Challenges related to data collection and availability for railway management

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Introduction

High quality information of current travel situations via railways can only be given if the underlying data bases are of high quality, sufficient and complete. These databases are required to create solutions such as artificially intelligent systems to provide travellers and railway management with the best possible information. The mapping of databases for railway management is investigated this study. The work is related to the EU-funded research project FutuRe, focusing on regional railway lines.

Analysis

Railway transportation databases and information can be divided into demand data (number of passengers using the railway system) and supply data (infrastructure, rolling stock and timetable features, describing the system capacity such as seats). However, this study delves into availability and update speeds of such data. Thus, a division between static and dynamic data is proposed. Regarding availability, much of the infrastructure and rolling stock data should be available (RailNet Europe, 2024), for example in Network Statements (BaneNor 2024) or from operators (for example Odin, 2024), but practical data availability varies.

Conclusions

It was observed that the division between static and dynamic data is not discrete but continuous. There are databases such as railway infrastructure and rolling stock specifications, which are unchanged for long time, making them relatively static. On the other hand, databases on passenger counts, delays in trains and disruptions can change much faster.

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Train Dispatcher in the Cloud: An efficient option for train operations

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Introduction

Railway operations of the future is often associated with high speed lines, ETCS and a high degree of automatization and digitisation. However, this approach completely neglects the necessity that we need modern, cost efficient means of railway operations for lines with lower density. In Germany, the topic of line reactivation is a very popular one and many studies show that it is feasible and sensible in many instances. The project FlexiDug has developed a variation of the German Zugleitbetrieb which works by replacing the train dispatcher with a software solution.

Analysis

German Zugleitbetrieb exists in different versions at German Railways. In all cases there is a human train dispatcher. If a train wants to enter a section, where sections usually go from one station to the next, a Zugführer (conductor, often the train driver) has to ask for approval from the train dispatcher. The dispatcher checks if the section is available, marks it as reserved on paper (Belegblatt) and gives a verbal movement authority. Once the train has arrived at the end of the movement authority the conductor will report the arrival and that the train is complete and the train dispatcher will mark this on the Belegblatt. In its most basic variation (which is hardly used anymore) there is no additional safety measures.

Zugleitbetrieb can be a very efficient mode of operations for low density lines. However the cost and availability of the train dispatcher is a barrier. In the project we replaced the human train dispatcher by a software solution which translates the spoken word of the conductor into code. The software checks if all requirements for giving a movement authority are fulfilled. It will make the necessary reservation on a digital Belegblatt and will issue a movement authority in code which is translated into spoken word. The translation process was chosen to keep changes to the original method minimal and by this helping certification. The notification about completeness and arrival follows the same protocol. After the prototypical implementation showed the feasibility of the approach, a risk assessment was performed. Together with the experiences gained from testing, a complete set of requirements can be derived so that a safety certification can be obtained in the future. Also, other configurations of Zugleitbetrieb with more safety barriers were conceptually developed which can be used to discuss with users and the safety authorities so that the application field can be widened.

Conclusions

Zugleitbetrieb with a train dispatcher in a cloud can be a cost-effective means of railway operations and a very successful model for low density lines. The project showed its feasibility which can now be used to obtain an official certification.

Learning from reliability and maintainability for predicting generation and propagation of trains' delays

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Introduction

The success of railway transport process needs the regular operation of all components: infrastructure elements must work properly during different periods of the travel time and the vehicle for the entire travel time. Disruptions generating irregularities are depending on reliability and maintainability of the single components,

Analysis

The approach to the problem can be purely stochastic, based on the analysis of failures and their spatial and temporal distributions, or by means of simulation models, including stochastic procedures, replaying the real operation and failure events on its components. Simulation models of traffic operation are today largely available, but they need tests on operational contexts, to better represent the reality. The mechanism of generation and propagation of delays is typically including: 1) primary delays, generated by technical disruptions or human behaviours; 2) secondary delays, generated by traffic conflicts due to deviations from the timetable produced by primary delays.

Conclusions

Learning from typical reliability and maintainability attitudes of infrastructures and vehicles, emerges as the most appropriate process to build a predictive mechanism to forecast generation and propagation of disruptions in typical applications of machine learning. This research analyses the potential role of the various components of infrastructures and vehicles in delays generation and propagation, basing on their reliability and maintainability profiles.

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Predicting train delay based on Random Forest

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Introduction

With the development of the social economy, the number of people engaging in global trade and traveling is increasing day by day, which intensifies the complexity and uncertainty of global trade. The railway network is also becoming more and more complex. Sometimes, some seemingly insignificant points may have a greater impact on the entire railway network, greatly delaying or even hindering people's travel and significantly reducing the capacity of the railway network. Predicting train delays involves using historical data along with machine learning models to predict potential disruptions in the rail network. This proactive approach enables transportation authorities and operators to take pre-emptive measures to minimize the impact of delays and improve the overall efficiency and reliability of train services.

Analysis

In the study, a range of data from British Railways was used as the original dataset. The original dataset includes a total of 319 features, encompassing weather conditions, vehicle operating conditions, delay times, etc. All train data arriving at King's Cross Railway Station from November 15 to December 13, 2019 (before COVID-19) was selected as the training set. All train data arriving at King's Cross train station on December 14, 2019, is used as the test set. In the experiment, train delays were classified into five categories: Category A for arriving early and on time, Category B for arriving 0 to 2 minutes late, Category C for arriving 2 to 4 minutes late, Category D for arriving 4 to 6 minutes late, and Category E for arriving more than 6 minutes. In the experiment, the data was first cleaned and classified, and the random forest method was used to predict the time interval classification of train delays. Secondly, explore the number of features and identify important features through feature selection.

Conclusions

The experimental results show that the prediction accuracy can reach 80%, and most of the errors are within 2 minutes. In feature extraction, it was found that the accuracy rate when the dataset contains 50 features is higher than the accuracy rate when the dataset contains 50 features is higher than the accuracy rate when the dataset contains all features.

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Benefits and drawbacks of integrating Maglev-derived systems in the design phase of new railway lines

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Introduction

Magnetic levitation systems are one kind of guided transport systems that are supported, guided, and propelled from the guideway by magnetic forces. The maglev systems use many non-conventional technologies, e.g., linear motors, levitation, and contactless power supply. The non-traditional and emerging maglev-derived technologies can have the potential to address the technical problems with the existing railways and improve the overall performance of future transportation. As the EU plans to build integrated, sustainable, multi-modal transport networks for the future, the technical feasibility of maglev-derived systems is evaluated in the EU-Rail program, to increase the knowledge about their technical performance and economic benefits.

Summary of work

In the project, the technologies used by the existing maglev-derived systems have been categorized and analysed with respect to functional, economic, operational, and technical perspectives. The technical maturity, the possible integration into the conventional railway system, and the impact of these technologies on railway transport (i.e., vehicle, infrastructure, energy system and traffic management system) are studied. In order to study the feasibility and effectiveness of the relevant maglev-derived systems and technologies, use-cases are proposed to see their costs and benefits. Considering the actual needs for transport infrastructures or services, with various experts and stakeholders involved in the project, the possible use cases have been selected and analysed.

Swedish use-case study

The Swedish high-speed line Gothenburg-Borås is selected as one of the use cases for detailed theoretical study. Due to the mountainous geography of the track route, there is much tunnelling work according to the original design, which makes the construction costly. Traction boosters, a maglev-derived technology under development, are used in the study to get an indication on the potential of the new technology and if it can help to reduce construction work and improve the overall performance in operation. The study conducts an economic analysis of the potential costs and benefits associated with two technologies (i.e., traditional tunnelling, and traction booster).

Reference

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