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Conceptual Architecture Design and Implementation of a Digital Twin-based High speed Railway Station: A Case Study of Guangzhou Baiyun Station

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Introduction

China's high-speed rail (HSR) network has transformed travel and economic development. Smart HSR stations are essential for improving efficiency, passenger experience, and safety. However, incidents like the Beijing West Station stranding highlight management challenges and the need for timely information and emergency responses.

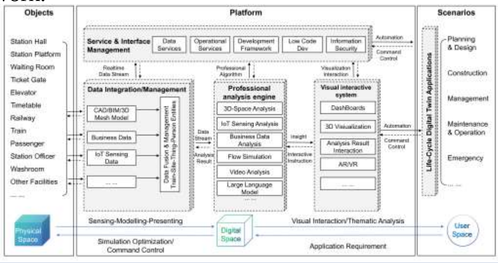
Digital Twin technology, through real-time virtual replicas, offers solutions for station management, maintenance, and emergency preparedness. This study explores its challenges, including data integration and cybersecurity, while proposing strategies for effective implementation.

Theoretical and Technological Foundations

Digital Twin technology creates real-time virtual replicas of physical assets, enabling monitoring, simulation, and optimization through data integration and advanced tools like IoT, AI, and cloud computing. In smart high-speed railway stations, it enhances operational efficiency, predictive maintenance, and safety management. For example, Shanghai Railway Station uses Digital Twin technology to improve facility maintenance and safety. By enabling intelligent operations and decision-making, it enhances passenger experience, resource management, and emergency response, promoting sustainable development.

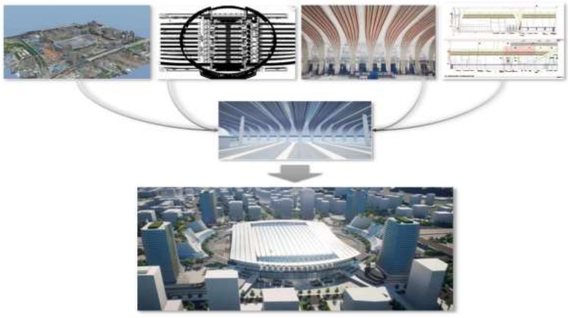
Conceptual Architecture

Figure illustrates the conceptual architecture of a Digital Twin for Smart High-Speed Railway Stations, integrating digital technologies with physical infrastructure through a multi-layered framework.



Case Study

Digital Twin Model Construction



The digital twin model of Guangzhou Baiyun High-Speed Railway Station is constructed using CAD, BIM, and 3D mesh modeling techniques.

System Development and Integration

The system integrates data from IoT, business intelligence, and external sources using a secure, low-code framework for rapid deployment and flexibility. It features natural language interaction via a large-scale language model, enhancing usability and supporting both daily operations and emergency management through a unified interface.

Full Lifecycle Application Validation

peak-hour passenger flow management

equipment maintenance

emergency evacuation drills

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