

INTER SAFE2

On-board Perception for Intersection Safety

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SICK

Sensor Intelligence. BMW Group
Research and Technology



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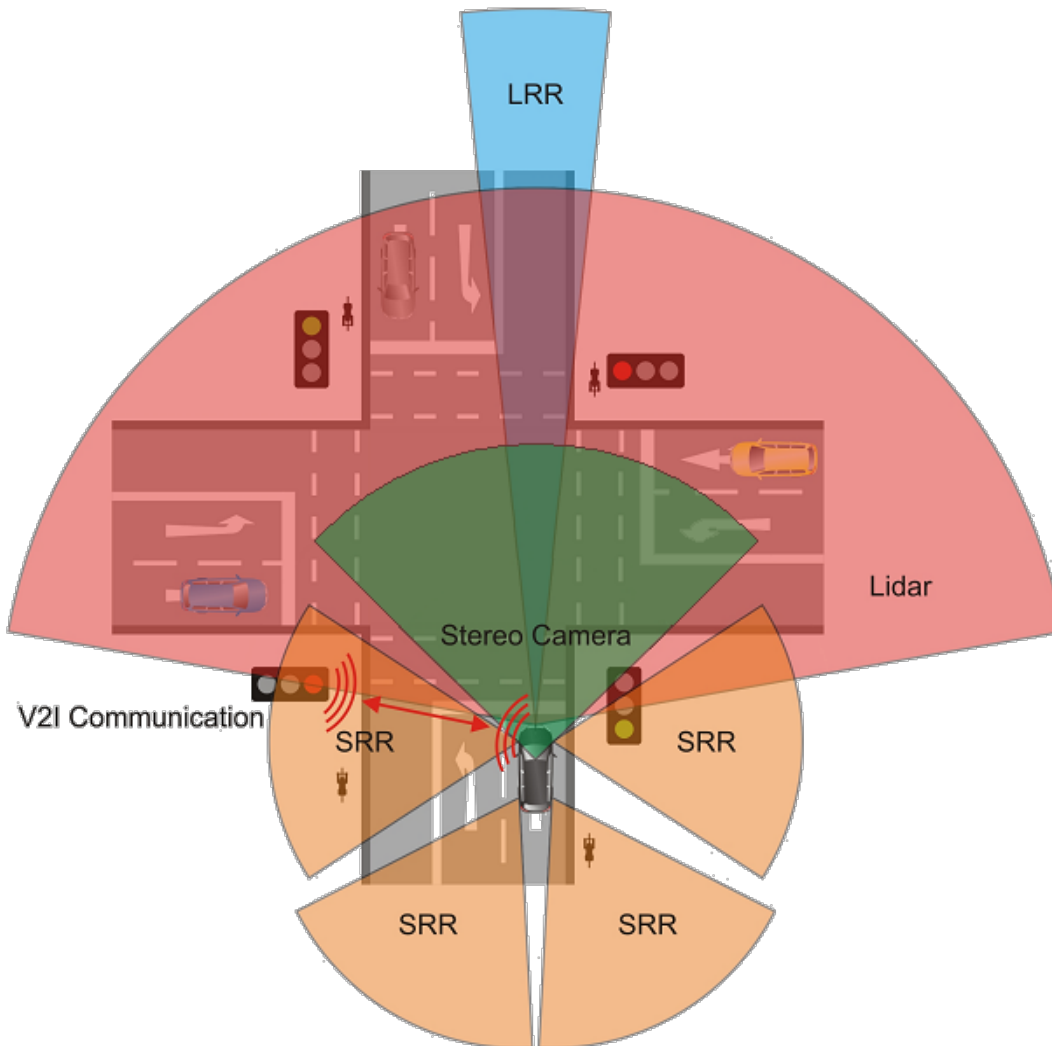
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On-board Perception for Intersection Safety

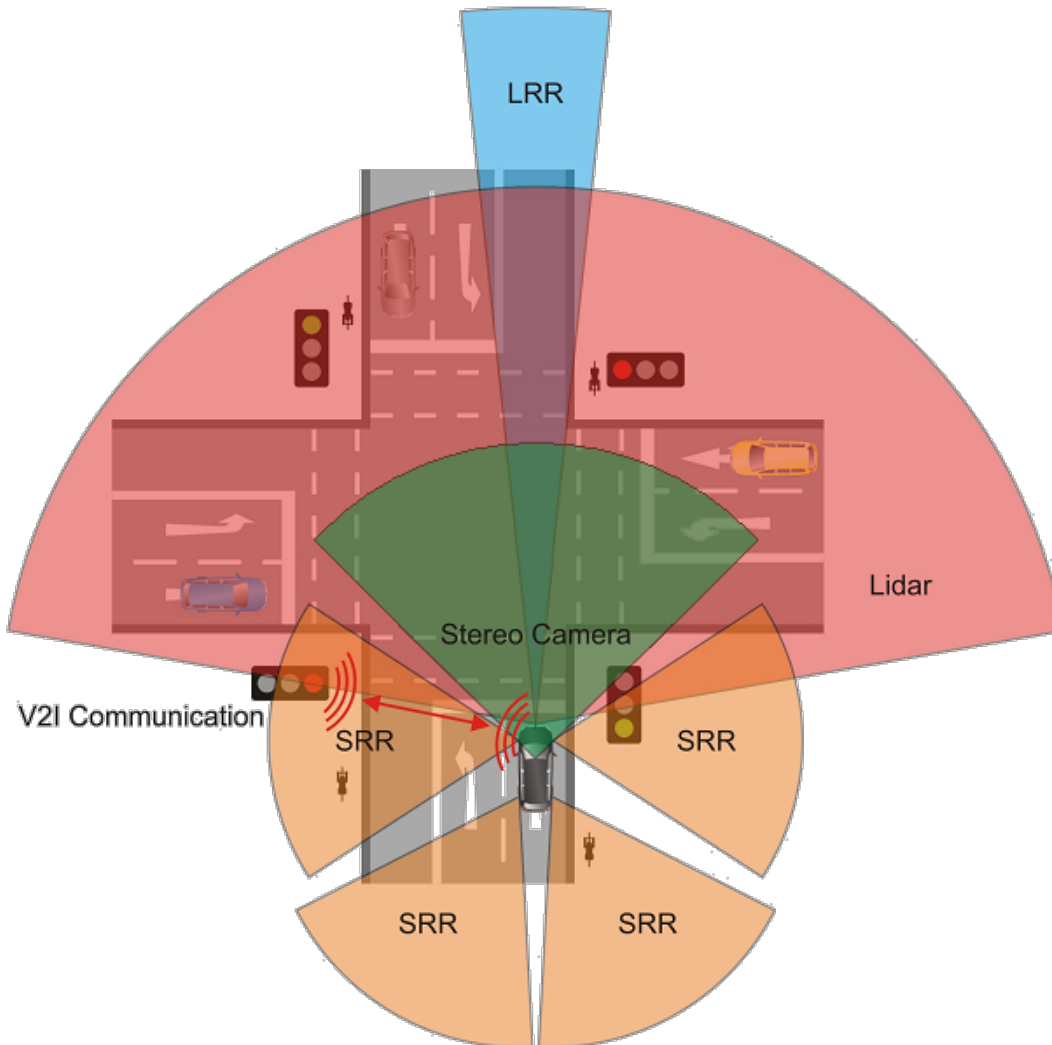


Stereo Camera

- Medium range sensor
- High density, medium accuracy 3D information
- Sensing of road and obstacle features

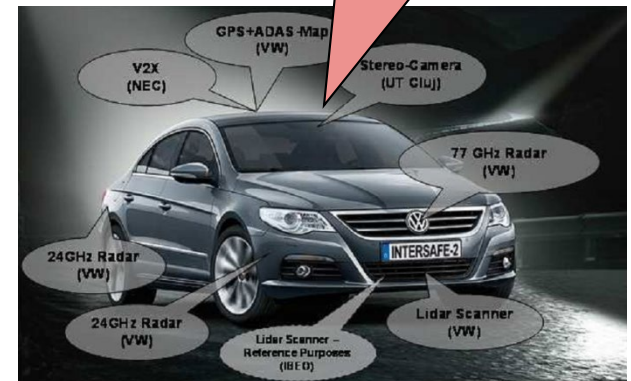


On-board Perception for Intersection Safety



Lidar

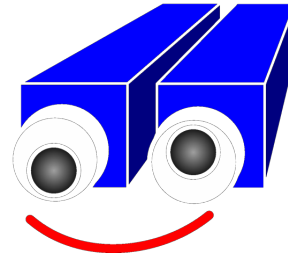
- Long range sensor
- High accuracy 3D information
- Sensing, tracking and classification of obstacles
- Intersection reconstruction



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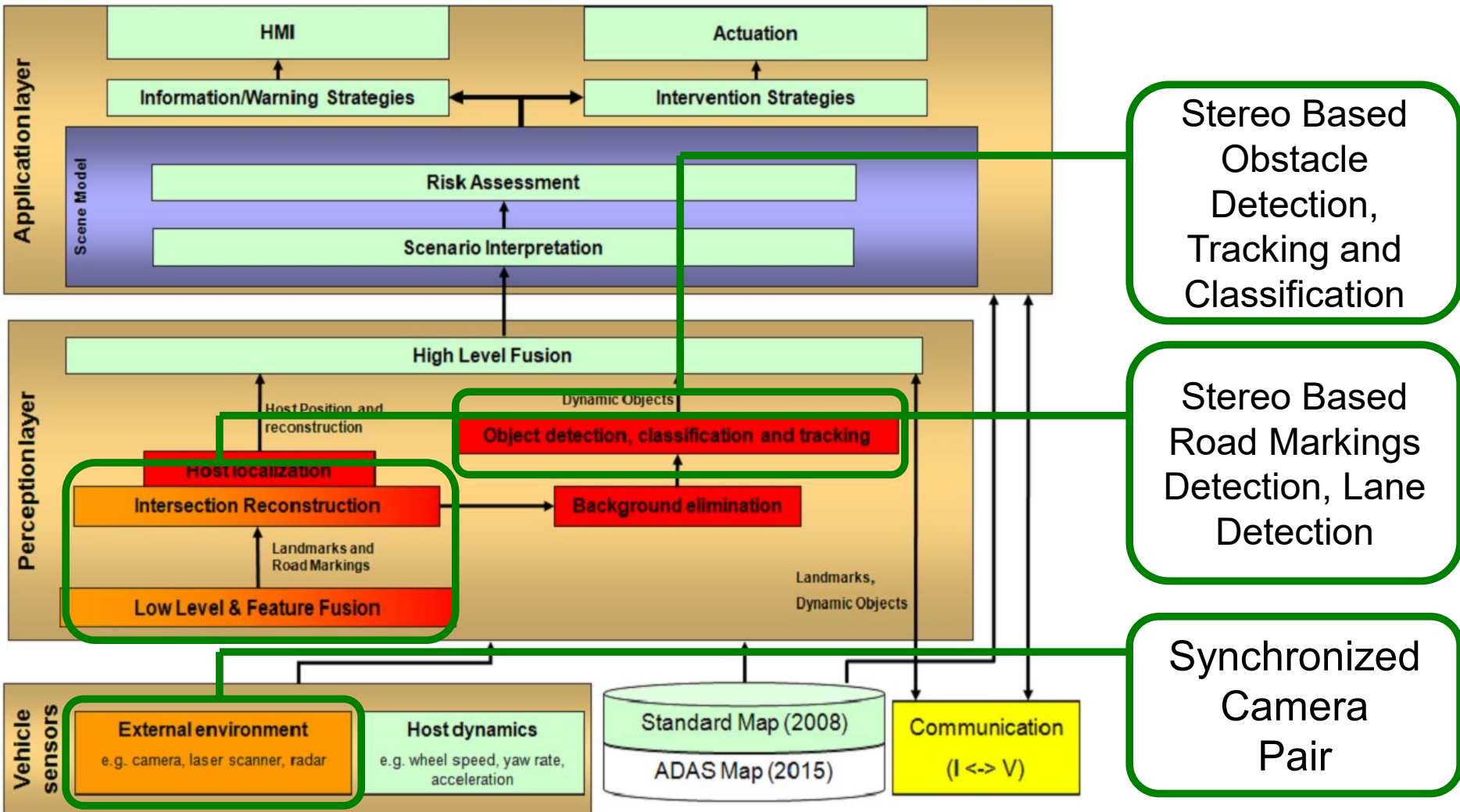
Perception through Stereovision

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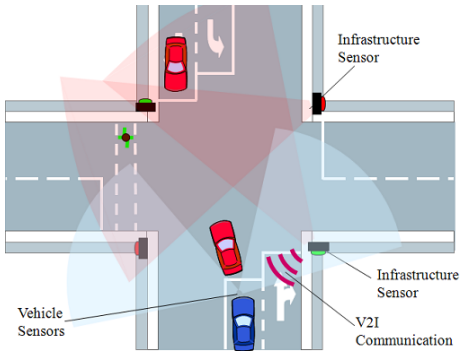




Requirements for the Stereo Sensor

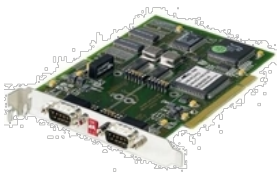


1. Detect the presence and measure the relative position and velocity of the oncoming vehicles.
2. Detect the presence of the crossing vehicles and crossing vulnerable road users and measure their position and velocity relative to the host vehicle.
3. Detect road markings and lane boundaries in front of the host vehicle and measure their relative position to the host vehicle.
4. Detect painted road signs in front of the host vehicle and measure their relative position to the host.
5. Localize the host vehicle when it is close to the stop line.
6. Localize the host vehicle within the intersection.





Stereo Camera Setup

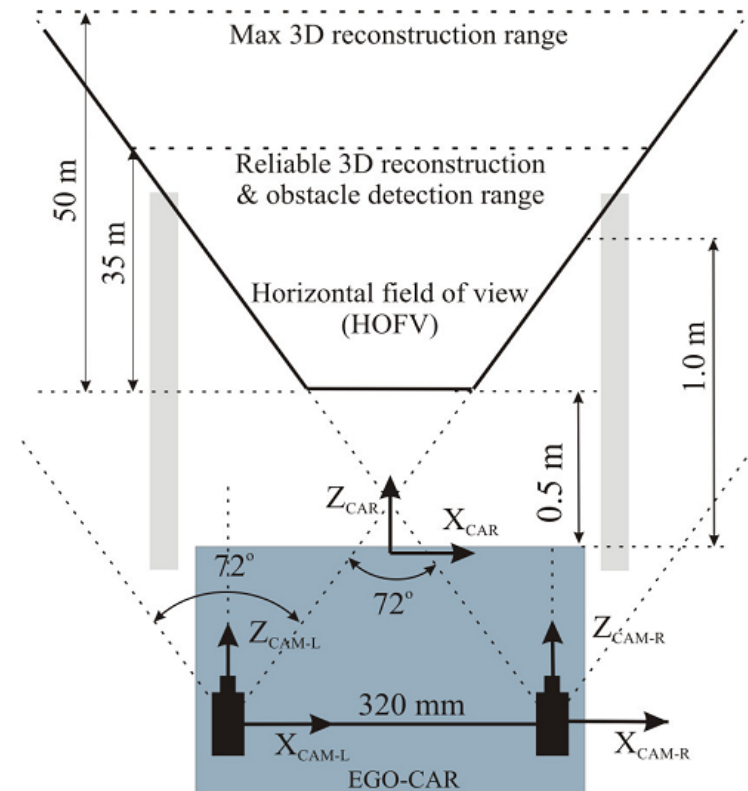


Specifications

- Focal length: 6.5 mm
- Imager size: 2/3"
- Digital image size: 1380x1030
- Baseline: 320 mm

Capabilities

- HFOV: 72 degrees
- Frame rate: 20 Hz





Stereo Image Acquisition

Specifications

- Synchronized image pair acquisition using a dual port CameraLink framegrabber.

Capabilities

- Image acquisition from multiple camera setups
- Adaptation to lighting conditions
- Real-time image rectification and downsampling





Dense Stereo Reconstruction and Dense Optical Flow Computation

Specifications

- Real-time stereo reconstruction using a dedicated TYZX board
- Real-time stereo reconstruction using original algorithms
- Real-time computation of optical flow

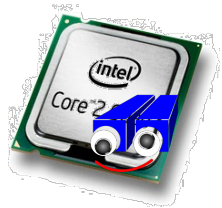
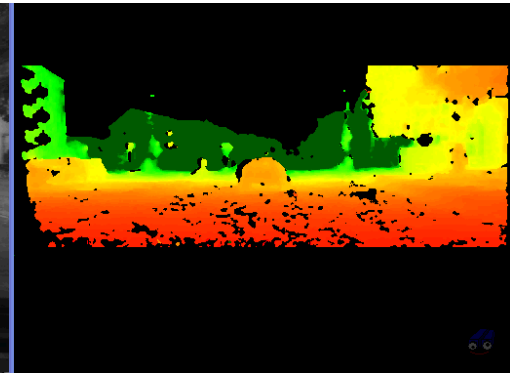
Capabilities

- Range: 0.5 – 50 m
- Frame rate: 20 Hz (limited by camera speed)
- Maximum error: 3% from depth





Dense Stereo Reconstruction and Dense Optical Flow Computation



Higher Level Functions

Structured Approach

- Current and side lanes detection and tracking.
- Road painted signs detection, localization and classification.
- Obstacle detection and tracking.
- Classification of relevant obstacles.

Unstructured Approach

- Environment perception by the use of digital elevation maps.

Lane Detection and Tracking

Specifications

- Lane width: 2 – 5 m
- Vehicle pitching: $\pm 2^\circ$
- Curvature radius: 50 m - infinity
- Range: 3 – 40 m
- Minimum visible road required for detection: 5 m



Road Painted Signs Detection, Localization and Classification

Specifications

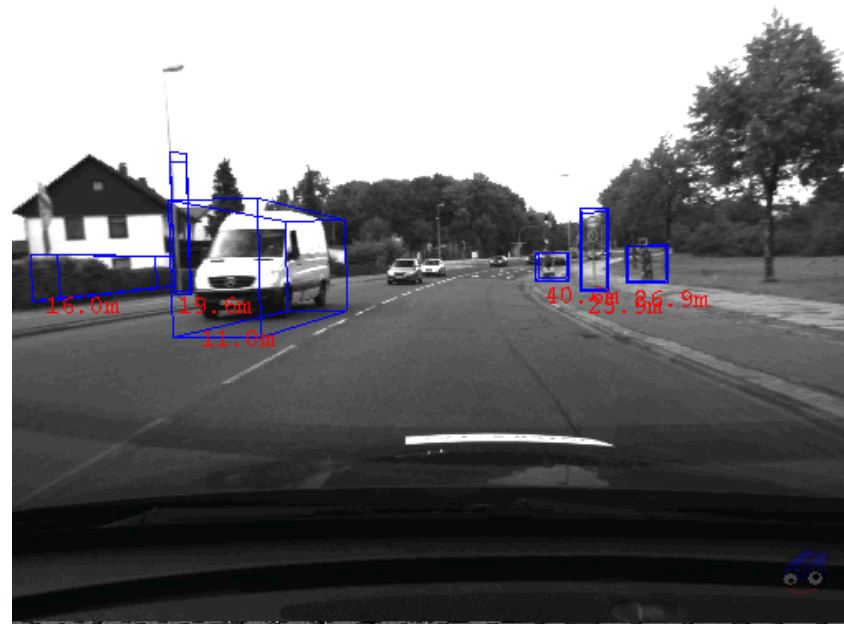
- Detection range, limited by the perspective effect: 3-15 m
- Classification accuracy: 90%
- Types of objects: Stop lines, Interrupted crossing lines, Lane markings, Arrows (forward, left, right, forward-left, forward-right)



Obstacle Detection and Tracking

Specifications

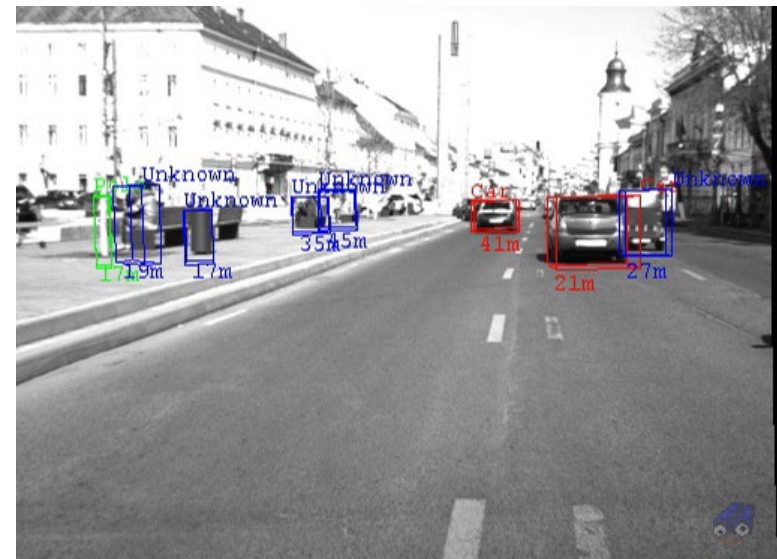
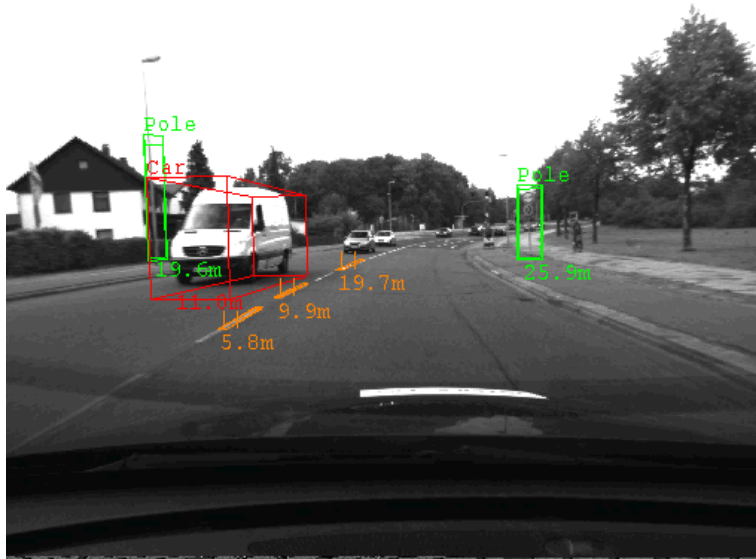
- Detection range: 0.5-40 m
- Positioning error: 3 % from range
- Detection rate: >95%



Classification of Relevant Obstacles

Specifications

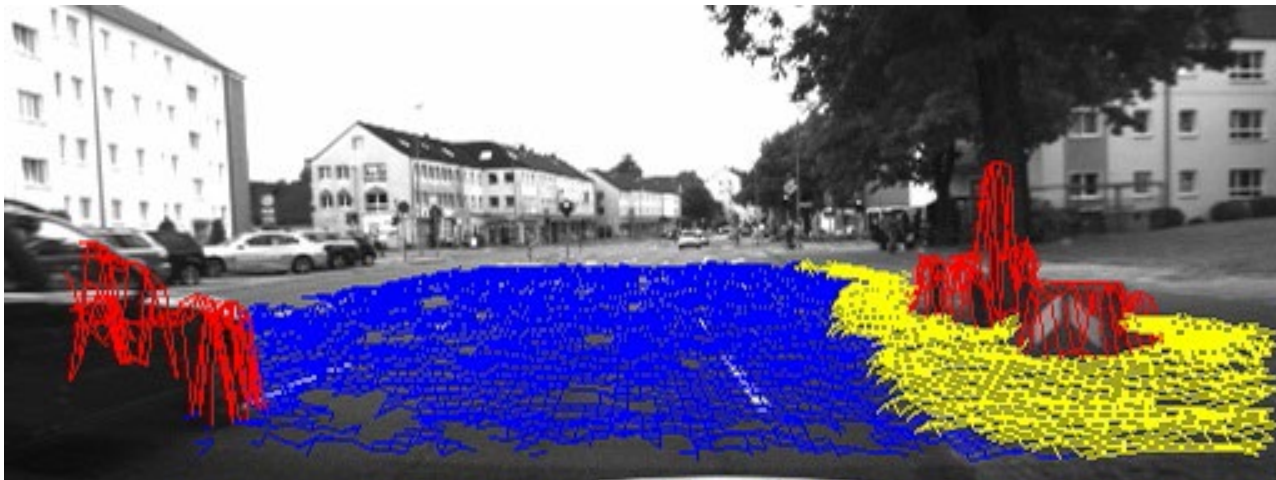
- Types of objects: Cars, Pedestrians, Bikes, Poles, Others: generic obstacles
- Classification accuracy: 90%



Environment Perception Using Elevation Maps

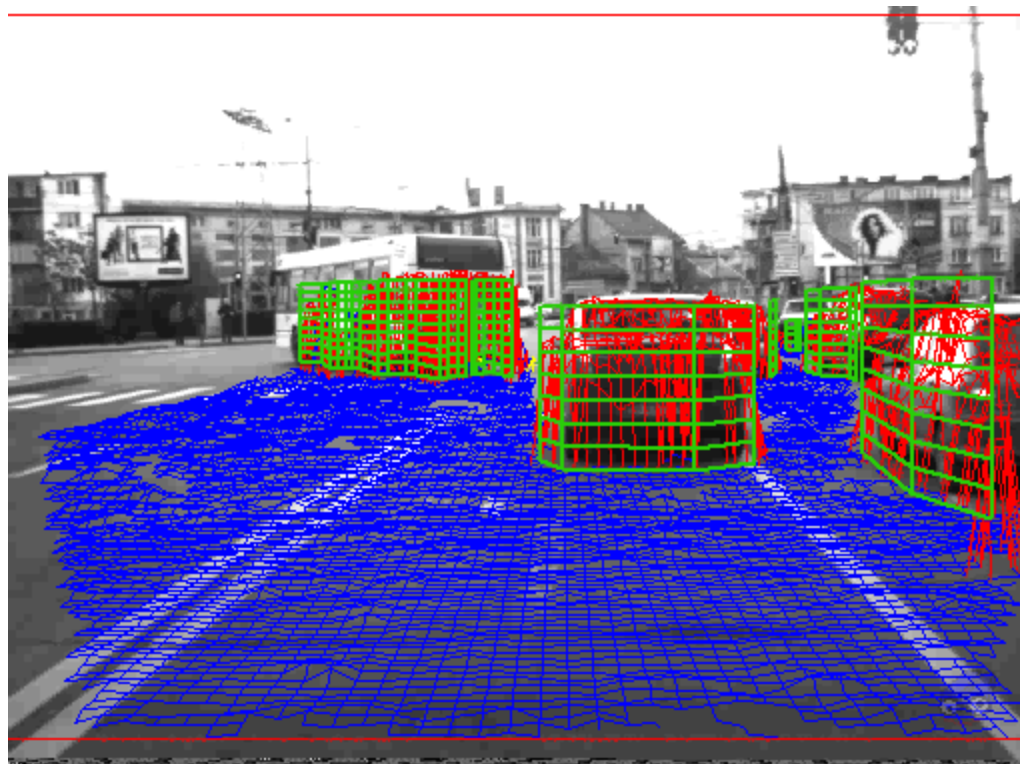
Specifications

- Cell size: 10 cm x 10 cm
- Grid size: 240 x 500 cells
- Scene covered: 24 m x 50 m
- Height (elevation) computed for each cell
- Class for each cell (road, obstacle, sidewalk)



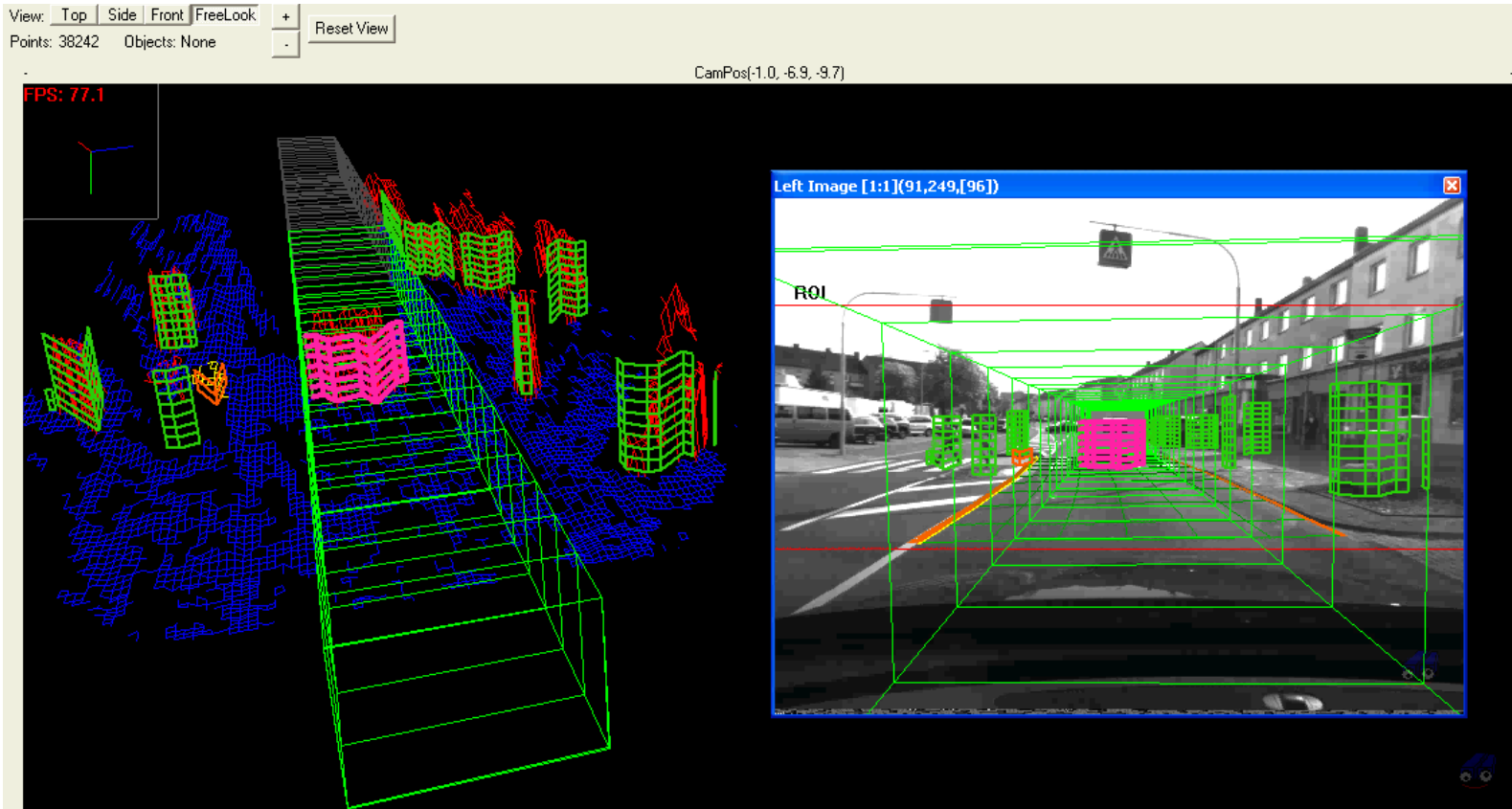
Environment Perception Using Elevation Maps

Compressed object representation based on attributed polygonal lines



Environment Perception Using Elevation Maps

Collision warning based on host vehicle trajectory prediction

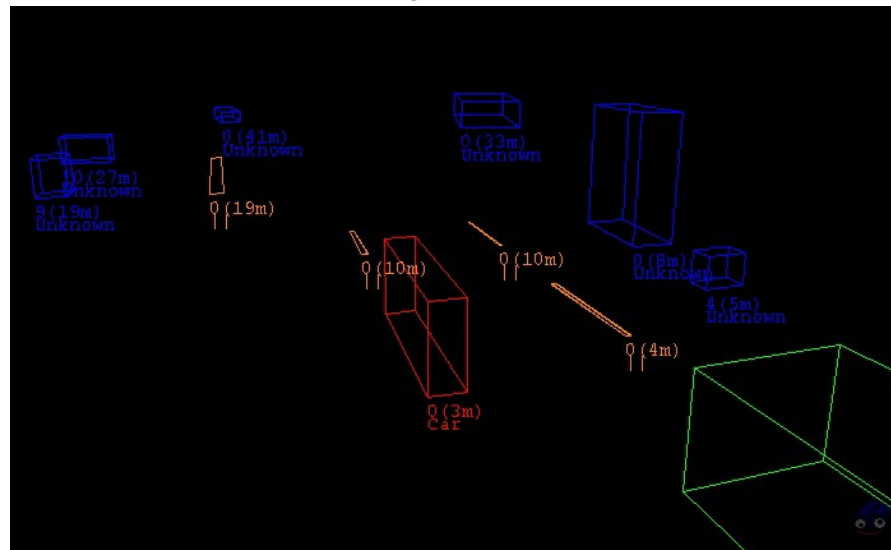


Communication of Results

Output structure

- Digital elevation map, with cells classified as curbs, obstacles and drivable area.
- Road data: list of painted road objects, description of lane geometry.
- Obstacle data: list of tracked and classified traffic objects.

The outputs are supplied through CAN or Ethernet.





Accurate perception of the vehicle position in intersections

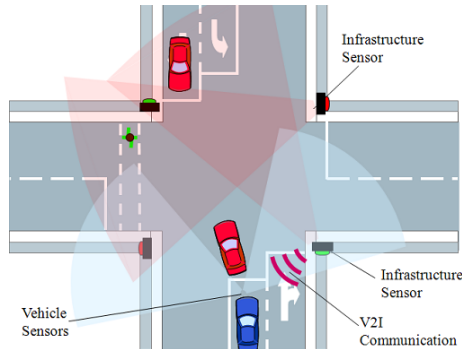
- Stereovision results can be fused with GPS and map information for precise determination of location and orientation in intersections.

Static and dynamic environment reconstruction

- Medium accuracy perception of most relevant aspects of the environment contributes towards a rich description of the driving environment.

Stereovision-based driving assistance applications: lane keeping assistance, automatic cruise control, stop and go, pedestrian avoidance, emergency braking.

- The stereovision sensor can provide most of the static and dynamic information needed for the most common driving assistance applications.



INTER SAFE2

Perception through Laser Scanner

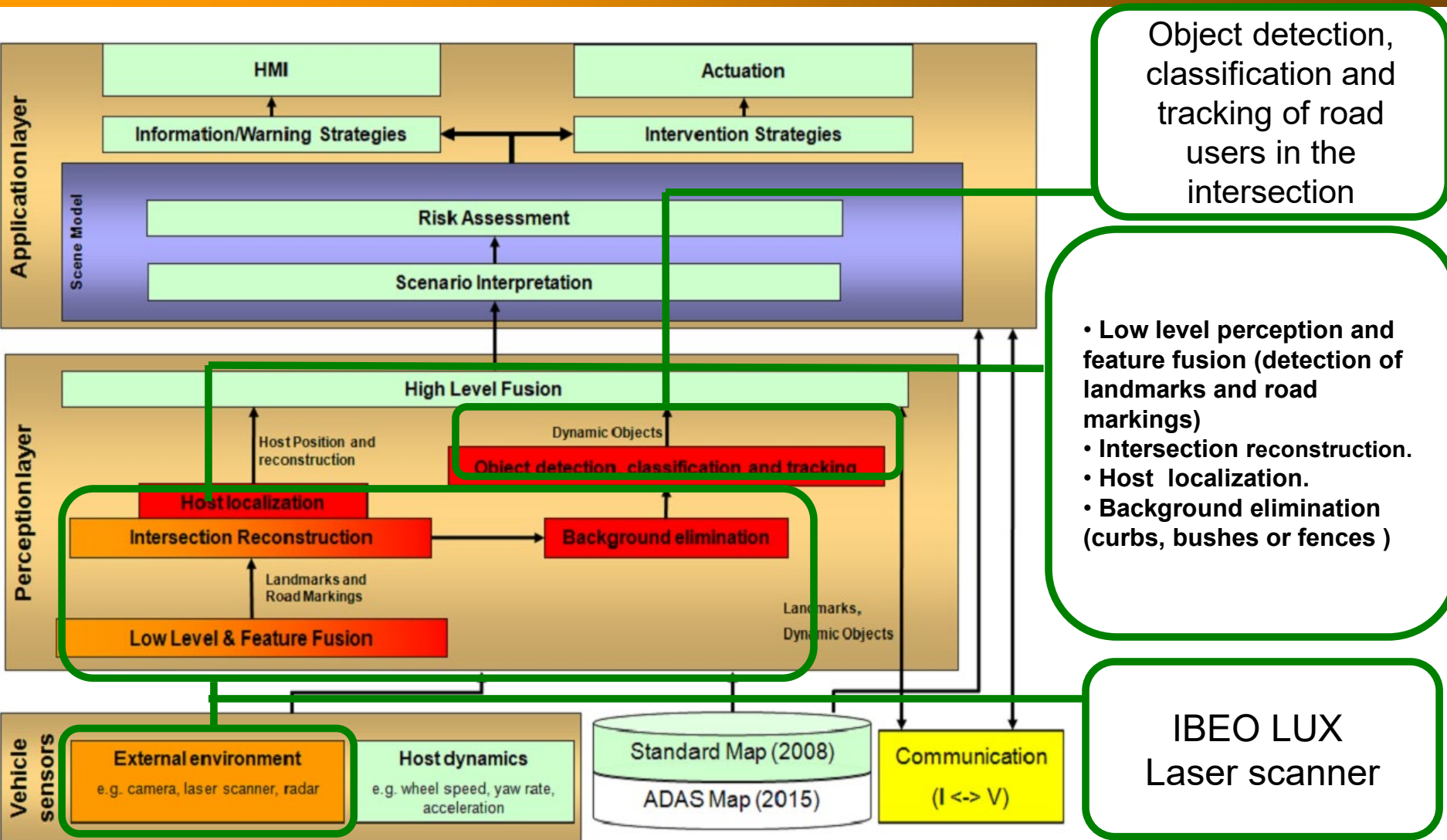
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Perception Through Laserscanner INTERSAFE2





Specifications

Inputs

- Installation parameters (e.g. height, orientation, offset to vehicle coordinate system)
- Host vehicle data (e.g. yaw rate, vehicle speed)
- Map data

Outputs

- Object data (tracked and classified)
- Intersection reconstruction

Performance

- The device is eye-safe (laser class 1)
- Scan frequency: 12.5/25 Hz
- Field of view (horizontal): 100°
- Range: 0.3m to 200m
- Angle resolution: 0.1° to 1°
- Built-in processing
- Parallel and simultaneous scanning layers

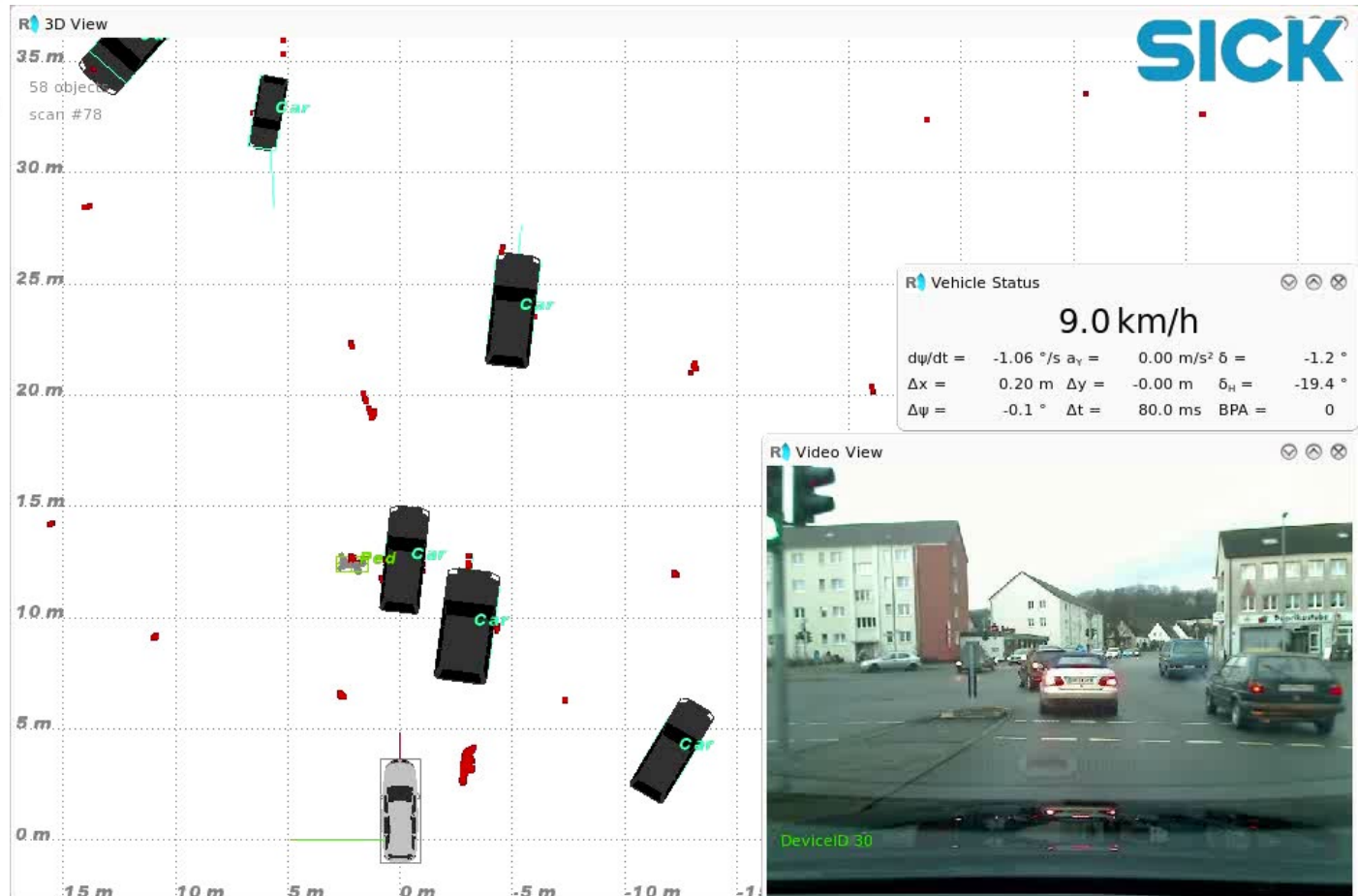


Detection, classification and tracking of obstacles





Detection, classification and tracking of obstacles



Laser Scanner-based Applications for Intersection Safety



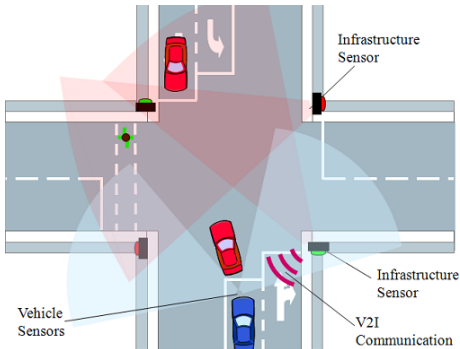
Accurate perception of the vehicle position in intersections

- Laser scanner results can be fused with GPS and map information for precise determination of location and orientation in intersections.

Static and dynamic environment reconstruction

- High accuracy perception of most static and dynamic obstacles in the intersection

Laser scanner-based driving assistance applications: automatic cruise control, stop and go, pedestrian avoidance, emergency braking.



Thank you !
Questions ?

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2009

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V. Popescu, M. Bace, S. Nedevschi, "Improved Localization and Enhanced Environment Representation by Sensorial and Digital Map Data Fusion in Intersections", in *Proceedings of the 8th International Workshop on Intelligent Transportation (WIT 2011)*, 29-24 March 2011, Hamburg, Germany.