

Digital Twin Frameworks for the Digitization of Historical Monuments: Enhancing Preservation and Visitor Experience through AR/VR Integration

Manu Vardhan

Department of Computer Science and Engineering, NIT Raipur Raipur, India

Shubham Sharma

Department of Computer Science and Engineering, NIT Raipur Raipur, India

Abstract

The preservation of historical monuments faces significant challenges due to environmental degradation, rapid urbanization, and limited accessibility. Digital Twin (DT) technology, representing a dynamic, virtual counterpart of a physical asset, offers a transformative solution for documentation and conservation. This paper proposes a comprehensive framework for digitizing historically rich monuments using Digital Twin technology integrated with Augmented Reality (AR) and Virtual Reality (VR). We present a comparative analysis of a Basic Monitoring Framework versus a proposed Hybrid AR/VR-Enabled Framework. The study explores the technical methodology for high-fidelity 3D reconstruction, sensor data integration, and immersive user interaction. Experimental results from a pilot implementation demonstrate a 40% improvement in structural anomaly detection speed and a 85% increase in visitor engagement scores compared to traditional methods. The paper concludes that the synergistic use of DT and XR (Extended Reality) technologies significantly contributes to the sustainable development and democratization of cultural heritage.

Keywords

Digital Twin, Cultural Heritage, Augmented Reality, Virtual Reality, Historic Preservation, HBIM, Smart Monuments.