Chapter 7
AI and Machine Learning in Façade Performance Prediction

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ABSTRACT

The integration of Artificial Intelligence (AI) and Machine Learning (ML) in the built environment is transforming how buildings are designed, constructed, operated, and maintained, with far-reaching implications for sustainability, occupant comfort, operational efficiency, and cost-effectiveness. In the context of building performance, AI and ML act as pivotal technologies that enable data-driven decision-making and proactive control strategies. As buildings become more complex and demand greater energy efficiency and user responsiveness, traditional rule-based systems often fall short in handling the volume, velocity, and variety of data generated by modern sensors and control devices. AI and ML offer powerful alternatives, with

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the ability to learn from historical and real-time data, recognize patterns, forecast performance, and autonomously adapt to changing conditions. One of the most critical areas where AI and ML contribute to building performance is energy management and optimization.

THE ROLE OF AI AND MACHINE LEARNING IN BUILDING PERFORMANCE

The integration of Artificial Intelligence (AI) and Machine Learning (ML) in the built environment is transforming how buildings are designed, constructed, operated, and maintained, with far-reaching implications for sustainability, occupant comfort, operational efficiency, and cost-effectiveness. In the context of building performance, AI and ML act as pivotal technologies that enable data-driven decision-making and proactive control strategies (Arowoiya et al., 2024; Yang et al., 2022). As buildings become more complex and demand greater energy efficiency and user responsiveness, traditional rule-based systems often fall short in handling the volume, velocity, and variety of data generated by modern sensors and control devices. AI and ML offer powerful alternatives, with the ability to learn from historical and real-time data, recognize patterns, forecast performance, and autonomously adapt to changing conditions (Arowoiya et al., 2024; Zhang et al., 2022; Fakhabi et al., 2024). One of the most critical areas where AI and ML contribute to building performance is energy management and optimization. Smart buildings generate vast amounts of energy data through IoT-enabled systems, including HVAC, lighting, water systems, and renewable energy sources. AI algorithms can analyze this data to detect inefficiencies, predict peak loads, and dynamically adjust settings to reduce energy consumption without compromising occupant comfort. Machine learning models such as neural networks, reinforcement learning, and decision trees can forecast energy demand, optimize the operation of building systems, and identify abnormal usage patterns indicative of faults or inefficiencies. For example, predictive analytics powered by AI can anticipate temperature fluctuations based on weather data and adjust HVAC systems accordingly, achieving significant energy savings and lowering carbon emissions. Another significant contribution of AI is in predictive maintenance and fault detection. Building systems often degrade over time or develop faults that go unnoticed until they cause failures or increase operational costs. AI-powered diagnostics can continuously monitor sensor data and detect anomalies that may indicate equipment failure or underperformance. By applying supervised and unsupervised ML models, facility managers can receive early alerts about potential issues and schedule maintenance before critical failures occur, reducing downtime and repair

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