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Recent Advancement of Predictive Maintenance Based Data-Driven Strategies for HVAC Equipment Health Monitoring

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Abstract: *HVAC systems play a vital role in supporting the comfort and energy efficiency of indoors, as well as in safeguarding and ensuring the reliability of indoor air; however, the sensors and sensors constantly have challenges related to wear, sensor noise, environmental variations, and the operating conditions of the system, which is why data-driven and artificial intelligence (AI) techniques are invaluably helpful to change the situation. Some of the functionalities enabled include monitoring of performance in real time, system operation optimization based on the real time sensor data and Fault detection and diagnostics based on the abnormal patterns that were identified to enable timely maintenance and hence reliability. Neural networks, autoencoders, and time-series machine learning (ML) and deep learning (DL) models are highly beneficial in fault detection, anomaly detection, and Remaining Useful Life (RUL) prediction processes, allowing identifying when equipment is getting old and can be detected sooner and more accurately. In addition to equipment diagnostics, the emergence of new technologies, including digital twins, blockchain-based data integrity models, and intelligent control systems, leads to a higher level of reliability, transparency in the functioning of devices, and automated decision-making. interpretability, hardware limitations, and inability to generalize in a variety of HVAC environments.*

Keywords: HVAC Systems, Predictive Maintenance, Data-Driven Monitoring, Machine Learning, Fault Detection, Remaining Useful Life, Digital Twins

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