Evolving Paradigms in Machinery Fault Diagnosis: From Learning-Based Models to Next-Generation Diagnostic Intelligence

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Abstract

Machinery fault diagnosis (MFD) is central to prognostics and health management, ensuring the safe and reliable operation of industrial systems. The field has evolved through successive paradigms, from signal-driven analysis and statistical learning to deep learning–based, data-centric diagnosis. While these advances have improved performance and automation, they expose fundamental limits in generalization, interpretability, and adaptability.

We are now at a transitional moment shaped by large language models and foundation models, which expand the representational and reasoning capacity of diagnostic systems. This keynote offers a unifying perspective on large-model paradigms for MFD and introduces the distinction between *"large models for MFD"* and *"large models of MFD,"* positioning large models as enablers rather than endpoints. Through the **PHM-GPT** case study, we illustrate unified diagnosis and reasoning and outline a vision for next-generation diagnostic intelligence driven by reasoning, knowledge, multimodality, and agent-enabled systems.