Multidimensional Digital Twin in the Built Environment

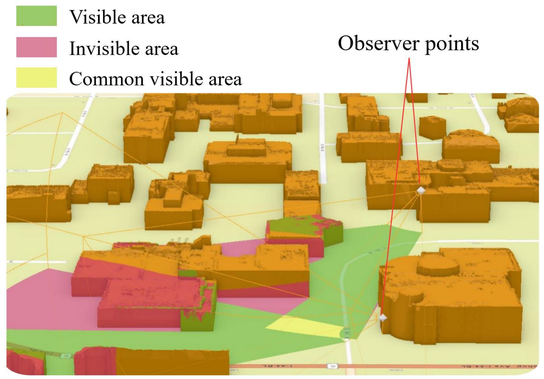
A System Integration, Coupled Modeling, and 3D Mapping Platform

Woubishet Taffese, Ibrahim Alomari, and Genda Chen

Introduction

CII has developed a large-scale multidimensional digital twin (DT) of the University campus to support eight functions:

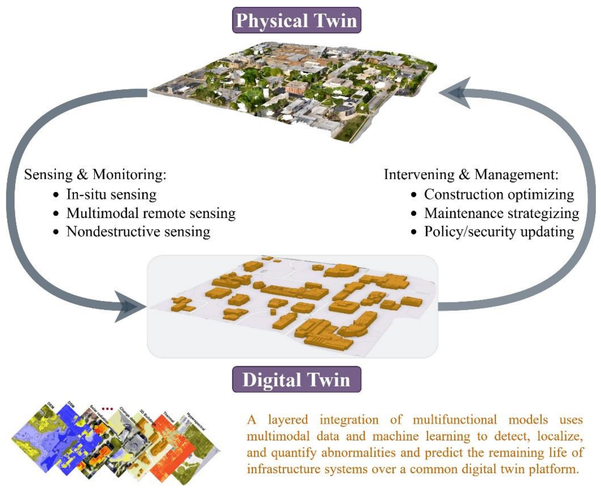
1. Building and infrastructure planning
2. Condition assessment of building envelopes
3. Construction management for efficiency and quality
4. Damage/cost scenario studies under earthquake events
5. Energy harvesting efficiency
6. Environmental planning for flood zone susceptibility
7. Master planning for green space development
8. Security protocol development



Definitions

A multidimensional DT is defined as a cross-referenced, multifunctional, effectively indistinguishable digital representation of an intended or actual real-world asset, system, or process – a physical twin in the built environment.

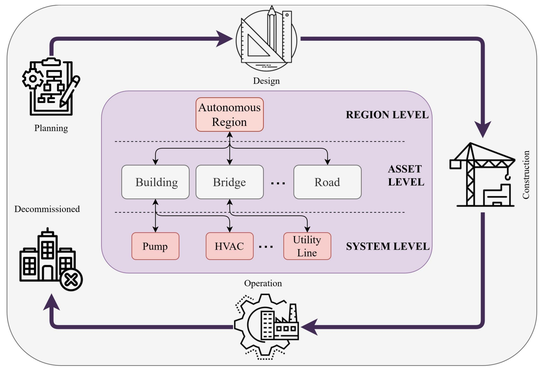
The degree of digital twinning to a real world is defined by the number of models enabled by a common digital twin platform. This concept is important to steer DT research to a value-driven approach on a grand scale.



A layered integration of multifunctional models uses multimodal data and machine learning to detect, localize, and quantify abnormalities and predict the remaining life of infrastructure systems over a common digital twin platform.

System Architecture

DT can be hierarchically structured to extend from a regional level down to asset and system levels. Depending on the security demand, the infrastructure at the asset level can be clustered into two segments: (1) an open-sourced segment catering to public buildings and standard infrastructure, and (2) a secured segment designed for information-sensitive buildings and critical infrastructure. Furthermore, the hierarchal asset and system structure undergoes evolution throughout the planning, design, construction, and operational phases.



Simplified Workflow

Heterogeneous datasets acquired from multimodal sensors are used either individually or fused between geo-referenced multilayers to develop multiple functions. Given those data are collected regularly to update the DT, the time-series data can track changes and utilize artificial intelligence (AI) and machine learning (ML) algorithms to assess the current condition of the built environment and forecast the future. This foresight enables predictive infrastructure asset maintenance.