Case Study: Intelligent Systems (WS25/26)

Technische Hochschule Deggendorf - Campus Cham

Fakultät Angewandte Naturwissenschaften und Wirtschaftsingenieurwesen

Studiengang Master Applied AI for Digital Production Management

Predictive Maintenance of Milling Machines using AI/ML

Irtaza Janjua	12404930
Sadeed Ahmad	22301000
Soman Tariq	22310003
Usama Ali	22300108

Problem Statement & Measurable Outcomes

Unplanned breakdowns in milling machines lead to production delays, high maintenance costs, and reduced equipment utilization. This project aims to develop and evaluate an AI-driven Predictive Maintenance (PdM) strategy capable of forecasting machine failures using sensor and operational data. The measurable outcomes include improved prediction accuracy for machine failures, higher reliability in detecting potential breakdowns, measurable reductions in unplanned downtime, and cost savings achieved through optimized and data-driven maintenance scheduling.

Motivation & Industrial Relevance

Predictive maintenance is critical for the Industry 4.0 transformation, where smart manufacturing depends on data-driven decision-making. By comparing Random Forest and Deep Learning models for PdM, this project demonstrates how AI can reduce unplanned downtime, extend equipment life, and improve production reliability. The outcomes are directly relevant to maintenance engineers, production planners, and industrial automation teams seeking to optimize resource efficiency and operational resilience.

Method & Feasibility

The project will utilize the HTW Berlin synthetic PdM dataset comprising 10,000 industrial milling records with six process features and five failure modes. Data preprocessing will involve scaling, outlier removal, and handling class imbalance. A Random Forest model will be developed as the proposed PdM strategy, benchmarked against a Deep Learning (Neural Network) model. Both models will be trained using cross-validation and evaluated using accuracy, precision, recall, F1-score, and ROC-AUC metrics. Explainable AI techniques will be applied to interpret model decisions and identify the most critical parameters influencing failure. Implementation will be carried out in Python using scikit-learn and TensorFlow, ensuring reproducibility and feasibility within the project duration.

Project Timeline & Milestones

- 16 Oct – 6 Nov: Data preprocessing and Machine Learning Model Development Phase
- 6 Nov – 27 Nov: Deep Learning Model Implementation Phase
- 27 Nov – 18 Dec: System Testing & Streamlit Integration Phase
- 18 Dec – 15 Jan: Project Completion & Presentation Phase

Risks & Ethics

Key risks include data imbalance and overfitting, which may affect model generalization; these will be mitigated using resampling and validation techniques. Ethically, the project ensures transparent and interpretable AI models, supporting responsible decision-making without replacing human expertise in industrial maintenance.

GitHub Repository URL

https://github.com/Soman10/Predictive-Maintenance-of-Machines---Case-Study-Intelligent-Systems-

Related Work

[1] T. P. Carvalho *et al.*, "A systematic literature review of machine learning methods applied to predictive maintenance," *Computers & Industrial Engineering*, vol. 137, p. 106024, 2019, doi: 10.1016/j.cie.2019.106024.

[2] S. Matzka, "Explainable Artificial Intelligence for Predictive Maintenance Applications," 2020 Third International Conference on Artificial Intelligence for Industries (AI4I), Irvine, CA, USA, 2020, pp. 69-74, doi: 10.1109/AI4I49448.2020.00023.

[3] A. Jaenal, J.-R. Ruiz-Sarmiento, and J. Gonzalez-Jimenez, "MachNet: A general Deep Learning architecture for Predictive Maintenance within the Industry 4.0 paradigm," Engineering Applications of Artificial Intelligence, vol. 127, no. Part B, p. 107365, 2024. doi: 10.1016/j.engappai.2023.107365.