequencing in assembly line:** In a typical automobile manufacturing plant, the product to be assembled is launched on the assembly line from a queue/buffer containing a variety of products or variants. Based on the availability of sub-assemblies, critical parts and the dispatch plan, a pool of orders is created, out of which, the order to be launched for assembly is randomly selected. Due to the variation in work content among the product variants, the random sequencing of orders creates delays and losses in the assembly line. Reinforcement learning can be used to devise a policy, which chooses the most suitable variant to be sequenced next on the assembly, based on the available pool of orders and current state of the assembly line, such that the production lead time is minimized, productivity is maximized and/or some other performance measure is optimized.