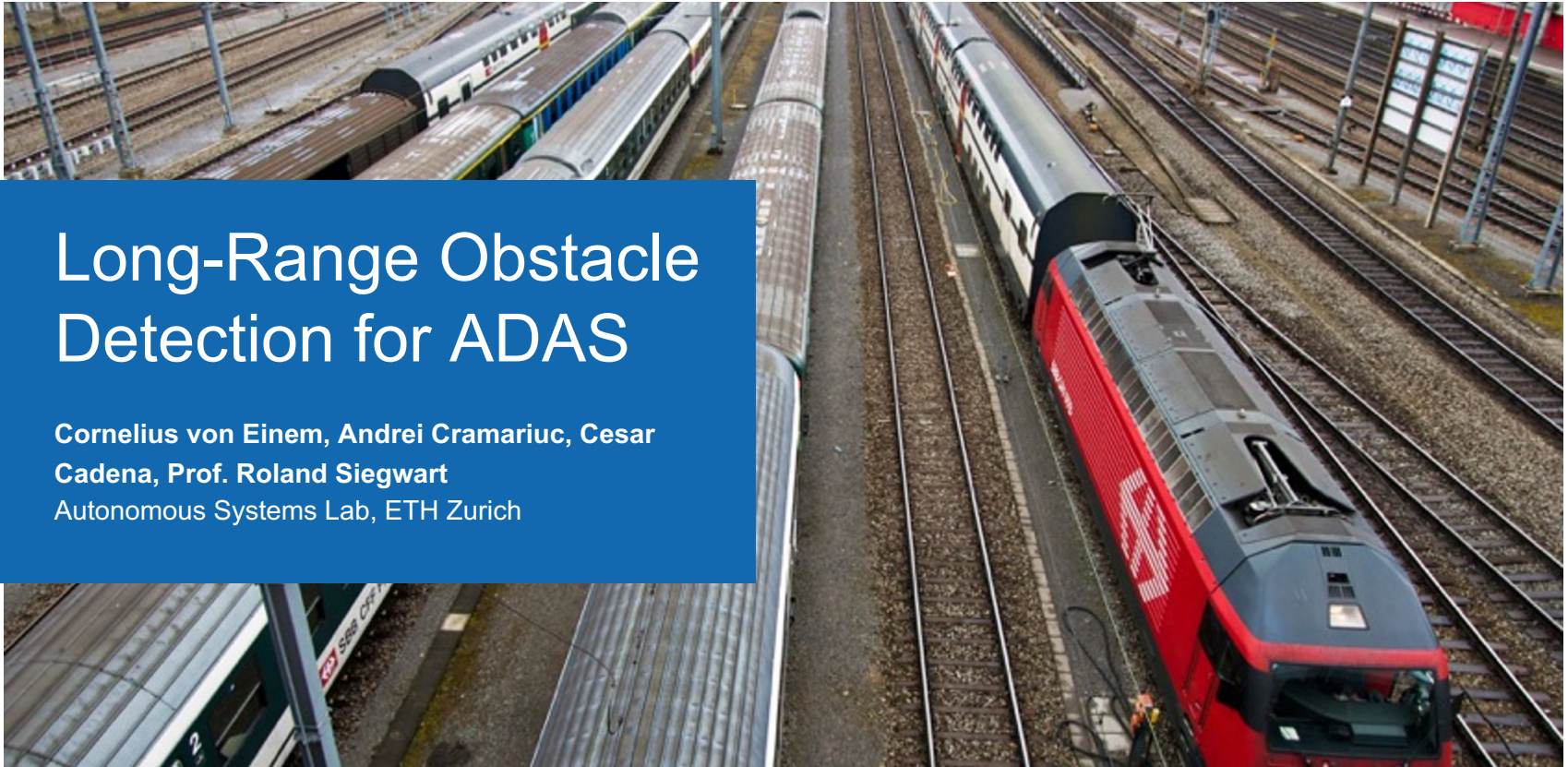


# Long-Range Obstacle Detection for ADAS

Cornelius von Einem, Andrei Cramariuc, Cesar  
Cadena, Prof. Roland Siegwart  
Autonomous Systems Lab, ETH Zurich



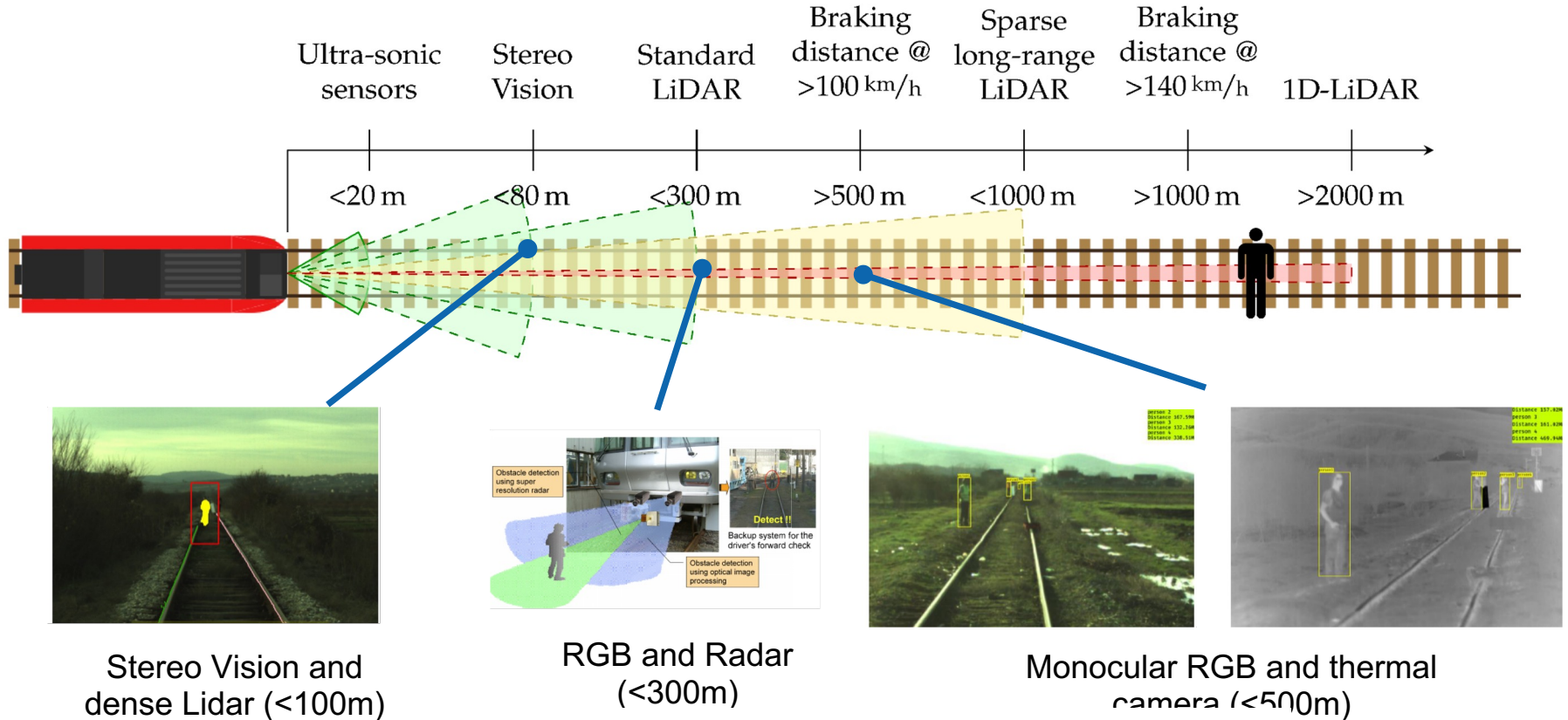
# Motivation



New and more advanced safety systems could help for accident prevention with:

- People
- Infrastructure
- Trees
- Other objects

# Related work



Durrant, D. R., Haseeb, M. A., Emami, D., & Gräser, A. (2018). Multimodal Sensor Fusion for Reliable Detection of Obstacles on Railway Tracks. 3(2), Smart Automation of Rail Transport Obstacle Detection System Requirements and Specification. (2019).  
 Haseeb, M. A., & Gräser, A. (n.d.). Long-range obstacle detection from a monocular camera.



# Approach

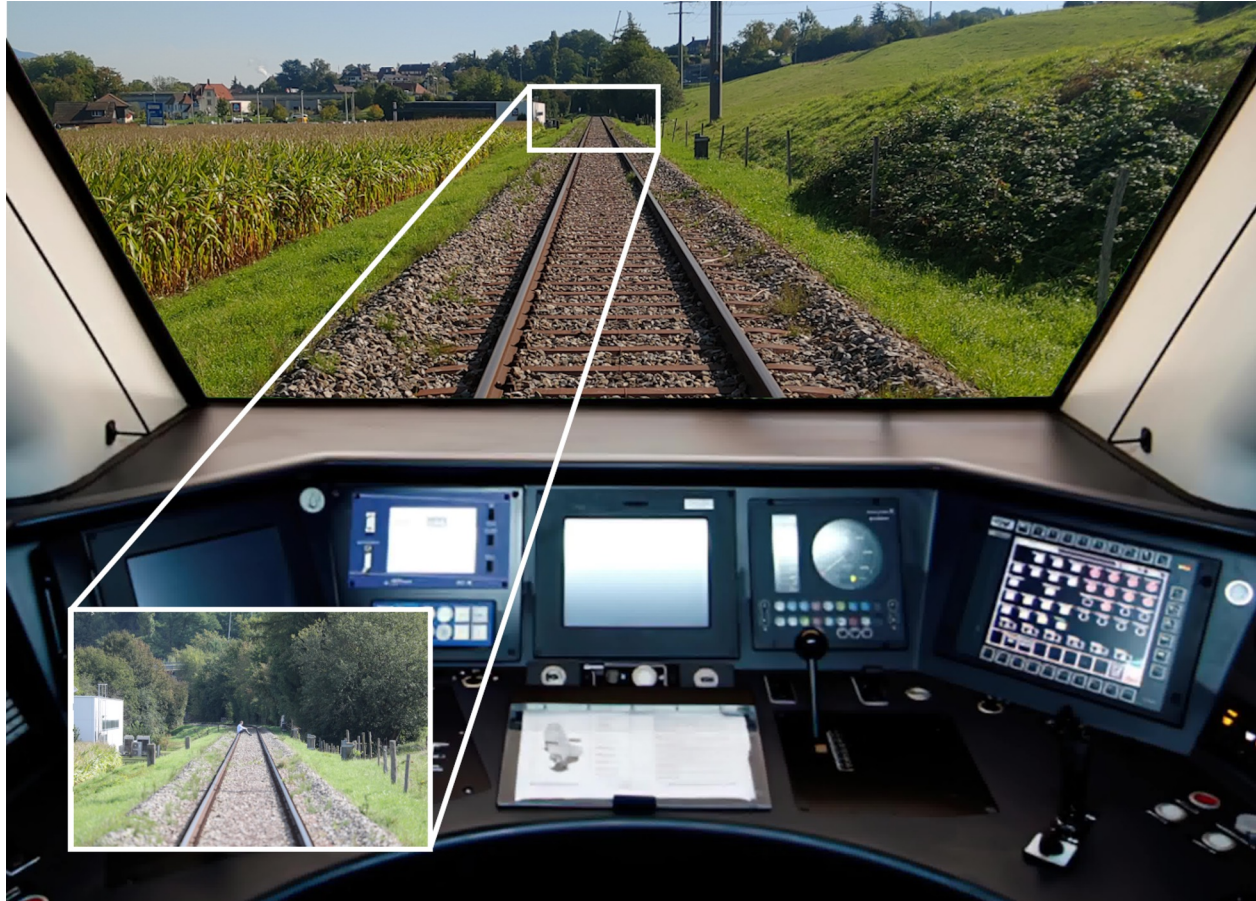




# Approach

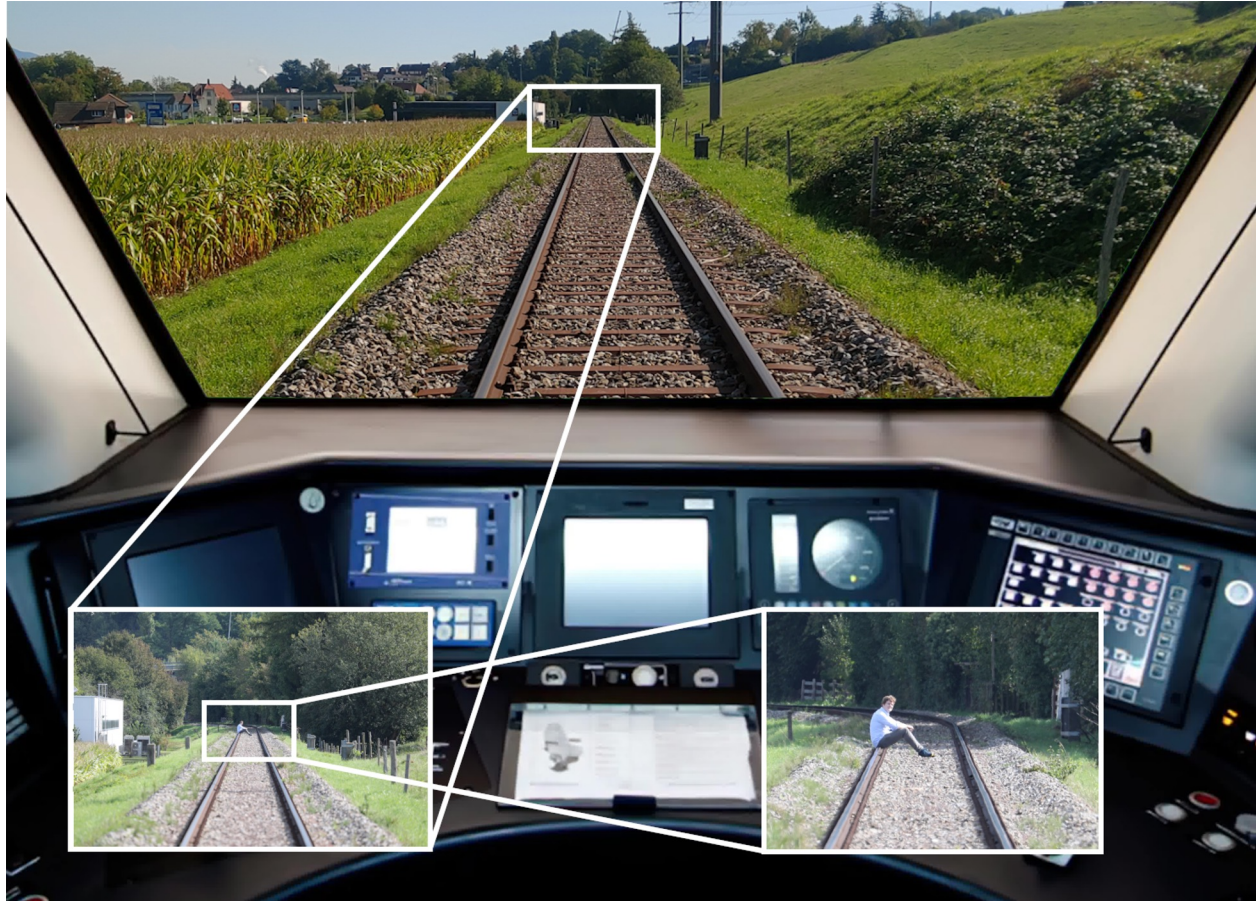


# Approach



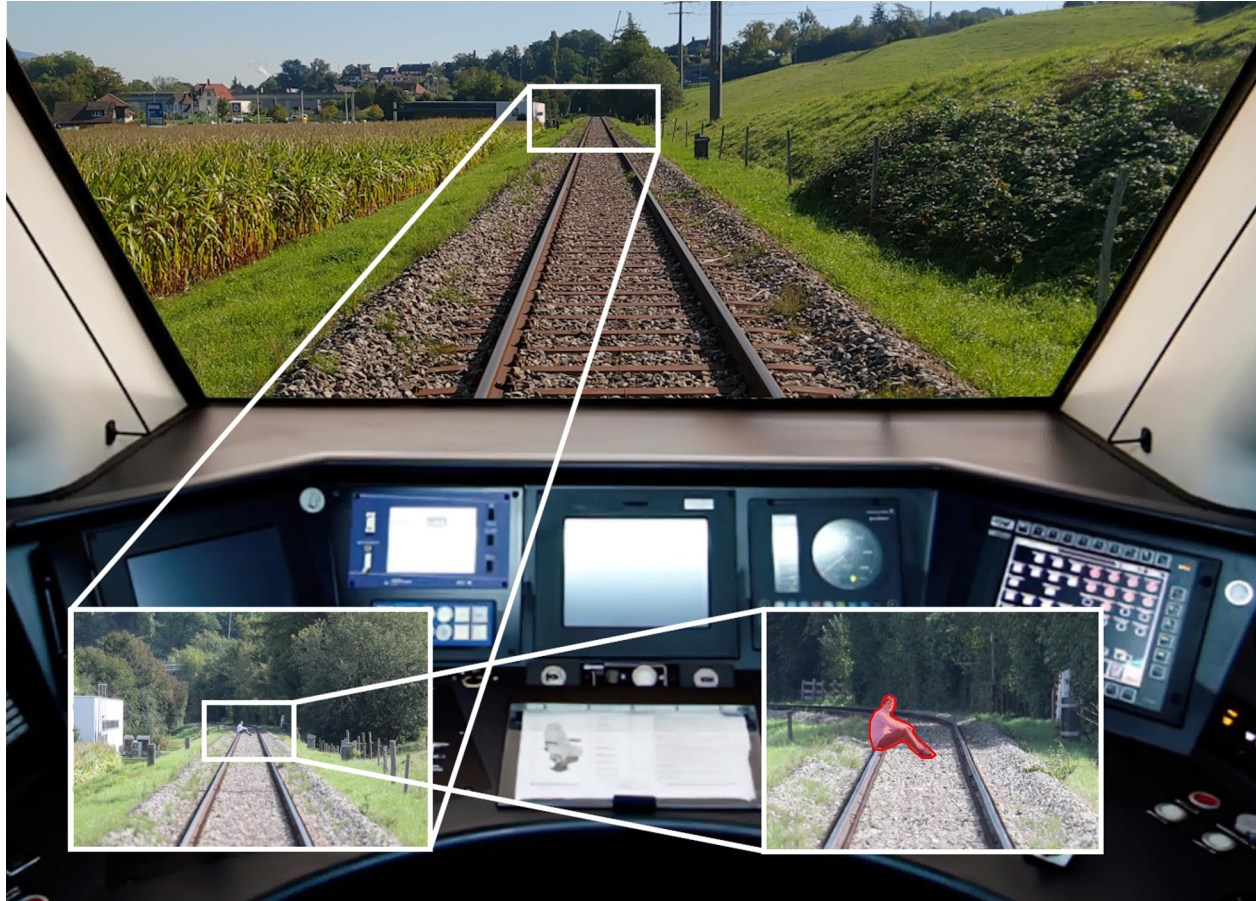


# Approach

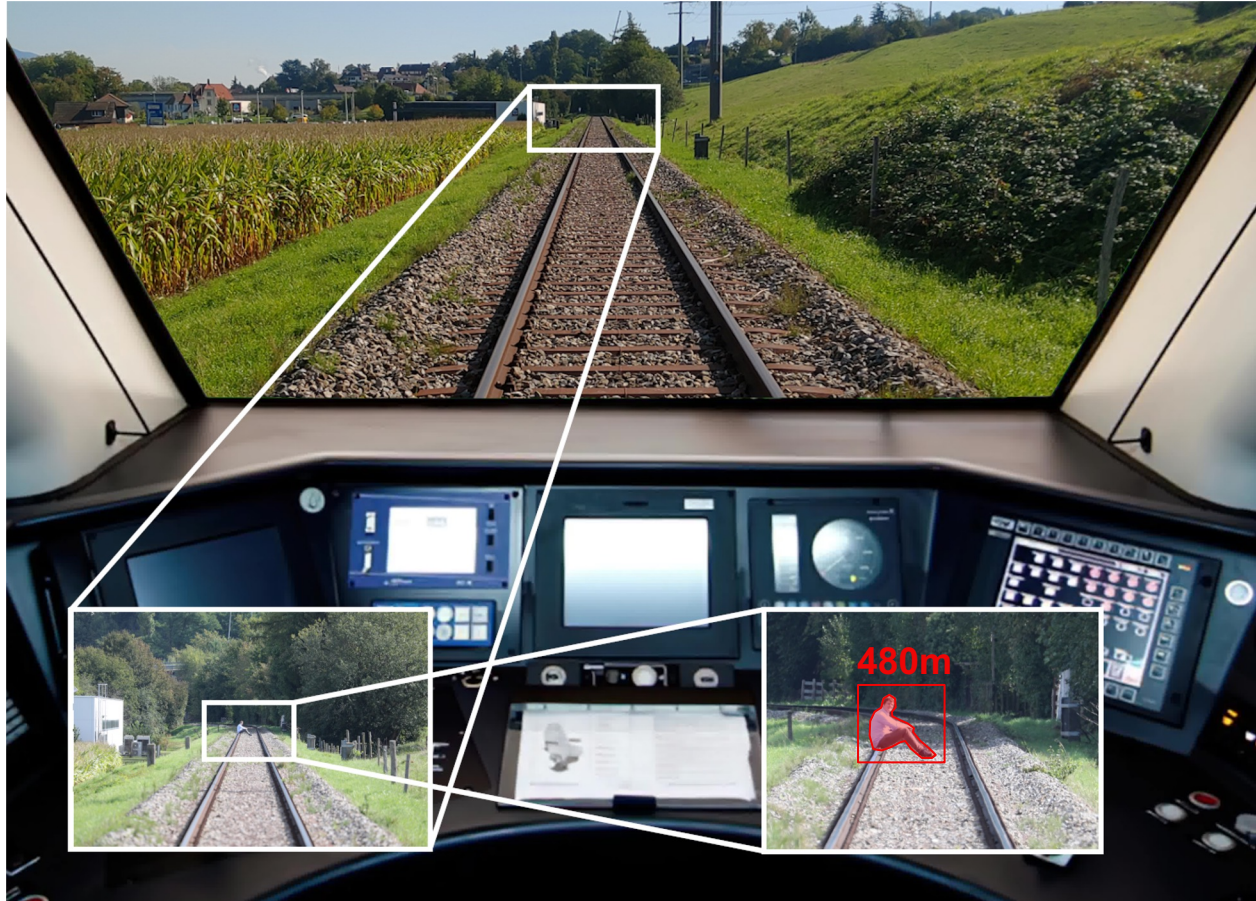




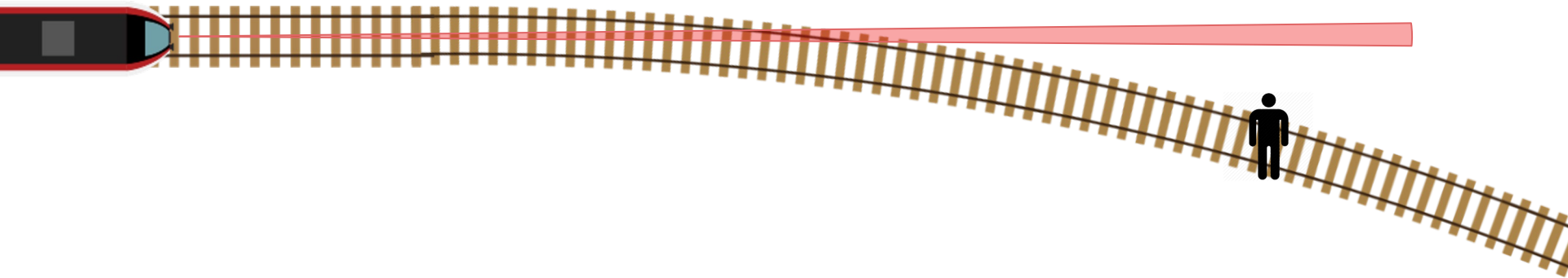
# Approach



# Approach

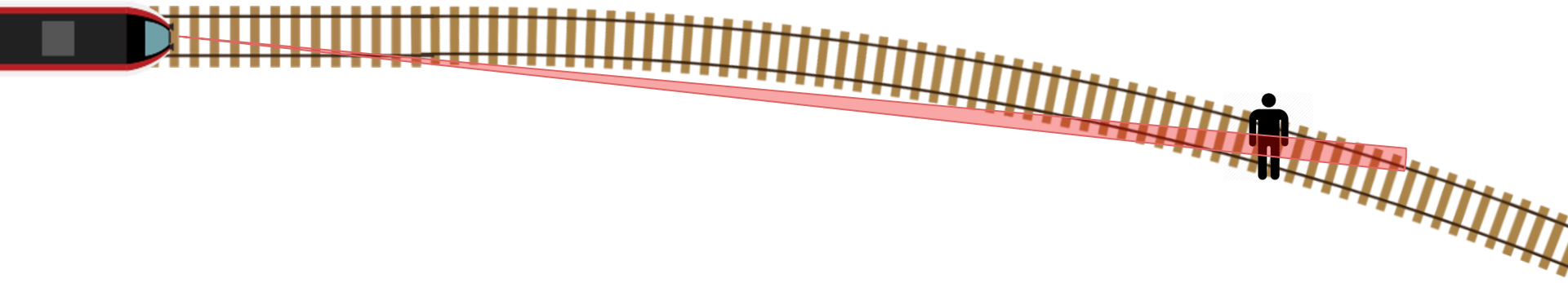


# Approach

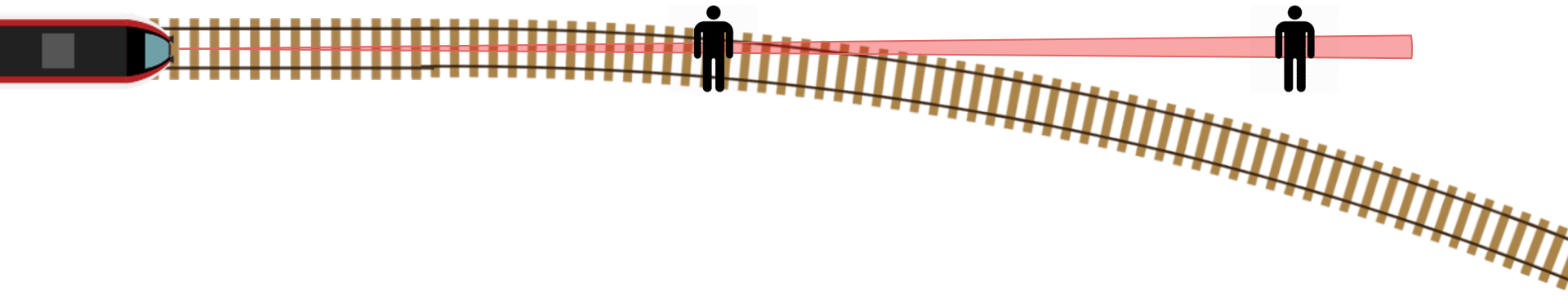




# Approach



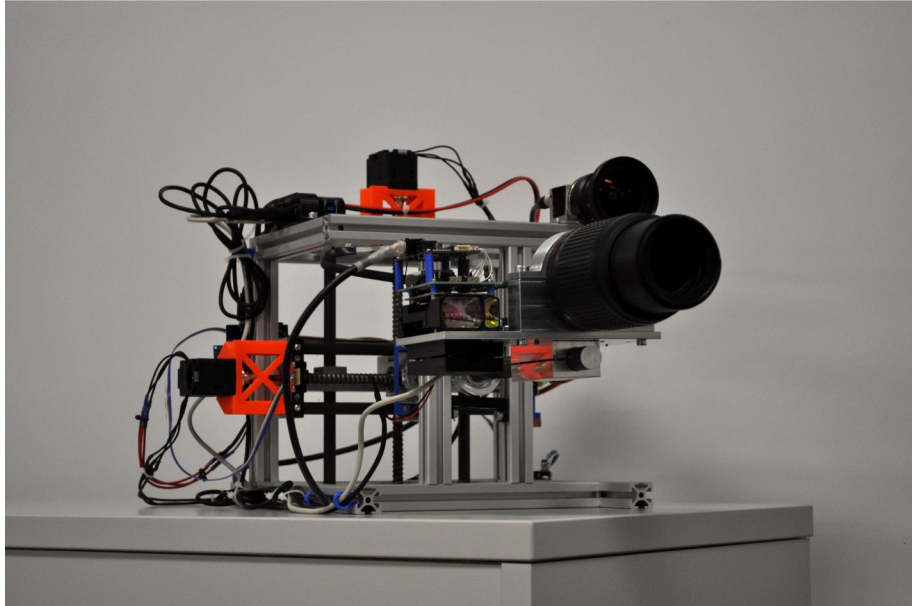
# Approach



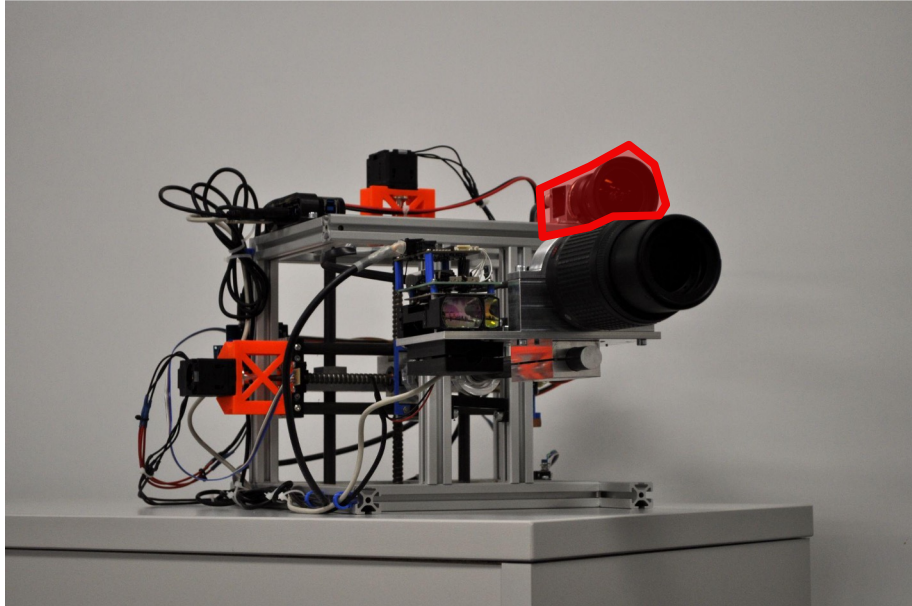
# Sensor Setup



# Sensor Setup



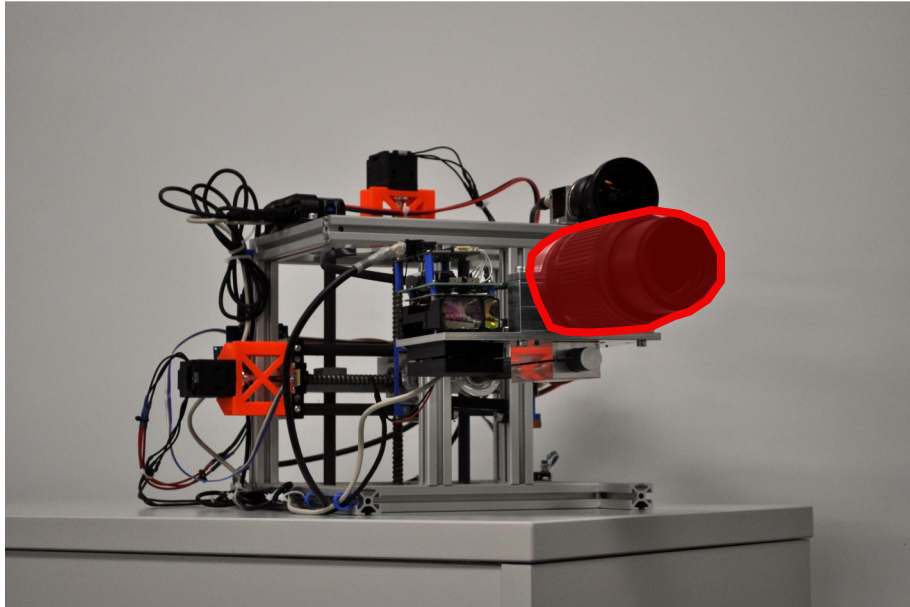
# Sensor Setup



- Overview camera



# Sensor Setup

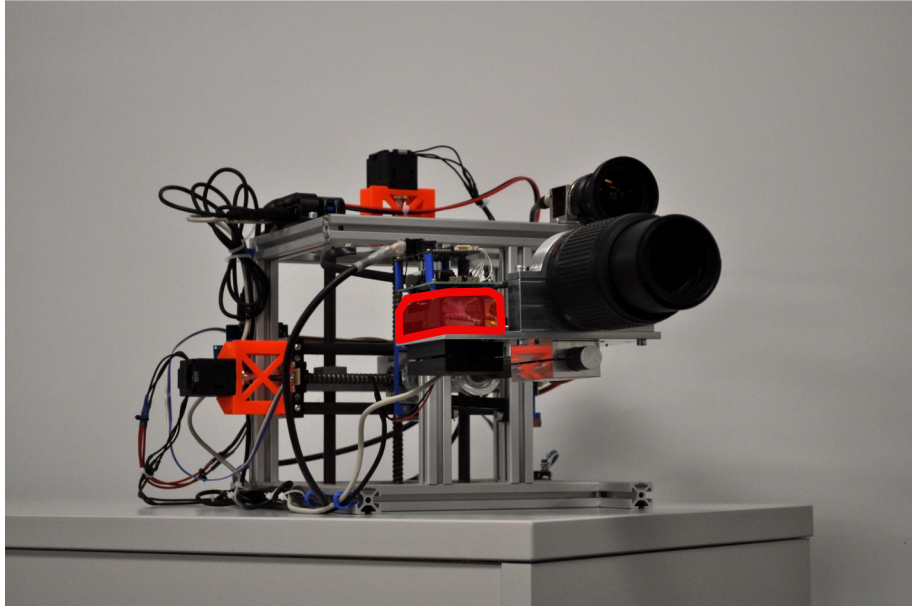


- Overview camera
- High focal-length detail camera





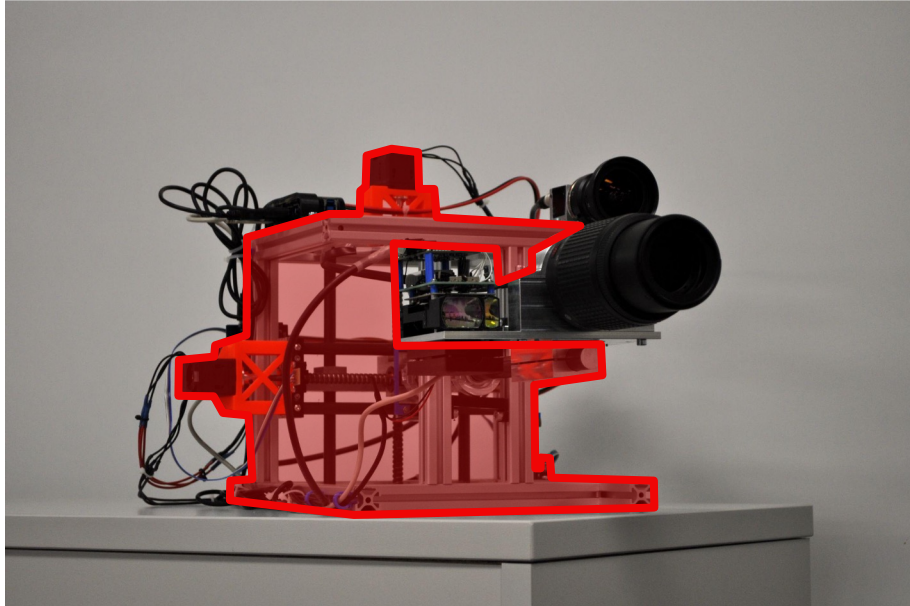
# Sensor Setup



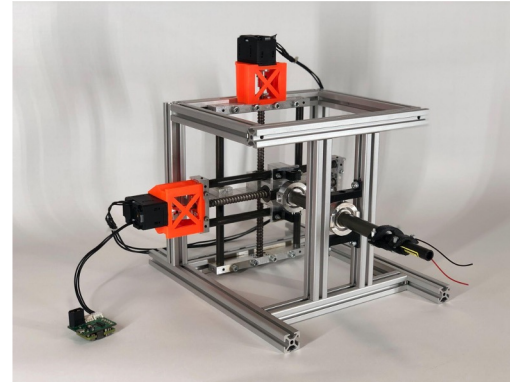
- Overview camera
- Detail camera
- Long-Range 1D LiDAR



# Sensor Setup



- Overview camera
- Detail camera
- Long-Range 1D LiDAR
- High-Precision actuation<sup>1</sup>



[1] Assaf, E.H.; von Einem, C.; Cadena, C.; Siegwart, R.; Tschopp, F. High-Precision Low-Cost Gimballing Platform for Long-Range Railway Obstacle Detection. *Sensors* **2022**, *22*, 474. <https://doi.org/10.3390/s22020474>

# How do we detect an obstacle?

# Obstacle Detection



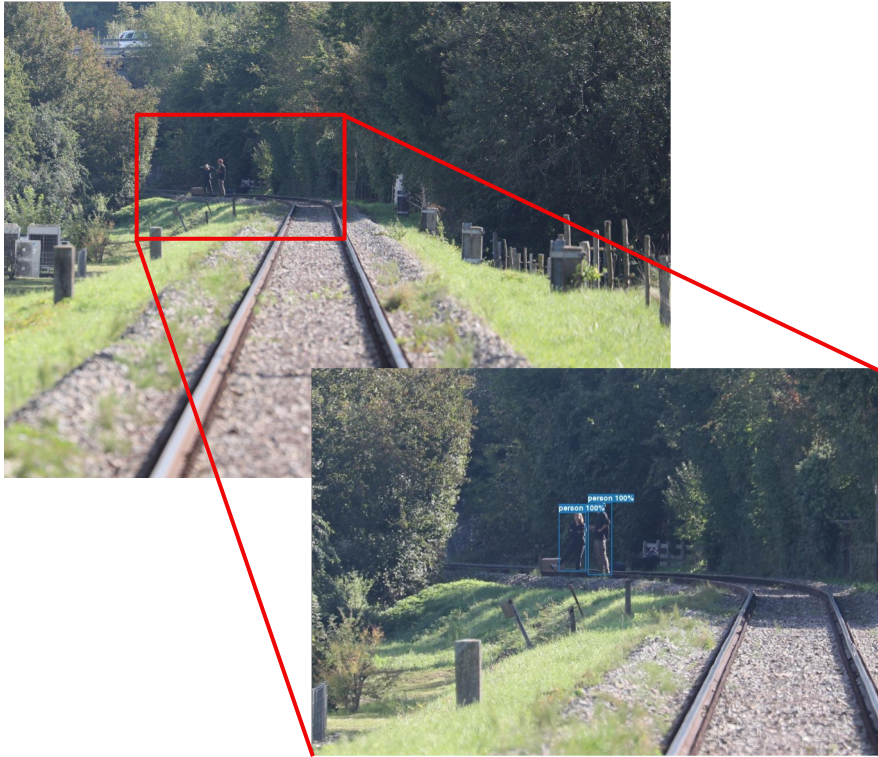


# Obstacle Detection



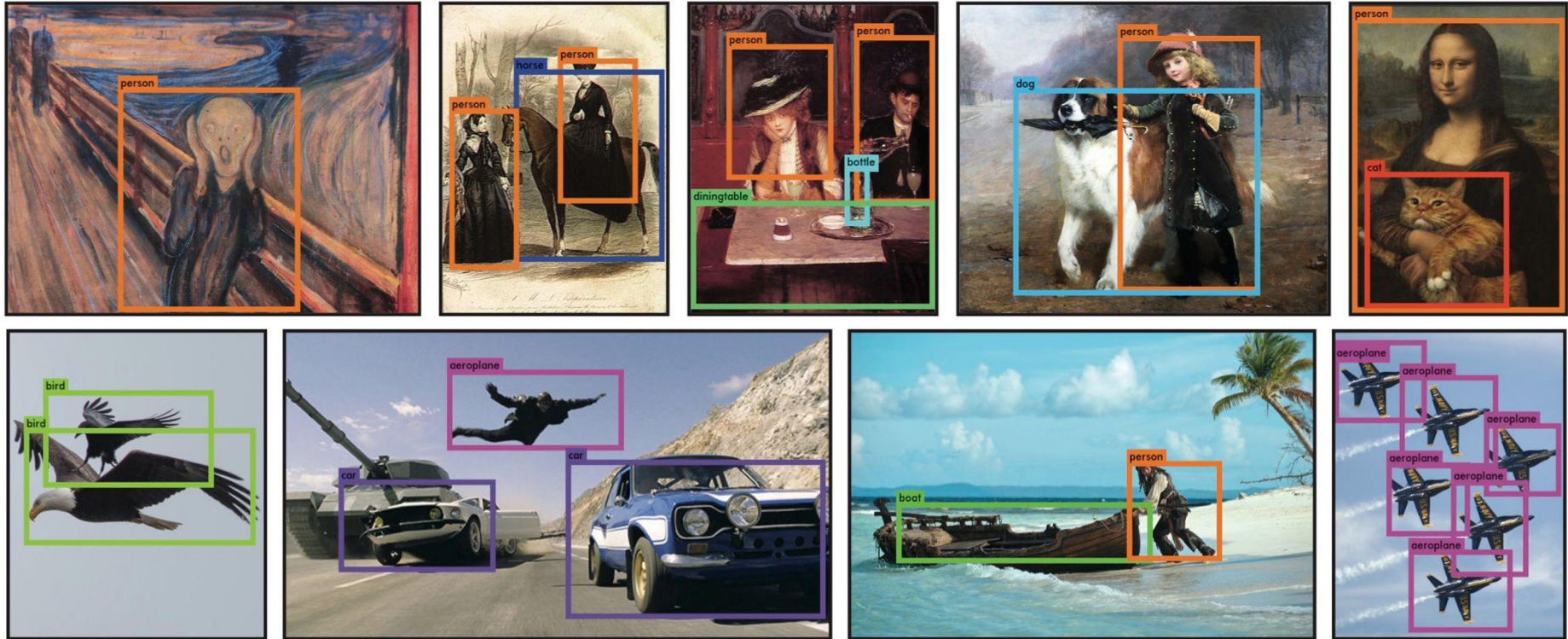


# Obstacle Detection



- Machine learning based object detectors are common
  - YOLO
  - R-CNN

# Obstacle Detection - Training



Redmon, J., Divvala, S., Girshick, R. and Farhadi, A., 2016. You only look once: Unified, real-time object detection. In *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 779-788).



# Obstacle Detection - Training



Failure on unknown obstacles



No context to train tracks

# Anomaly Detection

“Detecting anything that shouldn’t be there”

# Anomaly Detection



- Typically solved using one-class detector: normal vs anomaly



# Anomaly Detection



- Typically solved using one-class detector: normal vs anomaly

Problem:

- Only limited samples of anomalous scenes

# Anomaly Detection



- Typically solved using one-class detector: normal vs anomaly

Problem:

- Only limited samples of anomalous scenes

Solution:

- Create a proxy task
- Utilizing the detection of train tracks as a proxy for detecting anomalies

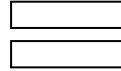




# Anomaly Detection



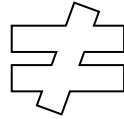
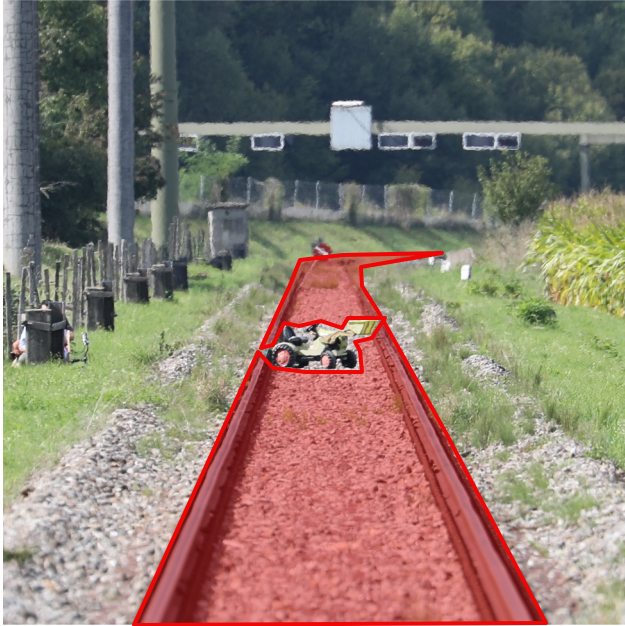
Railway segmentation



Projection of map into image



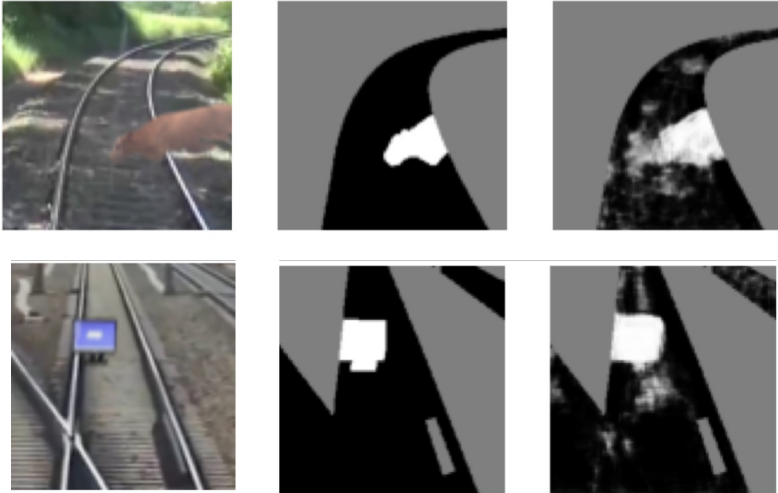
# Anomaly Detection



Railway segmentation

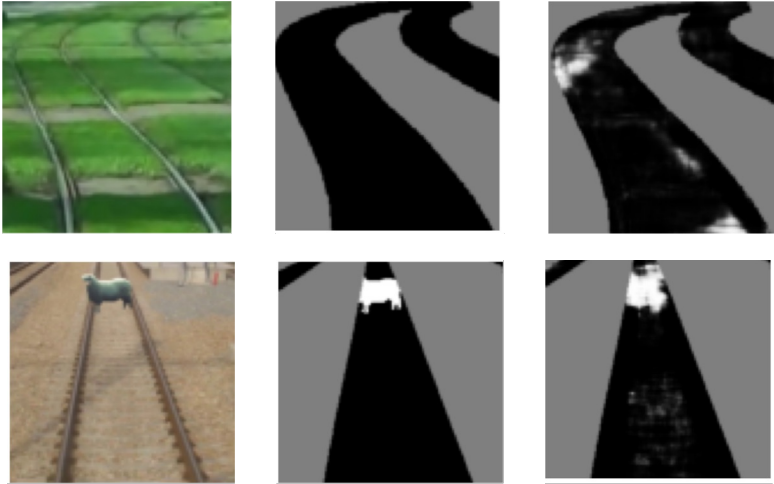
Projection of map into image

# Anomaly Detection - Results



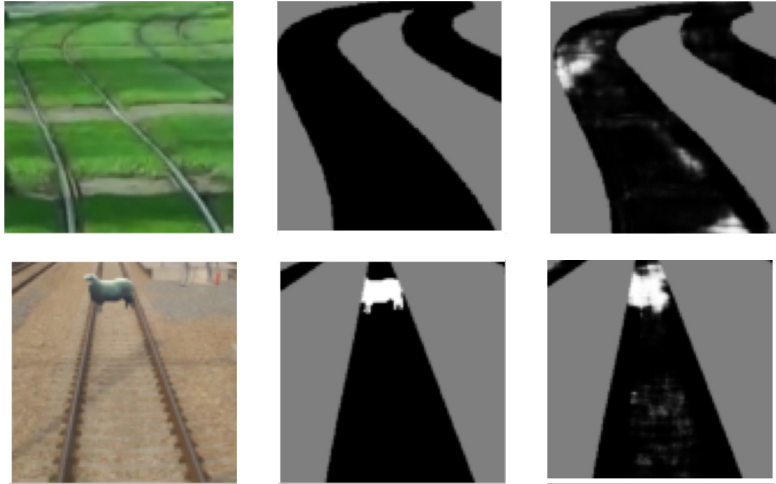
- Reliable detection of anomalies on tracks

# Anomaly Detection - Results



- Reliable detection of anomalies on tracks
- Also in challenging scenarios, reliable detection
- Few false positives

# Anomaly Detection - Results



## Issues:

- Limited to obstacles directly on the tracks
- Limited by the performance of the track segmentation network
  - Labelled training data is scarce
- Limited real-world railway anomaly datasets



# Anomaly Detection



# Anomaly Detection



# Conclusion

- Individual functioning components
- Working hardware system with integrated and synchronized sensors
- Railway anomaly detection system for arbitrary obstacles

# Conclusion

- Individual functioning components
- Working hardware system with integrated and synchronized sensors
- Railway anomaly detection system for arbitrary obstacles

## Next steps:

- Sensor calibration in the wild
  - Utilizing outdoor structures for accurate long-range calibration
- Stationary long-range tests on train tracks



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