Improved rules and regulations of damaged wheels

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To increase passenger and freight traffic, railway transportation needs to be safe, reliable, environmentally friendly, (cost-)efficient, and on time. To achieve this, the aims of this new project are to propose improved regulations and procedures to avoid traffic disruptions caused by infrastructure failures and unnecessary stopping of trains. This will provide means to better plan track maintenance actions based on traffic conditions, and it will promote an increased collaboration and understanding between the infrastructure owner and the rolling stock operators. The basis for the improved regulations and procedures are innovative means of relating wheel loads to the risk of failure and their influence on deterioration. In this manner, regulations and procedures for wheel removal will obtain a firm physical basis allowing actions to be based on objective measured quantities. This removes potential human errors, establishes a scientific foundation for legal demands, and allows a new level of digitisation in maintenance planning.

To obtain the required level of accuracy in the relation between wheel loads and consequences, the project employs large amounts of research, predictive models, and full-scale field tests. The project is funded by VINNOVA. The presentation will show a summary of work conducted by the partners Trafikverket, Green Cargo, SJ and Chalmers. It will show an assessment of current wheel impact load detectors, and which effects the measured load levels have on deterioration and the risk of failures. From this, a level of confidence will be built such that wheel removal regulations based on automated load measurements can be designed.

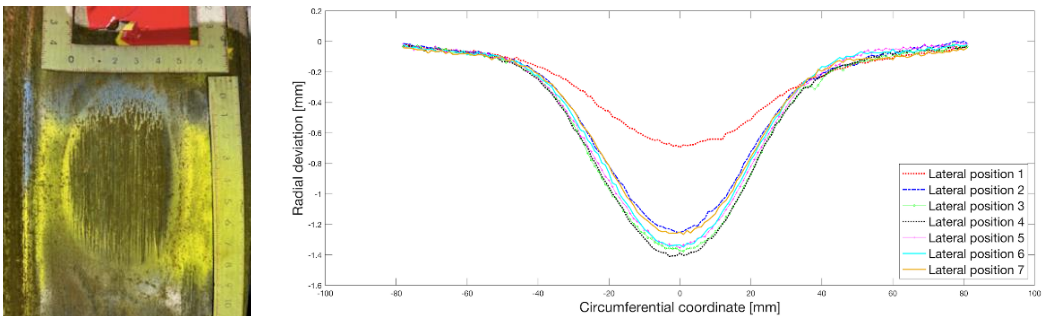

Figure. Wheel flat with measured radial deviation at different lateral positions on the wheel

References

Klara Mattsson. Wheel–rail impact loads generated by wheel flats – Detector measurements and simulations. Master's thesis in Mobility Engineering, Department of Mechanics and Maritime Sciences, Chalmers, 2023

Wheel Flat Detection and Length Estimation using Data from Multiple Wheel Impact Load Detectors

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Summary

This presentation discusses the detection and length estimation of wheel flats, which are generated by either malfunctioning components or ambient effects. The presence of wheel flats does affect vehicle and rail condition negatively and can also lead to accidents, Fu et. al. (2023). The article also reviews detection techniques.

Here, the detection of wheel flats on wheel sets is based upon a data fusion approach from multiple wheel impact load readings and the general assumption that a flat is generated on both wheels of a wheel set, while the size of the wheel flat may differ. It is further assumed that the wheel flat will always be exhibiting rail contact forces for both wheels during a passage over a wheel impact load detector, which is exploited to detect the occurrence of a wheel flat between subsequent passages. For the estimation of the wheel flat length a dynamic model is used to simulate the expected forces for a specific passage with speeds and flats lengths along the lines of Yunguang et.al. (2019). The most adequate flat length is then selected as the estimate.

The presentation will show results from the application of the methodology to fleets in the UK, Sweden, and the Netherlands.

Results & Conclusions

The approach was implemented on the Predge RollingStock solution. An example of the outcome is shown in Figure 1. It is concluded that the detection has high level reliability and flat length estimates are sufficiently accurate for maintenance decision making.

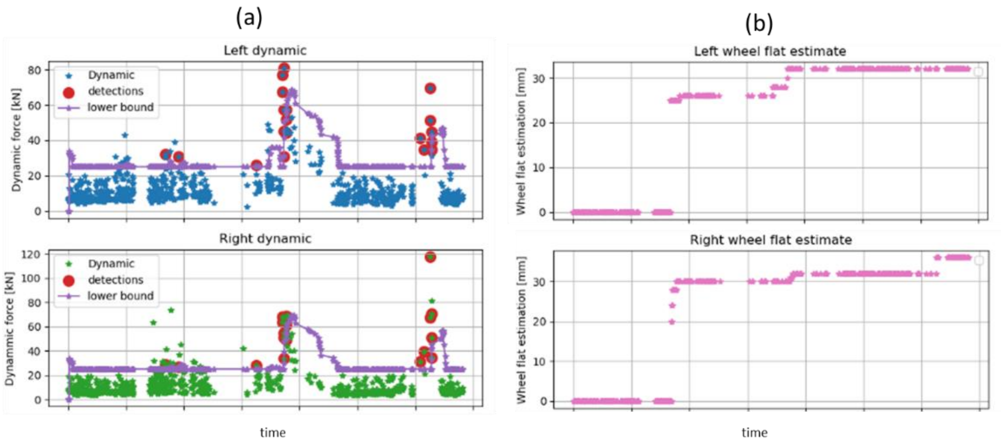

Figure 1. (a) Dynamic forces exhibited by a wheel set and the instances of the detection of a wheel flat. (b) Estimated wheel flat length from the first detection of a wheel flat and onward.

References

Fu, W., He, Q., Feng, Q., Li, J., Zheng, F., & Zhang, B. (2023). Recent Advances in Wayside Railway Wheel Flat Detection Techniques: A Review. Sensors, 23(8), 3916.

Yunguang Ye, Dachuan Shi, Philipp Krause & Markus Hecht (2020) A data-driven method for estimating wheel flat length, Vehicle System Dynamics, 58:9, 1329-1347

Condition Monitoring of Railway Catenary System

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Introduction (heading in 12 pt Calibri bold)

In this presentation first an overview of current research focusing on railway catenary condition monitoring(RCCM) will be introduced. And based on this, the research work of NTNU on railway catenary system condition monitoring would be talked about .

The overview of RCCM

Nowadays with the demand of higher speeds and heavier axle load as well as the increasing railway transportation volume, there are more needs and higher requirement for RCCM . And from massive of previous research we summarise the sensor type, monitoring targets, monitoring platforms. As shown in the Figure 1

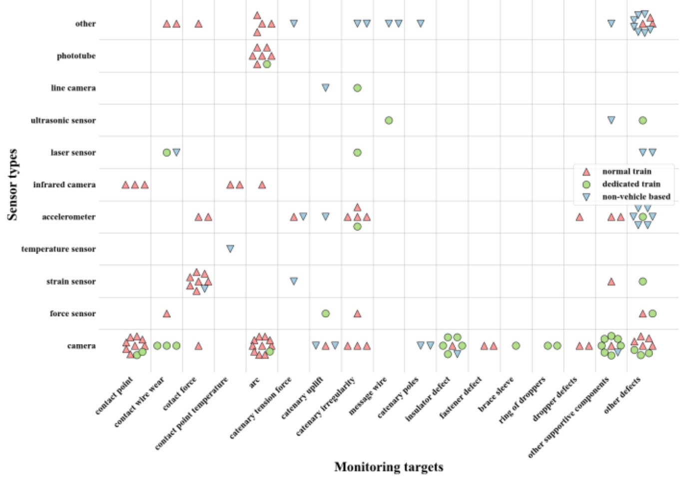

Figure 1. Summary of sensor type, monitoring targets and platforms

Proposed RCCM approach

Based on comparing different approaches, a new approach is proposed to carry out the railway catenary condition monitoring by utilising the contact force measured between catenary and pantograph with fully-connected neural network. And the example case is shown below in Figure 2 and Figure 3.

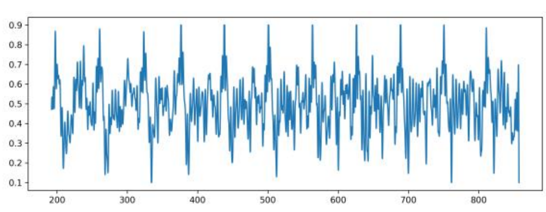

Figure 2. input signal for detecting defects

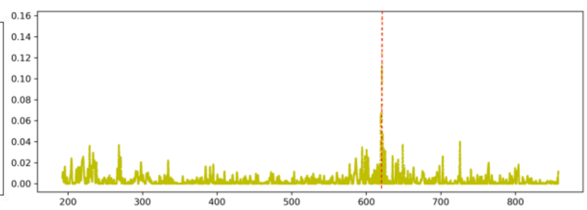

Figure 3. Defects detecting results

References: Frøseth, Gunnstein Thomas, P. Nåvik, and Anders Rønnquist. "Operational displacement estimations of railway catenary systems by photogrammetry and the integration of acceleration time series." Int J Railw Technol 6.3 (2017): 71-92.

A parallel high-capacity and fast calculation method for assessing track quality index in infrastructure maintenance

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Introduction

The track quality index plays a crucial role in railway infrastructure maintenance. It serves as a key indicator for assessing the condition of tracks and the safety of train operations. It helps railway management department identifies potential issues promptly, ensuring the stability and safety of train operations. By calculating the track quality index based on track geometric irregularities inspection data, railway management department can develop effective maintenance plans and priorities, allocate resources reasonably, conduct timely repairs, prolong the lifespan of tracks, reduce risk of accidents, and enhance efficiency and reliability of railway transportation.

Analysis

References is given as Xinyu (2008). The track quality index (TQI) is calculated as follows.

$$TQI = \sum_{i=1}^{7} \sigma_i = \sum_{i=1}^{7} \sqrt{\frac{1}{n}\sum_{j=1}^{n}\left[{x_{ij}}^2 - \left(\frac{1}{n}\sum_{j=1}^{n} x_{ij}\right)^2\right]} \tag{1}$$

σ_i represents standard deviation of 7 track geometric irregularities, corresponding to left and right rail surface, alignment, gauge, twist and cross-level irregularities. x_{ij} denotes the amplitude of track irregularities, n is the number of sampling points within 200 meters. It becomes challenging when dealing with a large volume of data. China has 45,000 kilometres of high-speed railways. With bi-monthly inspections and sampling frequency of 0.25 meters, one year data would form a matrix of 4.32 × 109 × 7 elements.

Conclusions

This paper proposes a parallel high-capacity and fast calculation method based on Spark distribution computing to address the challenge of rapid computation of massive high-dimensional data. This method enables rapid querying and calculation of track quality index within seconds. It supports users in quickly querying, calculating, and analysing data on a browser page, thereby assisting in track maintenance decision-making.

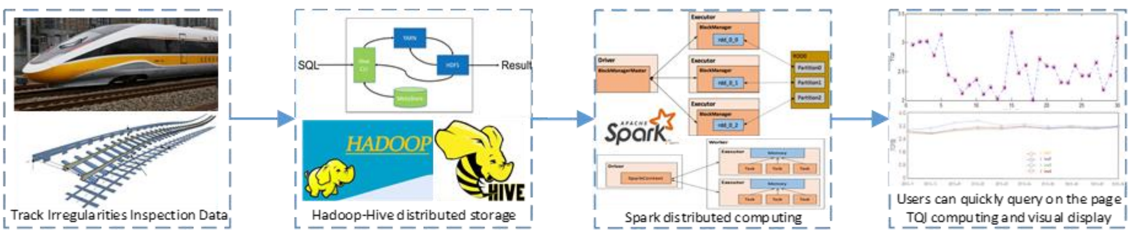

Figure 1. Parallel high-capacity and fast calculation architecture.

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A method for identifying and locating rail corrugation based on multi-source detection data feature fusion

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Introduction

A multi-source Transformer model based identification and localization model for rail corrugation in heavy-duty railways has been proposed. The model combines the original axle box acceleration waveform signal, time-frequency map, as well as external information such as detection speed and line conditions, using a Transformer encoder to solve the problem of complex and difficult recognition of heavy-duty railway corrugation. To achieve precise positioning of the grinding section, a multi task output model was constructed, which can classify whether there is grinding within the section while outputting the precise position of the grinding section.

Analysis

The multi-source data feature extraction network mainly consists of three parts, namely the time-domain signal segment feature extraction network based on 1D CNN and Bi LSTM network, the time-frequency map feature extraction network based on 2D CNN and Bi LSTM network, and the external information feature extraction network based on autoencoder. In a multi-source data fusion model, use a Transformer encoder to fuse multi-source features. Implementing classification and localization tasks simultaneously through a multi task output network module

Conclusions

This article proposes a model for identifying and locating rail corrugation in heavy-duty railways based on multi-source data, which improves the accuracy of corrugation identification through richer data sources. A multi task output model was constructed to simultaneously determine the presence or absence of corrugation and accurately locate corrugation sections, which can complete classification and regression tasks simultaneously.

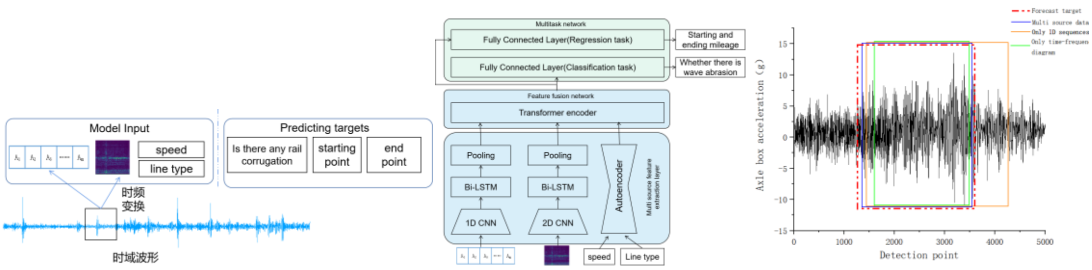

Figure 1. Multi source data fusion model

Acknowledgement

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