CONSTRUCTOR UNIVERSITY

BSc Industrial Engineering and Management

Prof. Dr.-Ing, Hendro Wicaksono

Bachelor Thesis

Bridging Gaps in EV Lifecycle Maintenance:

A Causal Machine Learning Approach to Maximise Battery Life in Electronic Vehicles

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Abstract

The global electric vehicle (EV) market is rapidly expanding, with sales projected to exceed 45 million units by 2030 (IEA, 2024). While advancements in battery technology have enabled remarkable performance gains, the operational lifespan of EV batteries is primarily determined during the usage phase, once vehicles are in the hands of consumers.

Most maintenance decisions still rely on observational data rather than a deep understanding of causal relationships, making it difficult to identify the true drivers of battery degradation or determine which interventions would be most effective. This gap limits the development of proactive, cause-driven maintenance strategies and hinders efforts to extend battery lifespan under real-world conditions.

This study applies causal machine learning (CML) techniques to uncover the causal relationships governing battery health. Using a real-world EV dataset, six causal discovery algorithms, LiNGAM, NOTEARS, GraN-DAG, DAG-GNN, CORL, and MCSL, were implemented and compared. Through rigorous evaluation metrics and robustness tests, CORL emerged as the most effective algorithm, demonstrating reliable identification of key causal links, such as the impact of driving behaviour patterns on battery degradation.

The results confirm that aggressive driving behaviour, captured by the Driving Behaviour Factor (DBF), has a direct negative effect on battery health and a positive effect on acceleration intensity. These insights support the development of behaviour-aware diagnostics, personalised energy-saving modes, and condition-based maintenance strategies for EVs, paving the way for smarter, more sustainable, and data-driven lifecycle management.