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Doctoral Dissertation

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AI-Based Novelty Detection for Industrial and Robotic Applications

By

Umberto Albertin

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Supervisor:

Prof. Marcello Chiaberge

Doctoral Examination Committee:

Prof. Giuseppe Tommaso Costanzo, HEIG-VD

Dr. Gabriele Gualco, ETEL SA

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Abstract

Current applications in both industry and academia often attempt to implement anomaly detection and predictive maintenance solutions without a thorough understanding of fault modes or their behavior in real systems. Similarly, in robotics, sensor data are frequently assumed to be perfectly reliable and are trusted uncritically when performing tasks such as navigation or localization. However, this assumption can lead to inaccurate predictions and unreliable system behavior.

This thesis addresses these limitations by introducing and analyzing several techniques based on the Novelty Detection paradigm. The work is structured into two main parts. The first part focuses on industrial applications, where different novelty detection algorithms are evaluated for bearing monitoring. In this context, an unsupervised machine learning benchmark is also conducted to assess how models commonly proposed in the literature perform in real-world industrial scenarios.

The second part of the thesis is dedicated to the application of novelty detection in the robotics domain, with a particular focus on localization. Specifically, this work investigates the reliability of Ultra-Wideband range measurements obtained from multiple antennas under varying environmental conditions. Novelty detection is employed to identify unreliable sensor measurements and improve the robustness of localization pipeline.

A key design principle underlying the proposed methods is simplicity and computational efficiency. The models presented in this thesis are intentionally lightweight and easy to interpret, making them accessible even to non-expert users. Moreover, their low computational requirements enable deployment on embedded systems, thereby supporting edge computing applications.

Overall, the contributions of this thesis demonstrate how novelty detection techniques can surpass existing state-of-the-art approaches in specific application domains. In addition, this work clarifies the fundamental conceptual differences

between anomaly detection and novelty detection, two terms that are often used interchangeably despite referring to distinct problem formulations.