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**IROS 2018**

**10th Workshop on Planning, Perception and Navigation for Intelligent Vehicles (PPNIV)**

# DisNet: A novel method for distance estimation from monocular camera

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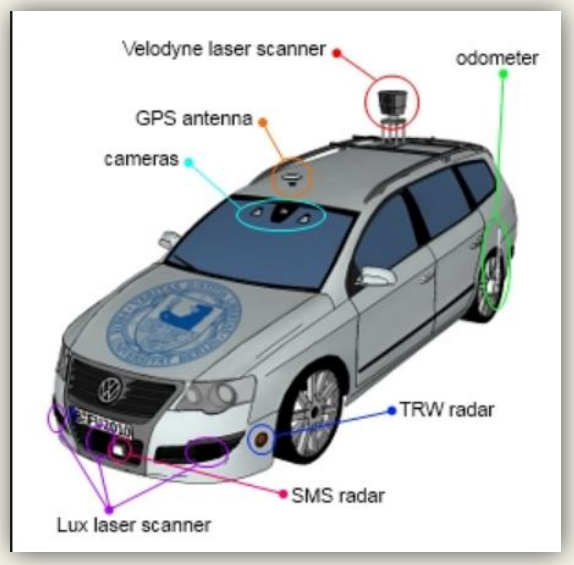
# Motivation

- reliable and accurate detection of obstacles is one of the challenges of safe autonomous driving
- the main principle of obstacle detection in front of a vehicle from the automotive sector can be applied to railway applications
- one of the key challenges is long-range obstacle detection




[1]


[2]

*[1] AutoNOMOS Labs, http://autonomos.inf.fu-berlin.de*
*[2] Accurate 3D-vision-based obstacle detection for an autonomous train, J. Weichselbaum, C. Zinner, O. Gebauer, W. Pree, Computers in Industry Volume 64, Issue 9, December 2013, Pages 1209-1220*

# *SMART* - obstacle detection system

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- a novel fully integrated multi-sensor on-board system
- for mid (up to 200 m) and long range (up to 1000 m) obstacle detection (approx. required braking distance for freight trains ~ 700 meters at 80 km/h)
- can operate in day and night conditions as well as in poor visibility conditions

Smart
Shift2Rail
Horizon 2020 European Union Funding for Research & Innovation
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# Proposed Solution

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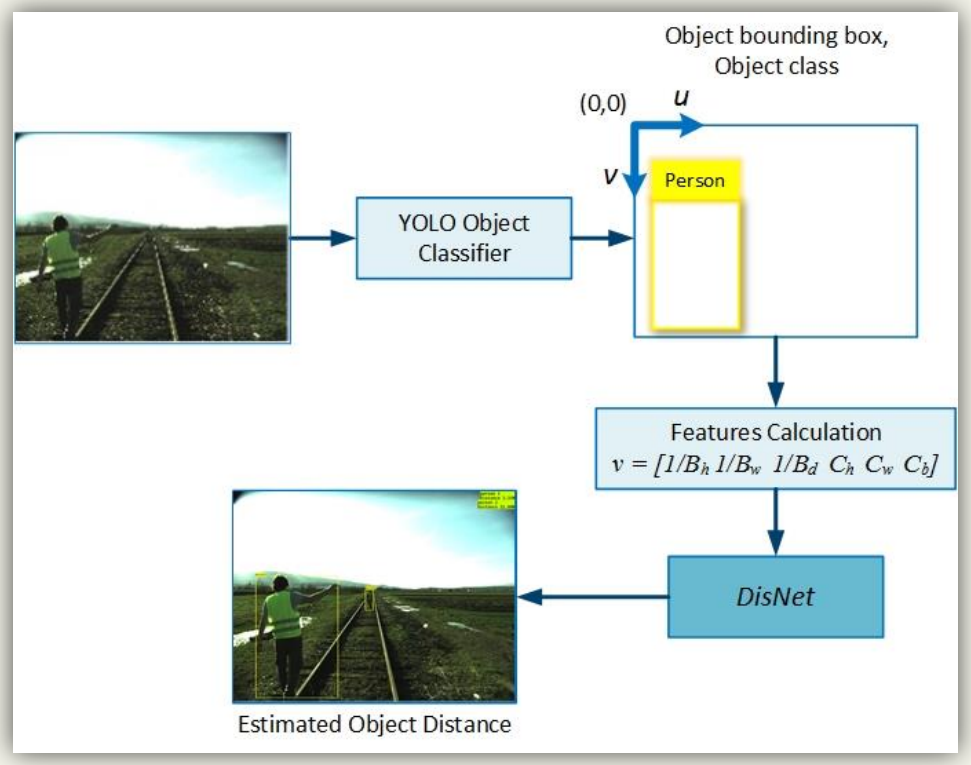
A novel **machine learning-based method** for long-range obstacle detection and distance estimation from a single monocular camera




❖ Working principle

Object distance estimation is based on learning the change in object appearance in an image (in terms of size) due to the change of the object distance with respect to the camera viewing the object.

# Features and DisNet Structure

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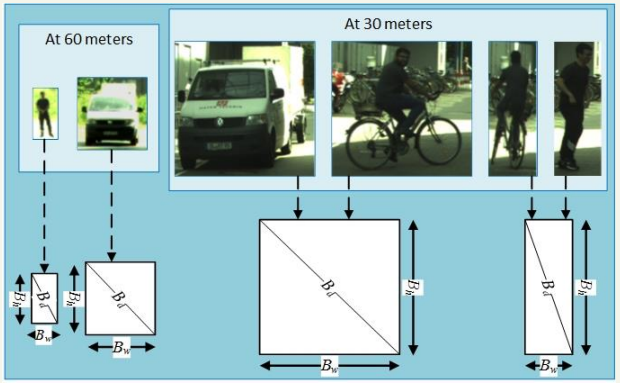
- Dataset - manually extracted bounding boxes of different objects from the images labelled with real distance measured using LiDAR.
- Features – Feature vector: $\boldsymbol{v} = [1/B_h \; 1/B_w \; 1/B_d \; C_h \; C_w \; C_b]$

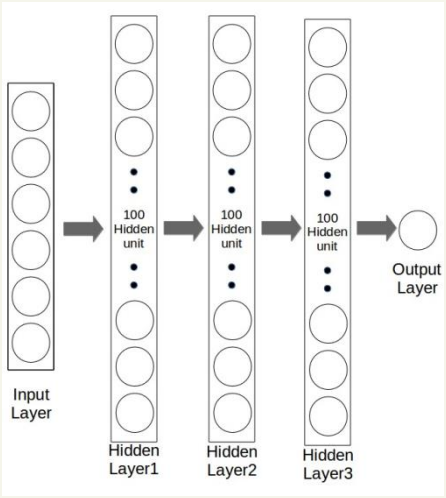
  $B_h$=(height of the object bounding box in pixels/image height in pixels)

  $B_w$=(width of the object bounding box in pixels/image width in pixels)

  $B_d$=(diagonal of the object bounding box in pixels/image diagonal in pixels)

  $C_h$ , $C_w$ , $C_b$ are the values of average height, width and breadth of an object of the particular class.



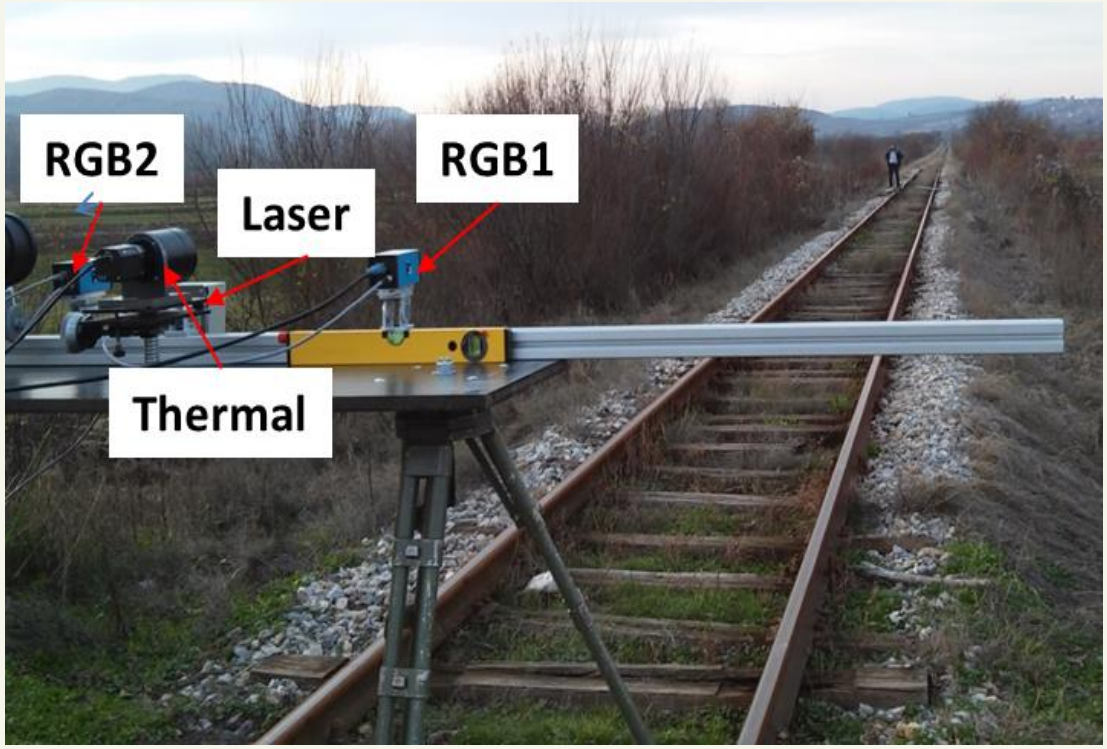

- DisNet Structure - A Neural Network with 3 hidden layers with 100 hidden neurons per layer.

Supervised learning for the training of DisNet:

- training set of 2000 features;
- ground truth - LiDAR distance measurement

# Static experiment

- Setup for recording the scene

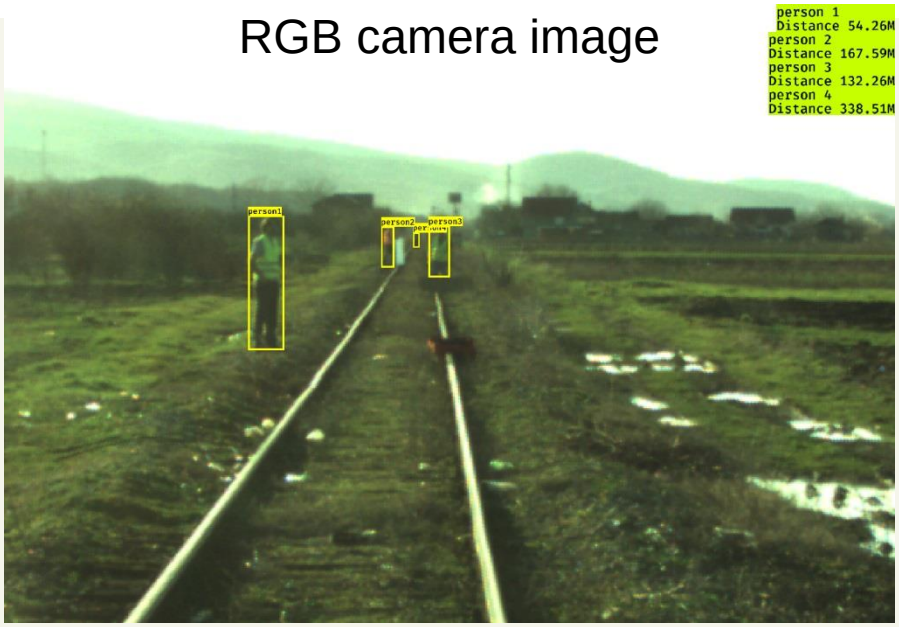



Test-stand with the cameras and laser scanner viewing the rail tracks and an object

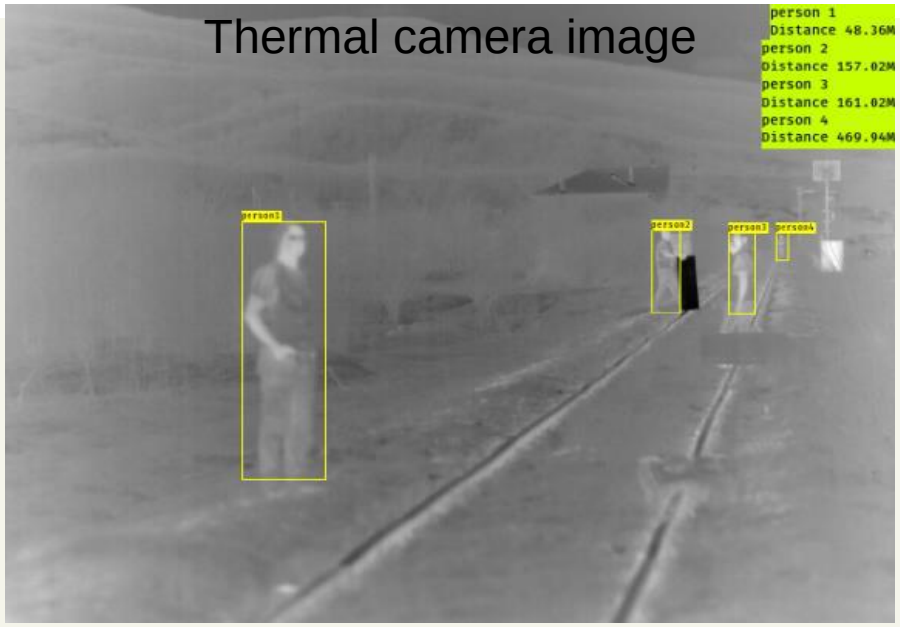
*SMART – Shift2Rail project* - funded by the European Union under the Horizon 2020 framework programme

# Results (Static experiment)

RGB camera image




Thermal camera image

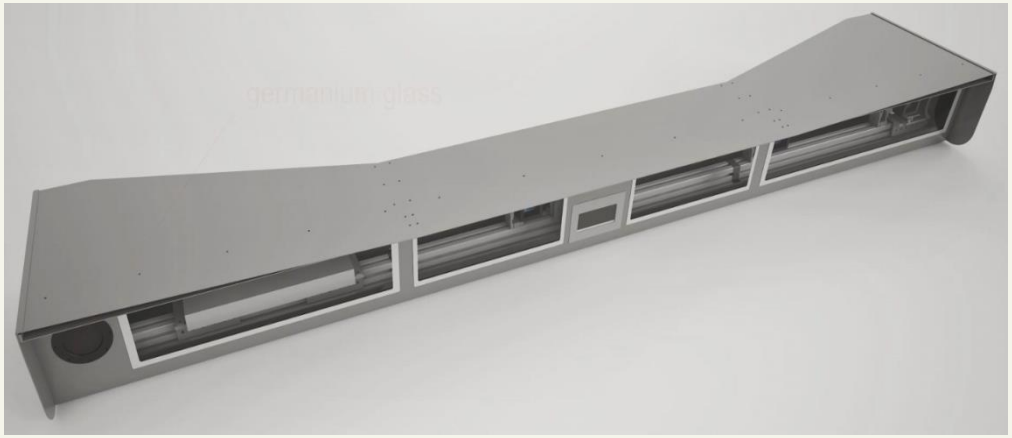



| Object distance with respect to Obstacle Detection System | | | |
|---|---|---|---|
| Ground Truth | | RGB Camera | Thermal Camera |
| Person 1 | 50 m | 54.26 m | 48.36 m |
| Person 2 | 100 m | 132.26 m | 161.02 m |
| Person 3 | 150 m | 167.59 m | 157.02 m |
| Person 4 | 300 m | 338.51 m | not-visible |
| Person 5 | 500 m | not-visible | 469.94 |

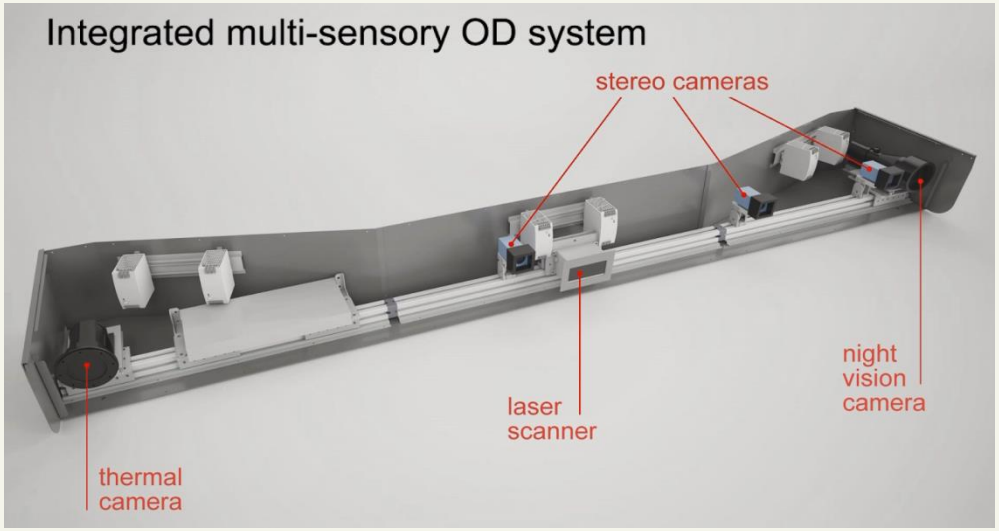
# Dynamic experiment


Mounted on Serbian locamotive

# Dynamic experiment



SMART - multi-sensor obstacle detection system



# Results (dynamic experiments)

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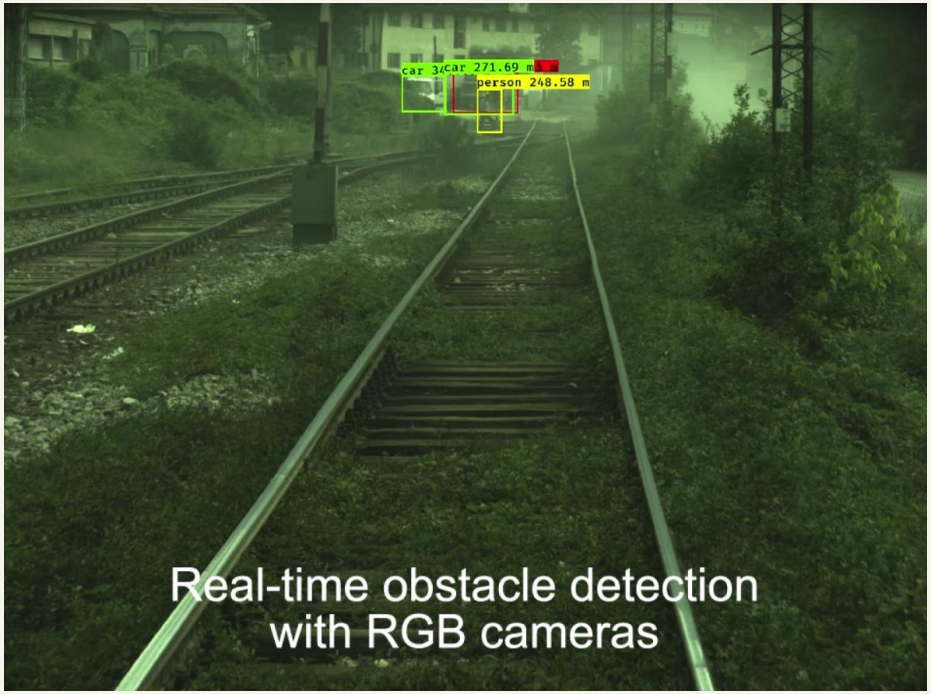


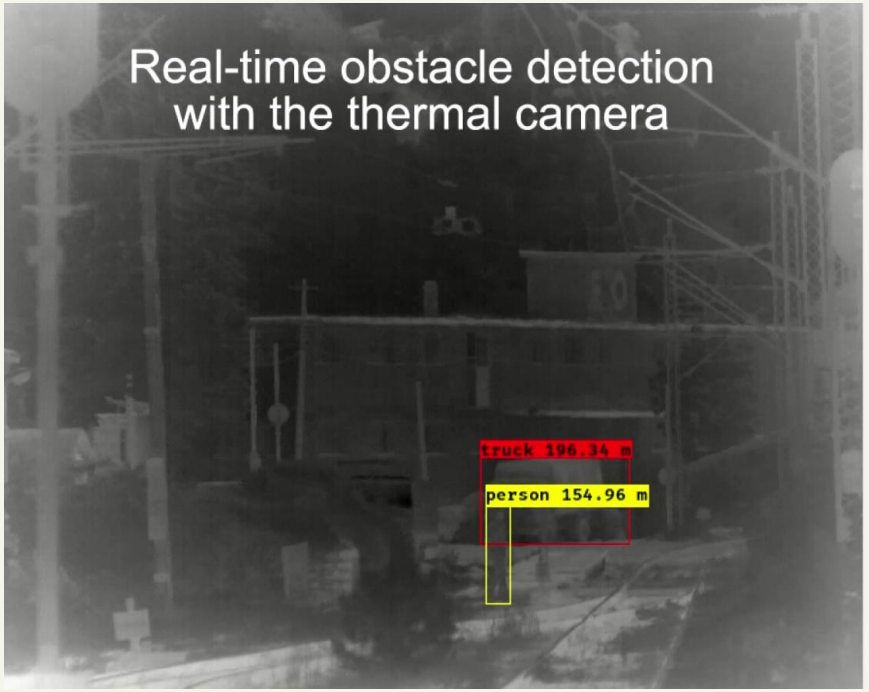

# Results (Road Scene)

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# Thank you very much for your attention!

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