Ph.D. in Information Technology
Thesis Defense

February 16th, 2026
at 2:30 p.m.
Room Alpha - Building 24

Sabrina MILANI – XXXVIII Cycle

LEARNING-BASED SOLUTIONS FOR ACTIVE MONITORING AND ANOMALY DETECTION FOR ADVANCED INDUSTRIAL APPLICATIONS
Supervisor: Prof. Mara Tanelli

Abstract:

In modern engineering applications, the increasing complexity of systems and the availability of high-frequency sensor data have motivated the development of advanced monitoring, condition recognition and diagnostic frameworks capable of ensuring safety, usage-health monitoring, reliability and adaptability. Physics-based models ensure interpretability and robustness but may fail under non-nominal conditions, whereas data-driven methods, like Machine Learning (ML), excel in pattern recognition but lack physical consistency. This thesis develops two domain-specific frameworks: one for wind turbine monitoring, providing ML-based detection and classification of pitch misalignment anomalies, and another for automotive applications, enabling early classification of road surfaces and tyre types from braking dynamics. Building upon these foundations, the core methodological contribution of this thesis is the development of a domain-informed Mixture of Experts (MoE) framework, which integrates multiple specialized experts within a unified decision-making architecture. Each expert is designed to handle either classification or regression, and operates according to the local properties of the system. The MoE approach allows simultaneous classification and reconstruction of unmeasured signals, while maintaining interpretability and robustness. The proposed methodologies are validated on both real and simulated datasets from the two application domains. Results demonstrate accurate early detection of pitch misalignment in wind turbines, as well as reliable classification of road surfaces and tyre types in automotive scenarios. Overall, the findings confirm the potential of hybrid, domain-informed architectures to improve monitoring, anomaly detection, and predictive decision-making in real-world engineering systems, highlighting their versatility and applicability across structurally different domains.

PhD Committee

Prof. Gian Paolo Incremona, **Politecnico di Milano**

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Prof. Stephanie Stockar, **The Ohio State University**