

# Intensity and Depth Data Integration for Vehicle Detection

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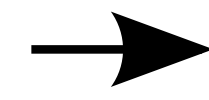
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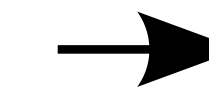


## Vehicle Detection Problem

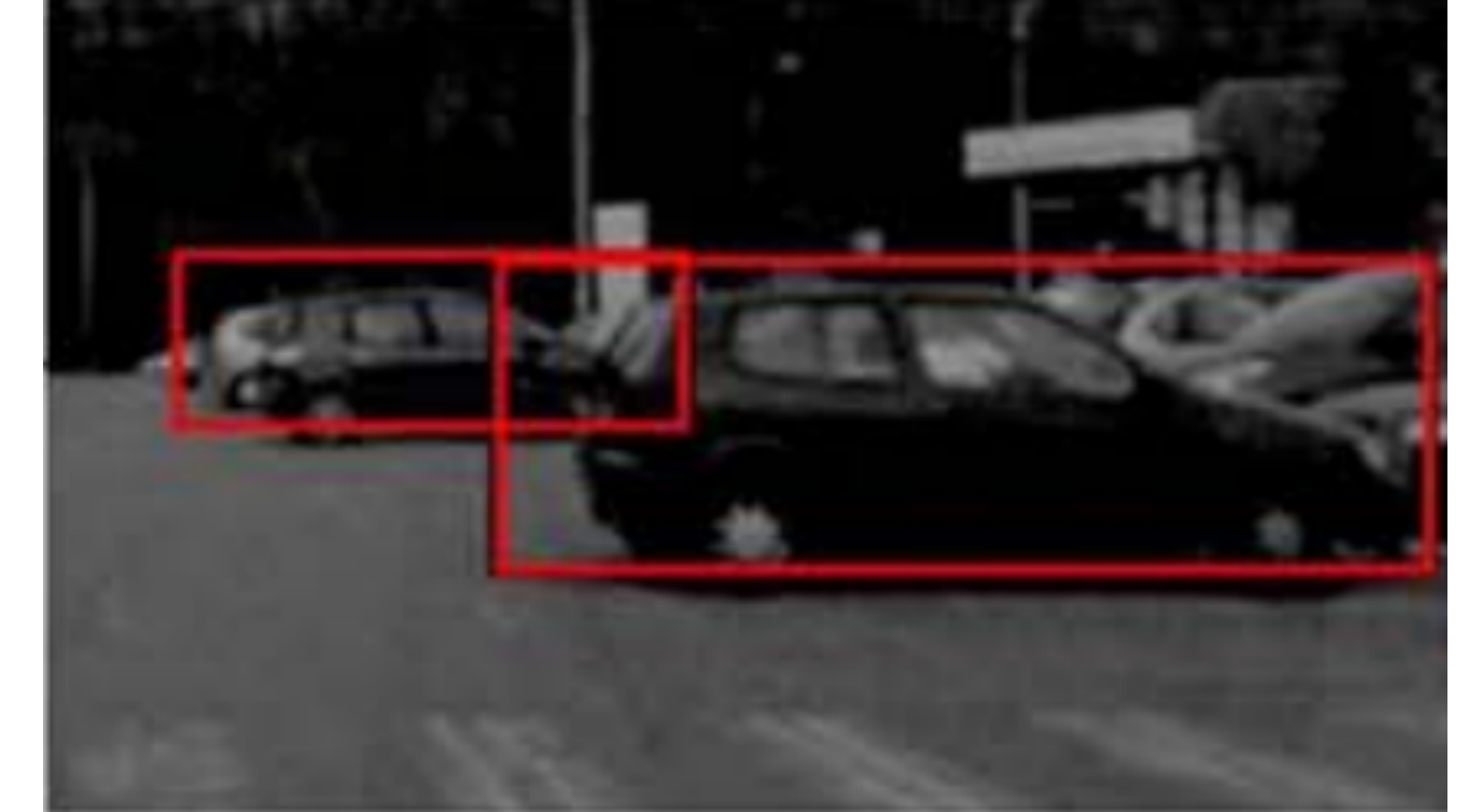
Original Scene



Lexus LS600h  
TYZX Stereo Camera [500x312 px]



3D Vehicle  
Detections/Localizations



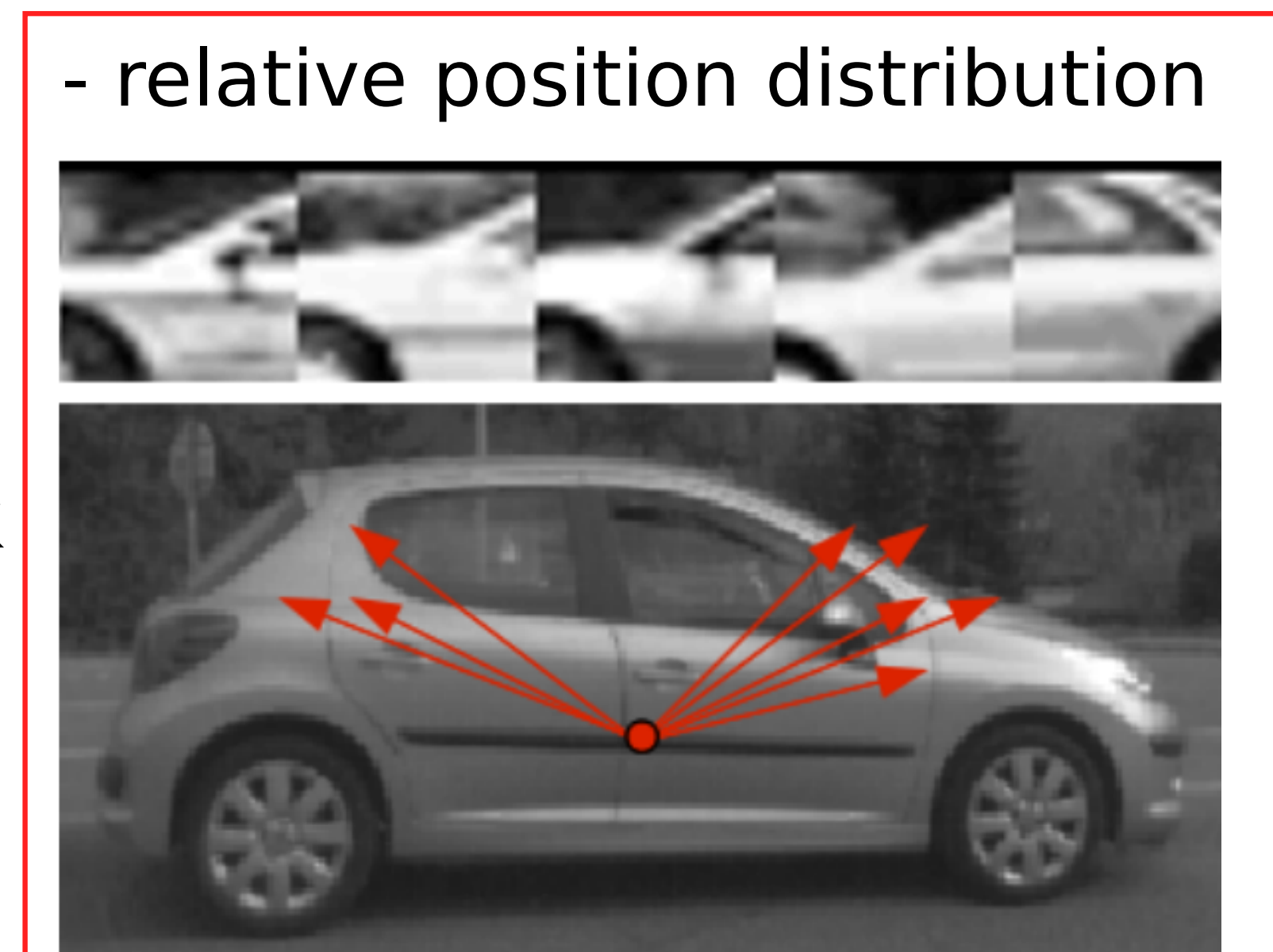
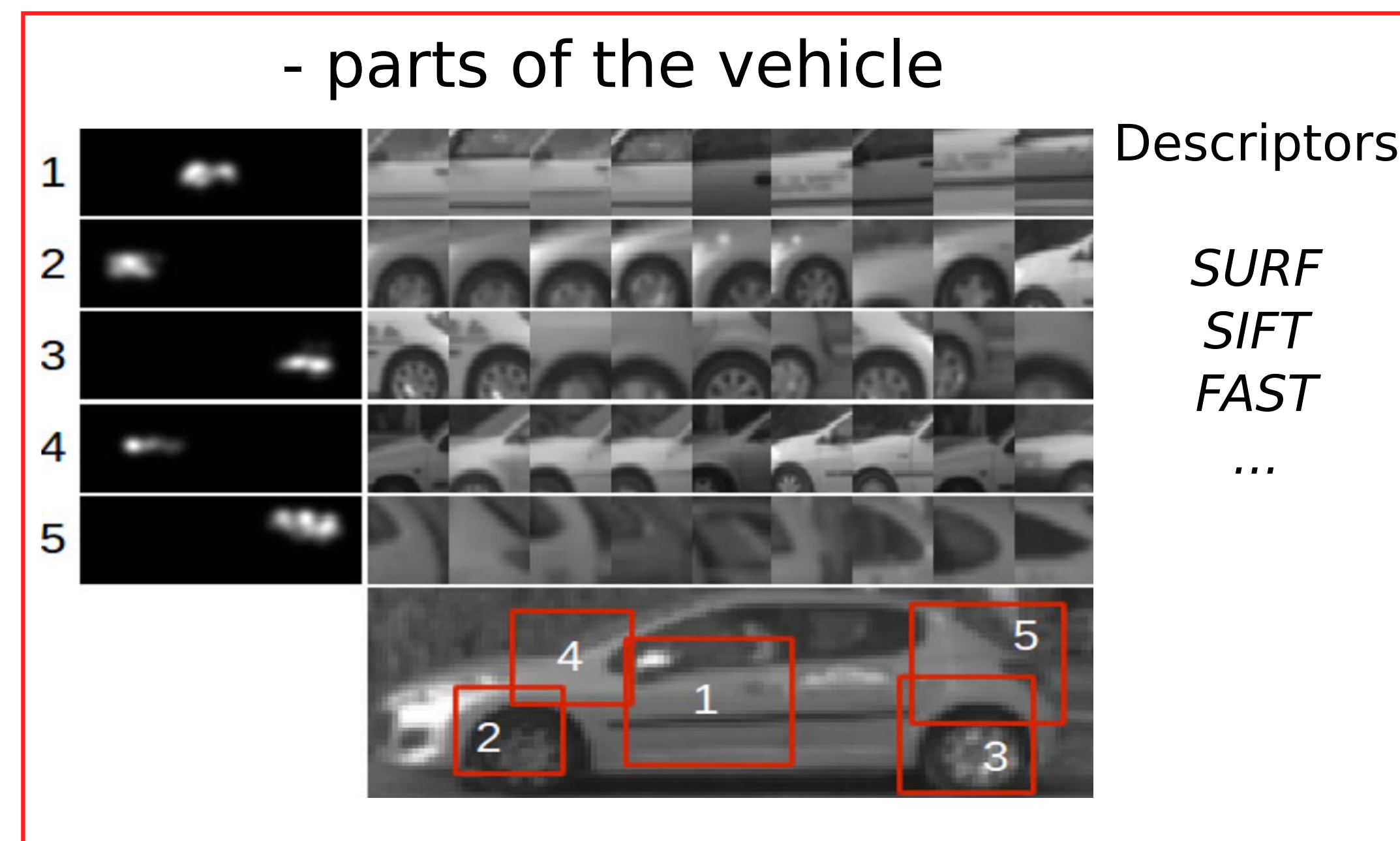
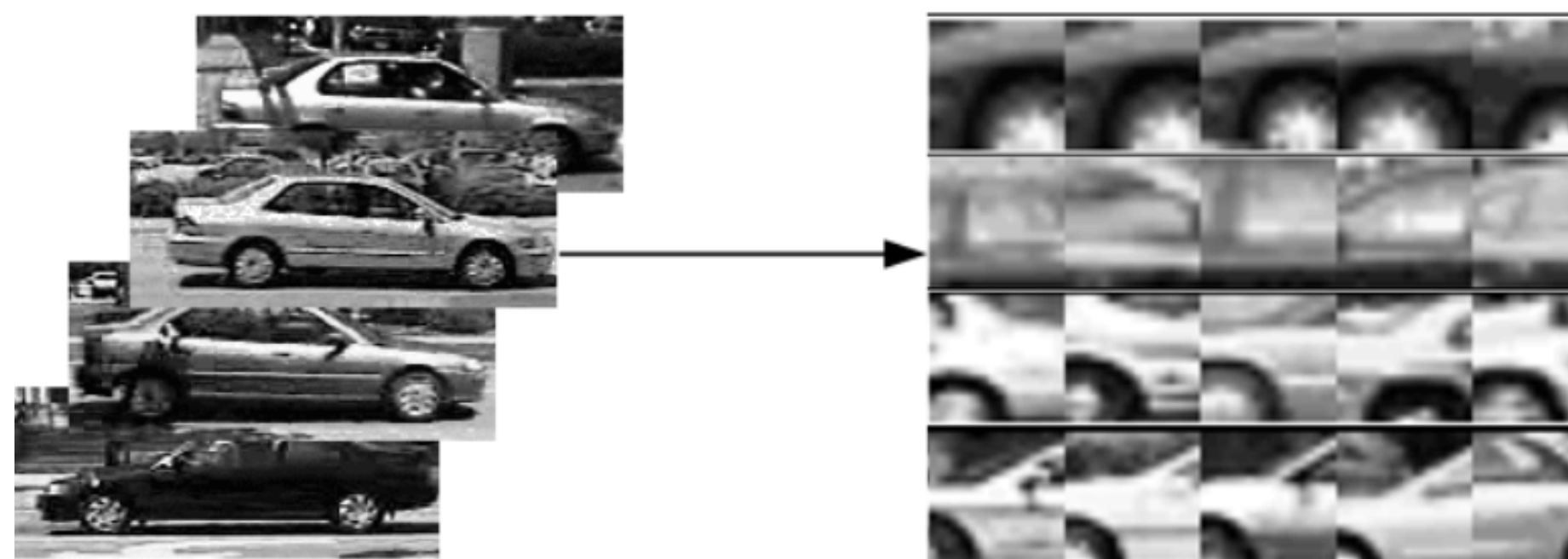
**Purpose** Driver Assistance in (Semi) Autonomous Driving Systems:  
- warn the driver  
- automatically initiate appropriate protective measure

**Challenges** - various viewpoints & scales  
- partial occlusions  
- moving sensor  
- large illumination variances  
- different possible vehicle appearances  
- cluttered background  
- real-time constraints

## Vehicle Detection Process [4,5]

### Off-Line Learning

Codebooks include the set of clusters representing:



### On-Line Detection

#### Filters out:

- road surface
- objects over a predefined height

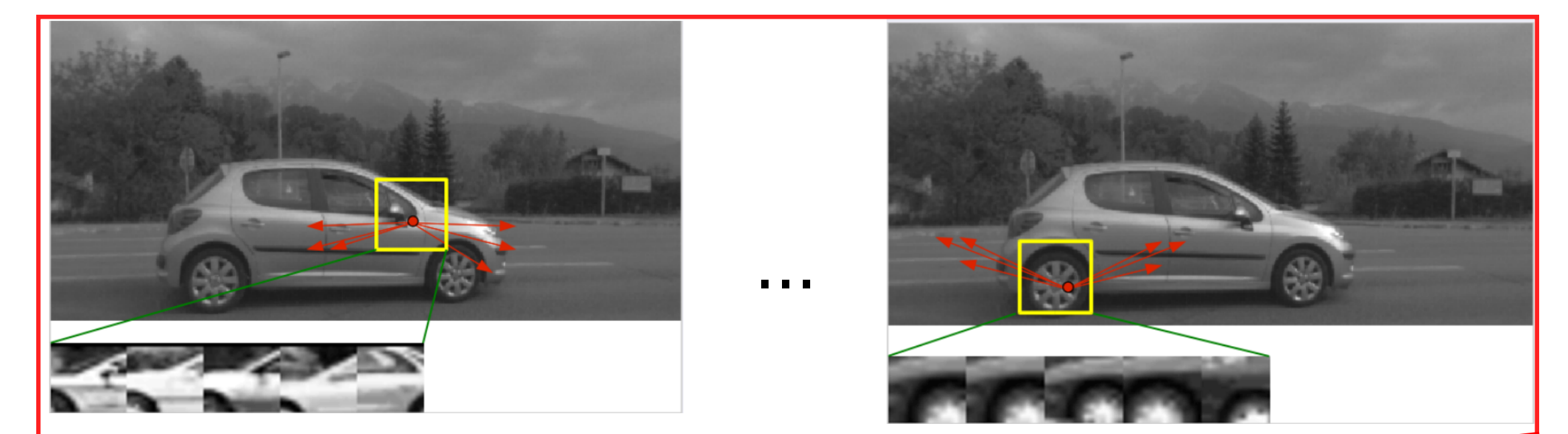


#### Camera Inputs

#### Intensity Features [1]



#### Depth Features [2,3]



Original Image

Stereo Mask



Codebook Matching

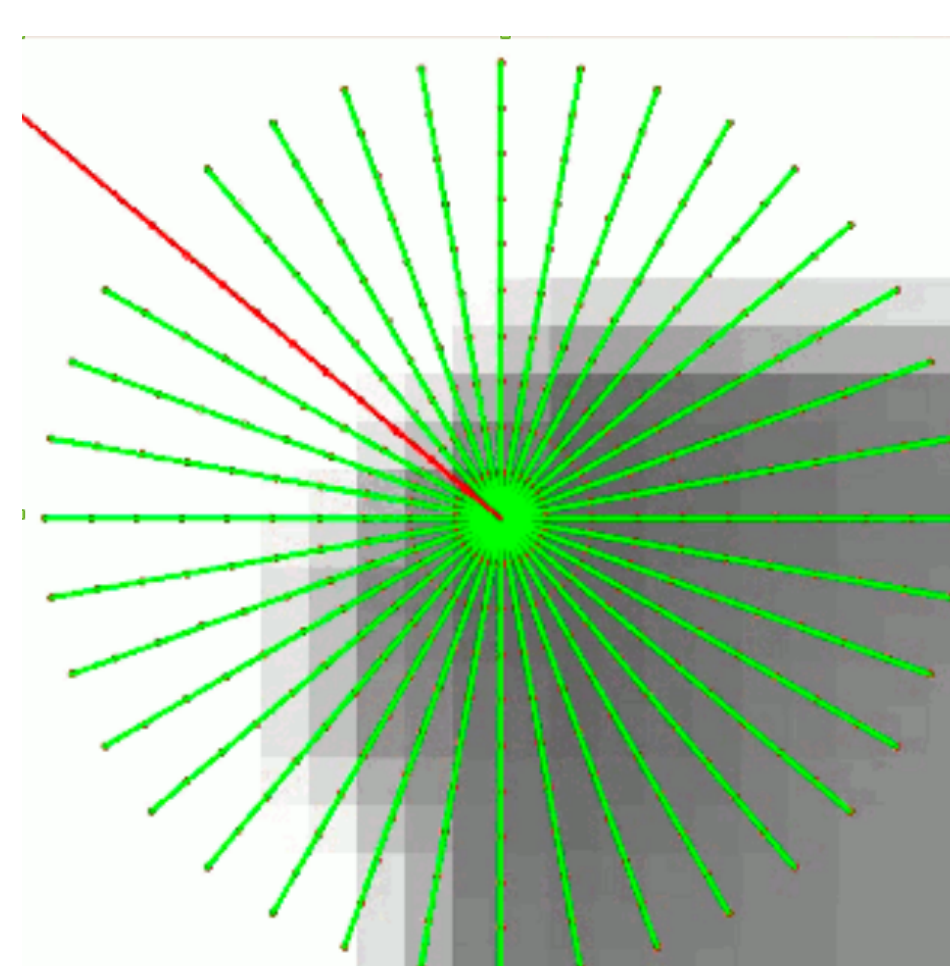
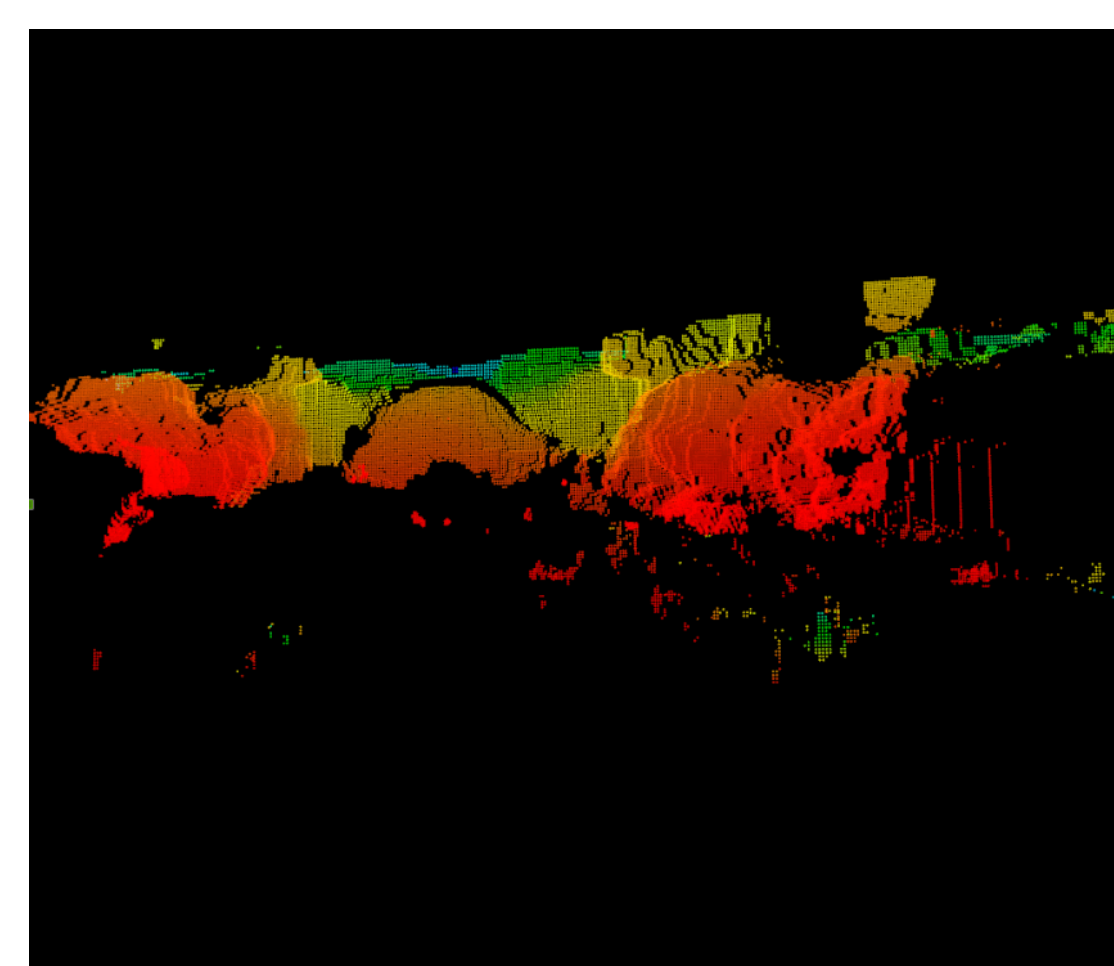


Detections

**Depth Features** Sufficient Changes in the Immediate Depth  
*focus on areas that are unique, e.g. car borders*

[NARF (Normal Aligned Radial Feature)]

Original Scene



## References

- [1] Leibe, Leonardis, Schiele, "Robust Object Detection with Interleaved Categorization and Segmentation", International Journal of Computer Vision, 2008, 77 (1-3):259-289.
- [2] Alonso, Llorca, Sotelo, Bergasa, de Toro, Nuevo, Ocana, Garrido, "Combination of Feature Extraction Methods for SVM Pedestrian Detection", IEEE Transactions on Intelligent Transportation Systems, 2007, 8(2):292-307.
- [3] Rohrbach, Enzweiler, Gavrila, "High-level Fusion of Depth and Intensity for Pedestrian Classification", DAGM-Symposium, 2009, pg 101-110.
- [4] Makris, Perrollaz, Paromtchik, Laugier, "Integration of Visual and Depth Information for Vehicle Detection", 2011, IROS.
- [5] Makris, Perrollaz, Laugier, "Probabilistic Integration of Intensity and Depth Information for Part-Based Vehicle Detection", IEEE Transactions on Intelligent Transportation Systems, 2013, 14(4):1896-1906.