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Paper Abstract

Failure Knowledge Graphs

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The subject of this paper is a proposal to further the use of **knowledge graphs** in the realm of **failure analysis** of a ship's technical systems' operational life by focusing on recent advances in **machine learning**. Failure analysis is the cornerstone of asset management via **life-cycle costs** optimization. Knowledge graphs are semantic nets that are the next level of database technology. Machine learning (ML) is a field of inquiry devoted to understanding and building methods that “learn”, that is, methods that leverage data to improve performance on some set of tasks. We propose to structure the machine learning data into knowledge graphs.

The MA-CAD failure analysis was designed in 1994 within the scope of a Ph.D. dissertation “MA-CAD - Maintenance Concept Adjustment & Design”. The method was developed for the Royal Dutch Navy and the Nedlloyd Lines shipping company in the Netherlands. The method developed **actors' networks** which are semantic nets of *failure propagation and its effect on ship's operation, safety and the environment*. In the ‘90s the database technology was in its infancy (db4 was the reference) and actors' networks were modeled using Entity-Relationship models. Today, graph databases (neo4j, stardog, fluree, anzo, etc.) revolutionized the technology in that semantic nets (including both data and the relationships between data) can natively be stored and used. Thus, giving access to advanced inference mechanisms via Machine Learning to optimize Life Cycle Costs and safeguard the environment. A possible application of this technology to failure analysis is the subject of this paper.

The paper will summarize the well defined failure analysis method and will focus on the data model and its knowledge storage in a graph database. The data model will be defined with all underlying characteristic knowledge descriptors as: “Failure Cause Mode Combination”, “Reliability Weighted Cycle”, “Expected Life Failure Frequency”, etc. These describe the underlying failure behavior that we can control with different maintenance actions for operating ships. These will lead to advanced **feature engineering** opening the path to improved Machine Learning. In addition, the lessons learned from the knowledge accumulated in the **failure knowledge graphs** can further be used to improve **future designs** of ship's systems. The model will be specified in terms of nodes and relationships defining the knowledge graph network. JSON will be the preferred representation for the data structure. The use of the graph database technology will be shown by means of an example graph database that will be chosen among current market options. The paper will conclude with the benefits of using graph databases and machine learning for **maintenance optimisation**.

Knowledge Graphs have matured into a proven technology that could bring great benefits to information storing. In parallel, Machine Learning can greatly benefit from semantic nets to manipulate the intelligence we build up, about failures in ship's technical systems. The more our failure data and respective relationships are well structured and defined the more the decision making will be more effective and efficient.