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www.ampl.es

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MOBILITY SOLUTIONS BEYOND THE AUTONOMOUS CAR

PROF. FERNANDO GARCIA

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Founder and CTO of Seevia Technologies

uc3m | Universidad Carlos III de Madrid

Autonomous Cars

The eternal promise

Driverless car in 1928

- The future is near

Footage from the movie Speed Spook 1928

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Autonomous Cars

The eternal promise

Reality vs Expectations

Footage from the movie Speed Spook 1928

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Autonomous Cars

The eternal promise

Did it get any better?

Tesla Auto Pilot , 2015

Google Car (Waymo), 2009

Uber Self Driving Car, 2016

Argo Ai, 2016

Cruise, 2013

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Autonomous Cars

The eternal promise

How close are we to AV?

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AMPL AV Challenges

The AV are getting closer, but we still need some challenges

- Perception
- Localization
- Evaluation / performance
- Human Factors

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AMPL AV Challenges

The AV are getting closer, but we still need some challenges

- **Perception**
- Localization
- Evaluation / performance
- Human Factors

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Perception

The AV are getting closer, but we still need some challenges

- Adaptability
- Reliability
- Scalability
- Generalization

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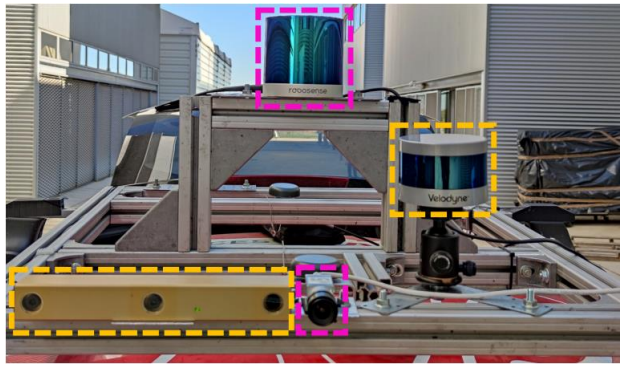
Perception

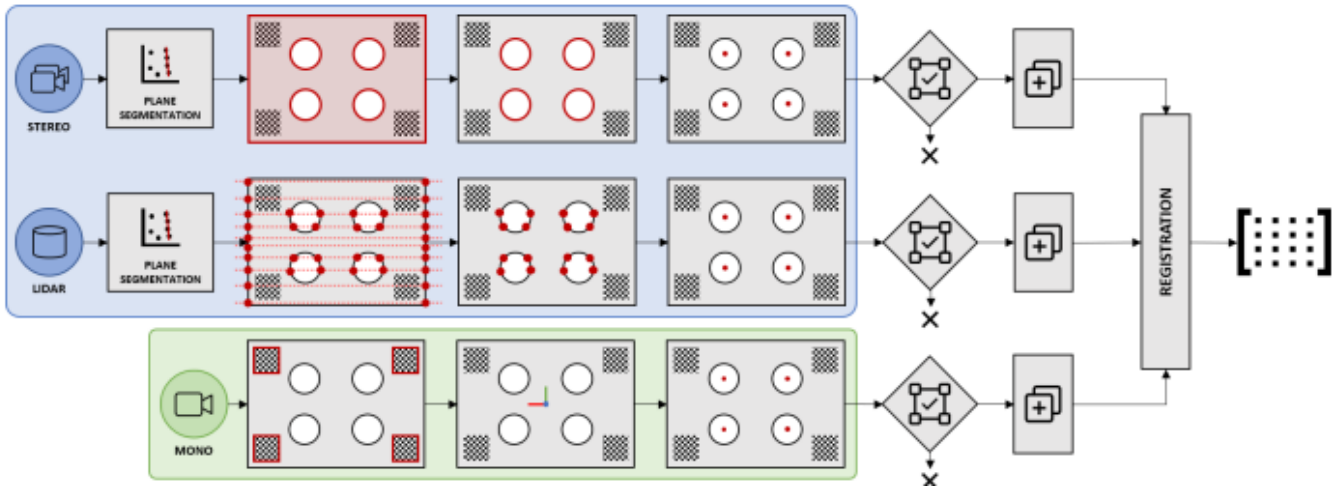
—

Adaptability

Calibration & Sync

Sensors should share a common framework





J. Beltrán, C. Guindel, A. de la Escalera and F. García, "Automatic Extrinsic Calibration Method for LiDAR and Camera Sensor Setups," in *IEEE Transactions on Intelligent Transportation Systems*, vol. 23, no. 10, pp. 17677-17689, Oct. 2022, doi: 10.1109/TITS.2022.3155228.

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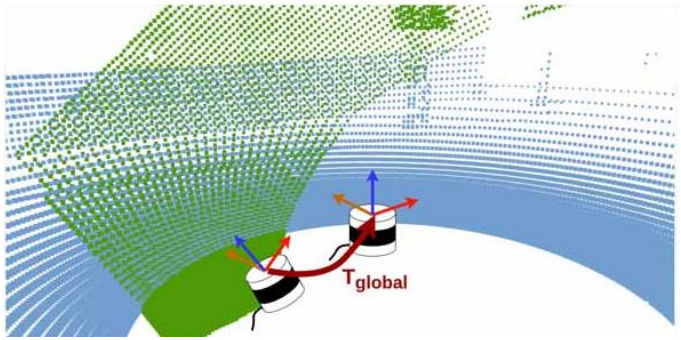
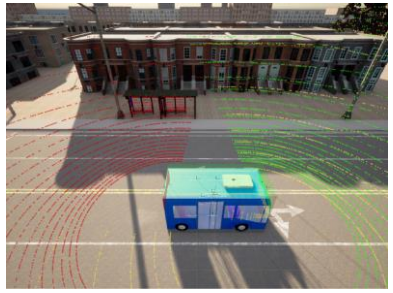
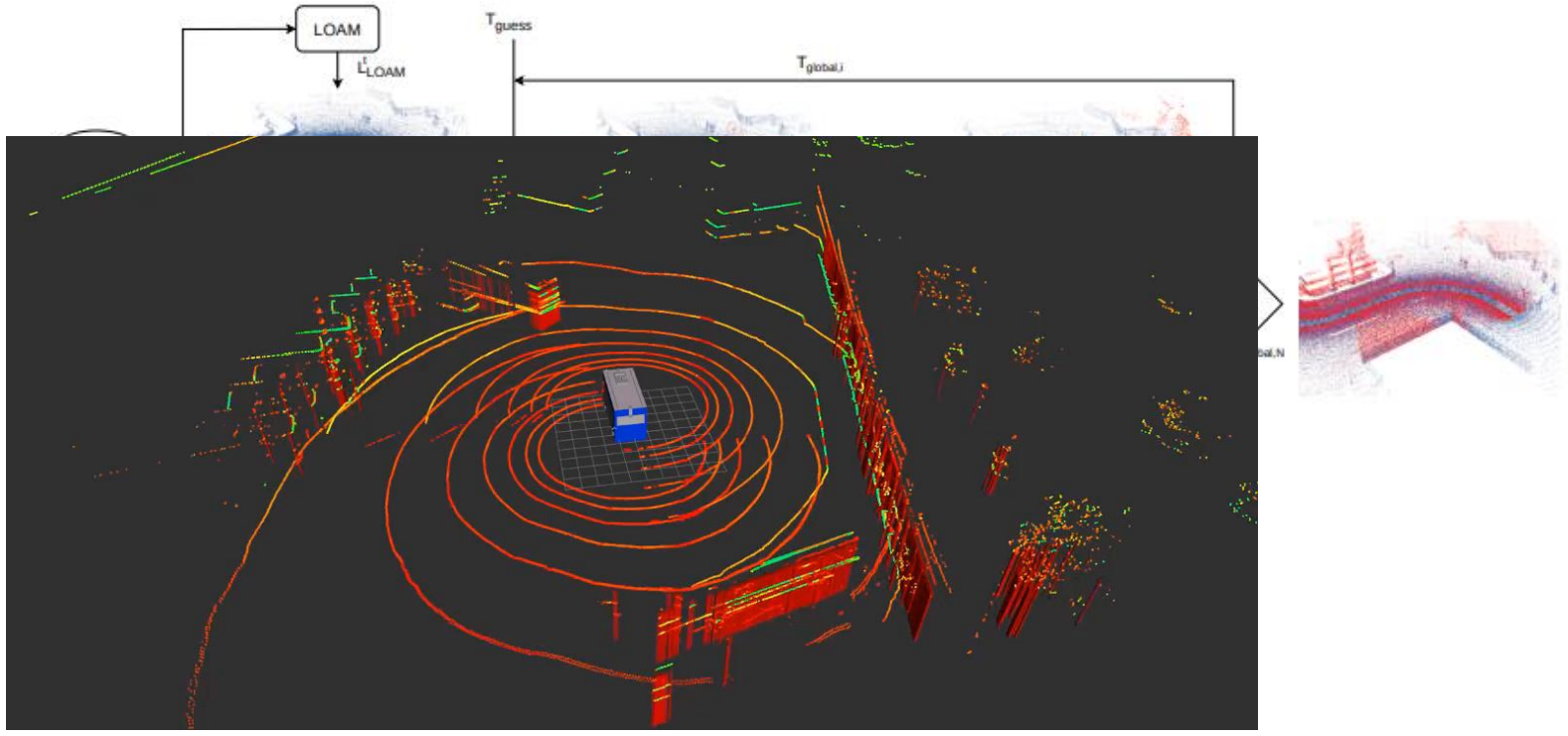
Calibration & Sync

Lidar 2 Lidar







M. Á. de Miguel, C. Guindel, A. Al-Kaff and F. García, "High-Accuracy Patternless Calibration of Multiple 3-D LiDARs for Autonomous Vehicles," in *IEEE Sensors Journal*, vol. 23, no. 11, pp. 12200-12208, 1 June1, 2023, doi: 10.1109/JSEN.2023.3268338

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Perception

Reliability

Reliability

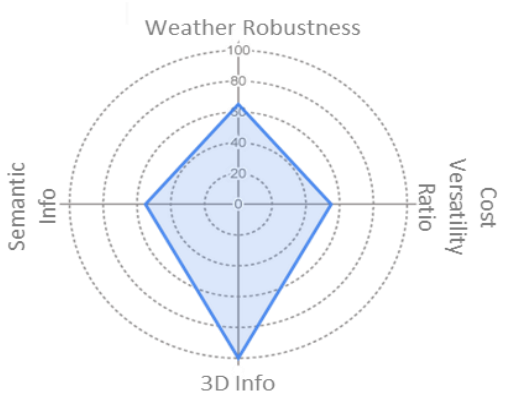
Multiple sources

LiDAR

Precise 3D Information

Versatility (360, near range)

Very Expensive

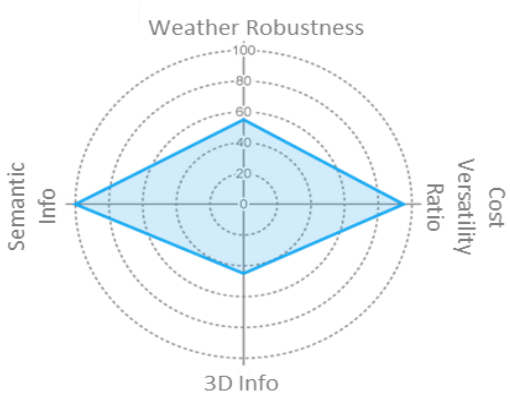


Camera

Visual Representation

High density and variety of information (RGB, HDR, IR)

Light-sensitive

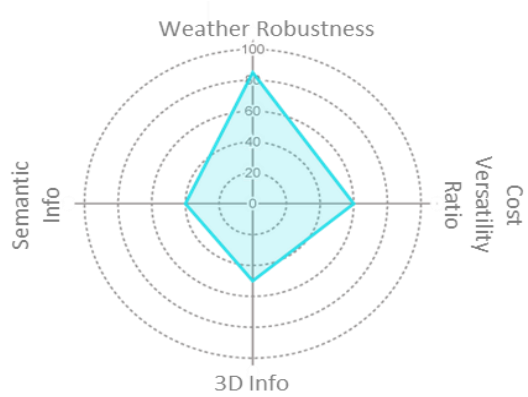


RADAR

3D Information on Any Weather

Velocity Information

Low Accuracy

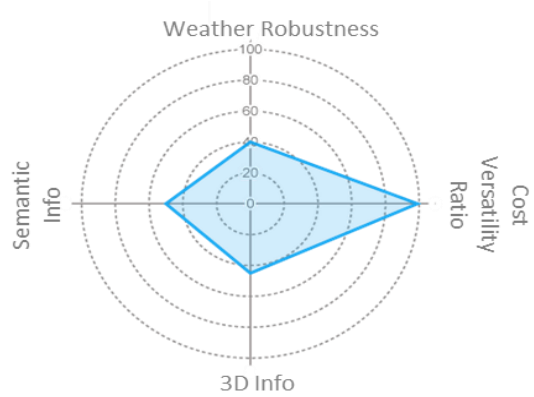


ULTRASOUND

3D Information on any Weather

Cost-Effective Sensor

Very Short-Range



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Marti, Enrique, et al. "A review of sensor technologies for perception in automated driving." IEEE Intelligent Transportation Systems Magazine 11.4 (2019): 94-108.

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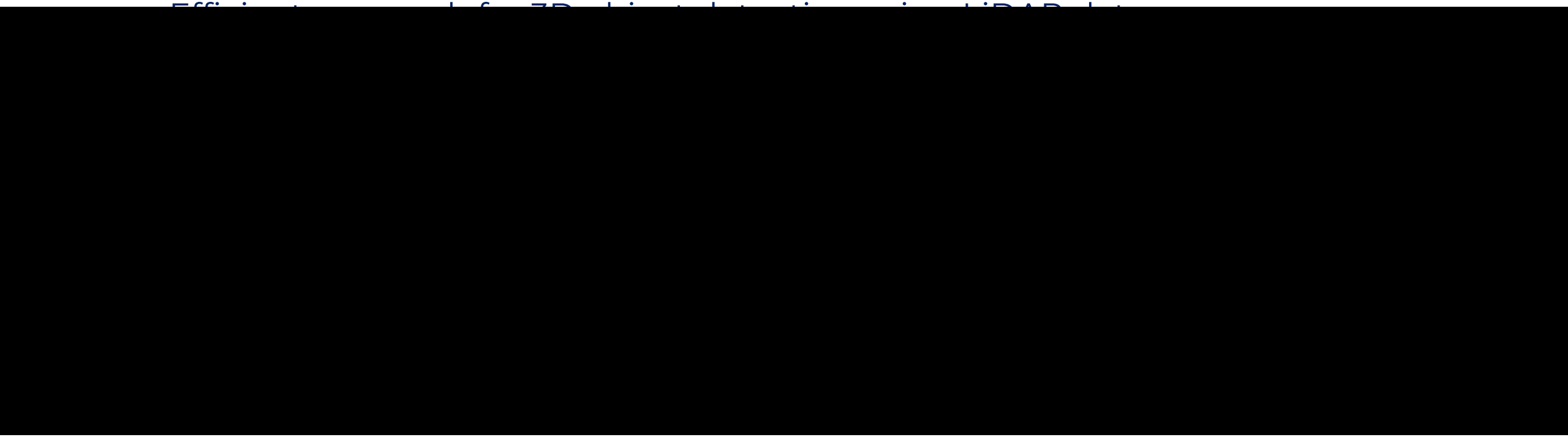
LiDAR Detection

Birdnet & BirdNet+



Beltrán, J., Guindel, C., Moreno, F. M., Cruzado, D., Garcia, F., & De La Escalera, A. (2018, November). Birdnet: a 3d object detection framework from lidar information. In 2018 21st International Conference on Intelligent Transportation Systems (ITSC) (pp. 3517-3523). IEEE.

&

Barrera, A., Beltran, J., Guindel, C., Iglesias, J. A., & Garcia, F. (2021). Birdnet+: two-stage 3d object detection in lidar through a sparsity-invariant bird's eye view. IEEE Access, 9, 160299-160316.

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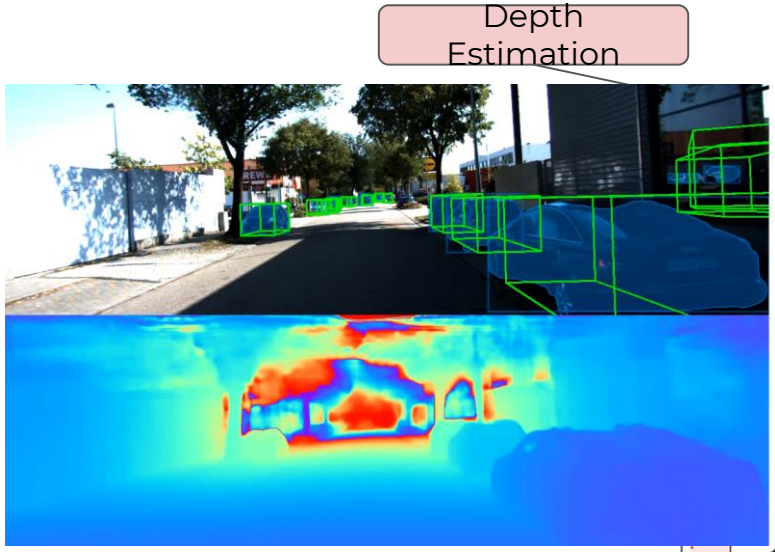
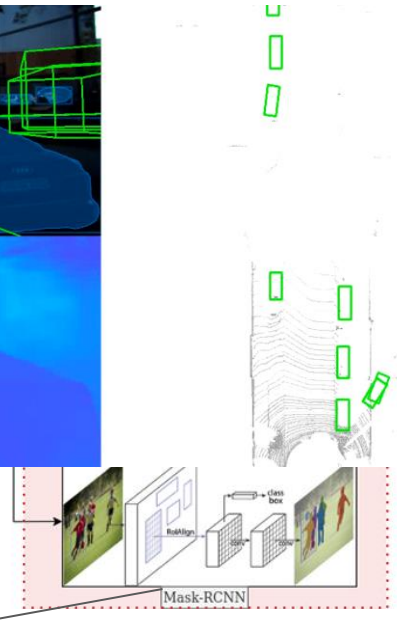
3D estimation

3D information from monocular camera

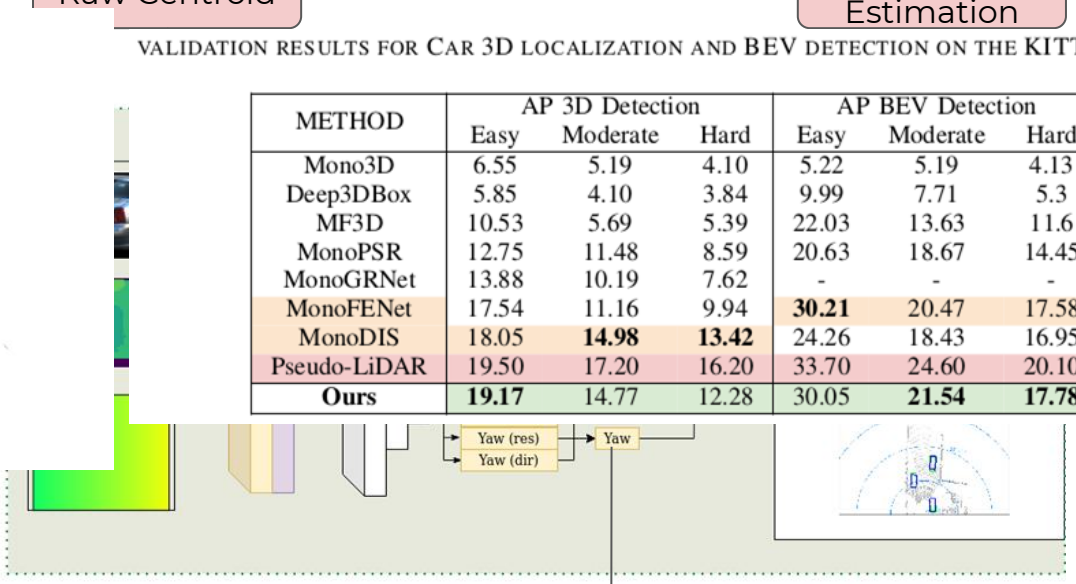


Depth Estimation



2D Mask Detector

Raw Centroid



Hybrid Angle

Final Estimation

VALIDATION RESULTS FOR CAR 3D LOCALIZATION AND BEV DETECTION ON THE KITTI VAL SPLIT WITH 0.7 OF IOU.

METHOD	AP 3D Detection			AP BEV Detection			Inference Time
	Easy	Moderate	Hard	Easy	Moderate	Hard	[seconds]
Mono3D	6.55	5.19	4.10	5.22	5.19	4.13	-
Deep3DBox	5.85	4.10	3.84	9.99	7.71	5.3	-
MF3D	10.53	5.69	5.39	22.03	13.63	11.6	0.03
MonoPSR	12.75	11.48	8.59	20.63	18.67	14.45	0.20
MonoGRNet	13.88	10.19	7.62	-	-	-	0.04
MonoFENet	17.54	11.16	9.94	**30.21**	20.47	17.58	0.15
MonoDIS	18.05	**14.98**	**13.42**	24.26	18.43	16.95	0.10
Pseudo-LiDAR	19.50	17.20	16.20	33.70	24.60	20.10	0.40
Ours	**19.17**	14.77	12.28	30.05	**21.54**	**17.78**	0.13

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A. Astudillo, A. Al-Kaff, F. Garcia. “Mono-DCNet: Monocular 3D Object Detection via Depth-based Centroid Refinement and Pose Estimation”. IEEE Intelligent Vehicles Symposium (IV), 2022.

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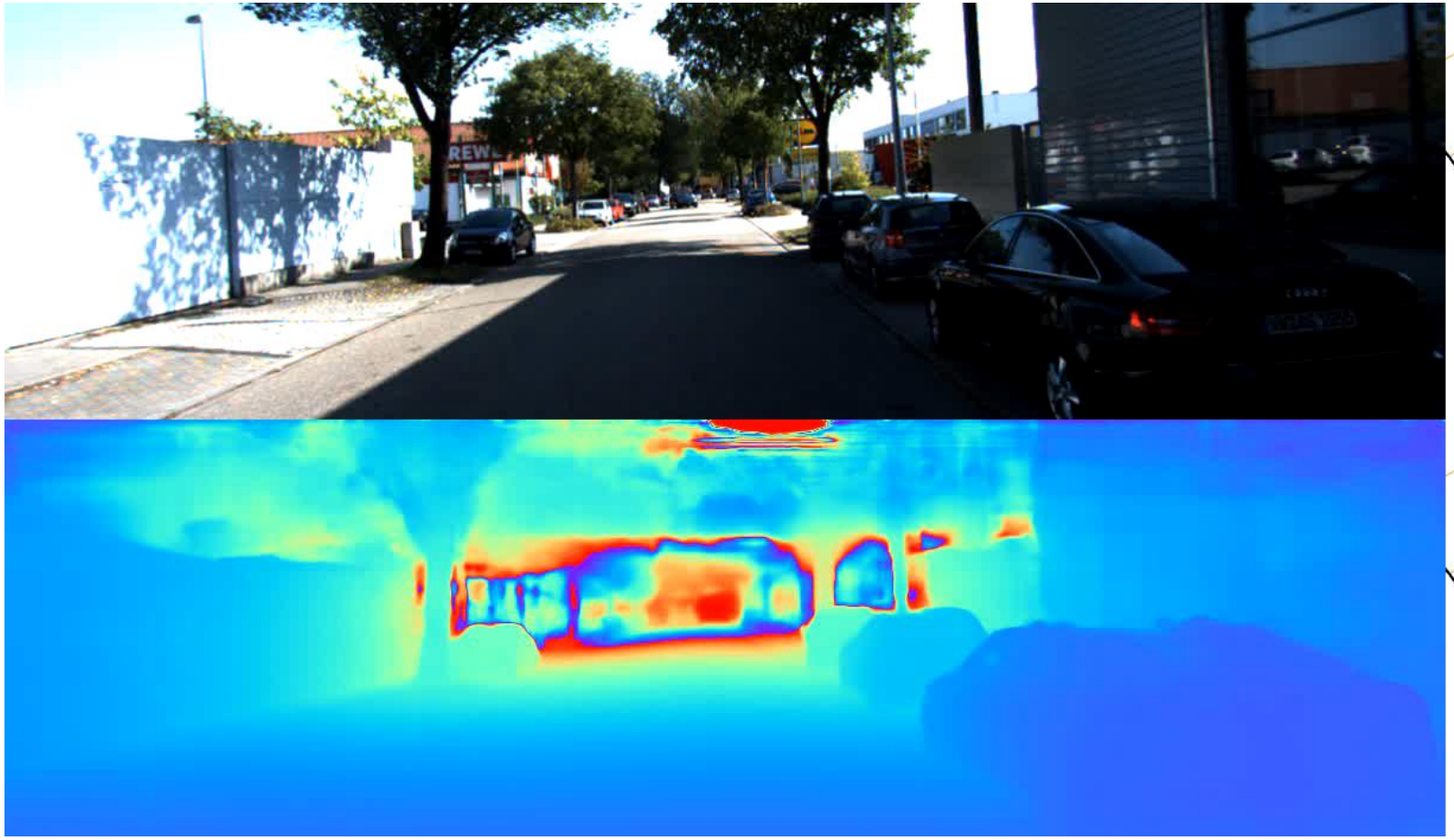
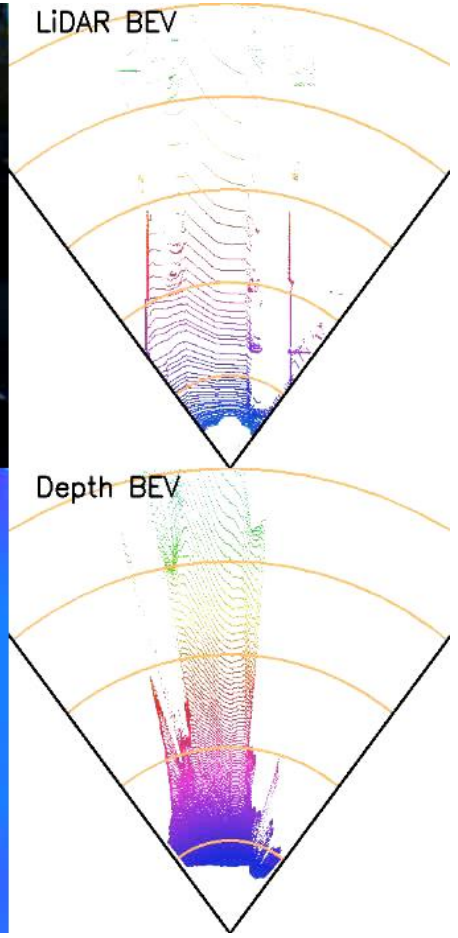
3D estimation

3D information from monocular camera





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A. Astudillo, A. Barrera, C. Guindel, F. García, A. Kaff. “DAttNet: monocular depth estimation network based on attention mechanisms”. Neural Comput & Applications. 36, 3347–3356 (2024). https://doi.org/10.1007/s00521-023-09210-8

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Environment Detection

Real vehicle implementation

- Development of the perception pipeline in Project Tornado
- 20km of peri-urban area
- 360 degrees detection
- From sensor placement to

Mask R-CNN → Segmentation → 3D Estimation → Tracking

Milanés, V., González, D., Navas, F., Mahtout, I., Armand, A., Zinoune, C., ... & Garcia, F. (2021). The tornado project: An automated driving demonstration in peri-urban and rural areas. IEEE Intelligent Transportation Systems Magazine, 14(4), 20-36.

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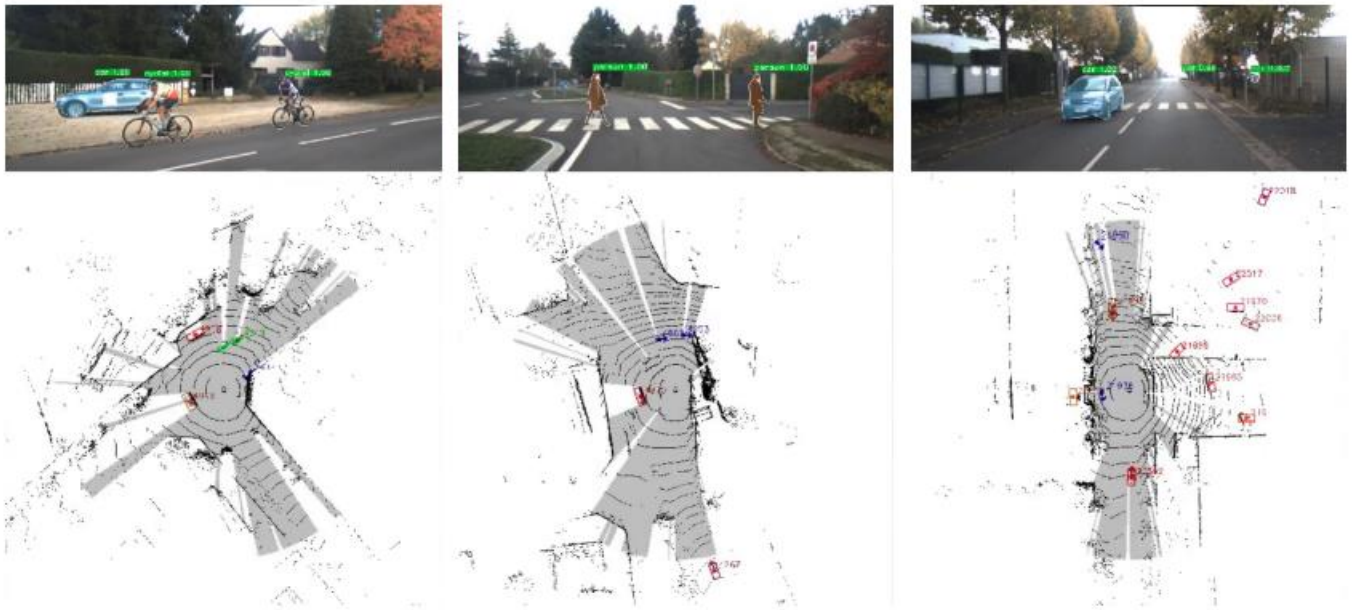
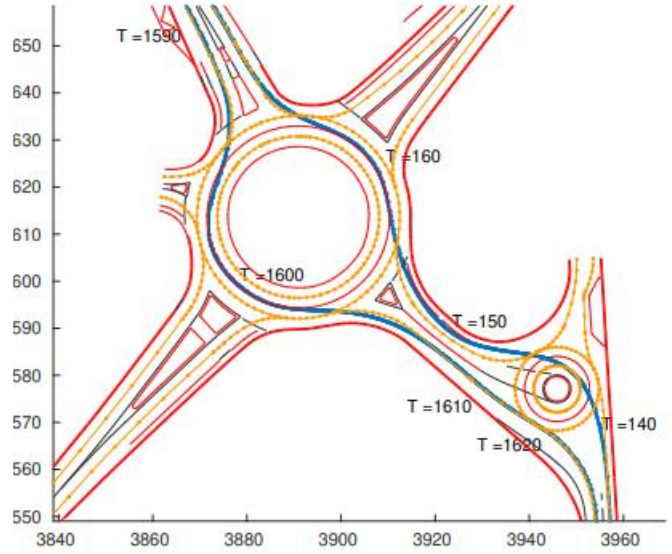
Trustability

Sensor field of view prediction





Astudillo, Armando, et al. "Visibility-aware adaptative speed planner for human-like navigation in roundabouts." 2021 IEEE International intelligent transportation systems conference (ITSC). IEEE, 2021.

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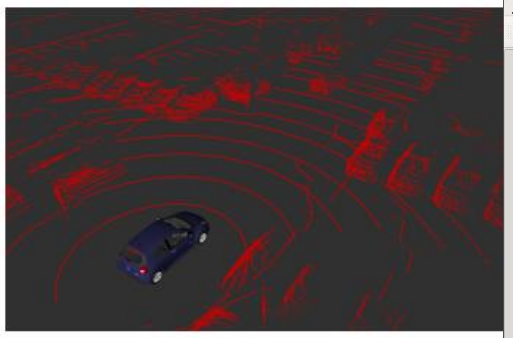
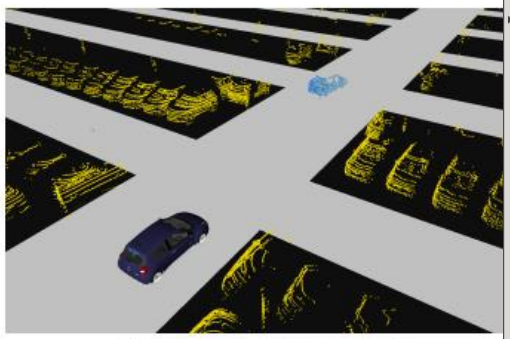
Trustability

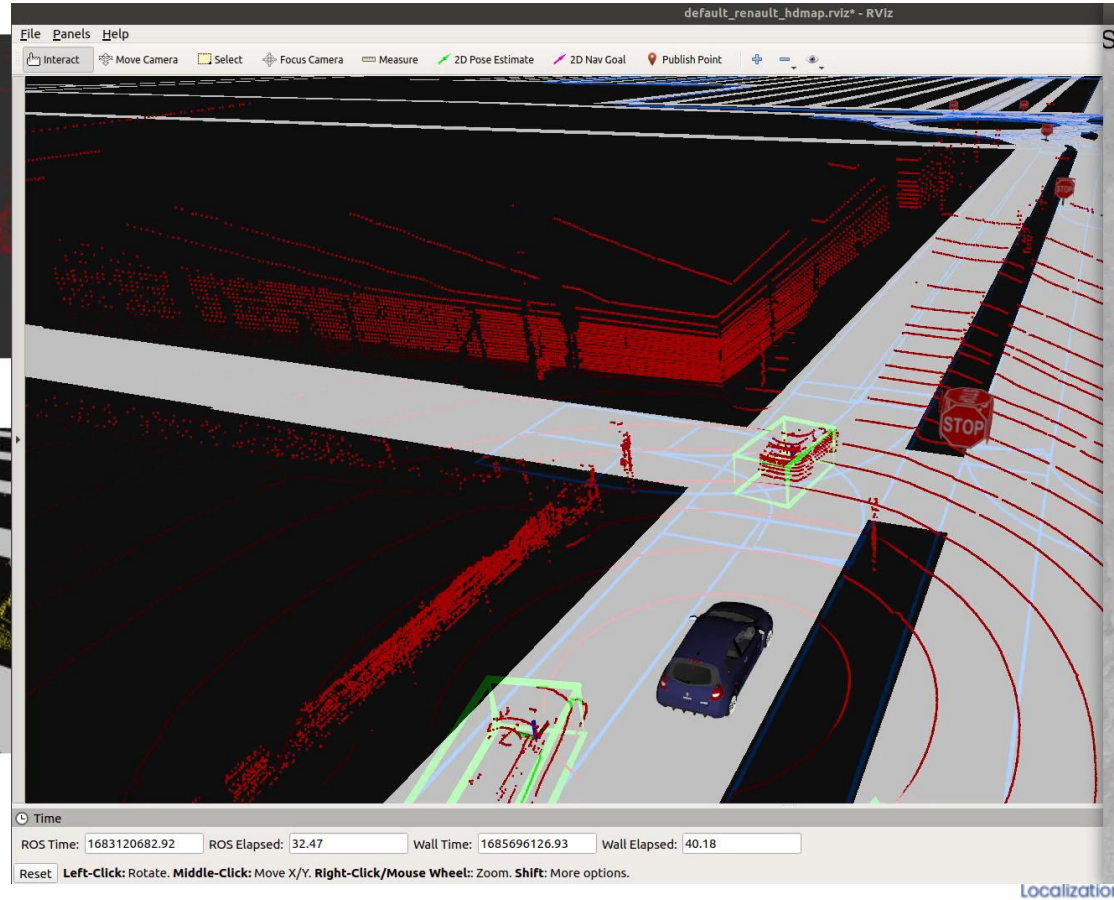
Predictability of the perception solution

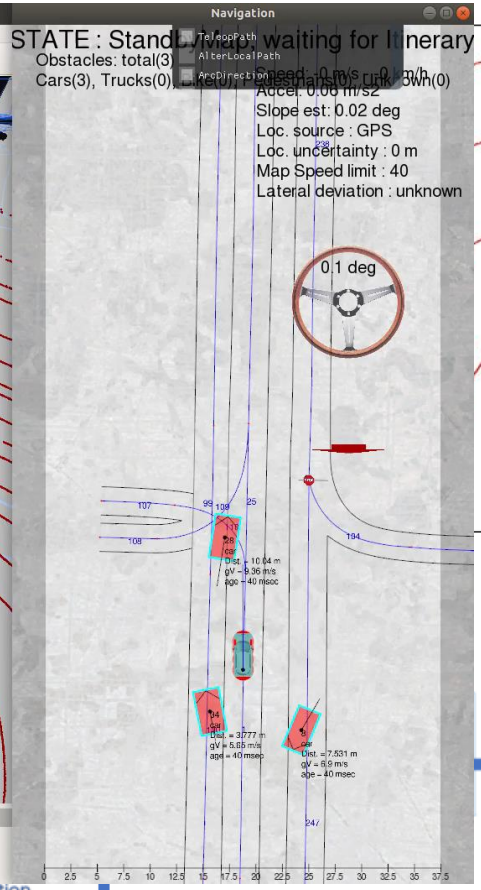


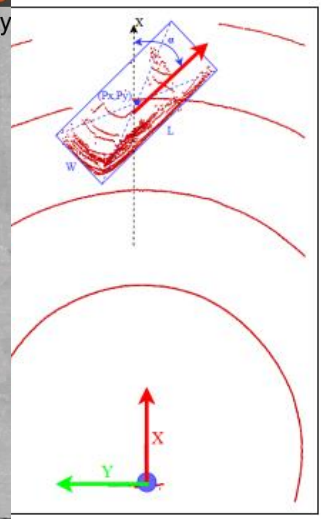
(a) Input Point Cloud

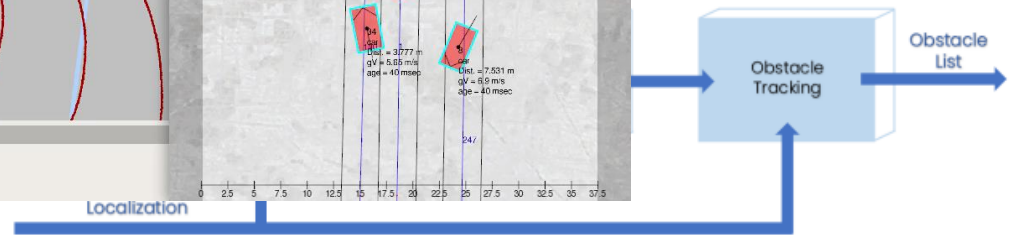


(c) Point Cloud Segmentation









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Palos, M, Cortes,I Madridano, A, Navas F. , Barbero C. , Milanes V. , Garcia F. "LiDAR-based Perception System for Logistics in Industrial Environments." , 2024.

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Perception

Scalability

Multiple Camera Solution

Camera stitching

(a) Without image alignment.

(b) With image alignment.

(a) Without image alignment.

(b) With image alignment.

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C. Kinzig, I. Cortés, C. Fernández and M. Lauer, "Real-time Seamless Image Stitching in Autonomous Driving," 2022 25th International Conference on Information Fusion (FUSION), Linköping, Sweden, 2022, pp. 1-8, doi: 10.23919/FUSION49751.2022.9841307.

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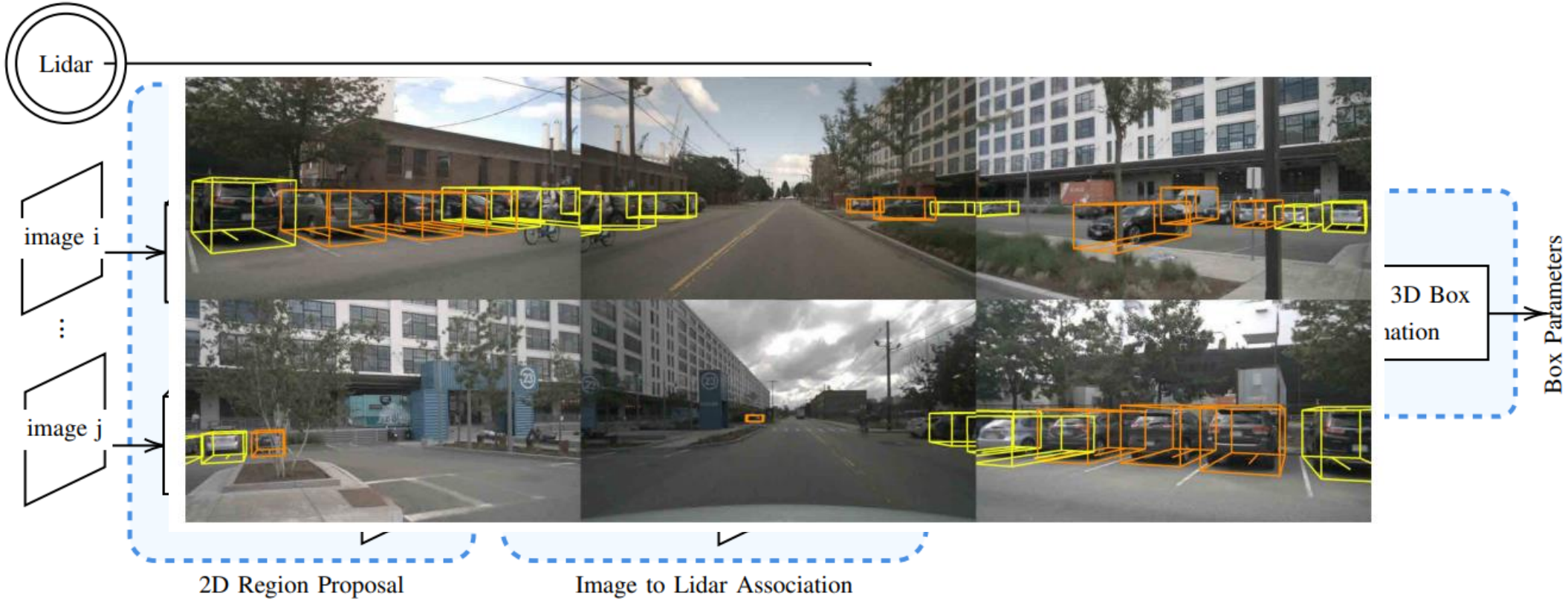
Multiple Camera Solution

Multiple camera fusion using reidentification techniques



I. Cortés, J. Beltrán, A. de la Escalera and F. García, "siaNMS: Non-Maximum Suppression with Siamese Networks for Multi-Camera 3D Object Detection," 2020 IEEE Intelligent Vehicles Symposium (IV), Las Vegas, NV, USA, 2020, pp. 933-938, doi: 10.1109/IV47402.2020.9304685.

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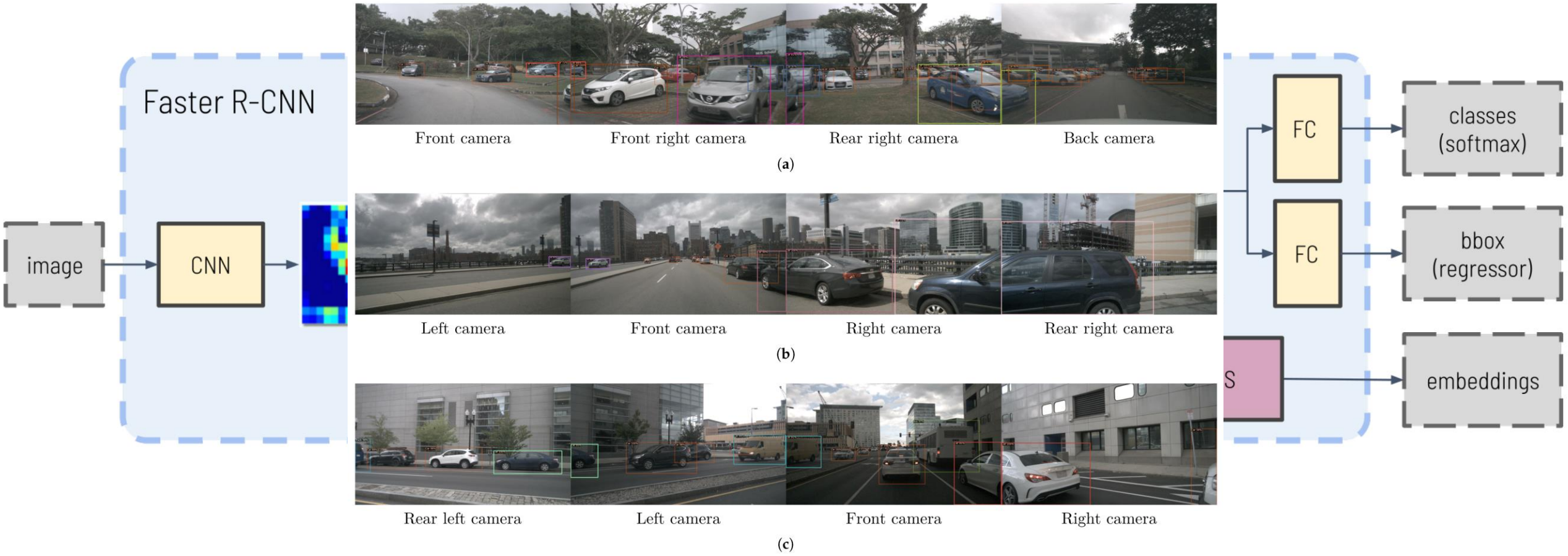
Multiple Camera Solution

Multiple camera fusion using reidentification techniques

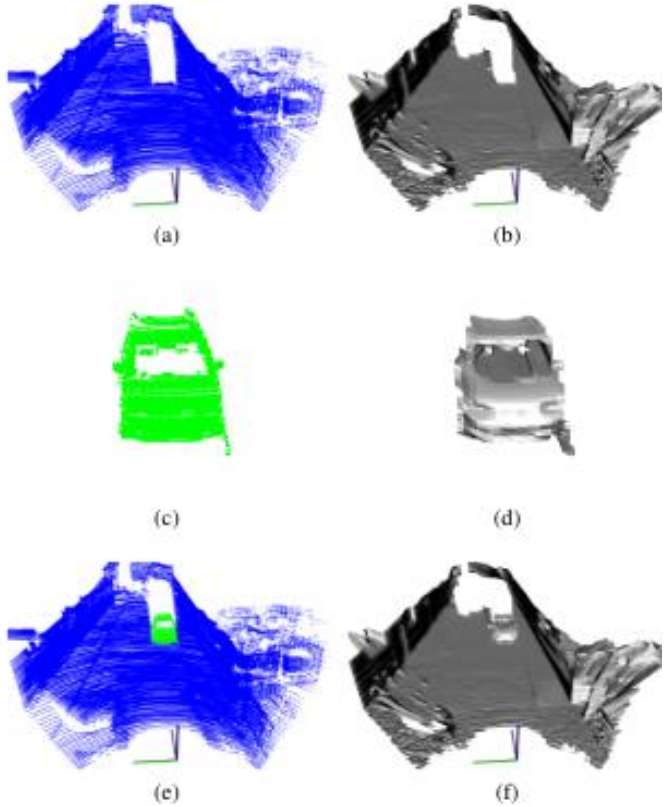


Cortés, I.; Beltrán, J.; de la Escalera, A.; García, F. Joint Object Detection and Re-Identification for 3D Obstacle Multi-Camera Systems. Sensors 2023, 23, 9395. https://doi.org/10.3390/s23239395.

Generalization

Synthetic LiDAR generation

Method to create Lidar pattern for any target LiDAR



Original VLP32C HDL64E VLS128

Beltrán, Jorge, et al. "A method for synthetic LiDAR generation to create annotated datasets for autonomous vehicles perception." 2019 IEEE Intelligent Transportation Systems Conference (ITSC). IEEE, 2019.

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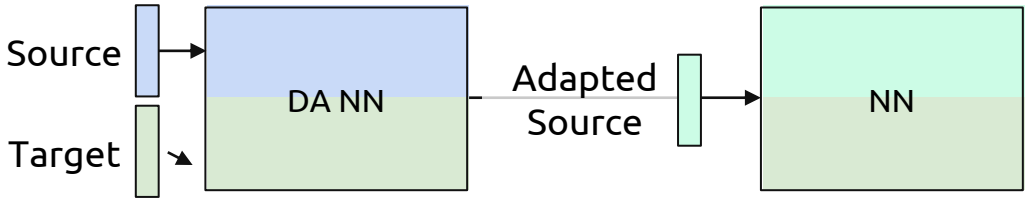
Domain Adaptation

Improve the performance of a NN on a target domain that uses a related domain for training



Source - Sim | Adaptation | Target - Real

A. Barrera, J. Beltrán, C. Guindel, J. A. Iglesias and F. García, "Cycle and Semantic Consistent Adversarial Domain Adaptation for Reducing Simulation-to-Real Domain Shift in LiDAR Bird's Eye View," 2021 IEEE International Intelligent Transportation Systems Conference (ITSC), Indianapolis, IN, USA, 2021, pp. 3081-3086, doi: 10.1109/ITSC48978.2021.9564553.

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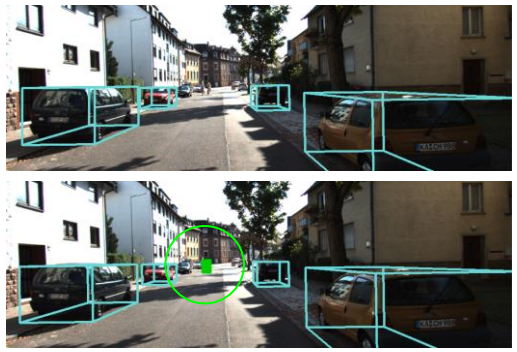
Domain Adaptation

Adaptation for Reducing Simulation-to-Real Domain Shift in LiDAR Bird's Eye View

3D output (projection)

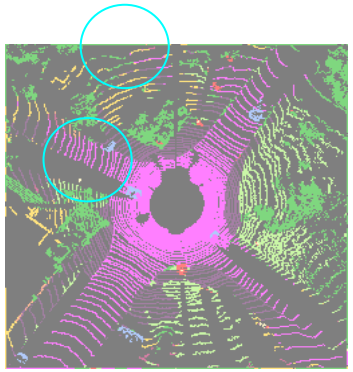
Synthetic

Aligned

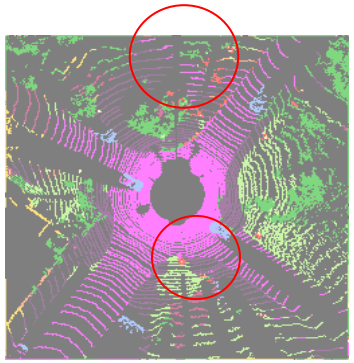


3D Semantic Segmentation

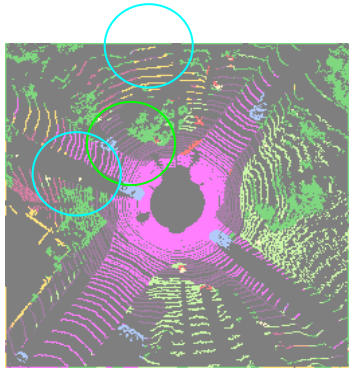
Real



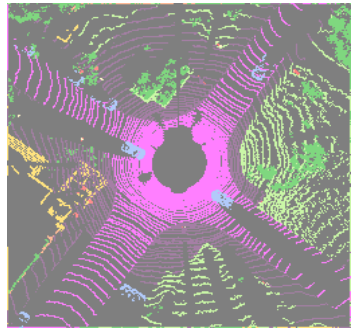
Real + Synt



Real + Aligned



GT



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A. Barrera, J. Beltrán, C. Guindel, J. A. Iglesias and F. García, "Cycle and Semantic Consistent Adversarial Domain Adaptation for Reducing Simulation-to-Real Domain Shift in LiDAR Bird's Eye View," 2021 IEEE International Intelligent Transportation Systems Conference (ITSC), Indianapolis, IN, USA, 2021, pp. 3081-3086, doi: 10.1109/ITSC48978.2021.9564553.

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AMPL AV Challenges

The AV are getting closer, but we still need some challenges

- Perception
- **Localization**
- Evaluation / performance
- Human Factors

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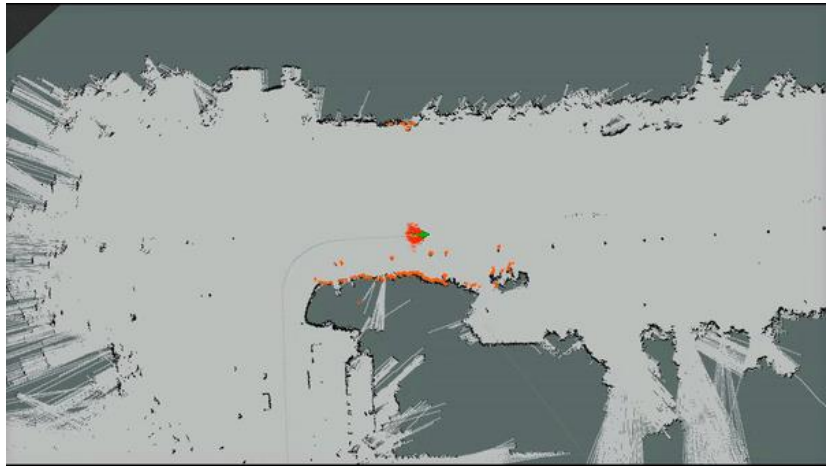
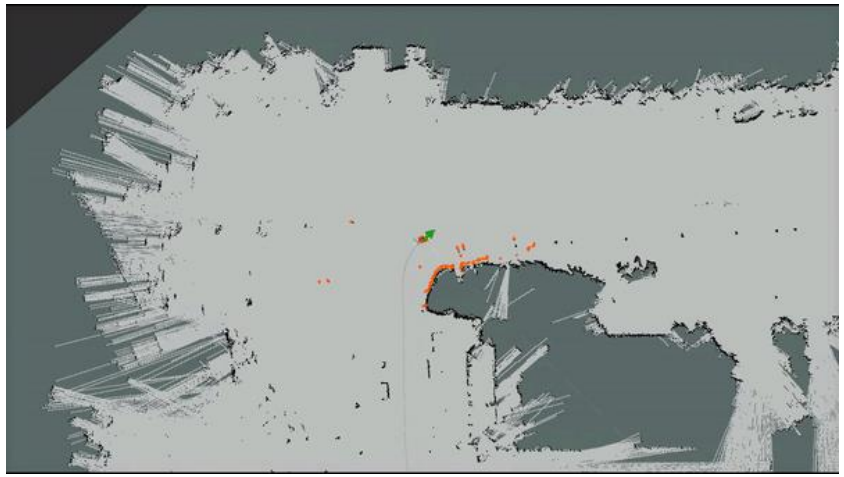
GNSS Localization Enhancement

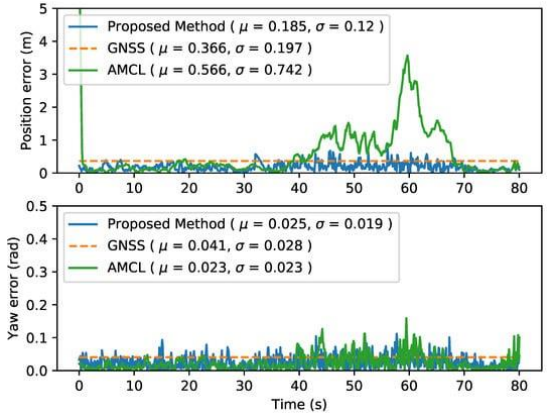
localization enhancement through data fusion



GPS



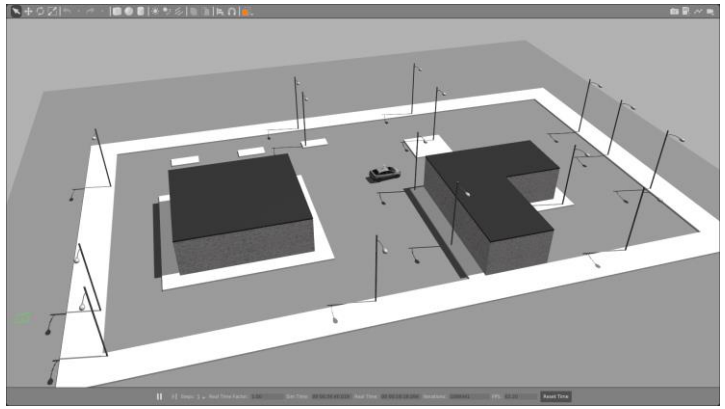
GPS-AMCL



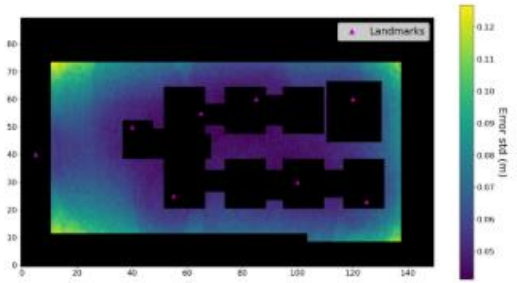
De Miguel, M. Á., García, F., & Armingol, J. M. (2020). Improved LiDAR probabilistic localization for autonomous vehicles using GNSS. Sensors, 20(11), 3145.

Landmark Localization

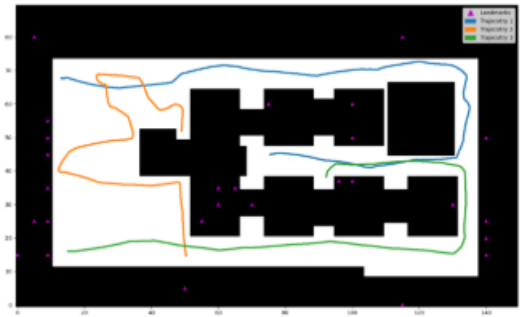
Landmark Placement Optimization, for landmark placement localization-based approaches



Map generation
&
Localization
Requirements



Landmark localization



validation

F. M. Moreno, A. Hussein and F. Garcia, "Landmark Placement Optimization for Accurate Localization in Autonomous Vehicles," 2021 IEEE International Intelligent Transportation Systems Conference (ITSC), Indianapolis, IN, USA, 2021, pp. 128-134, doi: 10.1109/ITSC48978.2021.9564926.

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AMPL AV Challenges

The AV are getting closer, but we still need some challenges

- Perception
- Localization
- **Evaluation / performance**
- Human Factors

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Digitalizer

Use of perception technologies as digitalization opportunity

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Digital twin

Use of Digitalized data for Digital Twinning

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Digital twin

Use of Digitalized data for Digital Twinning






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AMPL AV Challenges

The AV are getting closer, but we still need some challenges

- Perception
- Localization
- Evaluation / performance
- **Human Factors**

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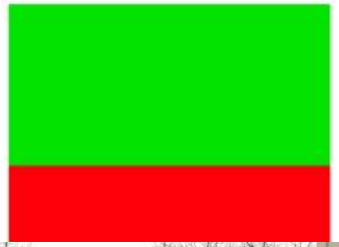
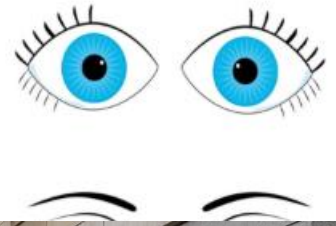
Driver-Pedestrian Interaction

Test of different HMI for pedestrians and Robo-vehicles





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Driver-Pedestrian Interaction

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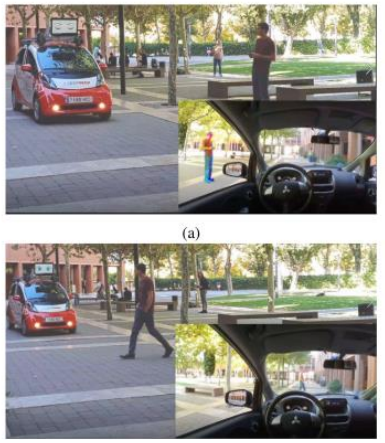

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M. Á. de Miguel, D. Fuchshuber, A. Hussein and C. Olaverri-Monreal, "Perceived Pedestrian Safety: Public Interaction with Driverless Vehicles," *2019 IEEE Intelligent Vehicles Symposium (IV)*, Paris, France, 2019, pp. 90-95, doi: 10.1109/IVS.2019.8814145.

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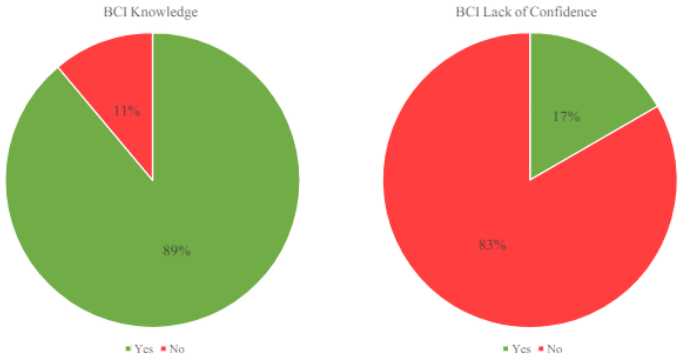
Brain waive

Use case for higher autonomy for people with disabilities



A. Astudillo, F. M. Moreno, A. Hussein and F. García, "Cost-efficient brainwave controller for automated vehicles route decisions," *2017 IEEE 20th International Conference on Intelligent Transportation Systems (ITSC)*, Yokohama, Japan, 2017, pp. 51-56, doi: 10.1109/ITSC.2017.8317949.

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Driver-Pedestrian Interaction

Test of acceptance of autonomous vehicles in 2022 with ATLAS platform

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Encinar, R., Madridano, Á., de Miguel, M. Á., Palos, M., García, F., & Bolte, J. (2023). Exploring the Evolution of Autonomous Vehicle Acceptance through Hands-On Demonstrations. Applied Sciences, 13(23), 12822.

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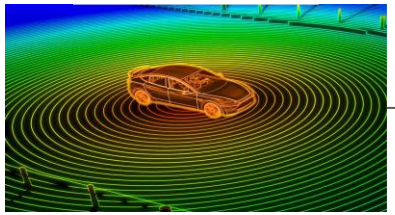
What is next?

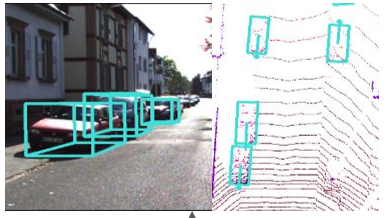
What is coming?

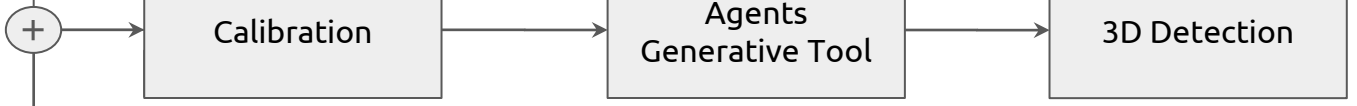
Automatic generation of agents from public datasets relying on camera and LiDAR sensors

LiDAR



Camera





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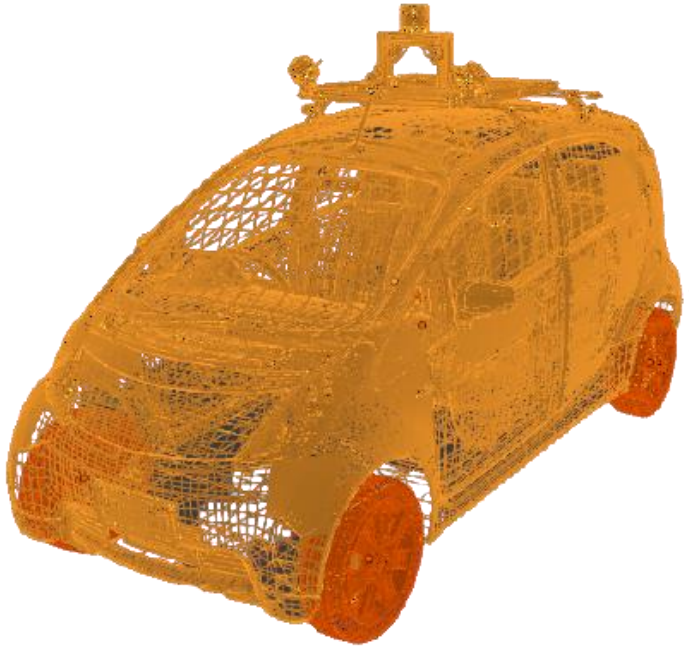
What is coming?

Digital twins moving ahead



Evaluation of vehicles sensors

Evaluation of AV performance

Scene reconstruction

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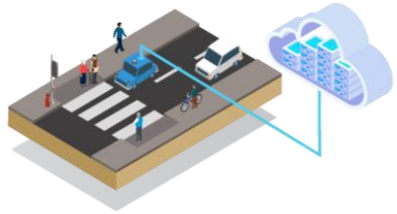
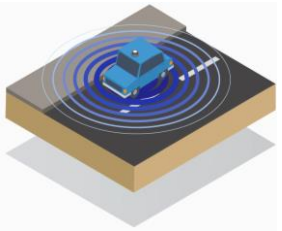
SEEVIA

The origin of the idea

- Seevia exists as:
  - Natural evolution of a successful laboratory
  - Response to the request of some of our clients
- Success in developing automotive applications
- Actors in the market:
  - 5 years of industrial applications
  - International visibility





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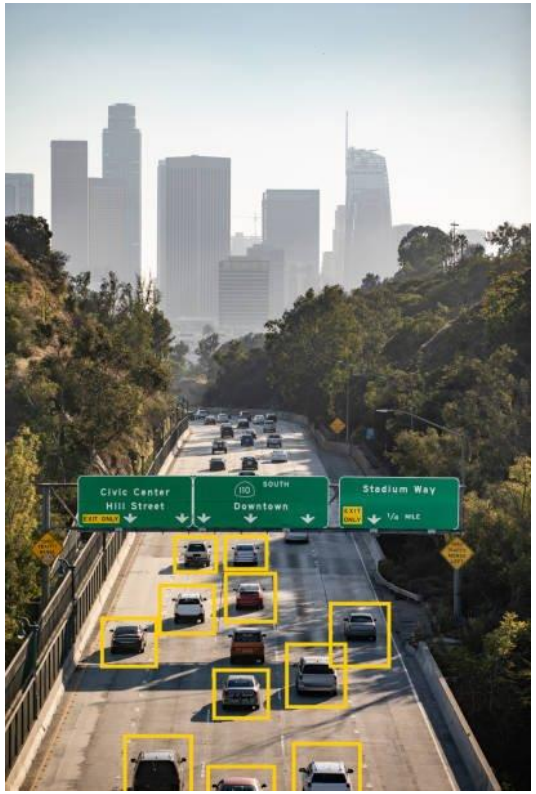
SEEVIA Core

AI-Powered Perception and Automation Solutions for a safer and more sustainable World

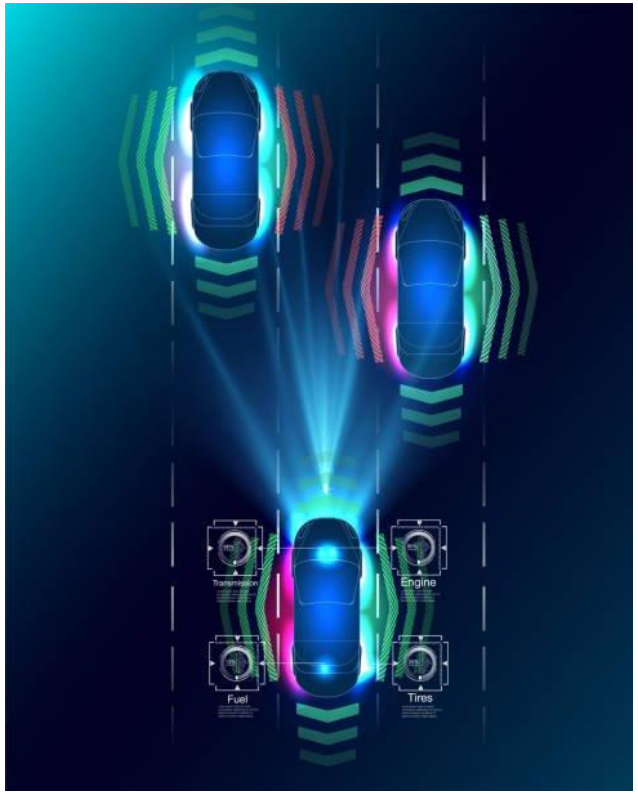
Smart City and Infrastructure

Fostering more sustainable, efficient and secure cities and infrastructures



Autonomous Mobility

Driving the automotive industry to the next level



Industry 4.0 and Energy

Automating and improving industrial processes

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Already providing solutions in AV domain

Renault DIVEC

Seevia Digitalizer

Crisalion Ground Service

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SEEVIA AUTO

Already providing solutions in AV domain

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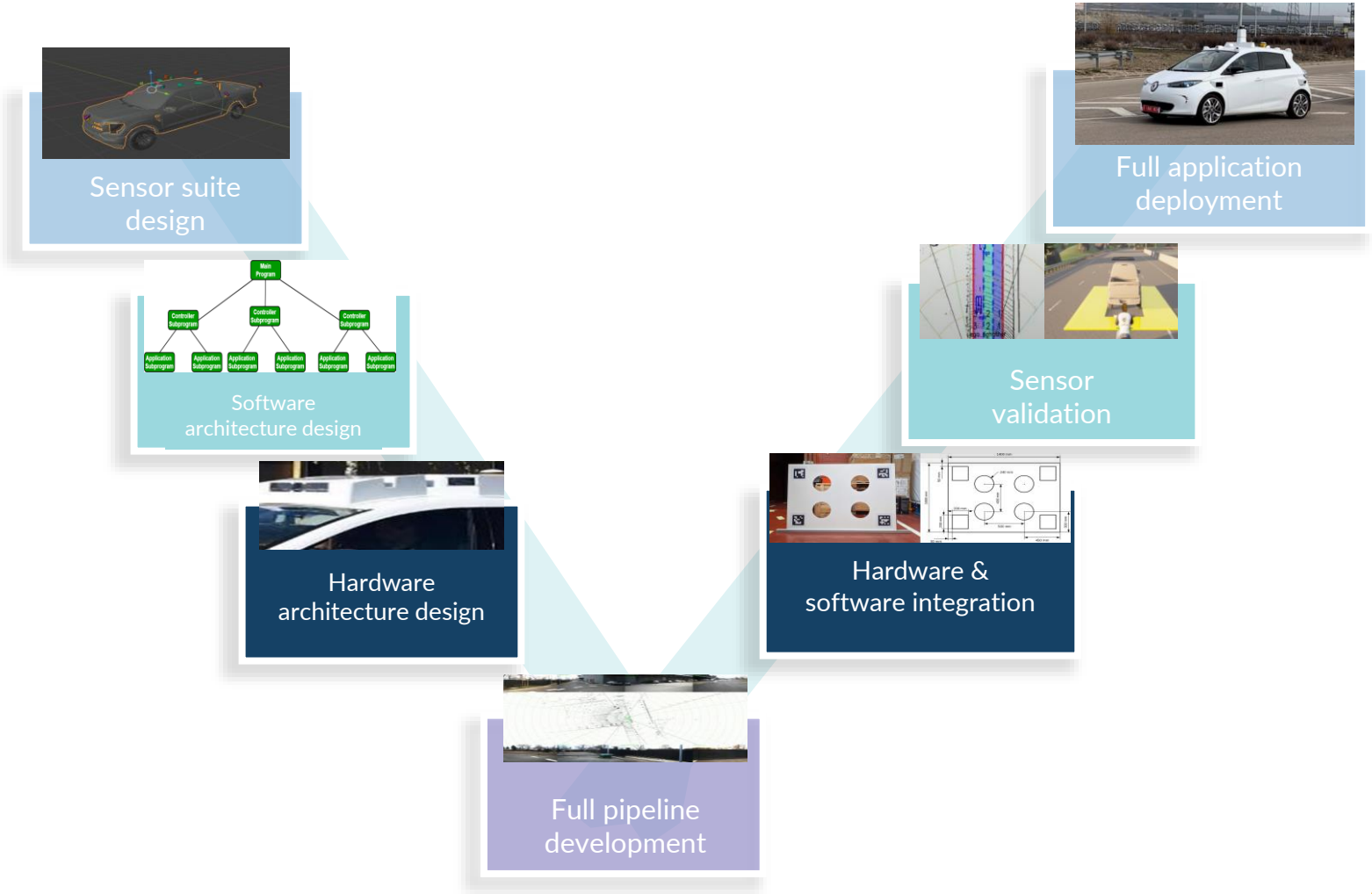
SEEVIA AUTO



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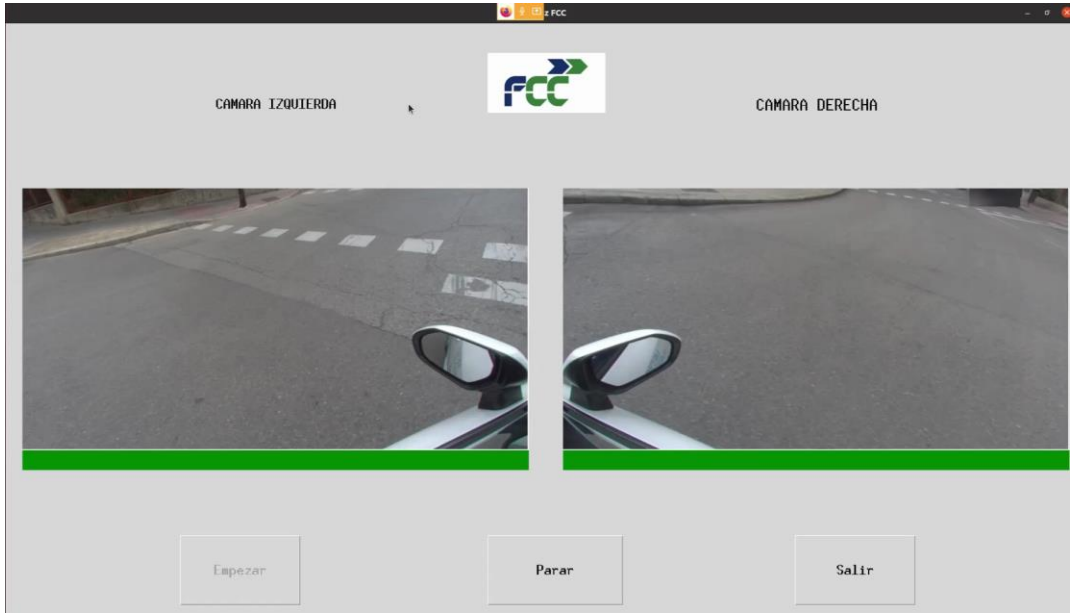
SEEVIA CITY

Smart city applications in development



Smart garbage detector

Smart ports

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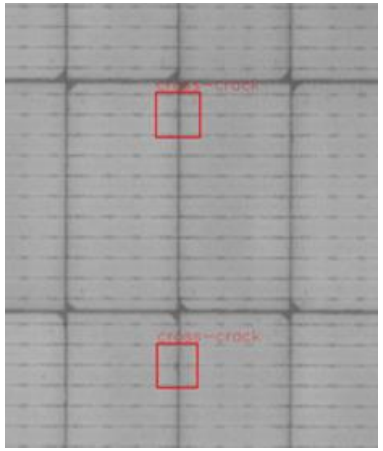
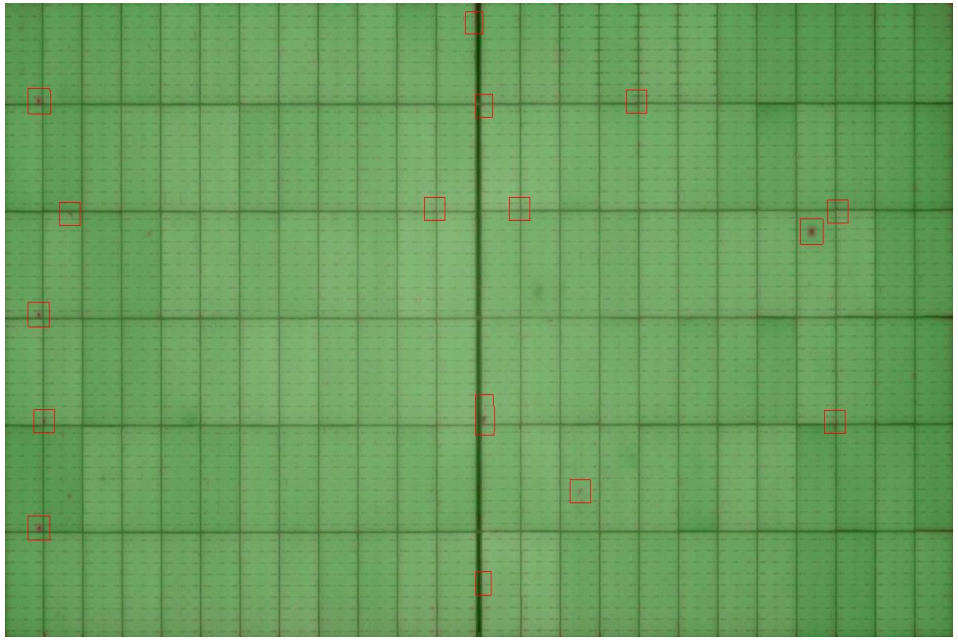
SEEVIA I 4.0

Solutions for inspection in industrial applications





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Navigating the future

Leading **AI-Powered** Perception and Automation Solutions

SEEVIA develops advanced technological solutions based on **Artificial Intelligence** and **Computer Vision.**

We **support our clients** in adopting these technologies, **adding value to their businesses** and processes.

THANK YOU

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