Development Process of a Sensor System for Obstacle Detection on Railways using Virtual Reality

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Introduction

Driverless rail transport can be a measure to realize energy-efficient transportation under the influence of a shortage of skilled workers. In addition to fallback level tasks, obstacle detection has not yet been reliably solved technically. The developments in the automotive industry towards an SAE Level 3 system with manufacturer responsibility could be a starting point, also for railways. In addition, for safety validation, developing an AI classifier based on simulations in virtual reality plays a key role.

Method

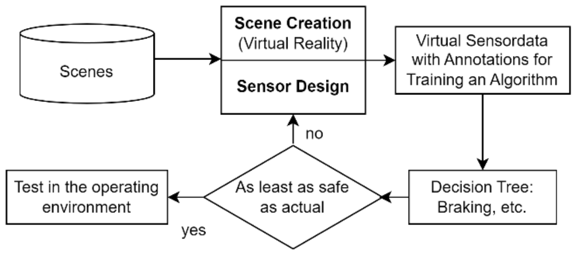

Figure 2: Development process

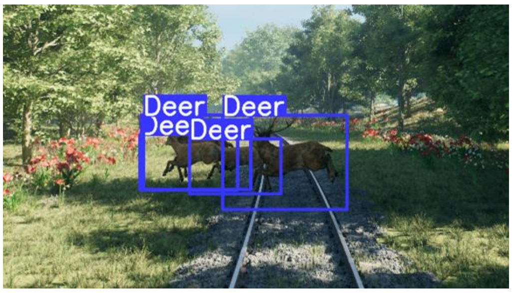

Figure 1: Photorealistic virtual scene with bounding boxes for AI training

The scene-based approach is the most promising one, as a sensor system with downstream artificial intelligence is not deterministic. After defining parameters of scenes and generating them according to specified requirements, photorealistic scenes can be generated virtually and the safe function can be verified statistically. Due to the high number of scenes, validation in the operating environment is not really feasible. Figure 1 shows the system development process, Figure 2 the sensor and the meta data of a camera for one scene in the virtual reality with labeled object bounding boxes for the AI training process. The sensor layout, the algorithms or the evaluation (e.g. human reliability) can be mapped using customizable models, making the process generic.

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Real-Time Semantic Railway Point Cloud Acquisition via Deep Learning: A Camera-Based Approach

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Abstract

This paper presents an innovative method for acquiring real-time semantic railway point clouds through the integration of state-of-the-art deep learning technologies. The proposed methodology employs a dual-branch framework combining semantic segmentation and monocular depth estimation to process images captured by cameras mounted on trains in real-time. Specifically, we leverage the YOLACT++ model (Zhou (2020)) for semantic segmentation and the PackNet model (Guizilini et al. (2020)) for depth estimation. These models operate in parallel to generate pixel-wise semantic and depth information, which are subsequently fused to construct detailed semantic point clouds.

The practicability and efficiency of our method are demonstrated through extensive experiments conducted at a test site within the Norwegian University of Science and Technology. Here, an unmanned ground vehicle equipped with standard cameras serves as the primary data collection tool, navigating through a simulated railway environment to capture the requisite imagery. This research highlights the significant cost advantages of our purely camera-based approach over traditional point cloud acquisition methods, which typically rely on more expensive LiDAR or 3D scanning technologies.

Moreover, we explore several practical applications of the generated semantic point clouds, with a particular focus on fail-safe, highly accurate real-time train localization. By utilizing breakthrough AI algorithms, our approach not only offers a cost-effective alternative to conventional methods but also enhances the capability for real-time processing and application in critical railway operations. Through this work, we aim to contribute to the advancement of intelligent railway monitoring systems, providing a foundation for future innovations in the field.

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Metaverse for Maintenance in the Railway Industry

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Introduction

Digital transformation within the Railway Industry is enhancing the reliability, efficiency, and sustainability of the system. The traditional railway maintenance techniques have limitations, e.g., in terms of access and inefficiency due to improper communication and collaboration (khanna et al., 2023). Metaverse offers a unique platform to overcome these limitations. It is an immersive and interactive digital space enabled using technologies such as VR, AR, 3D Modeling, Spatial computing, and AI, among others (Njoku et al., 2023). Thus, the objective of this work is to present a developed Metaverse platform for maintenance in railways to enhance interactions between human operators, software, and hardware components offering potential benefits in asset management and operations and maintenance processes.

Analysis

This research work has developed a Metaverse platform for maintenance in railways using 3D scanning, 3D modelling, visualisations, and gaming technologies (Figure 1). This platform helps to enhance the inspection process and facilitate decision-making in the operation and maintenance of the railway system. Therefore, Metaverse eliminates distance barriers between collaborators, enabling them to discuss railway assets for future maintenance decisions. Figure 1 depicts a Metaverse where AVATARS visualise and discuss wear on railway wheels and tracks. This platform enables the inspection and analysis of assets without disrupting the operations and overcoming any constraints on physical access.

Figure 1. Metaverse for maintenance using VR and AR tools.

Conclusions

Integrating Metaverse for maintenance in the railway industry offers a unique solution for overcoming traditional limitations in railway maintenance. It is expected to revolutionize asset management and operations and maintenance practices. This work demonstrates metaverse has the potential to enhance the reliability, efficiency and sustainability of the railway industry.

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Automation of Industrial Sidings by Using Road-Rail Vehicles as Automated Guided Vehicles

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Introduction

Since 1994 the number of industrial sidings in Germany has decreased by 80% acc. to Allianz Pro Schiene (2022). One reason is the labour-intensive and expensive operation of these tracks. On the other hand, automated guided vehicles (AGV) are state of the art in the logistic sector. By operating small road-rail vehicles (RRV) with technologies taken from AGVs, a relatively easy automation of the operation of industrial sidings is possible. In addition to the technical implementation, safety requirements, which differ from those of AGVs, must also be taken into account.

Analysis

The big advantage of RRVs is the ability to leave the track at certain locations in order to move to the other side of a waggon group or to move to another track and rerail there. While driving offside the tracks, we consider the RRVs like an AGV acc. to EN ISO 3691. We implemented different technologies from commercial AGVs at an RRV, like SLAM for localization shown in Figure 1. On operational aspects these technologies work without much adaptions. We also analysed the hazards and derived additional safety requirements for AGV technologies implemented in RVVs. As an example, Figure 2 shows that a brake control system of a AGV needs to fulfil requirements of Performance Level (PL) 2, but a hazard analysis of the brake system of an automated RRV acc. to ISO 13849-1 leads to PL 3. The main reasons are higher speeds and heavier loads up to many hundred tons if several waggons are attached. If RVVs are to have access to the public rail network, further safety requirements acc. to EN 15746 must be taken into account.

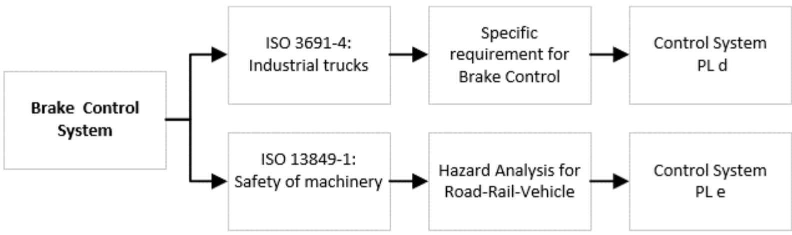

Figure 1: SLAM on an RRV   Figure 2: Differences of Peformance Level

Conclusions

We were able to show, that the operation of RVVs with technologies from AGVs is technically possible, but higher safety requirements are to be taken into account. Further steps are the validation in field tests and a formal certification of the system.

References

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FutuRe Innovative solutions for Regional rail services

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Introduction

Regional railway (lines with lower usage or secondary network) plays a crucial role not only in serving European regions, but also as feeders for passenger and freight traffic for the main network. Unfortunately, many of these routes were abandoned in the past - mainly due to high costs. These railway lines need to be revitalized to make them economically and environmentally sustainable and to meet current customer needs. To achieve these ambitious goals a novel approach is necessary, which is in the focus of the FutuRe – a project supported by the Europe's Rail Joint Undertaking research. Research is conducted in several areas, like traffic management, train positioning, automatic train control, wayside assets, multi-modal travelling and the vehicle itself, where the propulsion system and the running gear are key research areas. This project is finally expected to result in a compete vehicle demonstrator.

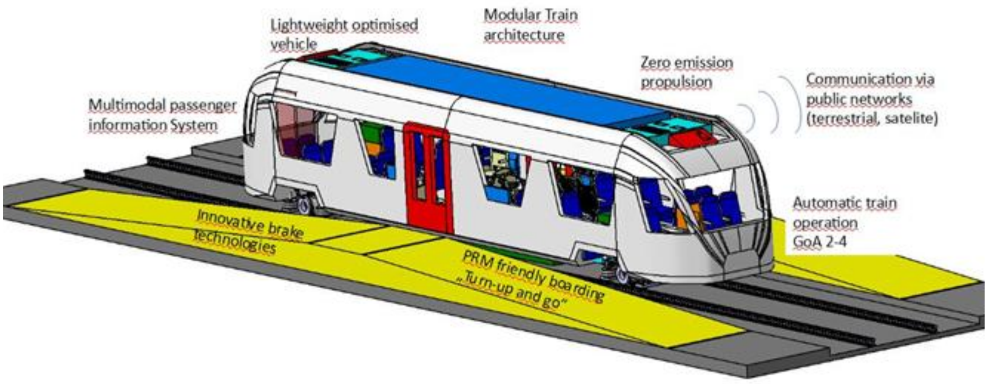

Figure 1. An illustration of a possible regional vehicle (Persson et.al.)

Propulsion system

A modern propulsion system is an enabler for an emission free regional vehicle. Many regional lines are unelectrified and electrification cannot be justified by the low passenger demand. Future energy storage on-board the vehicle may be based on battery or possibly complemented with hydrogen for extended services.

Active vertical suspension

A simplified, lightweight single axle running gear could contribute to achieve the goals when complemented by active suspension to match the performance of today's bogie-equipped vehicles. Active vertical suspension is studied for ride comfort improvements.

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