IJARSCT

ISSN: 2581-9429

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Volume 5, Issue 12, May 2025

Impact Factor: 7.67

Physics-Based Modeling in Digital Twins: Applications, Challenges, and Future Prospects

Stephy Thomas
Assistant Professor, Information Technology
ZSCTs Thakur Shyamnarayan Degree College, Mumbai

Abstract: *Digital twins have emerged as transformative technologies across diverse industries, offering advanced capabilities for real-time monitoring, simulation, and optimization of physical systems. A digital twin is a virtual counterpart of a real-world entity that dynamically reflects the current state, behavior, and performance of the physical system through continuous data exchange. This paper emphasizes the integration of physics-based modeling into digital twin systems, which significantly enhances their accuracy, reliability, and interpretability. Unlike purely data-driven approaches, physics based models are grounded in fundamental scientific laws such as Newtonian mechanics, thermodynamics, and electromagnetism, enabling more precise predictions and deeper understanding of system dynamics.*

The research looks at real-world uses of physics-based digital twins in industries like manufacturing, where they are used to predict equipment failure and streamline production processes; energy systems, where they assist in load balancing and heat management; and education, where they facilitate virtual labs for the study of science. Some of the methodologies such as differential equations, finite element analysis (FEA), and multiphysics simulations are mentioned to illustrate how the models are applied. The article also discusses important challenges like computational complexity, real-time sensor integration, and the requirement for interdisciplinary skills. Last but not least, it outlines future directions in digital twin development, specifically the potential of hybrid models that merge artificial intelligence and physics-based modelling for improved performance and scalability.

Keywords: DigitalTwin, PhysicsModeling, Simulation, RealTime, VirtualLearning, Industry4.0