Master Thesis Proposal

Title of the Master Research Thesis: Exploring the combination of data-driven AI, ontologies, and reasoning for prognostics and health management of production systems

Keywords: artificial intelligence; prognostics and health management; productions systems.

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Gratification: 600 euro/month

Application deadline : 15/01/2025

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Duration: approx. 4-6 months

Description:

Predictive Maintenance and Prognostics and Health Management (PM&PHM) approaches aim to intervene in the equipment of production systems before faults occur. To properly implement a PHM system, data-centric steps must be taken, including data acquisition and manipulation, detection of machine states, health assessment, prognosis of future failures, and advisory generation (ISO 13374-2: 2007; Franciosi et al., 2024). Nevertheless, data-driven approaches require knowledge to be exploited and provide their full "power". Indeed, data embed relevant information/knowledge in relation to the usage, health and context of systems, which needs to be exploited. However, revealing the real value of data and discovering useful patterns of knowledge embedded in maintenance data (encompassing data from Programmable Logic Controller up to Maintenance Management System) have presented a major challenge due to the heterogeneity of data sources and the variety of data types (Karray et al., 2019). Ontologies can effectively contribute to resolving this issue through the organization of data, semantic annotation and integration (Karray et al., 2010). Moreover, as reported in many reviews (see for instance Biggio & Kastanis, 2020; Fink et al., 2020; Nguyen et al., 2023), all PM&PHM steps will

benefit from leveraging data-driven AI algorithms. Indeed, data-driven AI technologies, such as machine learning and data mining, have been used in the literature to detect and predict potential anomalies and, hence, improve production efficiency within manufacturing processes (Cao et al., 2022). However, both the lack and the excess of heterogeneity of data can impact the predictability of the algorithms (Dalzochio et al., 2020) and therefore their performance.

This highlights the opportunity to combine symbolic AI (as ontologies), reasoning (as SWRL rule-based reasoning), and data-driven AI for predictive maintenance (Franciosi et al., 2024). In this respect, symbolic AI and data-driven AI can support each other and be combined toward the development of predictive maintenance approaches. On the one hand, machine learning algorithms can enable the extraction of concepts and patterns (as machine degradation models) from data or the calculation of information (as specific indices) that can then be enriched due to the querying performed by maintenance domain ontologies and rule-based reasoning on this input data. On the other hand, data from various sources and systems within a facility could be integrated to gather accurate information in order to improve data-driven approaches.

Therefore, the **objectives** of this Master Thesis are the following: ***(1)*** exploring the scientific literature on ontologies and machine learning techniques in order to understand in which way they are concretely combined and what are the applications in the production contexts; ***(2)*** proposing a learning and reasoning approach for PM&PHM of production systems.

References

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