Center for Sustainable
Future Mobility (CSFM)

LROD: Long-range obstacle detection for railway driver assistance systems

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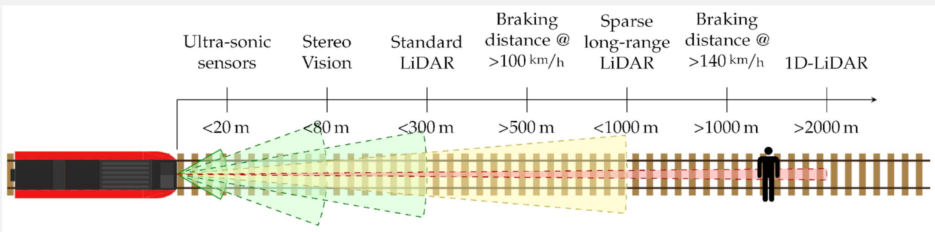
1 Introduction

Increasing demand for transportation by rail leads to a denser operation of the railway network. Furthermore, rising rail vehicle speeds require new and more advanced safety systems to ensure a safe and reliable operation of the network. Obstacle detection aims to prevent collisions with humans, infrastructure, trees or other objects on the tracks.

2 Related Work

Existing methods [1,2], mainly known from the automotive industry, fail to provide the required range for the operation of the train. Further sensor modalities such as Radar do not provide the required resolution or suffer from low reflectivity off of non-metal objects.



3 Method

The proposed system consists of three main hardware and software components:

- A fixed overview camera that identifies the train tracks and general region of interest (RoI, yellow).
- An actuated sensor setup (Section 4) consisting of a high focal-length camera and a long-range 1d LiDAR search through the RoI to identify and localize possible obstacles
- An anomaly detection framework (Section 6) that recognizes unexpected objects on the tracks based on the images provided by both cameras.

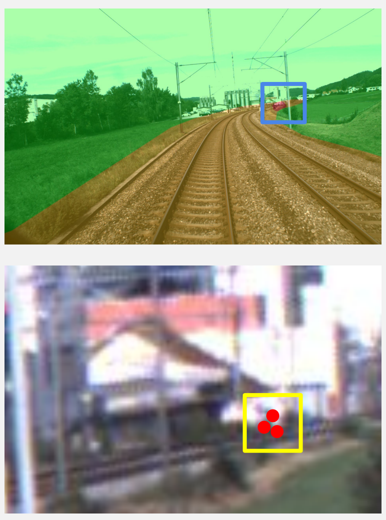


Fig. 1: Overview and detail image highlighting the detection of an obstacle

Fig. 2: Map overview, visualizing the field of view of the individual sensors.

4 Hardware development

The high requirements regarding the range and accuracy of the sensor system pose unique demands to the individual components. A custom pointing mechanism [3] was developed with a precision of 6 mdeg able to target objects at a distance of over 1.5 km. Both the camera and the laser provide sufficient detail and accuracy to detect a human at this range.

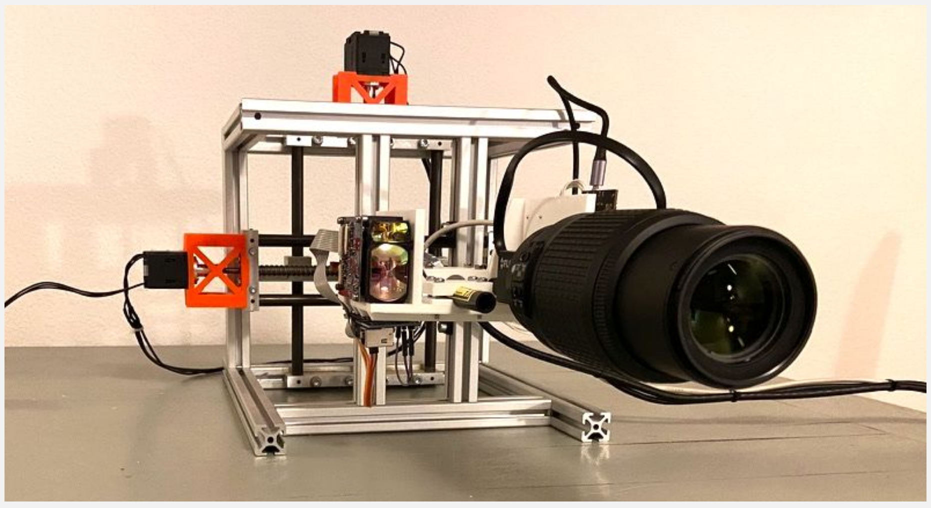


Fig. 3: Custom sensor setup consisting of a high-precision pointing mechanism, a high focal-length camera, and a 1D LiDAR with a range of up to 5 km.

5 Experiments

First qualitative experiments demonstrate the ability of the system to target and localize objects at great distance. An uncalibrated prototype setup was capable of targeting objects at 400 m and buildings at over 2 km range.

6 Anomaly Detection

Standard object detection neural networks are only capable of detecting objects which were explicitly part of their training set. In outdoor environments, it is inevitable to find instances not part of the training data. Anomaly detection recognizes these outsiders from the training distribution.

Fig. 4: Input image with an anomaly is reconstructed by the neural network. A difference measure highlights the anomaly as a white spot.

References

1. Durrant, D. R., Haseeb, M. A., Emami, D., & Gräser, A. (2018). Multimodal Sensor Fusion for Reliable Detection of Obstacles on Railway Tracks.
2. Haseeb, M.A.; Risti´c-Durrant, D.; Gräser, A. Long-range Obstacle Detection from a Monocular Camera. In Proceedings of the ACM Computer Science in Cars Symposium (CSCS), Munich, Germany, September 2018.
3. Elio Hajj Assaf; Cornelius von Einem; Cesar Cadena; Roland Siegwart; Florian Tschopp. 2022. "High-Precision Low-Cost Gimballing Platform for Long-Range Railway Obstacle Detection." Sensors 22, no. 2: 474.

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