

A Bibliometric and Thematic Analysis of Hybrid AI for Predictive Maintenance and Prognostics & Health Management in Cyber-Physical Manufacturing Systems (2018–2025)

Abstract

Predictive Maintenance (PdM) and Prognostics and Health Management (PHM) have become strategic pillars of Industry 4.0 and Industry 5.0, where intelligent, connected, and human-centered production systems rely on AI, Big Data, IoT, CPS, edge computing, blockchain, and digital twins to improve reliability, availability, and decision-making. In this context, this study presents a bibliometric and state-of-the-art analysis of hybrid AI approaches for PdM/PHM. Data were collected from Web of Science and Scopus using a merged search query covering predictive maintenance, PHM, remaining useful life, fault detection, fault diagnosis, fault prognostics, hybrid AI, machine learning, deep learning, CPS, and smart manufacturing. The selection process followed the PRISMA framework, and the final corpus was analyzed using the Bibliometrix package. The methodology focused on annual scientific production, source and country contributions, keyword co-occurrence, thematic evolution, and conceptual structure, while the selected documents were also examined as a state of the art to identify research streams and gaps. Results show growth in publication output from 2018 to 2025, confirming the increasing interest in intelligent maintenance. High-frequency and emerging keywords such as artificial intelligence, IoT, Big Data, blockchain, and digital twin indicate that PdM is increasingly integrated with digital transformation technologies. The review also highlights that PHM research is mainly structured into five interconnected functions: data acquisition and processing, degradation or fault detection, fault diagnostics, prognostics, and decision-making for health management. This structuring reveals an important research gap: stronger integration is still needed between these PHM stages to support robust, explainable, and deployable industrial solutions.

mots-clés :

Predictive Maintenance(pdm); Prognostics and Health Management(PHM); Hybrid AI; Bibliometric Analysis; PRISMA; Bibliometrix; Smart Manufacturing; industry 4.0, IOT , Cyber-Physical Systems