Autonomous GPU-based Driving

S. Silva[1,2], V. Campmany[1,2], L. Sellart[2], J.C. Moure[1], T. Espinosa[1], D. Vázquez[3], A. M. López[3]
[1]Computer Architecture & Operating Systems (Autonomous University of Barcelona)
[2]Computer Vision Center (Autonomous University of Barcelona)

Abstract

Human factors cause most driving accidents; this is why nowadays is common to hear about autonomous driving as an alternative. Autonomous driving will not only increase safety, but also will develop a system of cooperative self-driving cars that will reduce pollution and congestion. Furthermore, it will provide more freedom to handicapped people, elderly or kids.

Autonomous Driving requires perceiving and understanding the vehicle environment (e.g., road, traffic signs, pedestrians, vehicles) using sensors (e.g., cameras, lidars, sonars, and radars), self-localization (requiring GPS, inertial sensors and visual localization in precise maps), controlling the vehicle and planning the routes. These algorithms require high computation capability, and thanks to NVIDIA GPU acceleration this starts to become feasible.

NVIDIA® is developing a new platform for boosting the Autonomous Driving capabilities that is able of managing the vehicle via CAN-Bus: the **Drive™ PX**. It has 8 ARM cores with dual accelerated Tegra® X1 chips. It has 12 synchronized camera inputs for 360º vehicle perception, 4G and Wi-Fi capabilities allowing vehicle communications and GPS and inertial sensors inputs for self-localization .

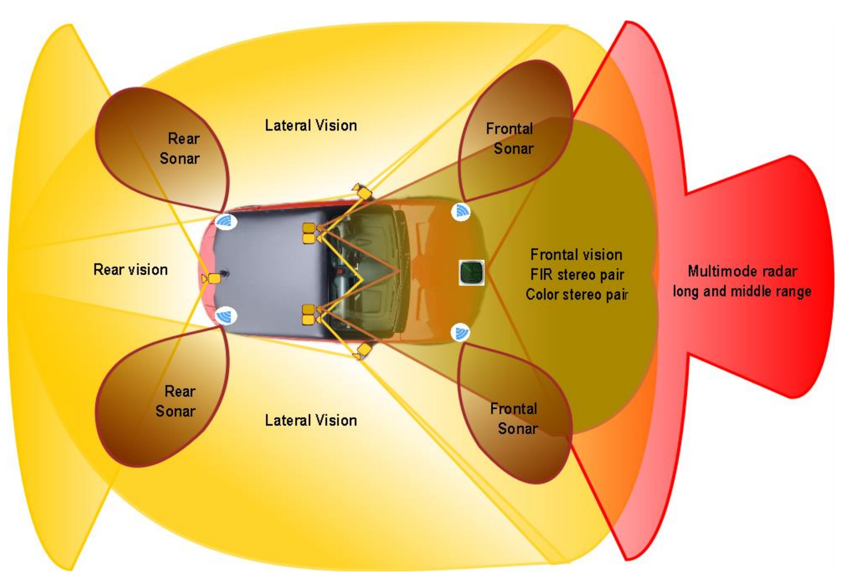
Our research group has been selected for testing Drive™ PX. Accordingly, we are developing a Drive™ PX based autonomous car. Currently, we are porting our previous CPU based algorithms (e.g., Lane Departure Warning, Collision Warning, Automatic Cruise Control, Pedestrian Protection, or Semantic Segmentation) for running in the GPU.

Car Sensing

Environment perception:
- Stereo cameras
- Radar
- Sonar

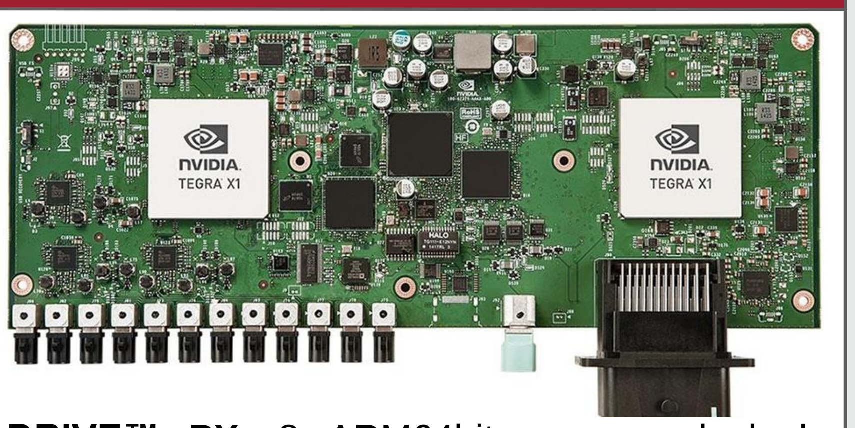
Positioning system:
- GPS
- IMU (Inertial Measurement Unit)
- Visual Odometry

Communications system:
- 4G
- Wi-Fi



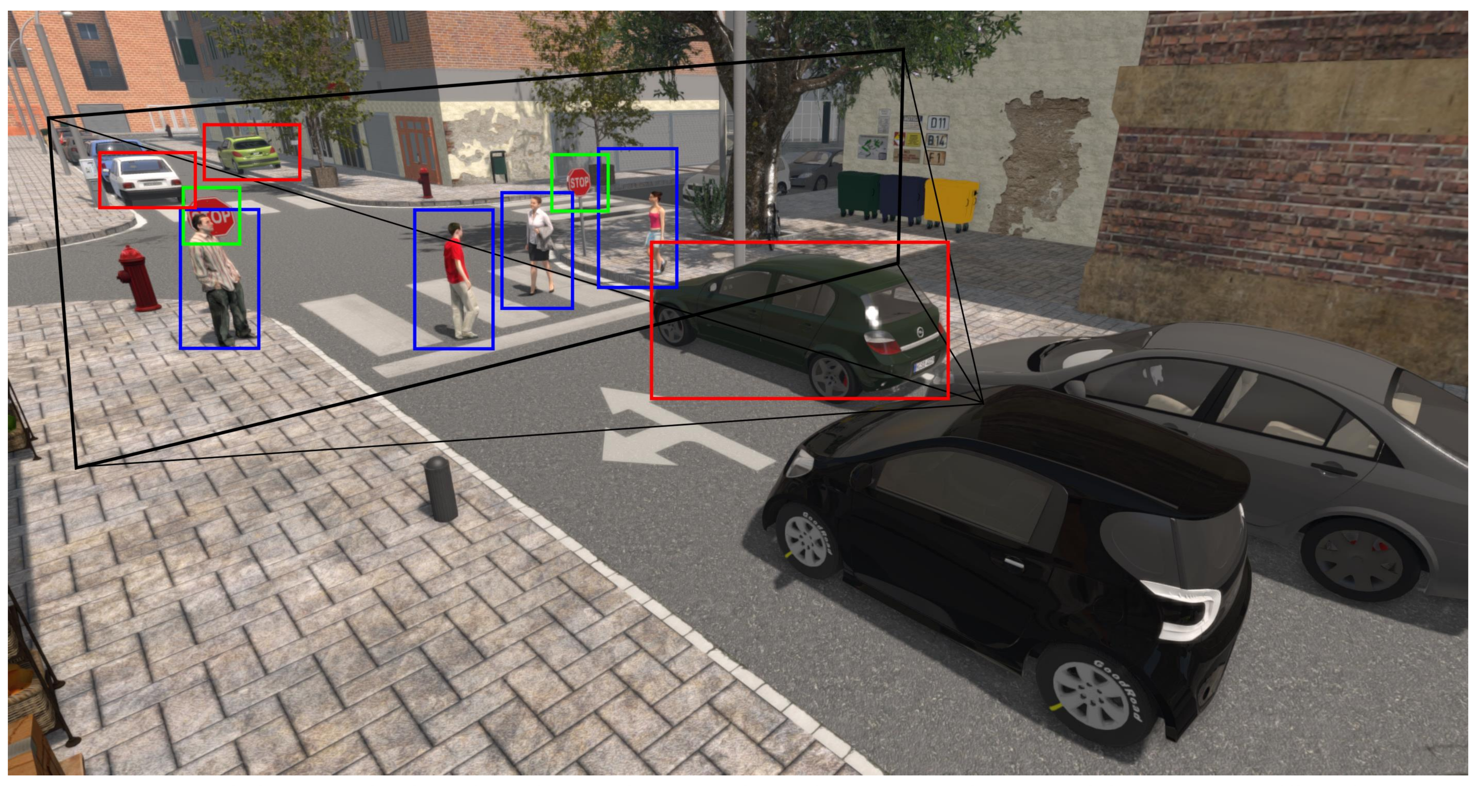
Control and Processing unit

JETSON™ PRO: quad core ARM32bit and Tegra® K1 chip, 8 cameras, CAN-BUS & Automotive Certified.



DRIVE™ PX: 8 ARM64bit cores and dual Tegra® X1 chip, 12 sync cameras, CAN-BUS & Automotive Certified.

Computer Vision Object Detectors [1]

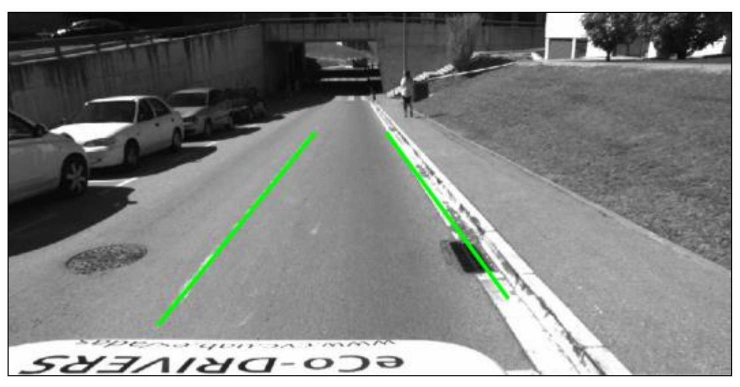


Computer Vision technics for detecting pedestrians, cyclists, vehicles & traffic signs.

Pedestrian collision avoidance.

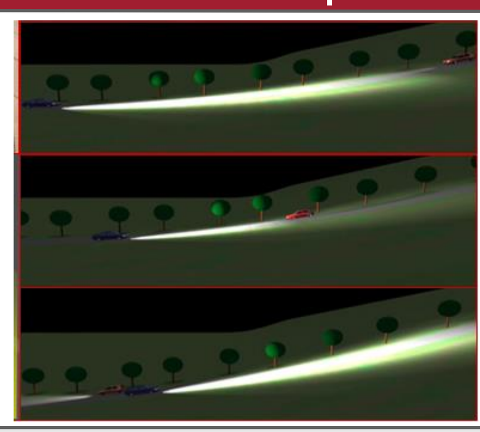
Traffic sign recognition.

Lane Departure Warning [2]

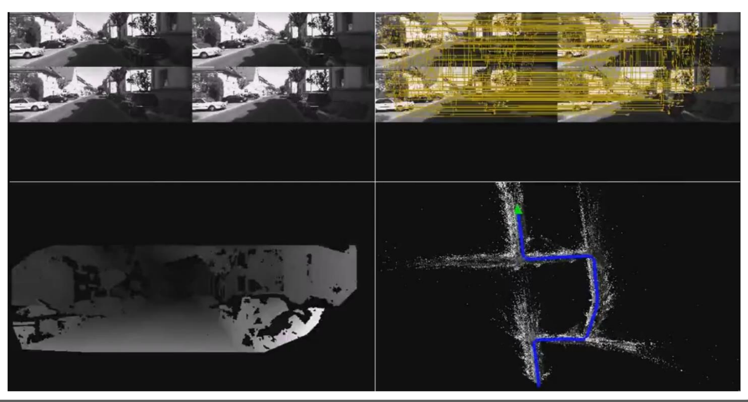


Free Space Computation [4]

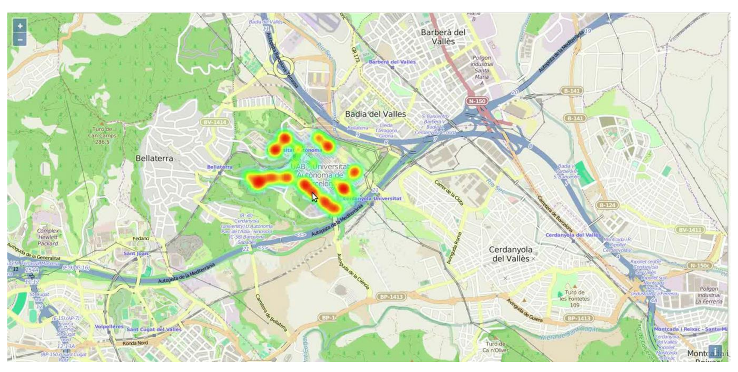
Autom. Headlamp control [3]



Self Localization & Mapping [5]

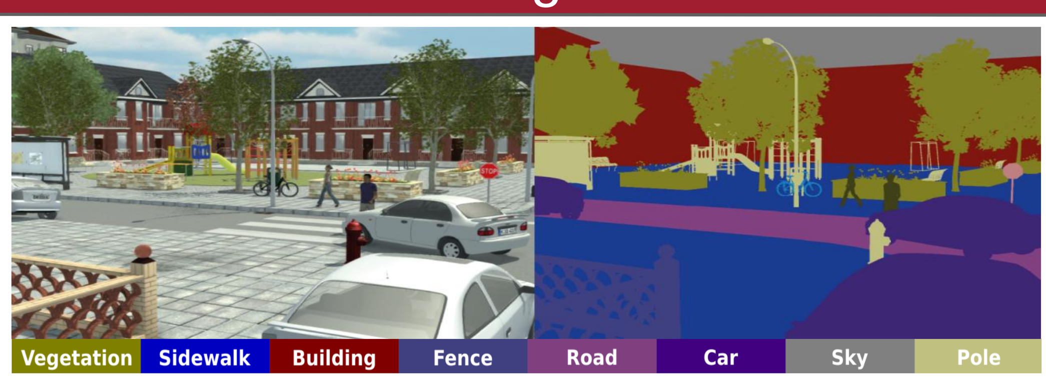


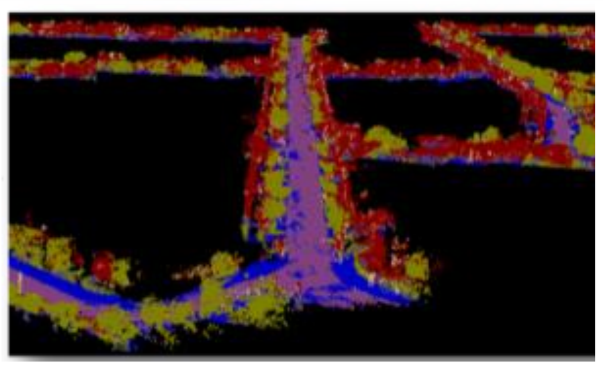
MAPEA2



Creation of heat maps of pedestrians

Semantic Segmentation & 3D Semantic Maps [6]





Classify each pixel on classes

Current Research

Deep Learning:
- Semantic Segmentation
- Object detection (e.g., pedestrians, cars, traffic signs etc.)

3D reconstruction

[1] D. Vazquez, J. Amores, & A. M. Lopez. (2015). "Multiview Random Forest of Local Experts Combining RGB and LIDAR data for Pedestrian Detection " In IEEE IV.
[2] A. M. Lopez, J. Serrat, C. Cañero, F. Lumbreras, T. Graf. (2010)."Robust lane markings detection and road geometry computation". In IJAT.
[3] A. M. Lopez, J. Hilgenstock, A Busse, R Baldrich, F Lumbreras, J Serrat, (2008). "Nightime vehicle detecion for intelligent headlight control", In ACIVS.
[4] J. M. Alvarez, A. M. Lopez, T. Gevers, F. Lumbreras, (2014). "Combining priors, appearance and context for road detection", In IEEE T-ITS.
[5] G Ros, J Guerrero, A D. Sappa, D. Ponsa & A. M. Lopez. (2013). "Fast and Robust L1-averaging-based Pose Estimation for Driving Scenarios", In BMVC.
[6] G. Ros, S. Ramos, M. Granados, A. Bakhtiary, D. Vazquez, & A.M. Lopez. (2015). "Vision-based Offline-Online Perception Paradigm for Autonomous Driving" In IEEE WACV.

This work is supported by the Spanish MICINN projects TRA2014-57088-C2-1-R by the Secretaria d'Universitats i Recerca del Departament d'Economia i Coneixement de la Generalitat de Catalunya (2014-SGR-1506) and DGT project SPIP2014-01352. Our research is also kindly supported by NVIDIA Corporation in the form of different GPU hardware.