ReMAIntAIn – AI-Based Repair and Reuse in Resource Intensive Machinery

A Data-Driven RUL-based Recommendation System for Sustainable Manufacturing

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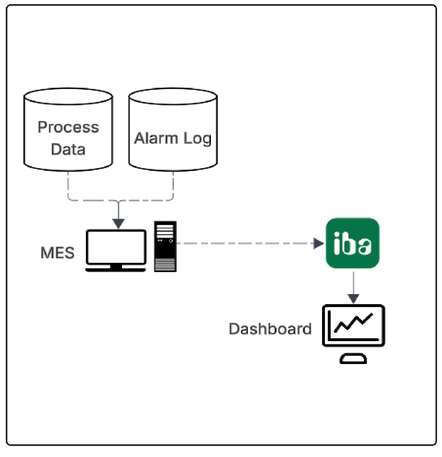
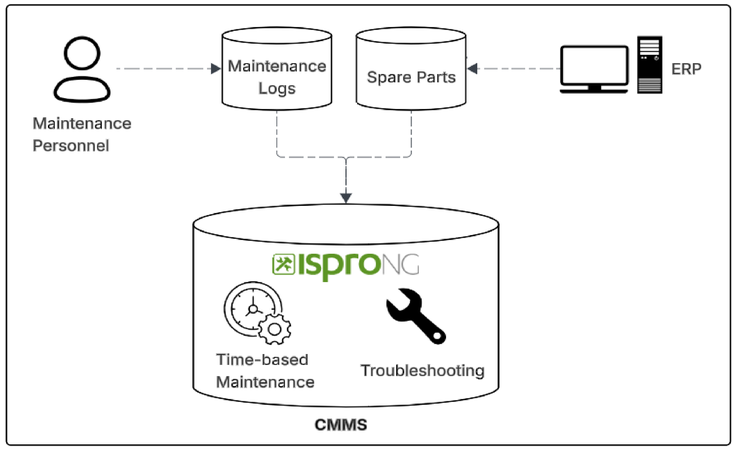
Motivation

Reducing Downtime and Improving Resource Efficiency: Traditional maintenance strategies for managing unplanned downtime rely on large spare-parts inventories and the premature replacement of components. While effective in reducing failure risk, this approach often results in inefficient resource utilization and excessive storage requirements.

Goal

The research project ReMAInTAIn aims to develop an innovative, resource-efficient maintenance recommendation system that supports maintenance personnel in decision-making. The system leverages artificial intelligence and historical data to identify patterns in equipment behavior. By combining **machine-learning algorithms and deep-learning** methods for anomaly detection with **Remaining Useful Life (RUL)** forecasting, the system enables predictive insights and recommends optimal maintenance actions. In addition, optimizing the use of spare parts helps reduce the environmental impact.





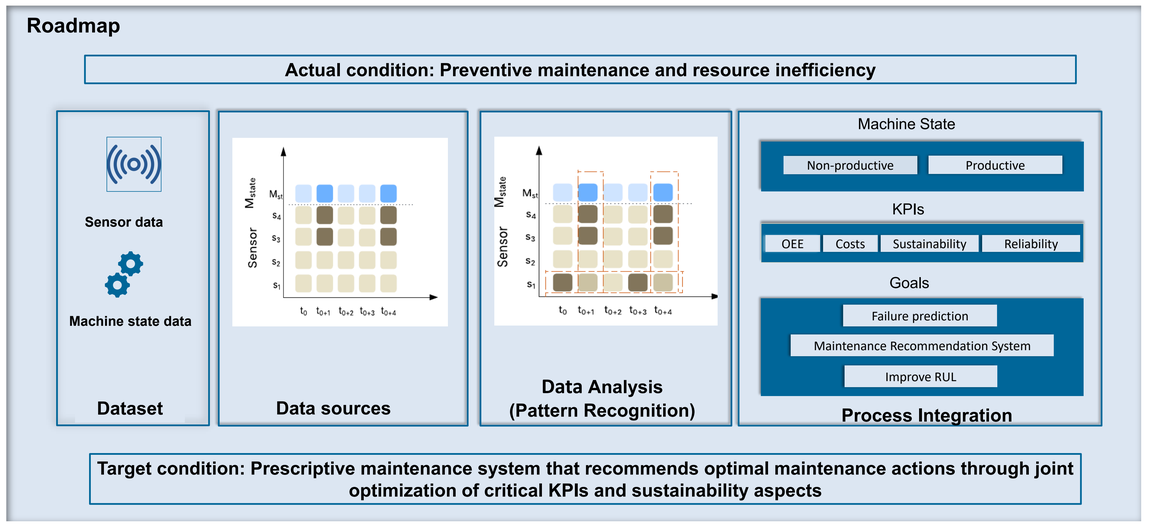
Methodology

The ReMAInTAIn project follows the **CRISP-DM** methodology. The process begins with a clear understanding of maintenance objectives and operational risks, followed by data understanding and preparation. This includes the selection, cleaning, and curation of both object-oriented and order-oriented data. Feature engineering is then applied to derive meaningful indicators of system degradation, which are subsequently used as inputs for advanced predictive models.

Navigating Key Challenges

- Extending the RUL of Machines and Components
- Reducing Unplanned Downtime
- Efficient Spare Parts Management
- Cost Saving and Increased Reliability

Roadmap



Results

A **non-stationary dynamic Bayesian network** will be developed to model time-varying system behavior in dynamic industrial environments, enabling more accurate maintenance prediction, **Remaining Useful Life (RUL)** estimation, and optimized maintenance decision-making to improve repairability and reusability. In parallel, an **LLM-based** approach will analyze object- and order-oriented historical data to extract actionable insights into maintenance patterns, further enhancing RUL prediction accuracy and supporting improved repairability across the maintenance lifecycle.

Outlook: Towards prescriptive maintenance

The ReMAIntAIn project represents a proactive approach to industrial assets maintenance, leveraging data-driven insights and predictive analytics to recommend optimal maintenance actions, ensuring higher reliability, reduced downtime, and extended asset life.

Partner

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