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DIGITAL TWIN-DRIVEN DESIGN AND OPTIMIZATION METHOD FOR SMART WAREHOUSE

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ABSTRACT

For the warehouse system, current new generation information technologies lead to high flexibility and agility. The digital twin technologies have caught the attention of industry and academia. This paper proposes a digital twin-driven design and optimization approach for smart warehouse system. A method for digital twin-driven warehouse design is proposed to integrate from the physical warehouse operational system to the virtual space. An optimization model aiming to allocate goods packing and storage space is proposed to integrate to the digital twin system. A case study on a real warehouse design is provided to validate and illustrate the proposed approach.

1 INTRODUCTION

With the development of smart warehouse, traditional warehouses are using more digital technologies to warehouse operation and optimization. Traditional warehouse design methods are not able to consider the dynamic behaviours of designed warehouse. The application of digital twin can support to solve this problem as it has the fidelity to physical warehouse. A digital twin-driven warehouse design framework is proposed including the dimension definition, digital twin module design, module relationship and the establishment of the virtual model. A case study is provided by using the digital twin in warehouse design. Through the digital twin model, the best design solution can be found. Moreover, the designers can compare the performance of digital warehouse with various solutions and scenarios. Finally, digital twin-driven warehouse can shorten the time-cost of the design cycle to evaluate the digital warehouse.

2 DIGITAL TWIN FOR WAREHOUSE OPERATION AND OPTIMIZATION

For the next generation of warehouse, digital twin will improve its decision support capabilities. Transferring the physical realm of the warehouse into the digital world, it can combine the artificial intelligence and simulation aspect of warehouse operation components (e.g. automated guided vehicles (AGVs), cranes, AS/RS movement, etc) to create a virtual sandbox environment for running simulation models and give real time suggestions. As shown in Figure 1 the digital twin for warehouse is the bridge between the physical space and the virtual space. The aim is to fully integrate the physical and digital aspects of the warehouse operations by getting real time data from the physical world to the digital world and inversely, so that both systems have mutual learning capabilities. It has four core capabilities, including simulation modelling, advanced analysis, visualization and connectivity.

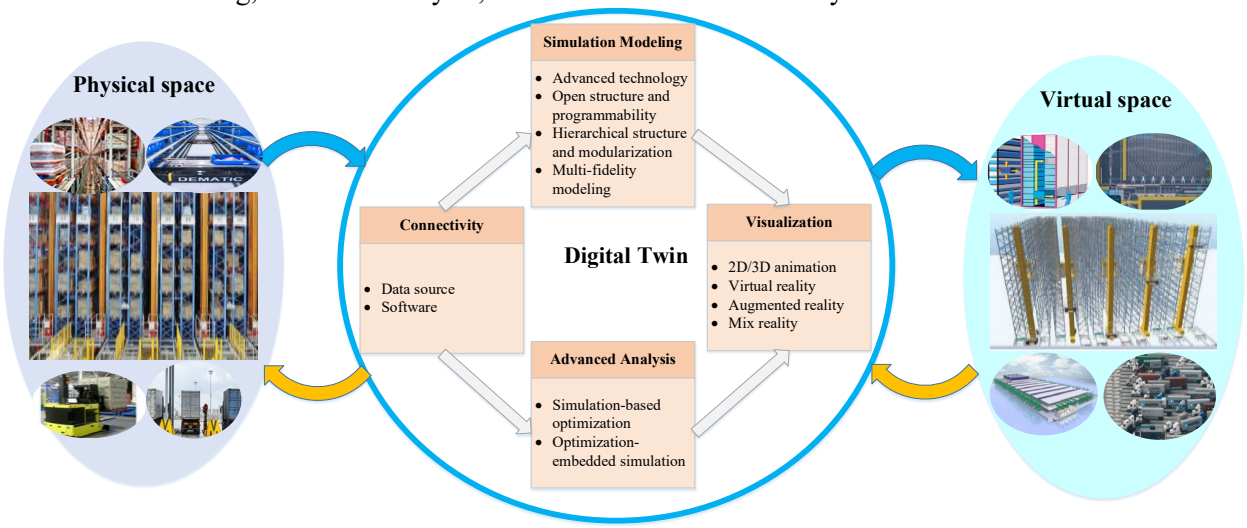

Figure 1. Dimensions of warehouse digital twin.

3 DIGITAL TWIN-DRIVEN WAREHOUSE DESIGN FRAMEWORK

This subsection proposes a Digital Twin-driven smart warehouse framework to conduct both optimization and analysis on a system. Through this digital twin based framework, the engineers can obtain new knowledge from big data and through simulation modelling and optimization studies. Analytical modules of variable sizes and complexities can be subsequently developed not only to enable descriptive and visual statistics, but also to explore and evaluate in a wide range of solution space with a smart method, ultimately leading to better business decisions. Simulation models can capture the system dynamics and conduct various "what-if" analysis. The conventional data analytics are passively perceived from the real system. This always has the issue of latency. Simulation models are designed and driven on purpose as building blocks for the digital twin or "clone" of the real system, which not only play out and evaluate lean analysis and simulation analytics tools on the decisions and their consequences, but also perform process optimization, resulting in a powerful decision-making tool that can avoid the potential anomalies ahead of time.

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