IV Jornadas de Encuentros Doctorales LSI

Advanced Driver Assistance Systems for Road Environments

Student:

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Supervisors:

- **Ph.D. José María Armingol**
- **Ph.D. David Martín (yet to formalize)**

Laboratorio de Sistemas Inteligentes | Intelligent Systems Lab

Universidad Carlos III de Madrid

Outline

- Introduction
- State of the art
- Work done
- Work in progress
- Work to do
- Conclusions

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Introduction

Drivers, Especially Women, Wary of Autonomous Cars

BY ANGELA MOSCARITOLO JUNE 9, 2015 04:05PM EST 9 COMMENTS

Fifty percent of respondents wouldn't pay extra for a self-driving car and 46 percent don't think they're safe.

335 SHARES

Google's Self-Driving Cars '… Grandma'

Robert Hackett / Fortune | June 1, 2015

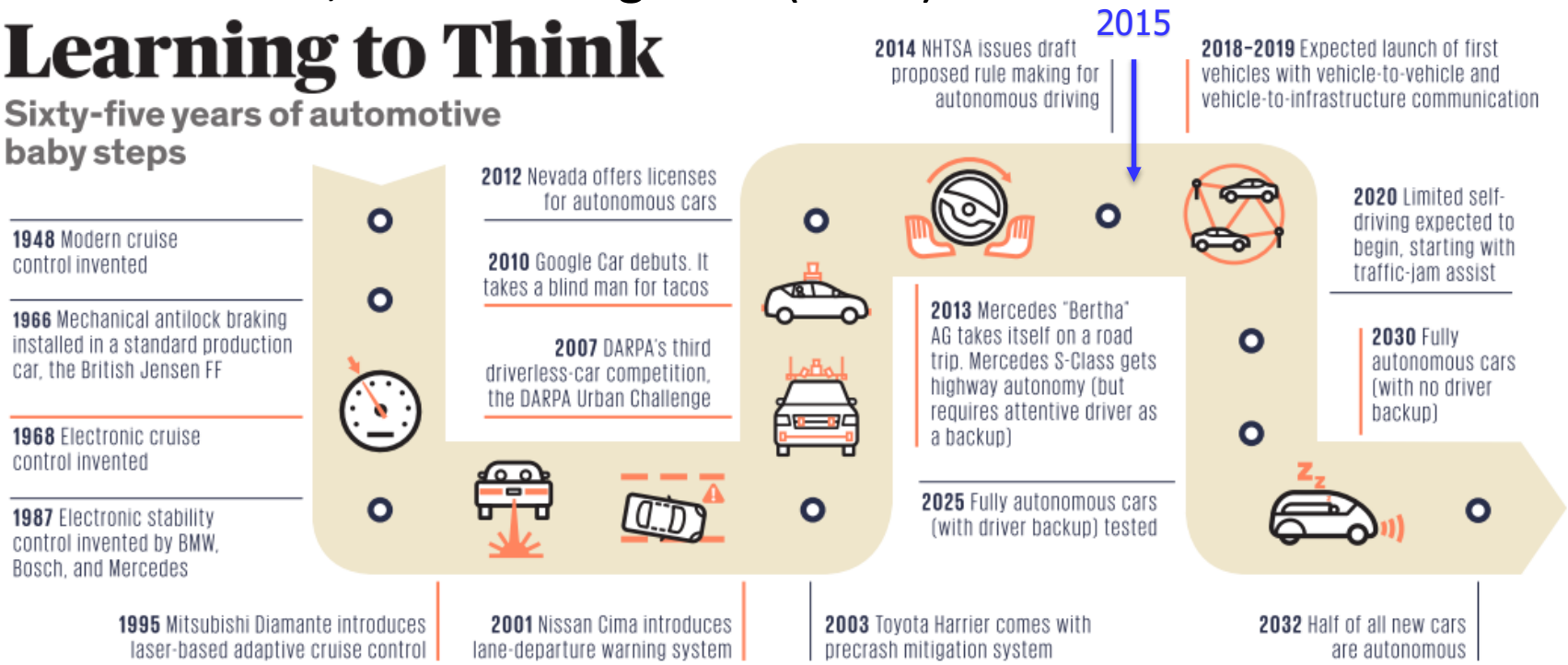
But that's probably a good thing

Slow and steady may win the race when it comes to autonomous vehicles.

A self-declared Mountain View,

Introduction

- "Automating the vehicle is a long continuum"
- "Really automatic, as for a blind driver? 50 years"
  J.Desens, Daimler engineer (2014)



ROSS, Patrick. Robot, you can drive my car. *Spectrum, IEEE*, 2014, vol. 51, no 6, p. 60-90.

Introduction

- **My PhD topics:**
  - ADAS-ROAD: Advanced driver assistance system for rural and intercity environments
  - Focused on single-carriageways
  - Poorly structured environments / more variability

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State of the art

Future research foci

Klaus Bengler
Technische Universität München

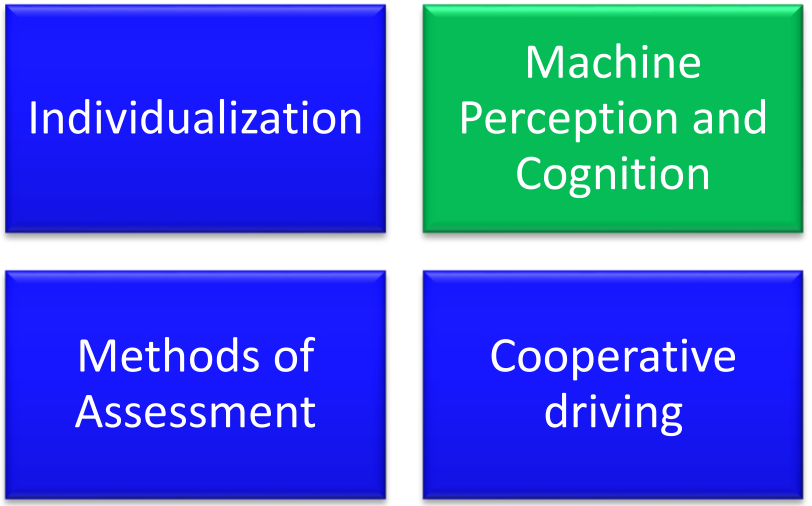
Klaus Dietmayer
Universität Ulm

Berthold Färber
Universität der Bundeswehr München

Markus Maurer
Technische Universität Braunschweig

Christoph Stiller
Karlsruher Institut für Technologie

Hermann Winner
Technische Universität Darmstadt



- "Machine cognition and situational awareness are still in their infancy"

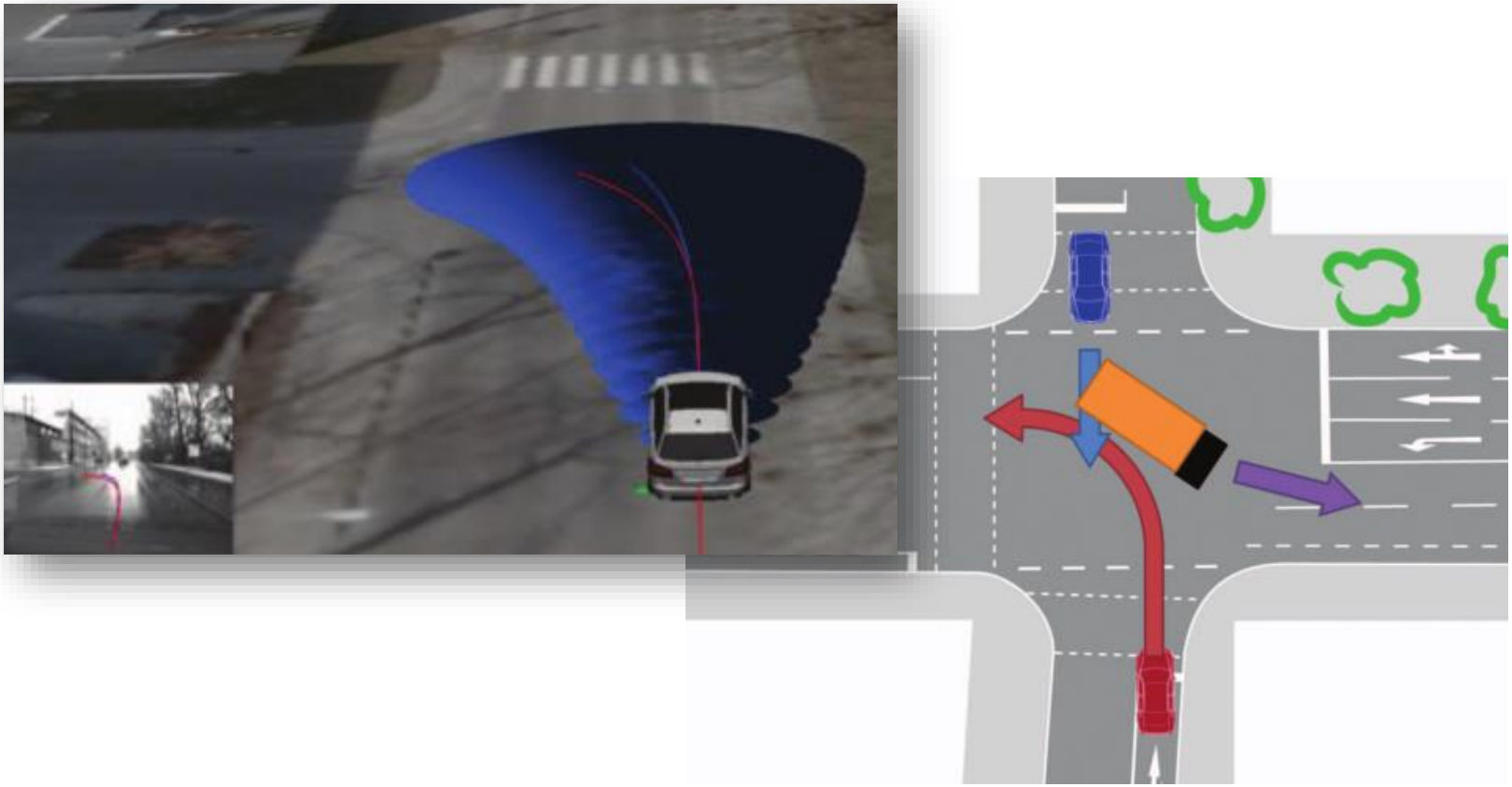
BENGLER, Klaus, et al. Three Decades of Driver Assistance Systems. *Intelligent Transportation Systems Magazine, IEEE*, 2014, vol. 6, no. 4, p. 6-22.

State of the art

- **Machine perception - Future research foci**
  - Improvement of sensor HW and SW
  - Generation of local dynamic maps
  - Improved algorithms for vehicle **situational awareness** in complex traffic scenarios
  - Development of methods and algorithms to acquire **situational awareness** at a safety-relevant level
  - Intention and behavior models to **predict the behavior** of the driver and other traffic participants

BENGLER, Klaus, et al. Three Decades of Driver Assistance Systems. *Intelligent Transportation Systems Magazine, IEEE*, 2014, vol. 6, no. 4, p. 6-22.

- **Machine perception - Future research foci**

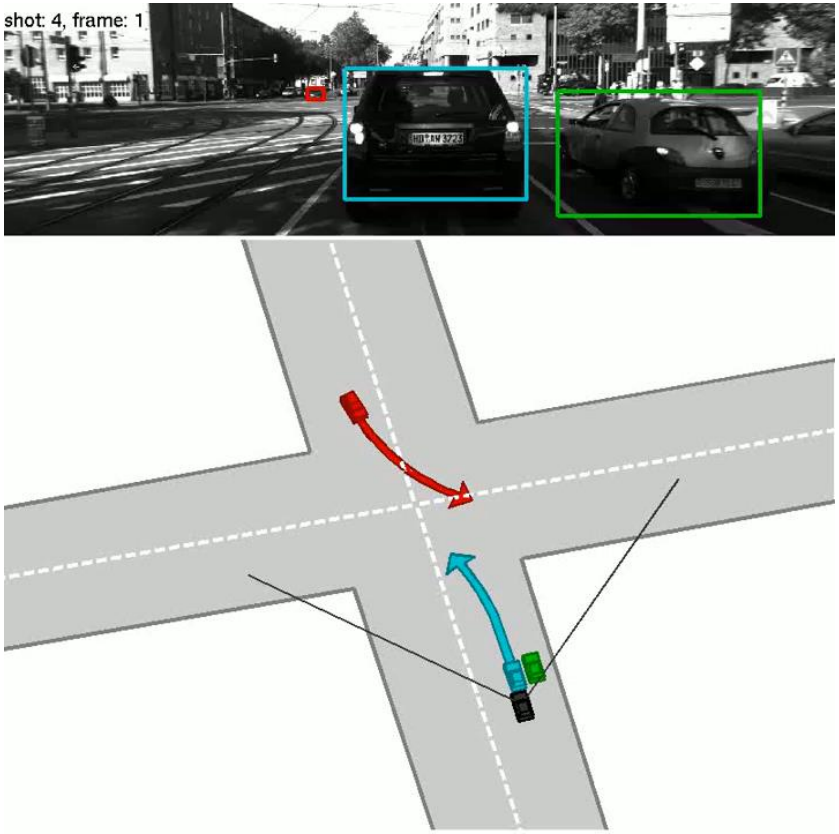


BENGLER, Klaus, et al. Three Decades of Driver Assistance Systems. *Intelligent Transportation Systems Magazine, IEEE*, 2014, vol. 6, no. 4, p. 6-22.

Scene understanding

- Estimating the road layout $\mathcal{R}$ from the image evidence $\mathcal{E}$, given a set of parameters Θ

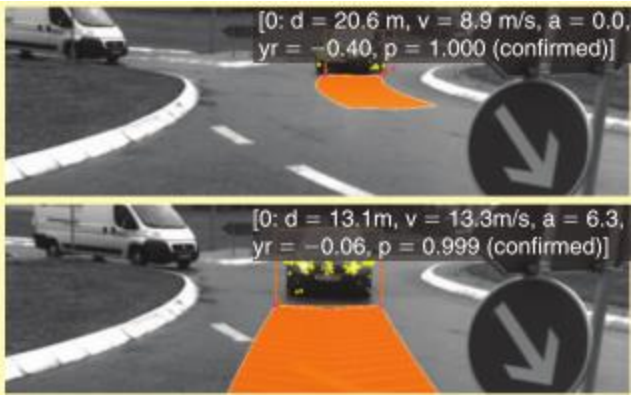
$$p(\mathcal{E},\mathcal{R}|\Theta) = \underbrace{p(\mathcal{R}|\Theta)}_{\text{Prior}} \underbrace{\prod_{i=1}^{N_t} p(\mathbf{t}_i|\mathcal{R},\Theta)}_{\text{Vehicle Tracklets}} \underbrace{\prod_{i=1}^{N_v} p(v_i|\mathcal{R},\Theta)}_{\text{Vanishing Points}}$$
$$\times \underbrace{\prod_{i=1}^{N_s} p(\mathbf{s}_i|\mathcal{R},\Theta)}_{\text{Scene Labels}} \underbrace{\prod_{i=1}^{N_f} p(\mathbf{f}_i|\mathcal{R},\Theta)}_{\text{Scene Flow}} \underbrace{\prod_{i=1}^{N_o} p(\rho_i|\mathcal{R},\Theta)}_{\text{Occupancy Grid}}$$

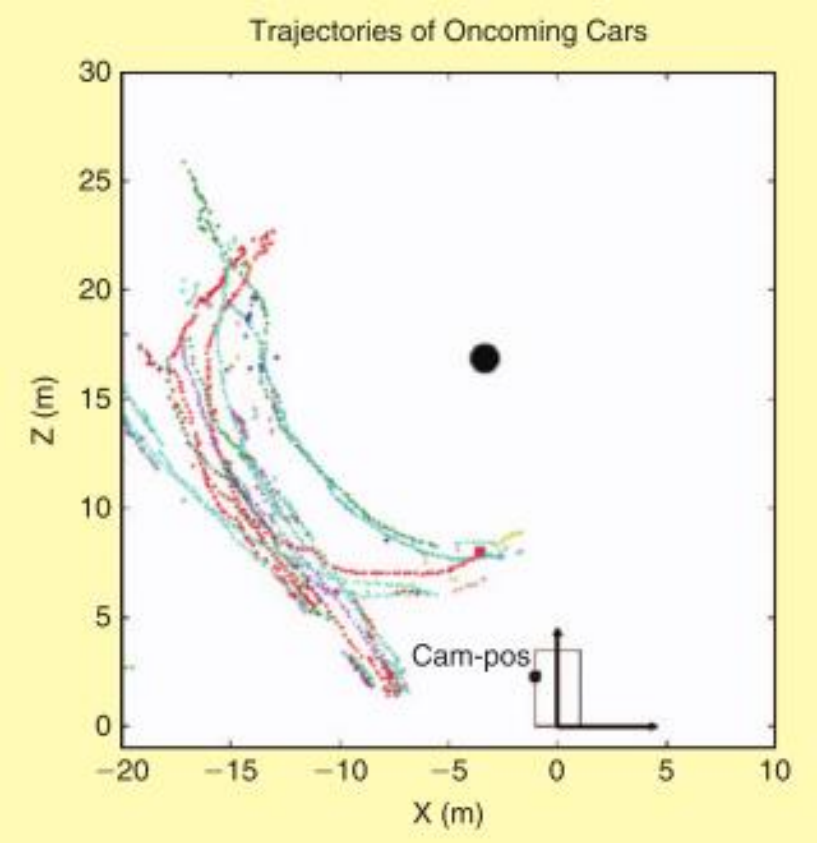


GEIGER, Andreas, et al. 3D traffic scene understanding from movable platforms. *Pattern Analysis and Machine Intelligence, IEEE Transactions on*, 2014, vol. 36, no 5, p. 1012-1025.

State of the art

- **Traffic behavior**
  - Recognition of dangerous situations at roundabouts from stereo vision





MUFFERT, Maximilian; PFEIFFER, David; FRANKE, Ulrik. A stereo-vision based object tracking approach at roundabouts. *Intelligent Transportation Systems Magazine, IEEE*, 2013, vol. 5, no 2, p. 22-32.

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Work done

- **Bumblebee XB3 driver for ROS**

ROS

Pablo
César

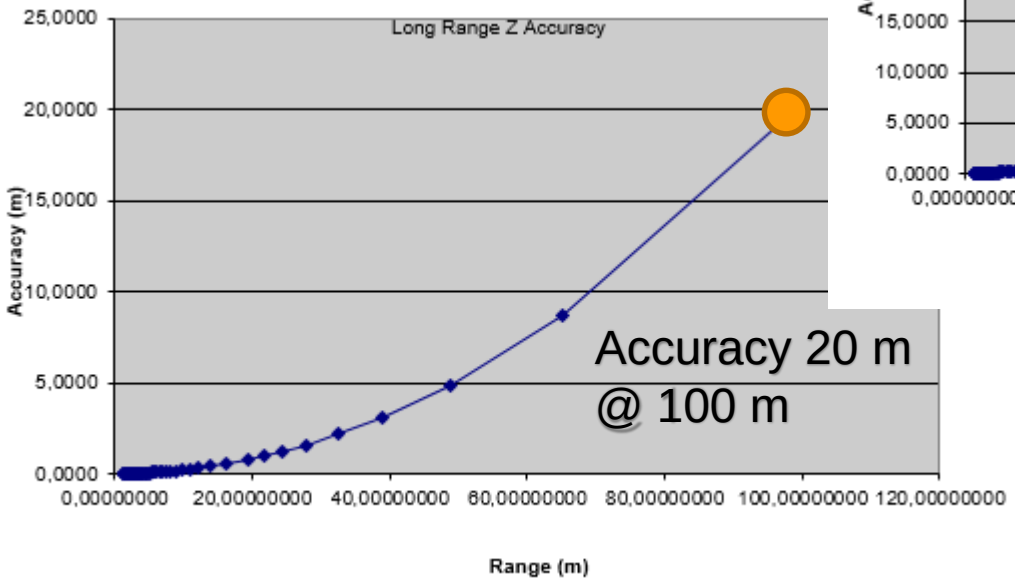
FRANKE, U.; GEHRIG, S. How cars learned to see. *Proceedings of 54th Photogrammetric Week*, 2013, p. 3-10.

Work done

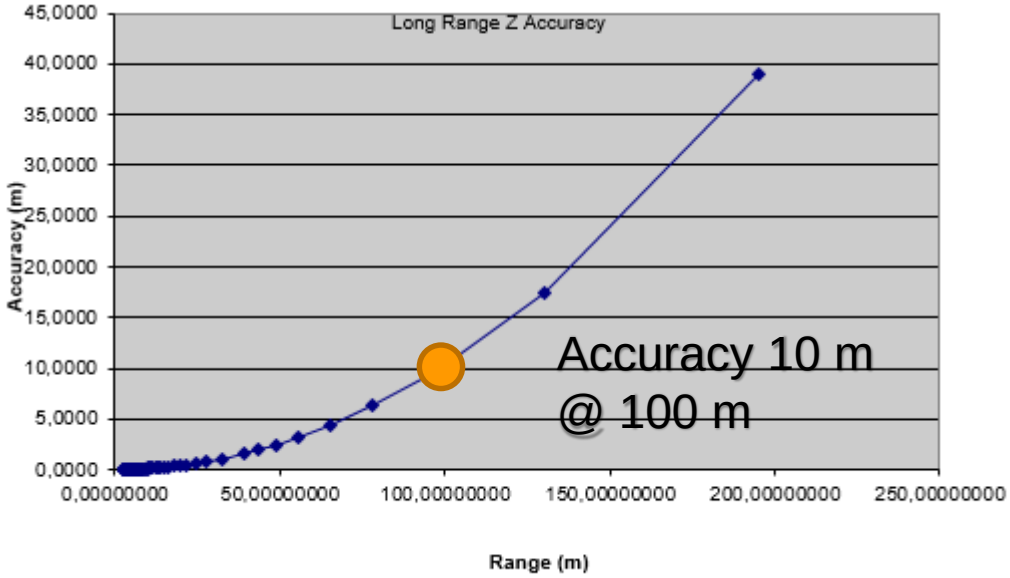
Bumblebee XB3 driver for ROS

$$\epsilon_Z = \frac{fB}{d} - \frac{fB}{d+\epsilon_d} \approx \frac{Z^2}{fB} \cdot \epsilon_d$$

Baseline = 120 mm



Baseline = 240 mm



Point Grey Research
Stereo Accuracy

Work done

- **Bumblebee XB3 driver for ROS + BM disparity**

KONOLIGE, Kurt. Small vision systems: Hardware and implementation. In *Robotics Research*. Springer London, 1998. p. 203-212.

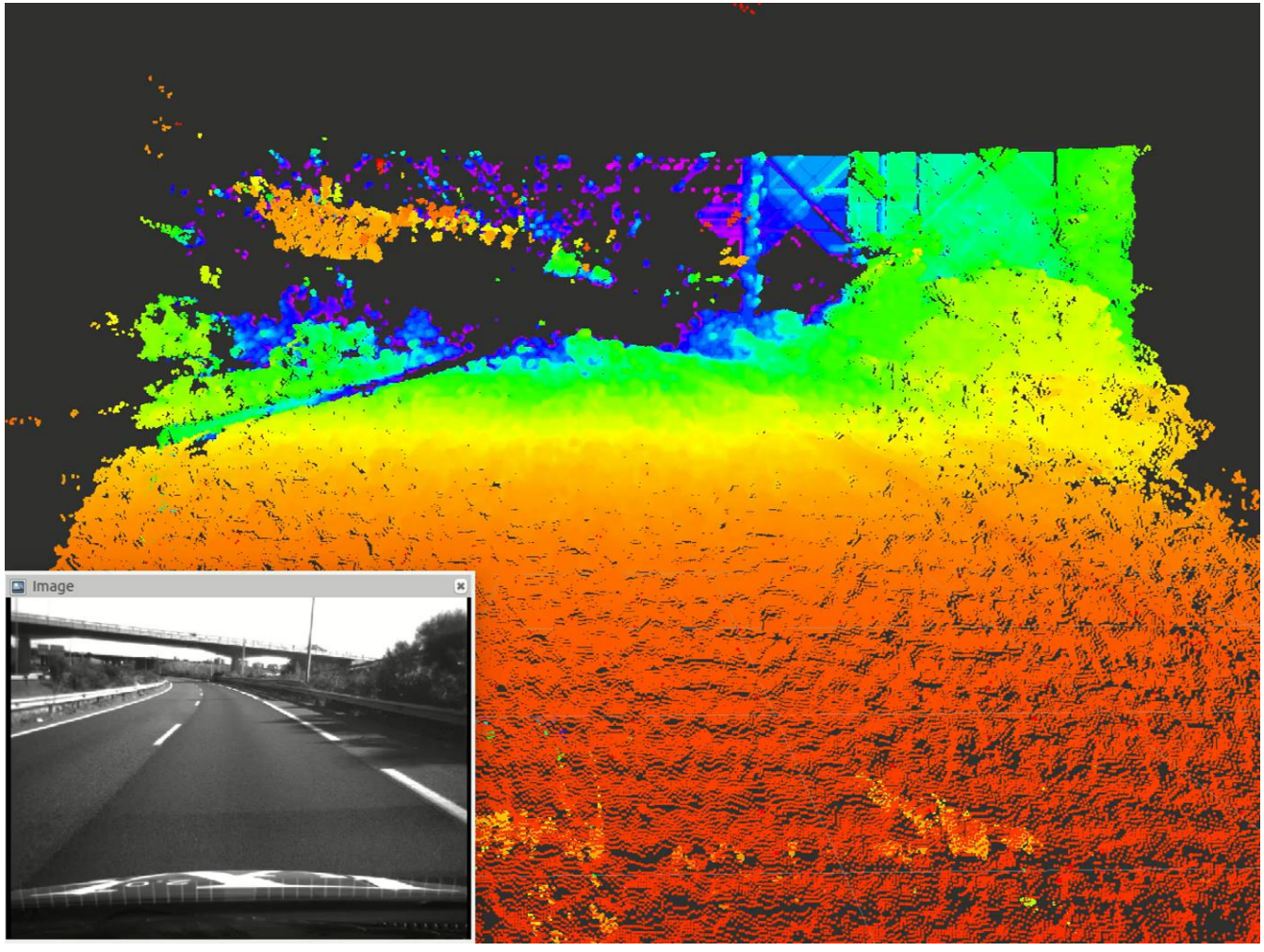
Work done

- **Bumblebee XB3 driver for ROS + SGBM disparity**

HIRSCHMÜLLER, Heiko. Stereo processing by semiglobal matching and mutual information. *Pattern Analysis and Machine Intelligence, IEEE Transactions on*, 2008, vol. 30, no 2, p. 328-341.

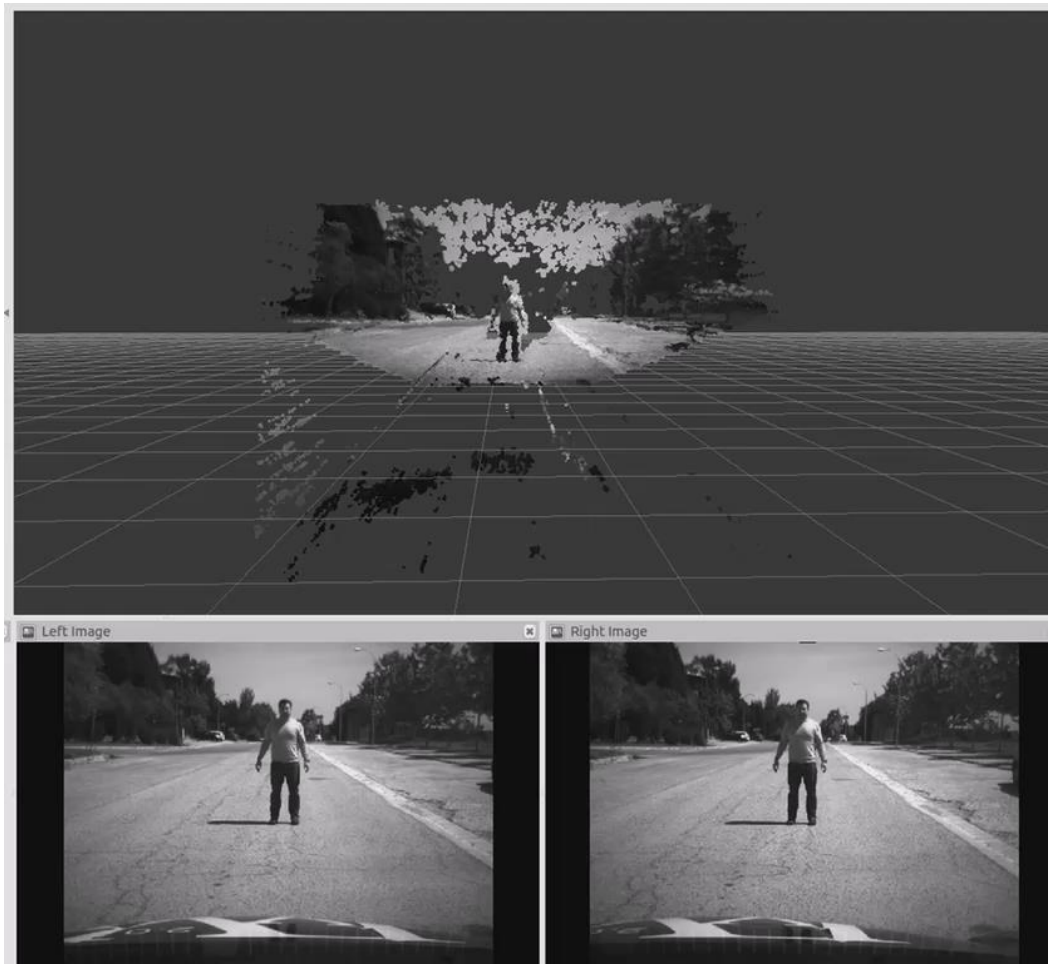
Work done

- **Bumblebee XB3 driver for ROS + PCL**



Work done

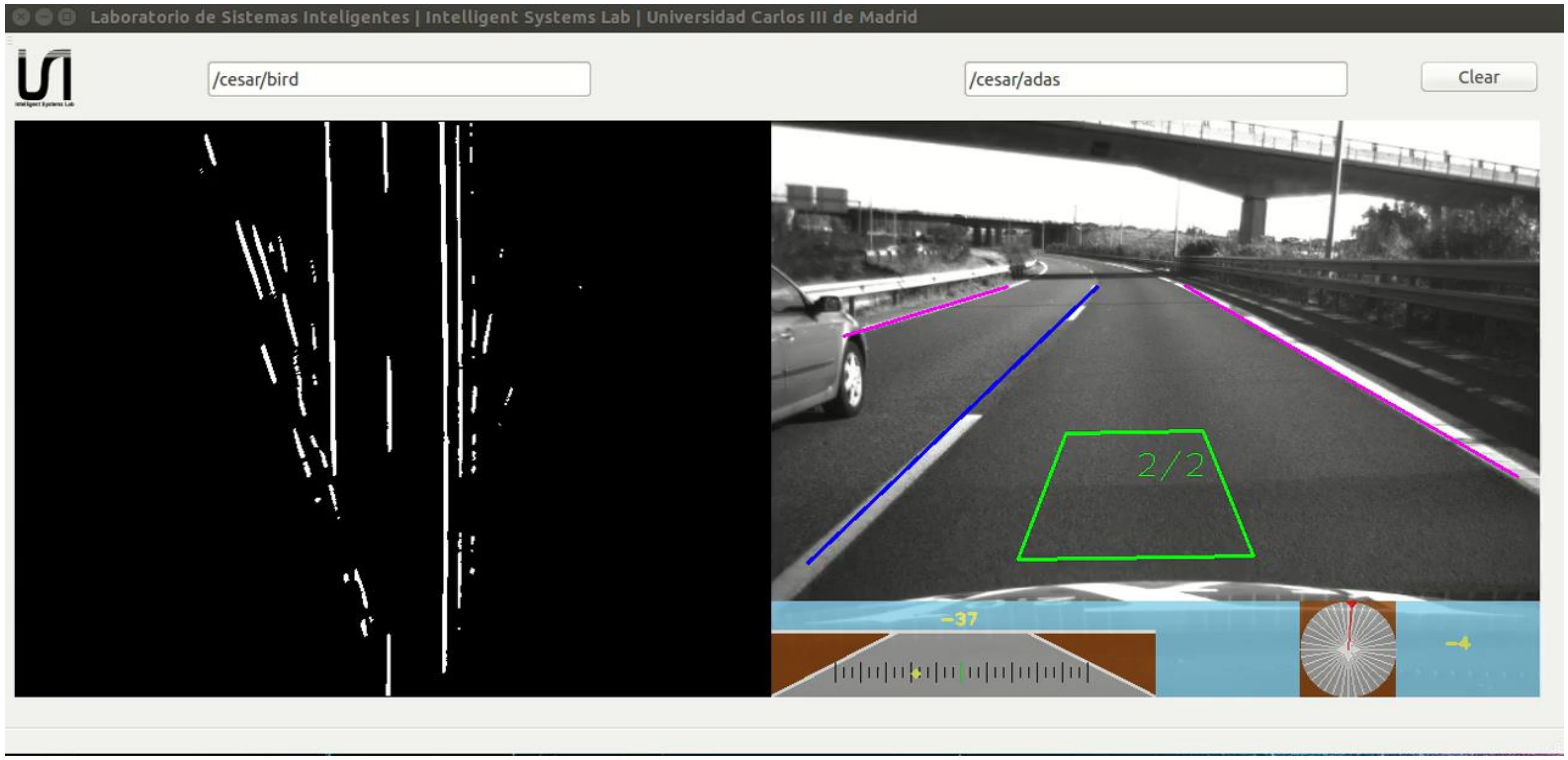
- **Bumblebee XB3 driver for ROS + PCL**



Work done

- **Cesar's Road Model Algorithm on ROS**

César

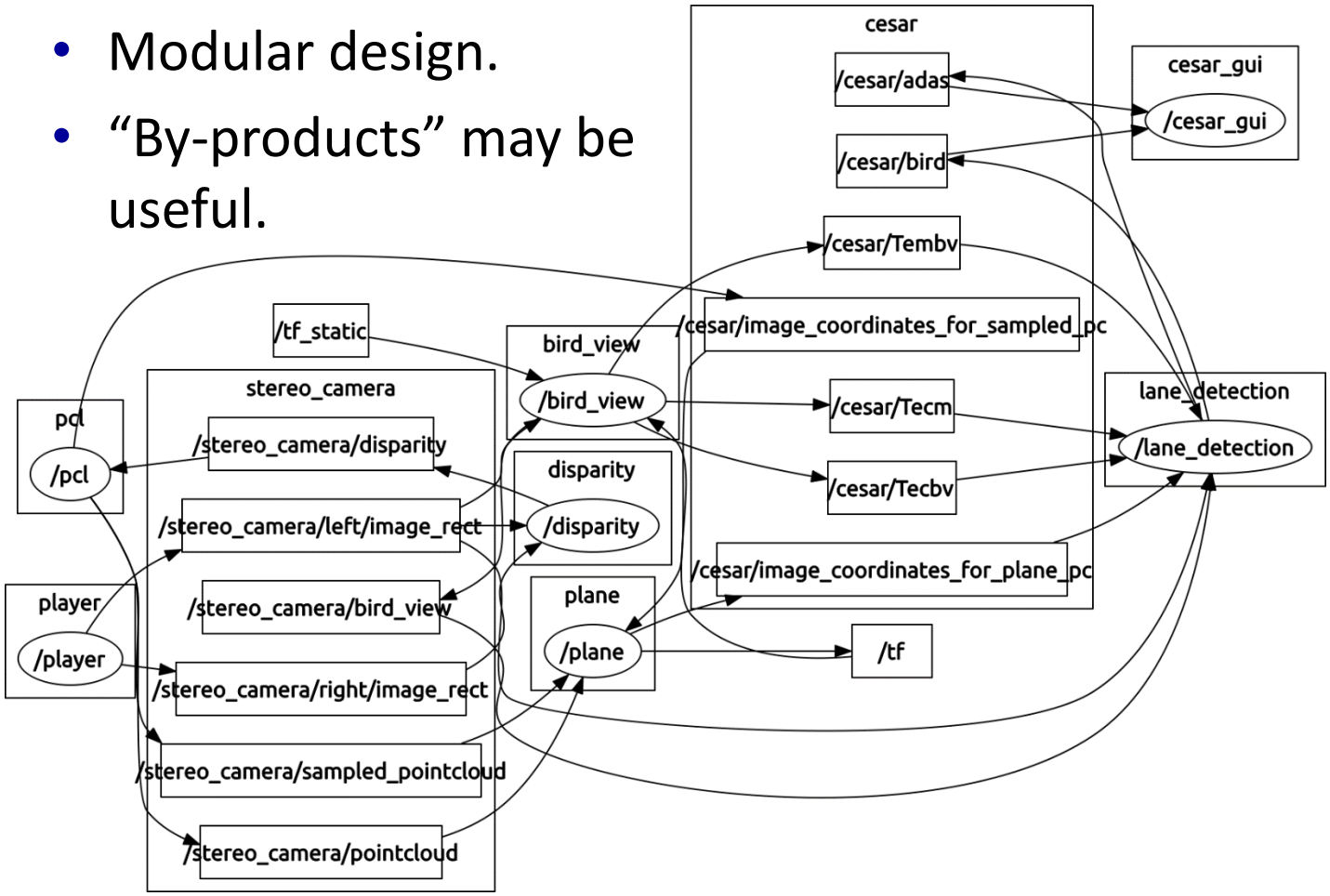


(EXPECTED) RODRÍGUEZ-GARAVITO, C. H., GUINDEL, C., ARMINGOL, J.M. Sistema de asistencia a la conducción para detección y clasificación de carriles. *Jornadas de Automática 2015.*

Work done

Cesar's Road Model Algorithm on ROS

- Modular design.
- "By-products" may be useful.



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Work in progress

Improvements in the Road Model Alg.

César

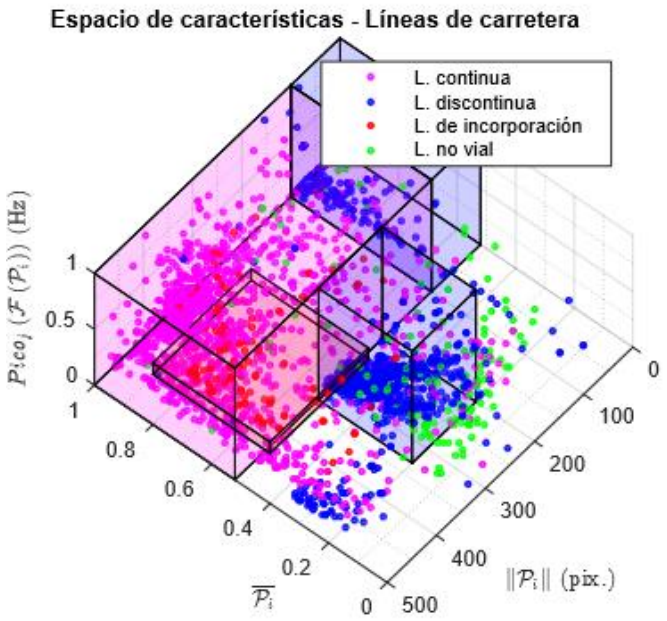
- Road plane extraction – e.g. Basam's road profile

MUSLEH, Basam, et al. Continuous pose estimation for stereo vision based on UV disparity applied to visual odometry in urban environments. In *Robotics and Automation (ICRA), 2014 IEEE International Conference on*. IEEE, 2014. p. 3983-3988.

Jorge
(M.Sc. Thesis)

- Road lines segmentation and classification by means of machine learning techniques

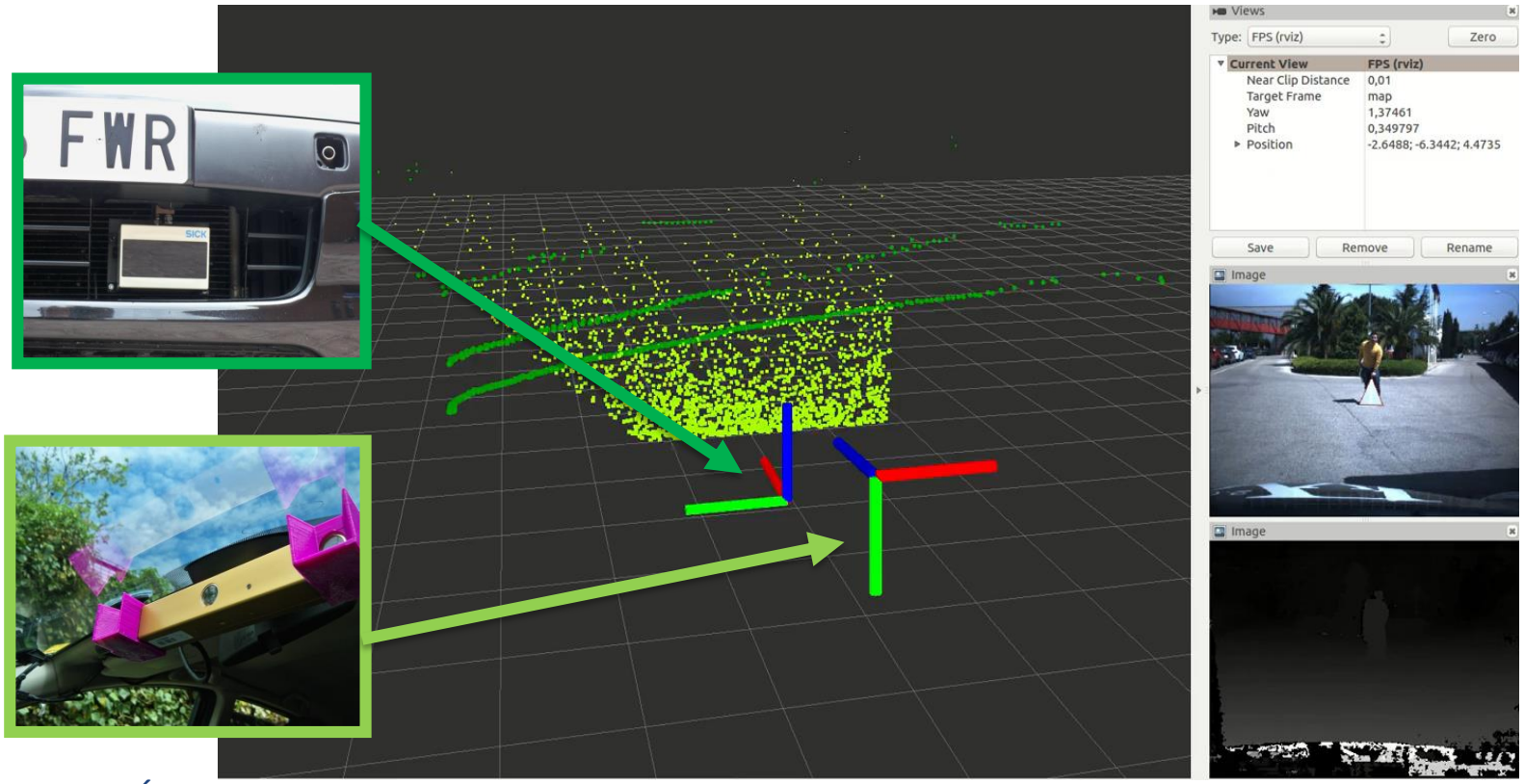
David
(M.Sc. Thesis)



Work in progress

- **Laser-Camera Calibration Alg.**

César Aurelio (CVC)



RODRÍGUEZ-GARAVITO, C. H., et al. Automatic laser and camera extrinsic calibration for data fusion using road plane. In *Information Fusion (FUSION), 2014 17th International Conference on*. IEEE, 2014. p. 1-6.

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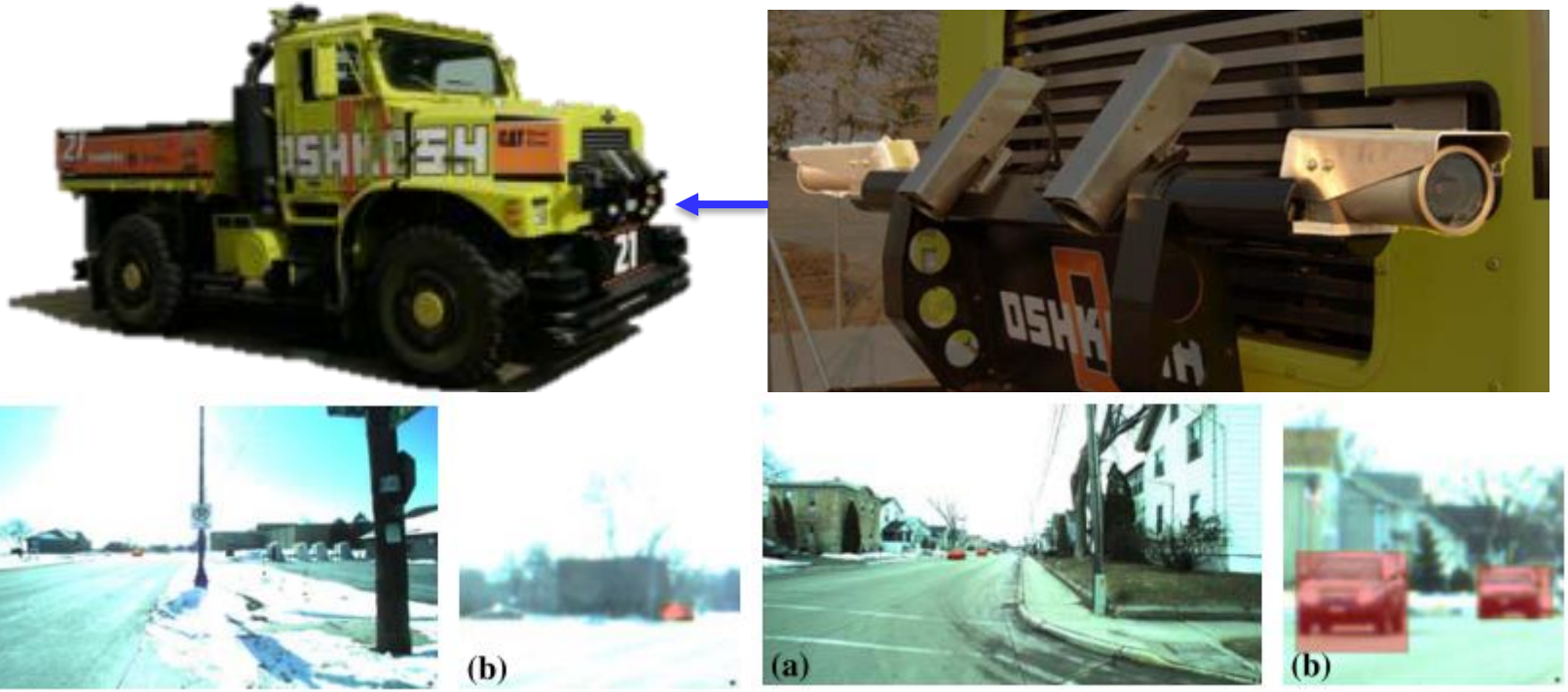
Work to do

- **Side-looking cameras for the IvVi 2.0**
  - Oshkosh - Vislab's TerraMax



BROGGI, Alberto, et al. Lateral vehicles detection using monocular high resolution cameras on TerraMax™. In *Intelligent Vehicles Symposium, 2008 IEEE*. IEEE, 2008. p. 1143-1148.

Work to do

- **Optimization for high-speed roads**
  - GPU and multi-thread will come in handy

My Final Degree Project → GUINDEL, Carlos., MUSLEH, Basam. Algoritmo de odometría visual estéreo para sistemas de ayuda a la conducción: Implementación en GPU mediante CUDA. 2012.

  - Embedded SBCs (ODROID) might be taken into account

    Expertise gained from diferent R&D projects (INDIO,…)

- **And everything else…**
  - Almost everything is still to be done using these tools

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Conclusions

- New ADAS demand high-level information
- Data from many applications is avaliable on the IVVI: An oportunity to work together
  - `www.bitbucket.org/lsi` git
  - e.g. CAN bus
- We should benchmark against the best

LSI team

GEIGER, Andreas, et al. Vision meets robotics: The KITTI dataset. *The International Journal of Robotics Research*, 2013

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Thank you for your attention