Game-based Cybersecurity: An Approach Towards Resilient Railway

Ravdeep Kour[1], Ramin Karim[1] and Jaya Kumari[1]
[1] Division of Operation and Maintenance Engineering, Lulea University of Technology, Luleå, Sweden,

Introduction

Digital transformation is changing the railway industry. One of the major considerations in digital transformation is the increased exposure to cyberattacks. Therefore, cyber resilience becomes an important part of digitalisation process. According to Haque (2021), cyber resilience consists of different stages of cyber operations, reflecting the system's performance evolution during a cyberattack incident. Cyber resilience helps to complement the existing security measures so that system can maintain and maximize the operations. Hence, the objective of this abstract is to propose a strategic game-based model to quantify cybersecurity and understand the dynamics between attackers and defenders and enhance the resilience and effectiveness of cybersecurity systems on the defender's side. Using game-based model helps to create realistic simulations for cybersecurity threats and attacks and changes in the behaviour of the attacker and defender.

Analysis

Integrating game theory with the Cyber Kill Chain (CKC) that describes the attacker behaviour enhances cyber resilience by understanding the stages of cyberattack and the dynamics of competition among multiple entities, as defined by Gibbons (1992). Using this approach, a cyber resilient system can be developed to quantify cybersecurity and understand the interactions between attacker and defender. The proposed strategic approach uses a non-cooperative game which is based on mixed strategies. This will help the railway stakeholders to be more proactive, allocate optimal resources, and balance the costs of security measures against potential losses from a successful attack. This optimisation helps enhance the system's resilience by efficiently utilising resources.

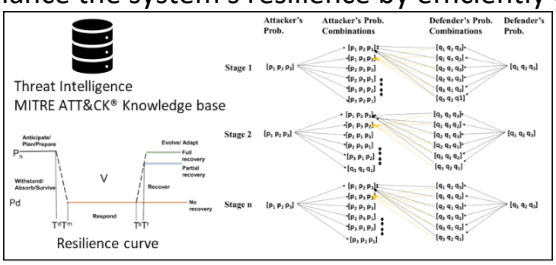

Figure 1. Proposed strategic game model.

Conclusions

It has been concluded that applying game theory with CKC (Figurer 1) can help to quantify cybersecurity and understand the interactions between attacker and defender and facilitate resilient and effective cybersecurity system at the defender end.

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Leveraging ISO Standard 81346 for Enhanced Railway Asset Management: A Cross-Organizational Approach for Big Data Analytics

Surya T. Kandukuri[1], Rune Schlanbusch[1], Nathaniel P. Gallishaw[2], Gunnstein T. Frøseth[2]
[1]Darwin (Data, AI, robotics), NORCE Norwegian Research Centre, Grimstad, Norway
[2]Department of Structural Engineering, Norwegian University of Science and Technology, Trondheim, Norway
E-mail: suka@norceresearch.no

In railway asset management, the integration of heterogenous data sources poses a significant challenge for effective monitoring and maintenance decision-making. This paper proposes a novel approach utilizing ISO Standard 81346, specifically Part 12 - Construction Works, as a framework to explore nomenclature and relational architecture for railway assets. By leveraging this standard, our research aims to facilitate cross-organizational and cross-border data integration within the railway sector, thereby enhancing the capabilities of big data analytics. ISO 81346 has so far only been discussed in a handful of research papers regarding the establishment of asset digitalization frameworks, such as for road bridges (Fernández et al., 2024).

The primary objective of this research is to enable efficient and accurate predictive operation and maintenance decisions by harmonizing heterogeneous data sources across various organizational boundaries. Through the adoption of ISO 81346, we seek to establish a common language and structure for defining railway assets, thereby enabling interoperability and seamless data exchange. A standardized approach will streamline data management processes and enhance the scalability and reliability of predictive analytics models.

Our methodology involves an in-depth analysis of ISO 81346's structuring principles and reference designations, followed by their adaptation to the specific context of railway assets. We propose a systematic framework for categorizing and labelling railway assets according to the standard's guidelines, ensuring consistency and clarity in asset identification and classification. Additionally, we explore the implementation of relational architecture to establish meaningful connections between data sources components, enabling comprehensive asset monitoring and analysis.

Through a case study on a railway bridge, we showcase the utility of standardized nomenclature and relational architecture, thereby empowering railway operators to make informed decisions regarding operation and maintenance activities. By embracing standardized practices, stakeholders in the railway sector can unlock new opportunities for collaboration, innovation, and optimization, paving the way for a smarter and more resilient railway infrastructure.

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Virtual Ground Truth – Towards Reliable Obstacle Detection

Steffen Schäfer[1], Martin Cichon[2]
[1] Karlsruhe Institute of Technology, Karlsruhe, Germany. s.schaefer@kit.edu
[2] Karlsruhe Institute of Technology, Karlsruhe, Germany. martin.cichon@kit.edu

Abstract

Following Blumenschein (2022), automation is an innovative approach for overcoming structural challenges of the railway system, such as Wang (2016) demonstrated for metros, Cichon (2018) for shunting and also Vogler (2021) for branch lines and trams. Especially when integrating autonomous systems into more complex traffic scenarios, stable object detection, classification and subsequent obstacle warnings are essential for trouble-free operation. Deep learning as a field of machine learning is according to Wang (2017) a promising approach to the imitation of a human driver but requires large training data sets in a huge variety of eventualities. The OSDR23 data set published by Tilly (2023) is one of a few sources of labelled RGB camera and LiDAR data from the rail environment. A preliminary study on the classification of these point clouds showed unfavorable effects of class imbalances and low confidence scores for unknown scenes due to low data quantity and quality. Furthermore, it turned out 3D point cloud classifiers are sensitive to resolution and scan patterns and thus require sensor specific training data sets. Starting from a virtual railway environment (VRE), Schäfer (2023) demonstrated the mining of labeled training data sets for the classification of RGB images in the field. This paper introduces the research on a modular extension of the VRE enabling the emulation of the corresponding labeled point cloud data set. It is shown how the 7-layer scenario variation model proposed by Greiner-Fuchs (2023) can be applied to guide an efficient training process. The resulting point cloud classification models are verified against the OSDR23 data set. It is discussed, to what extend virtual training data can compensate the lag on expensive and resource-intensive real-world data.

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A new testing method based on Model-Based Testing for the Railway Onboard Control System

Y. Liao[1], L. Chen[2], K. Venkateswaran[3] and C. Roberts[4]
[1] School of Engineering, University of Birmingham, Birmingham, UK. yxl1715@student.bham.ac.uk
[2] School of Engineering, University of Birmingham, Birmingham, UK. l.chen.3@bham.ac.uk
[3] School of Engineering, University of Birmingham, Birmingham, UK. k.venkateswaran@bham.ac.uk
[4] School of Engineering, University of Birmingham, Birmingham, UK. c.roberts.20@bham.ac.uk

Introduction

Onboard control systems are pivotal in modern railway technology, ensuring safe train operations. With technological advancement, these systems have grown in complexity, enhancing functionalities but also increasing the need for rigorous testing. This study addresses the challenges in testing an existing onboard control system, focusing on managing the testing process amidst growing complexity and cost.

Testing method and tool

We introduce a model-based testing (MBT) method, capable of automatically generating test traces. Previous study Hessel (2004) have shown that MBT could enhances the accuracy and completeness of tests, and this has been explored for train control systems from Wang (2018). By employing time automata models as depicted in Figure 1, along with our python tool, this tool helps generates traces by different method. Including our method multi-dimension coverage criteria which considered a combination of factors. The MBT simplifies the process of test case generation in onboard control system.

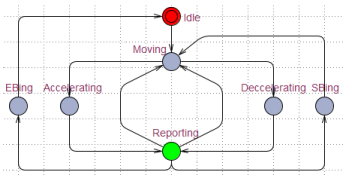

Figure 1. Timed automata of Onboard control System diagram.

Conclusions

We show MBT in improving the dependability and cost-efficiency of onboard control systems. This approach helps the testing progress of railway systems, introducing a method for tackling the intricacies of contemporary onboard systems.

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Remote monitoring of the Iron Ore Line with InSAR

Frida Carlvik[1], Peter T. Torstensson[2], and Carl-William Palmqvist[3]
[1] Department of Technology and Society, Lund University, Lund, Sweden. frida.carlvik@tft.lth.se
[2]The Swedish National Road and Transport Research Institute, Gothenburg, Sweden. peter.torstensson@vti.se
[3]Department of Technology and Society, Lund University, Lund, Sweden. carl-william.palmqvist@tft.lth.se

Introduction

Rail passenger traffic in Sweden has doubled during the past 30 years. This demand for rail transport has led to a scarcity of capacity at several locations along the track network which conveys increased sensitivity and societal consequences of disruptions due to for example infrastructure failures. The current investigation examines pre-conditions to prevent traffic disruptions caused by discrete track irregularities such as settlements. A method of remote sensing, called Interferometric synthetic aperture radar (InSAR) can be used to observe ground movement as time series data. InSAR is a method of analyzing synthetic aperture radar (SAR) images through phase differences and has the possibility to measure vertical deformations in the millimeter-scale (Bamler & Hartl, 1998; Chang et al., 2014).

Analysis

The Iron ore line in northern Sweden is used as case study. Sentinel-1A InSAR data were acquired for the area using the online service InSAR Sweden. Railway network data and alert limit data of railway track alignment was acquired from the Swedish National Transportation Agency (Trafikverket). The three data sources were aggregated using the Feature Manipulation Engine (FME), where InSAR data points were related to the railway network using an Inverse distance weighting function (Mitas & Mitasova, 2005).

Conclusions

Results on the correlation between ground settlement and railway track alignment will provide the basis for remote evaluation of railway infrastructure and understanding on the relationship between geological factors and the development of track misalignment.

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