Online Validation of Manufacturing System Digital Twins

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Short Abstract

The proposed methodology in this work aims to validate the similarity between a manufacturing system and its simulation-based digital twin. It accomplishes this by comparing data sets of events and Key Performance Indicators (KPIs). To assess their similarity, both information types are treated as sequences and appropriate techniques are employed to measure their resemblance. A preliminary implementation of one of the proposed techniques is done within a lab-scale digital twin demonstration.

Keywords

Digital twin; digital model; simulation; online validation; lego; digital twin demonstration

Introduction

With the recent technological advances, there is a continuing trend to increase the level of detail of digital twins to correctly capture the behavior of a complex system (Tao et al., 2019). Increasing complexity introduces challenges for maintaining the physical-to-digital alignment (Tan and Matta, 2022). Given the short-term decision support that must be provided by digital twins, it is essential to guarantee the validity of the underlying digital models with relatively small sets of data. This means traditional validation techniques cannot be used, and new methods should be developed to address the validity of both the model logic (i.e., topology) and the model inputs (i.e., statistical distributions, data models) (Lugaresi et al. 2019). To the best of authors knowledge, no significant contribution on the online validation of digital twins is present in literature.

Contribution

This work proposes a validation methodology to assess similarity between a manufacturing system and its simulation-based digital twin by comparing sequences of events and sequences of Key Performance Indicators (KPIs). The validation is done treating both information types as sequences and exploiting proper techniques to measure their similarity. The contributions of this work are twofold: (1) To describe the problem of online validation of digital twins within the scope of production planning and control. The same problem can be present in several other contexts in which the physical system can be modeled as a discrete event system, such as logistics and transportation, warehouse management, and supply chain management. (2) To propose of a methodology for online validation that can be used at different levels of detail and in an automated way during the production operations.

Conclusions

Offline experiments are conducted to understand the properties of three techniques that have been identified as proper. Moreover, the proposed methodology is applied in real-time on a lab-scale manufacturing system to reach a proof-of-concept digital twin demonstrator (Lugaresi et al., 2022).

References

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