Economic, Social and Environmental Sustainability: The Role of Technology and Political Dialogue
18–20 May 2023
Valetta, Malta & Online
make learn TIIM PIConf
Management, Knowledge and Learning
International Conference
Technology, Innovation and Industrial Management
Sustainable Development

A Framework for Data-driven Modelling of Degradation of Linear Assets

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Abstract

Linear assets such as roads, pipelines and railways are an essential part of a society's infrastructure, so their proper maintenance has a significant societal and financial impact. They are characterized by having geographical beginning and end points; they're typically split into segments; these segments are heterogenous. Time series data of their condition is often nonlinear, non-stationary, short, and noisy due to long inspection intervals and varying environmental factors. This makes it difficult to accurately model degradation for condition-based maintenance, possibly resulting in unnecessary maintenance or increased risk. Data-driven approaches to degradation modelling have many useful features such as automation potential, scalability, and the possibility to provide and improve predictions in real time. Even though this potential is well recognized, further insight on their practical application is needed. In this study, we aim to deepen this understanding through applying data-driven degradation modelling techniques to a railway track section located in Northern Sweden. As our results, we present a framework for applying data-driven models for degradation modelling of linear assets. We evaluate the key strengths, limitations, and assumptions of our applied methods: Linear regression, Random Forest, Support Vector Machine, and the Wiener process model. We also explore the use of hyperparameter tuning techniques to improve predictive performance. Finally, we evaluate the performance and computational efficiency of each model in our case environment. The results provide guidelines for practitioners and contribute to the scientific discussion on the application of data-driven approaches in maintenance.

Keywords: data-driven, degradation, modelling, maintenance, railway, machine learning, expert systems