SIS 60: Challenges of multi modal ML-based perception development & testing for automated driving applications

Organizer: Angelos Amditis (ICCS)
Moderator: Anastasia Bolovinou (ICCS)

Speaker: Abhinav Valada,
Professor (University of Freiburg
Speaker: Antti Kangasrääsiö,
Head of Research, Sensible 4
Speaker: Eren Aksoy
Professor, Halmstad University

LISBON 2023

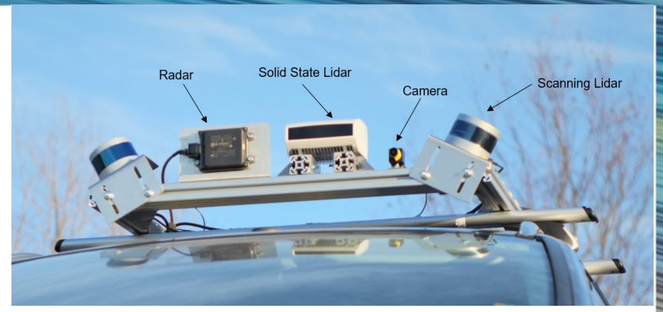
Session format

Intro by Moderator

Part A: Speakers short pitches (up to 30’ total)

Part B: Roundtable discussion and QnAs from the audience (up to 20’ total)

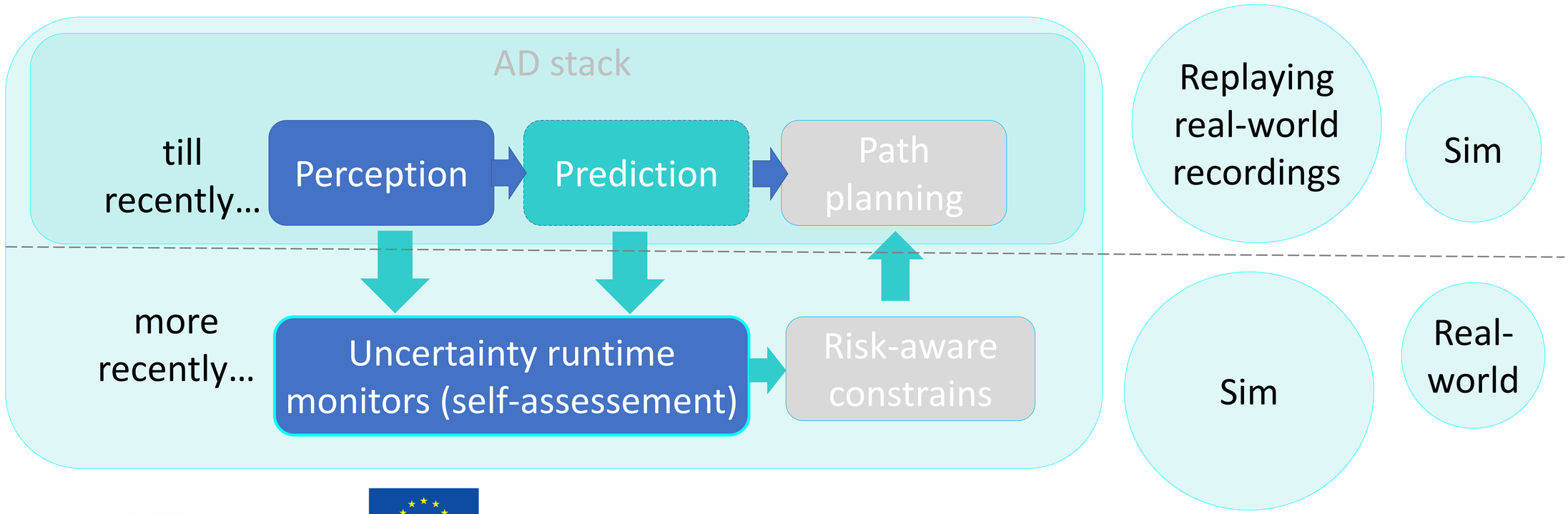
Intro (1/4)



Perception based on Radar, Camera, LiDAR
↳ Scene understanding (2D/3D visual + audio)

EVENTS

Safety of the intended functionality => Fusion, Redundancy by design



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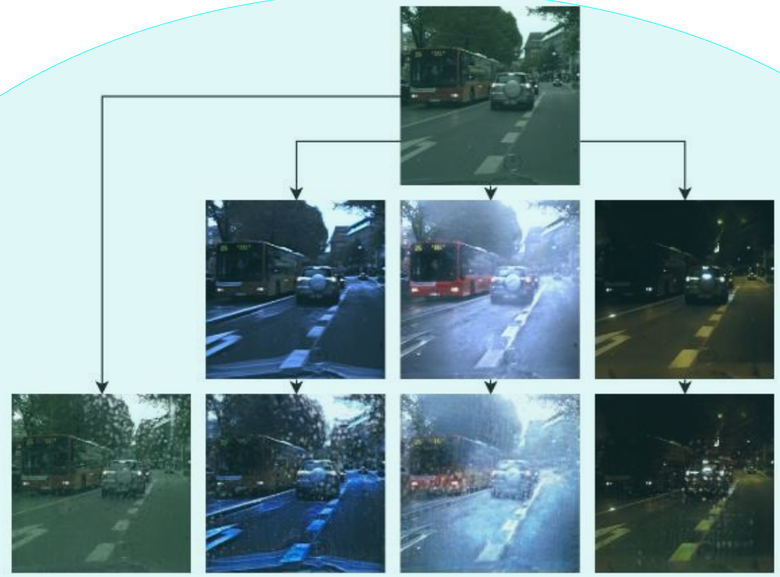
Intro by moderator (2/4)

Perception testing

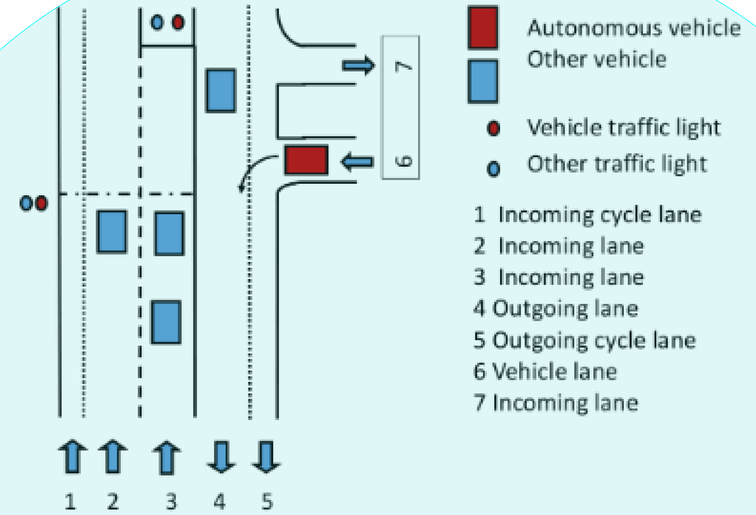
Open Road Trials, Closed Test track trials, Chamber trials

Virtual testing and synthetic data augmentation

New Benchmark Datasets (raw data, annotated objects, annotated scenarios)



*Source: Multi-weather city: Adverse weather stacking for autonomous driving, ICCV, Oxf Brookes Uni



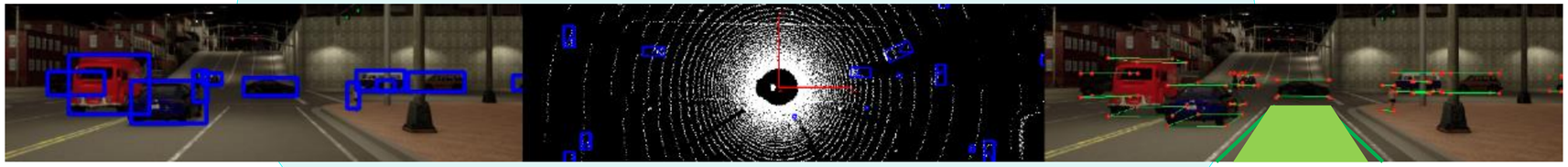
*Source: ROAD: The ROad event Awareness Dataset forAutonomous Driving, PAMI, 2022

Intro (3/4)

Object and events detection and their representations:

2D-bounding box, 3D-bounding box
segmented instances, pixel-based
Lanes, **Driving free space**
actions, events

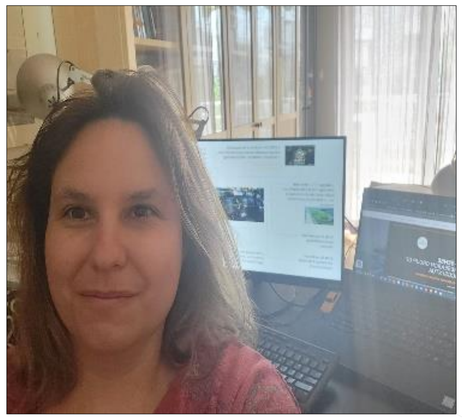
Source: AD PerDevKit: An Autonomous Driving Perception Development Kit using CARLA simulator and ROS



2D BEV 3D

Intro by moderator (4/4)

Our panel participants



Anastasia Bolovinou
Research engineer, Institute of Communication and Computer Systems (ICCS)

Antti Kangasrääsiö
Head of Research at Sensible 4, a Finnish all-weather autonomous driving startup

Eren Erdal Aksoy
Professor (Associate) at Halmstad University
Germany

Abhinav Valada
Assistant Professor and Director of the Robot Learning Lab at the University of Freiburg, Germany.

4EVENTS ROADVIEW

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Ener-Alcoy_HH-coordinator-e1663766875246.webp

Pitches

Semantics-aware Multi-modal Domain Translation: Going from LiDAR to Camera

An industry view: Dealing with environment change in all-weather perception for autonomous driving.

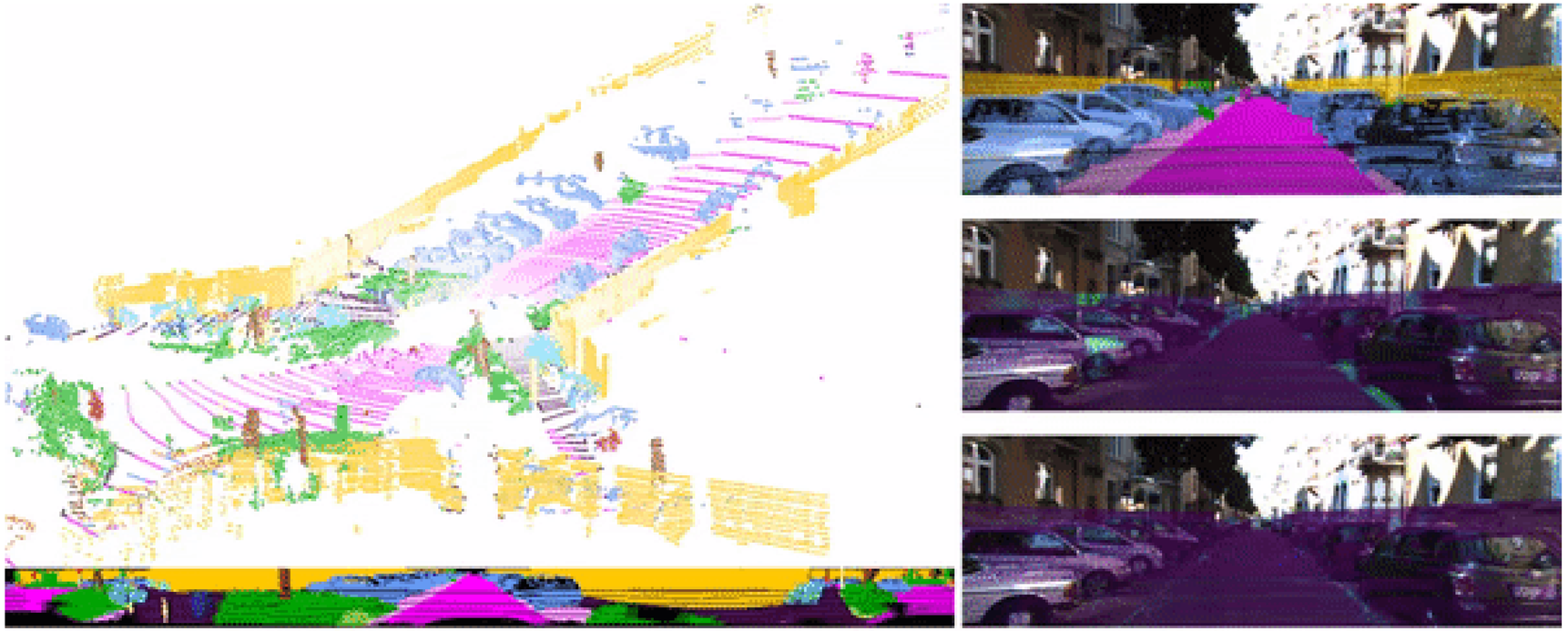
Training an amodal panoptic segmentation module able to understand occluded regions.

Semantics-aware Multi-modal Domain Translation: Going from LiDAR to Camera

Eren Erdal Aksoy

Associate Professor
Halmstad University
Sweden

Uncertainty-aware Semantic Perception with LiDAR-only Data

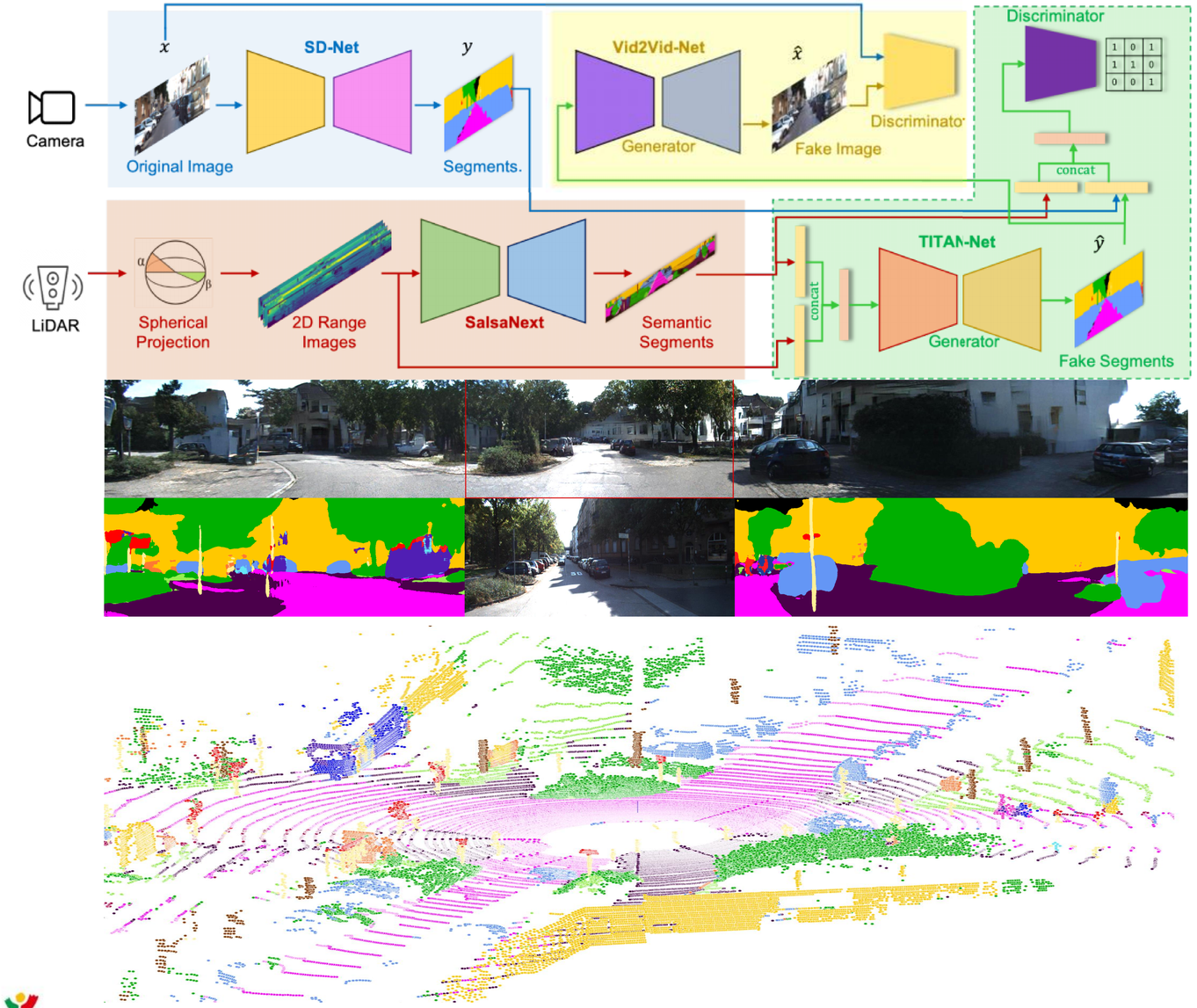


Interpretability makes clear what the system ***"knows"*** while ***uncertainty awareness*** reveals what the system ***does not "know."***

VINNOVA FFI HALMSTAD UNIVERSITY VOLVO Volvo Group Trucks Technology

Cortinhal et al., "Salsanext: Fast, Uncertainty-aware Semantic Segmentation of LiDAR Point Clouds for Autonomous Driving," in International Symposium on Visual Computing, 2020.

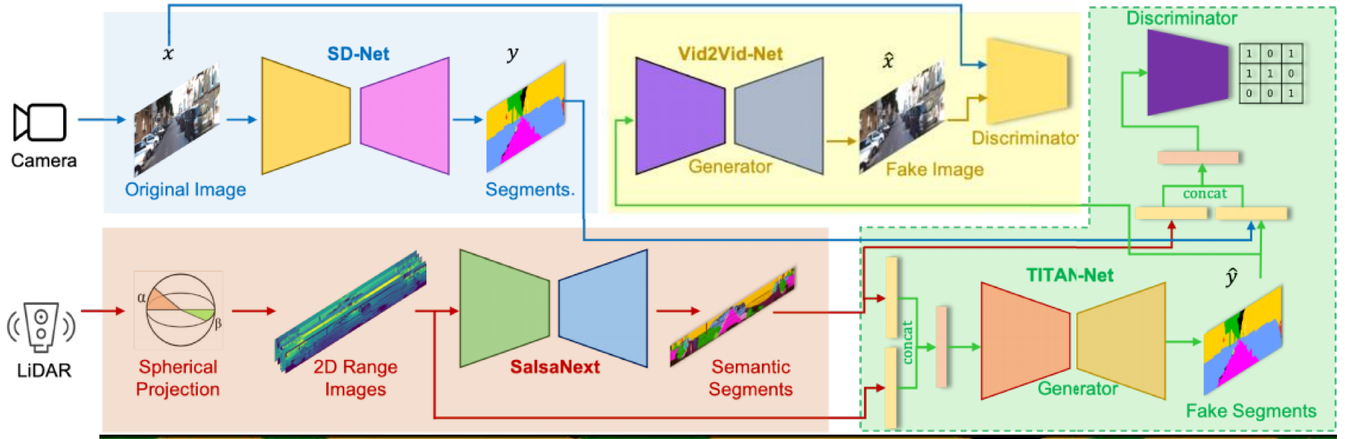
Semantics-aware Domain Translation: Sensor-to-sensor Mapping

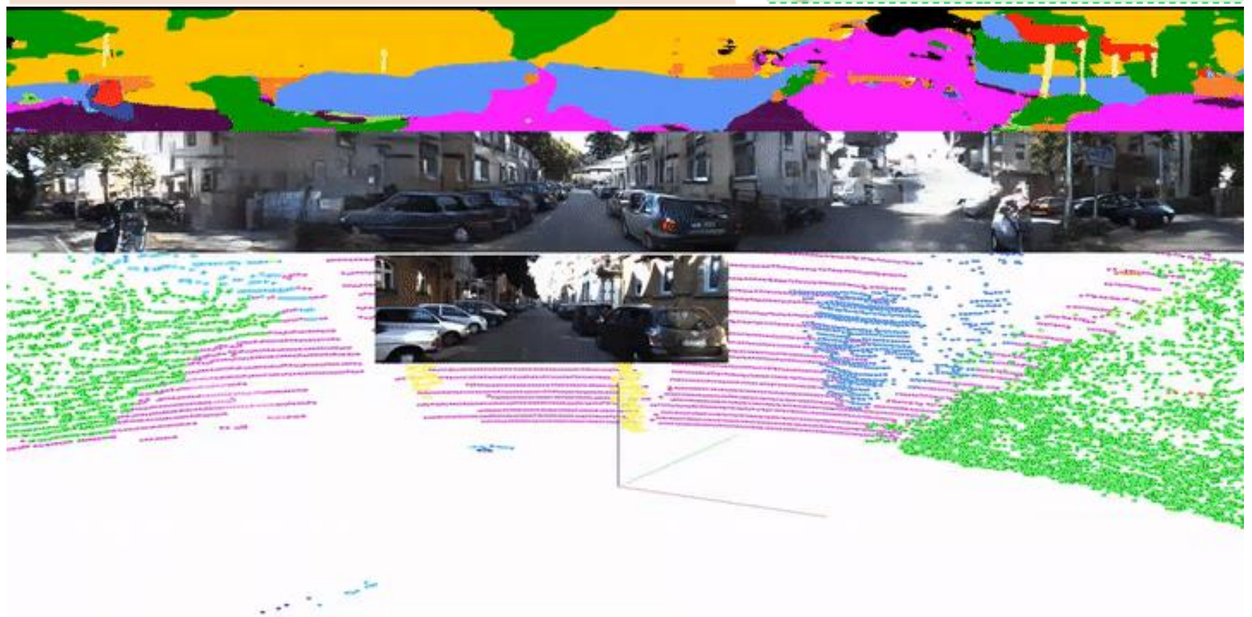


Cortinhal et al., "Semantics-aware Multi-modal Domain Translation" in ICCV-W, 2021.

Best Student Paper Award
IJCAI - AI4AD 2021

Semantics-aware Domain Translation: Sensor-to-sensor Mapping





We propose a modular generative neural network framework that receives a full 3D LiDAR point cloud and returns the panoramic color image by solely relying on the semantics of the scene.

Cortinhal et al., "Semantics-aware Multi-modal Domain Translation" in ICCV-W, 2021.

Best Student Paper Award
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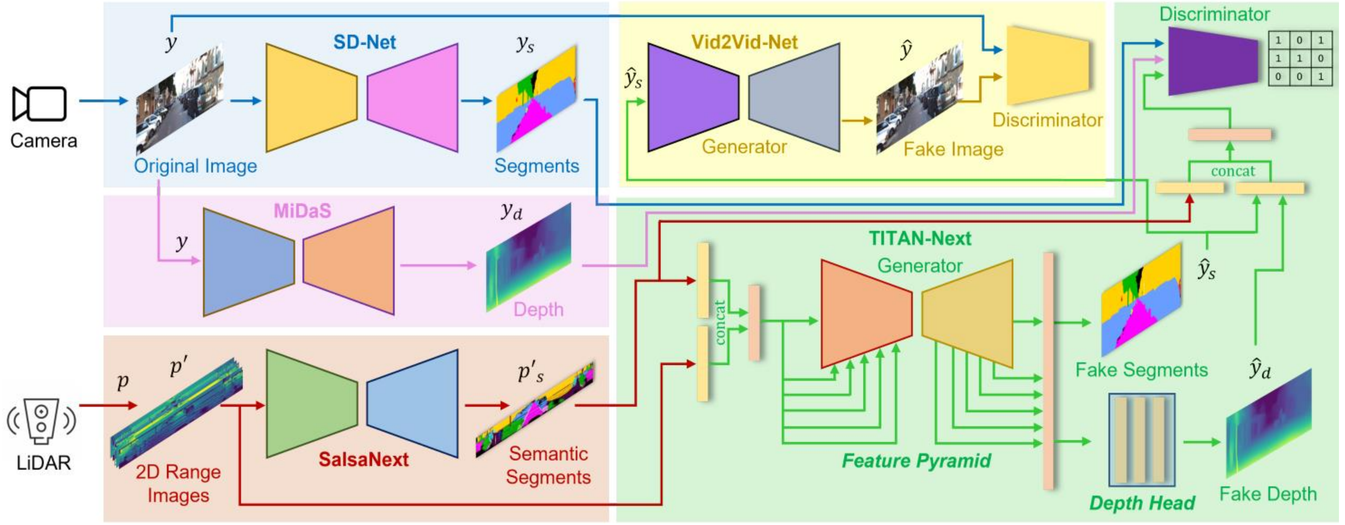
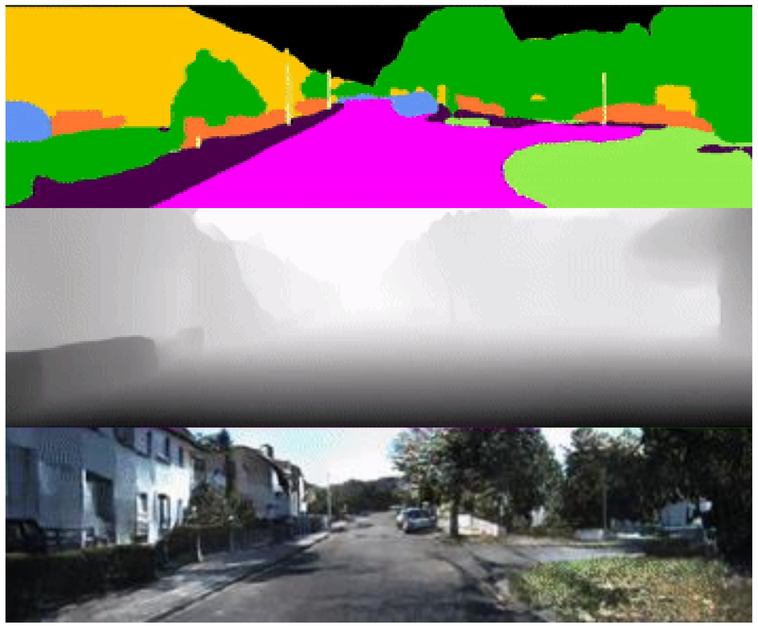
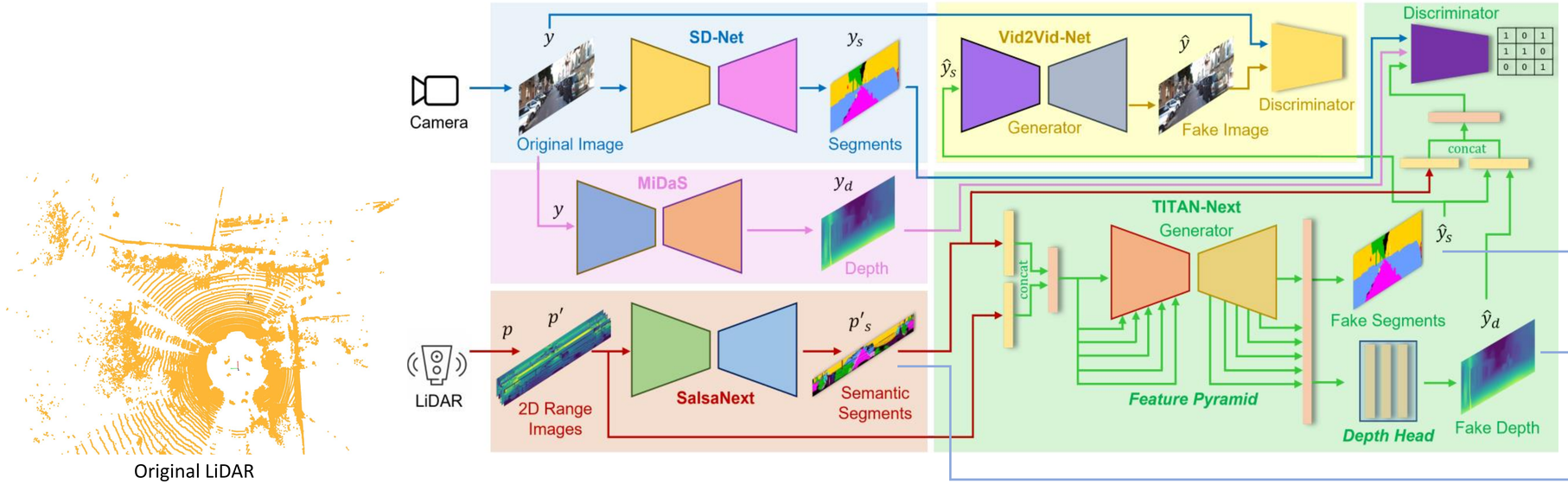
Semantics-aware Domain Translation: Sensor-to-sensor Mapping

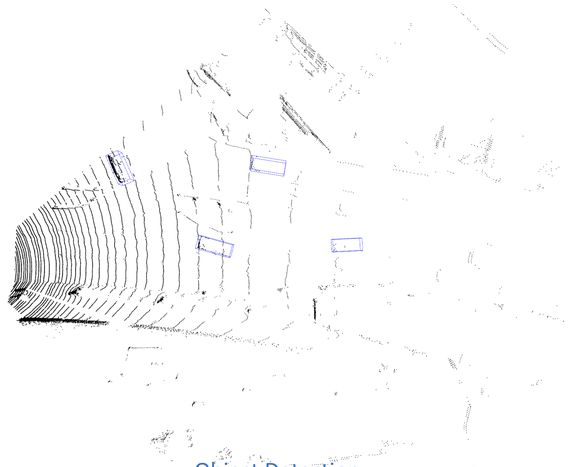




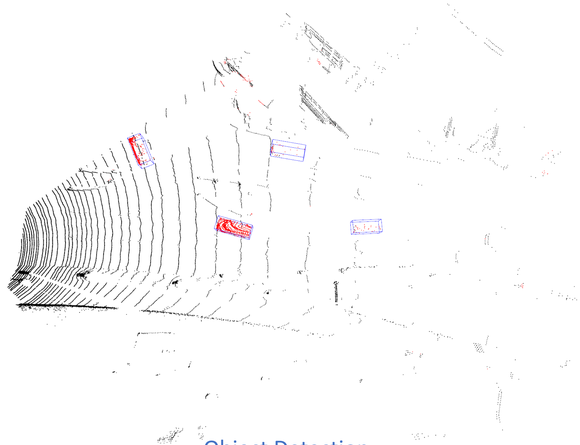
Cortinhal et al., "Depth- and Semantics-aware Multi-modal Domain Translation" in arXiv, 2023.

Semantics-aware Domain Translation for Object Detection





Object Detection
on Original LiDAR

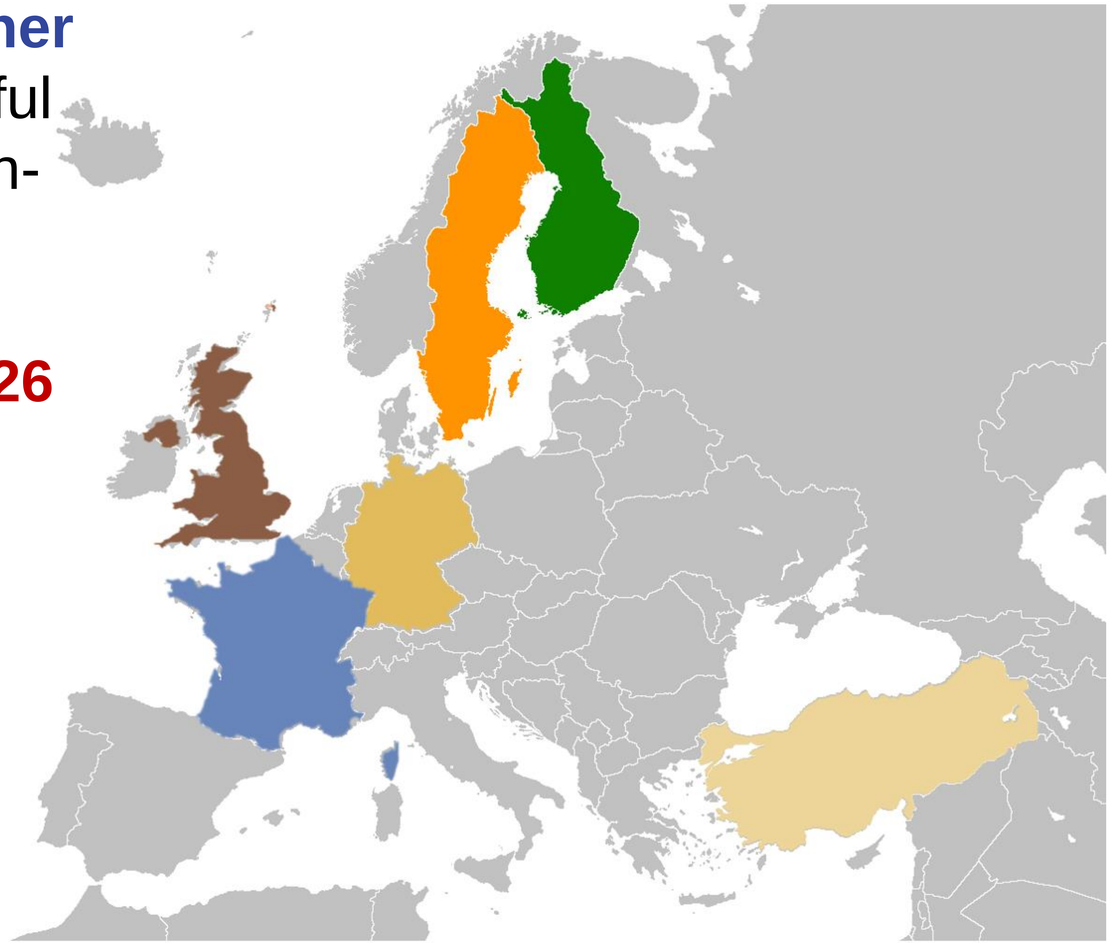


Object Detection
on Augmented LiDAR

ROADVIEW

Robust Automated Driving in Extreme Weather

- **HORIZON-CL5-2021-D6-01-01:** More powerful and reliable on-board perception and decision-making technologies addressing complex environmental conditions (Innovation Action)
- **15 partners, ~10 M Euro, TRL 6-7, 2022-2026**



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CLIMAT & TERRITOIRES DE DEMAIN

WARWICK
THE UNIVERSITY OF WARWICK

SNOWBOX

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Lapland University of Applied Sciences

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Technische Hochschule Ingolstadt

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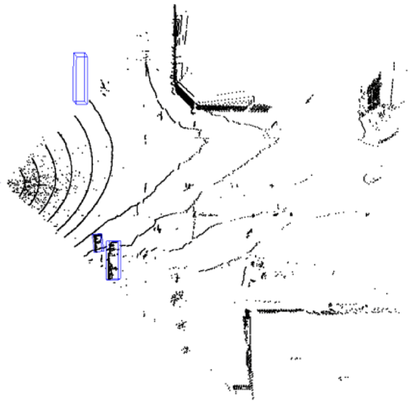
ROADVIEW

Robust Automated Driving in Extreme Weather

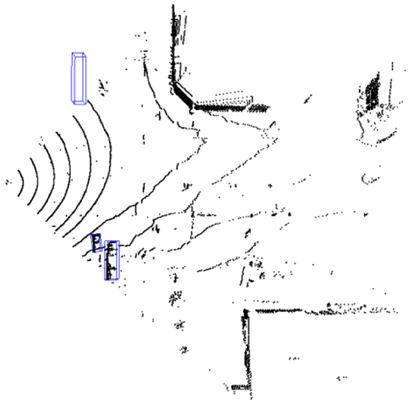
- De-noising LiDAR Point Clouds for Object Detection in Extreme Weather

LiDAR



Snowy LiDAR Point Cloud

De-noising



Filtered LiDAR Point Cloud

	mAP		
	Easy	Med	Hard
PointPillars (Baseline)	83.4	76.0	**73.5**
Augmented LiDAR	**85.0**	**77.6**	73.4

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Thank you!

Pitches

Semantics-aware Multi-modal Domain Translation: Going from LiDAR to Camera

An industry view: Dealing with environment change in all-weather perception for autonomous driving.

Training an amodal panoptic segmentation module able to understand occluded regions.

sensible4 ROADVIEW EVENTS GAMMS ROBOTS MAPPING FOR ROBOTS

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An Industry View: Dealing with Environment Change in All-weather Perception for Autonomous Driving

ITS European Congress 2023 Lisbon
Dr. Antti Kangasrääsiö, Head of Research
Sensible 4, Finland

Our mission is to enable autonomous driving everywhere

People, businesses and society should have the benefits of autonomous driving everywhere and everytime. We make that happen. Our unique software will take autonomous vehicles to places where others can't operate.

sensible 4

Key customers

TOYOTA NOKIA Panasonic MUJI 無印良品

All-weather Perception

The environment is always changing

Changes happen both suddenly and over a long time

- Weather around the vehicle: rain, slush, snow, fog
- Accumulation of ice and snow over the winter
- Seasonal changes in trees and other roadside plants
- Roadwork and new buildings

Perception systems need to adapt to these challenges

- Measurement noise due to particles in the air
- Maps of the environment lose precision over time

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Robust Object Detection

Always aware of the surroundings

Smart filtering

- Remove noise from the sensor signals
- Focus detection on where it matters
- Efficient high-speed filtering methods

Safe Object Detection

- Identify persistent parts of an object
- Robust to noise in the sensor signal
- Robust to partial occlusion of the object
- Low-latency updates

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Robust Localization

Never losing our way

Probabilistic mapping

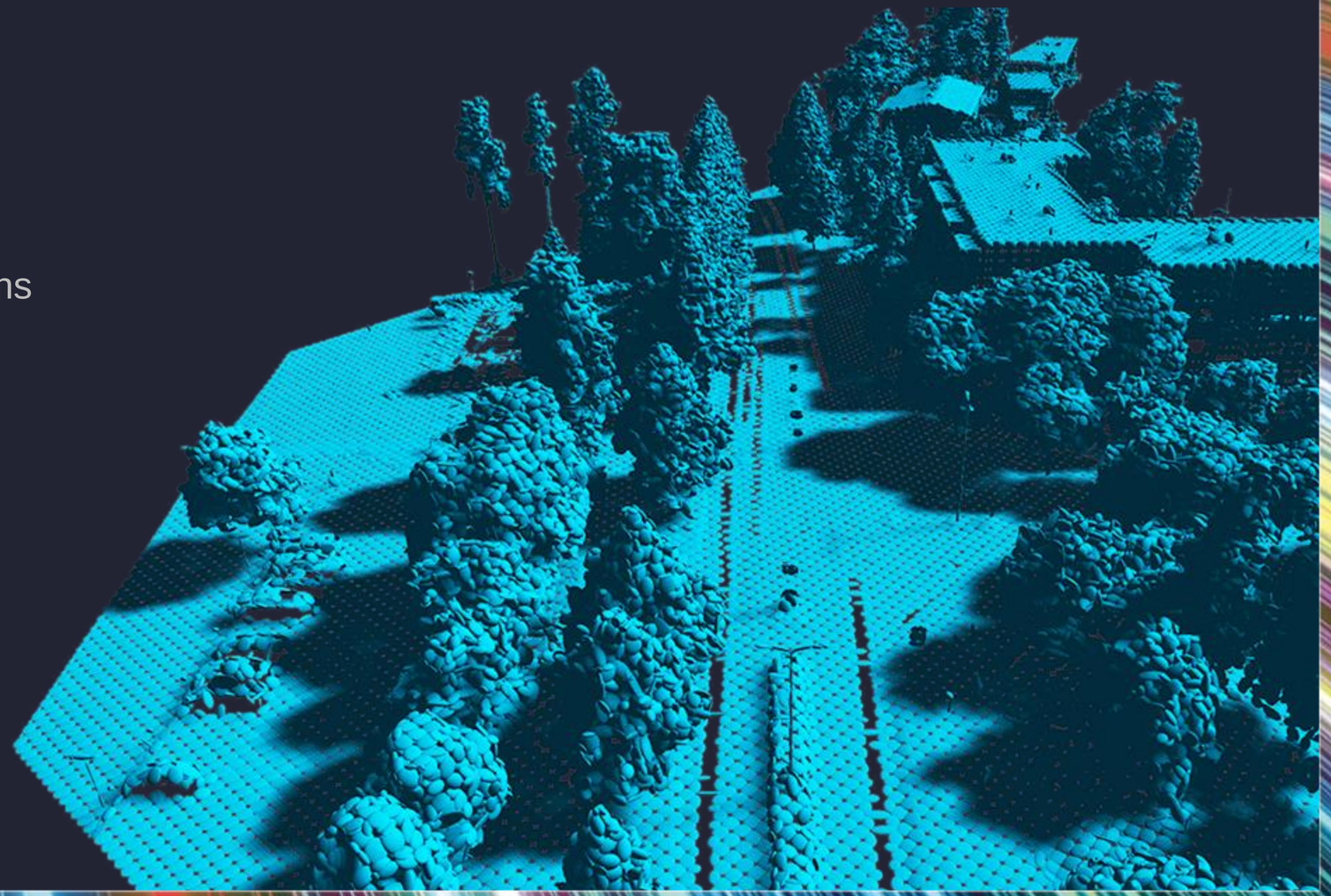
. High-definition 3D maps of the environment
. Enables efficient probabilistic localization

Robust Localization

. Probability distribution over possible locations
. Efficient high-frequency updates

Benefits

. Tolerates large changes in the environment
. Tolerates high measurement noise



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Research Collaboration

Defining the methods of the future

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ROADVIEW

Robust automated driving in extreme weather conditions

- Visibility estimation
- Friction estimation
- Safe control
- Safe navigation

EVENTS

Robust perception and decision making for autonomous driving

- Scene analysis
- Robust perception
- Robust localization
- Robust motion planning

GAMMS

ROBOTS MAPPING FOR ROBOTS

Robust & automated mapping and localization methods

- Autonomous mapping
- HD maps
- Map updating
- Map quality assessment

We are always open for new collaboration!

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www.sensible4.fi

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Pitches

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universität freiburg

Amodal Panoptic Segmentation

Prof. Dr. Abhinav Valada

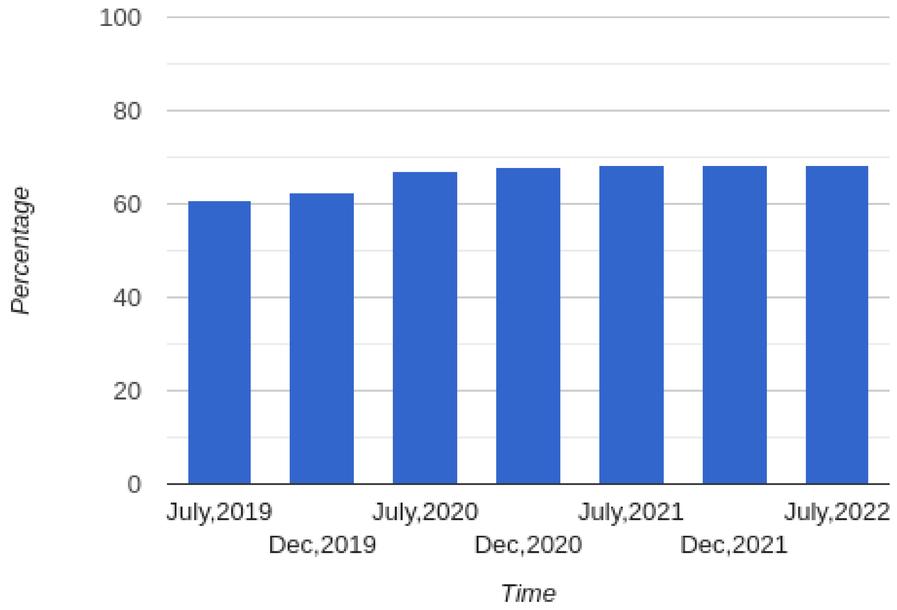
Robot Learning Lab

03 May 2023

ellis unit FREIBURG

What Is Panoptic Segmentation?

Pixel-level semantic segmentation of *stuff* classes and instance segmentation of *thing* classes



Cityscapes Panoptic Quality

How do we go beyond?

How Do Humans Perceive Objects?

- Amodal Perception: Humans perceive objects as a whole regardless of partial occlusion
- Connects our perception of the world to its cognitive understanding
- Autonomous Systems: Still limited to modal perception

Amodal Panoptic Segmentation

R. Mohan, A. Valada: CVPR’22

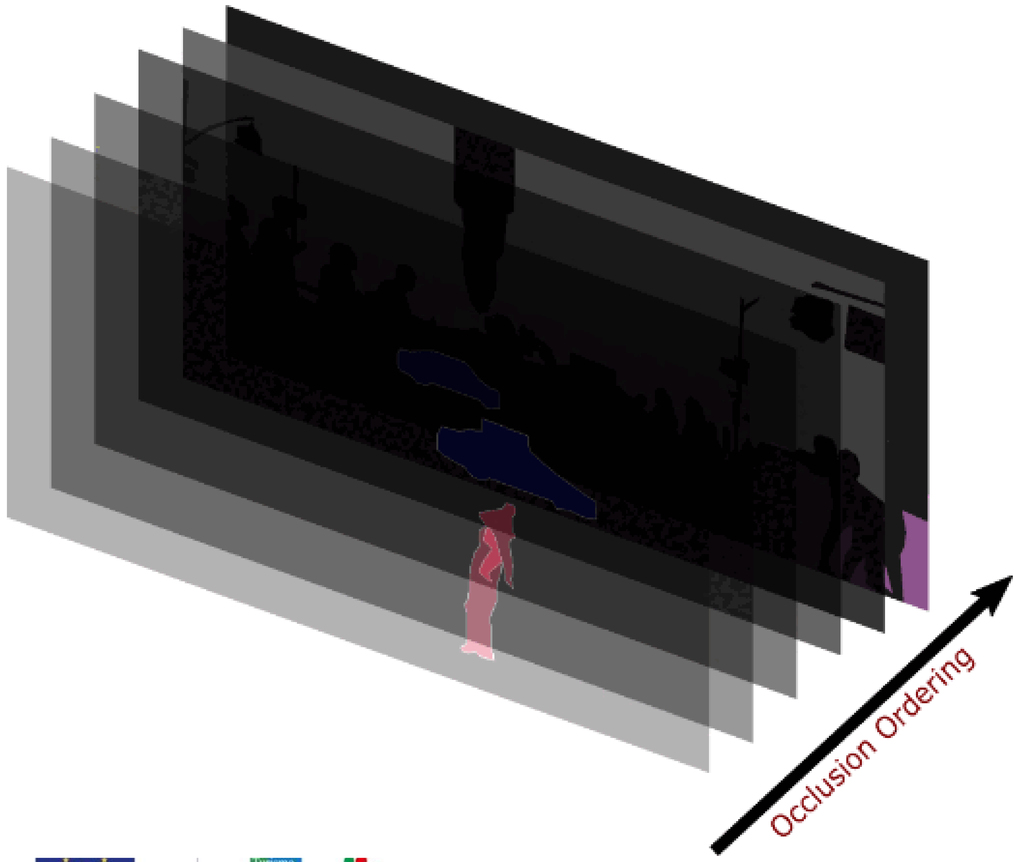
We bridge this gap by formulating the novel amodal panoptic segmentation task

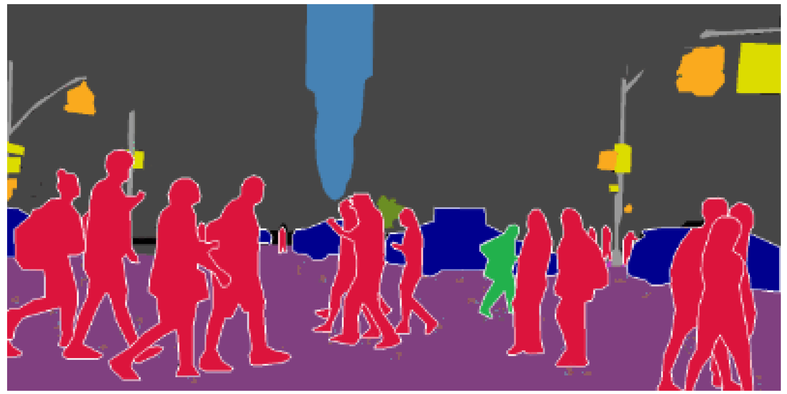
What Is Amodal Panoptic Segmentation?

Simultaneously predict pixel-wise semantic segmentation labels of visible regions of *stuff* classes such as buildings, road, sidewalk, etc

What Is Amodal Panoptic Segmentation?

and instance segmentation labels of both the visible and occluded regions of *thing* classes such as people, car, truck etc.





Why Amodal Panoptic Segmentation?

Perceiving the entire structure of traffic participants at all times, regardless of occlusions, will minimize the risk of accidents and extend the capabilities of autonomous robots

Datasets and Metrics

http://amodal-panoptic.cs.uni-freiburg.de

We extend two challenging urban automated driving datasets with amodal panoptic annotations

KITTI-360-APS

- 61,168 annotations
- 10 *stuff* classes, 7 *thing* classes

BDD100K-APS

- 3,000 annotations
- 10 *stuff* classes, 6 *thing* classes

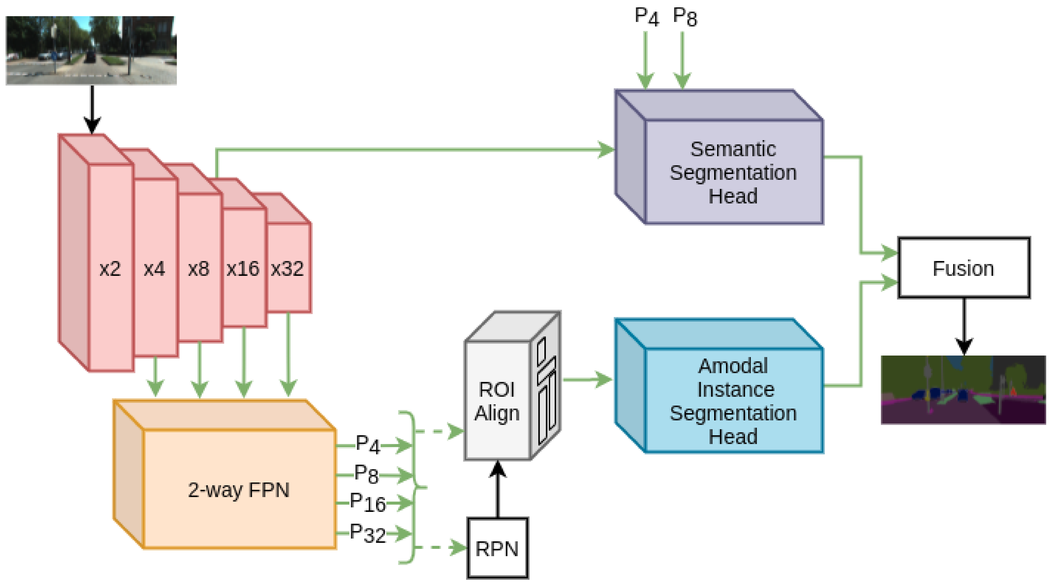
Two Novel Amodal Panoptic Segmentation Methods

We propose two methods

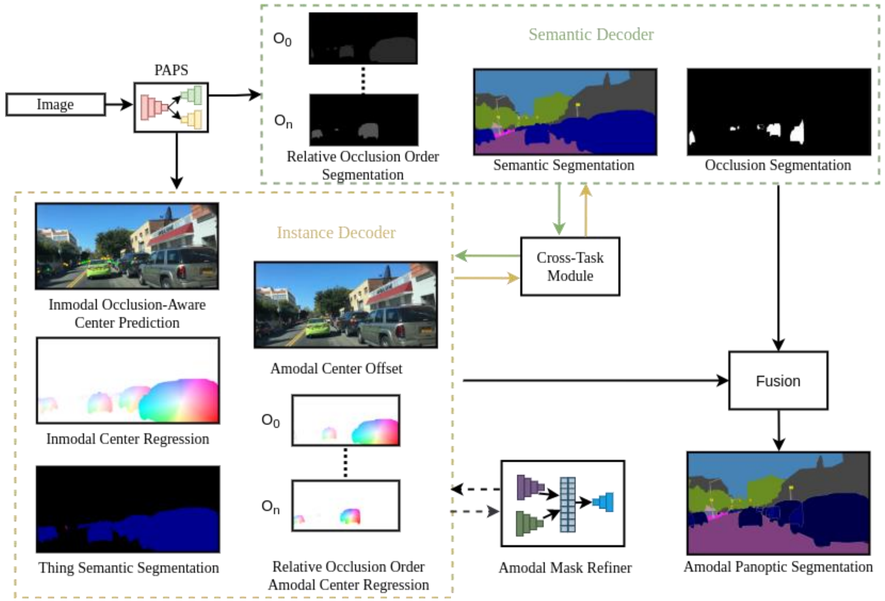
- Proposal-Based: APSNet
- Proposal-Free: PAPS

R. Mohan, A. Valada: CVPR'22

R. Mohan, A. Valada: RA-L'22

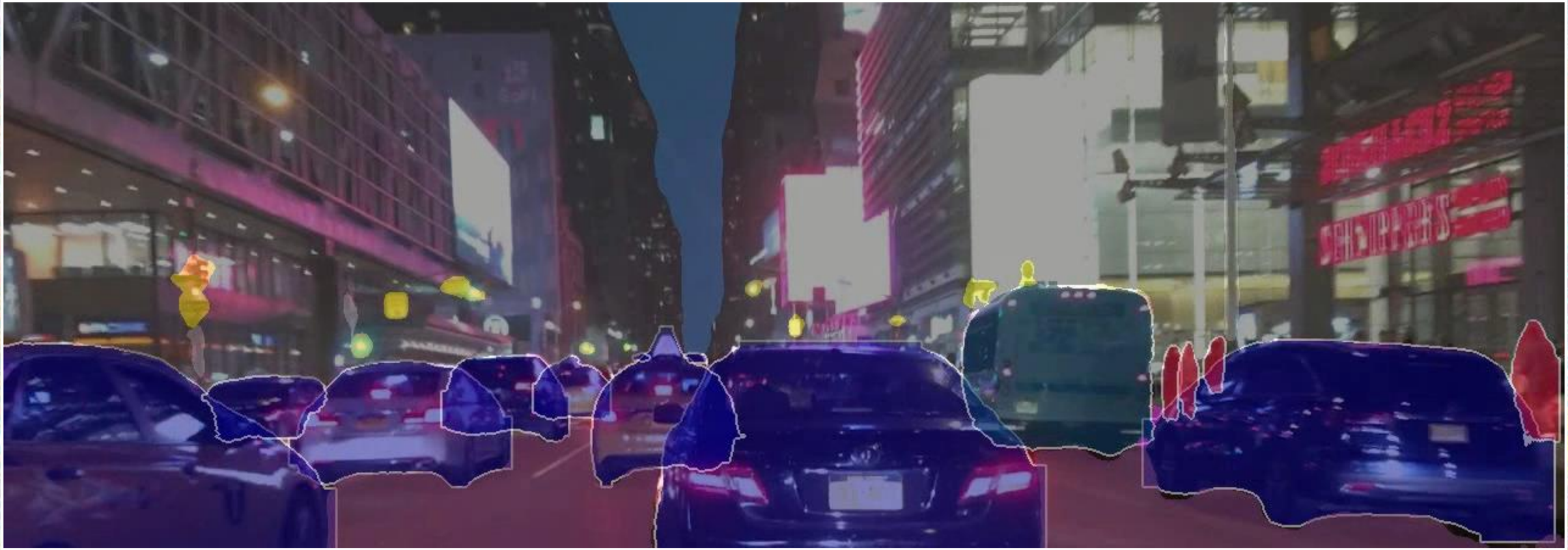


Proposal-Based APSNet Architecture



Proposal-Free PAPS Architecture

Amodal Panoptic Segmentation Results

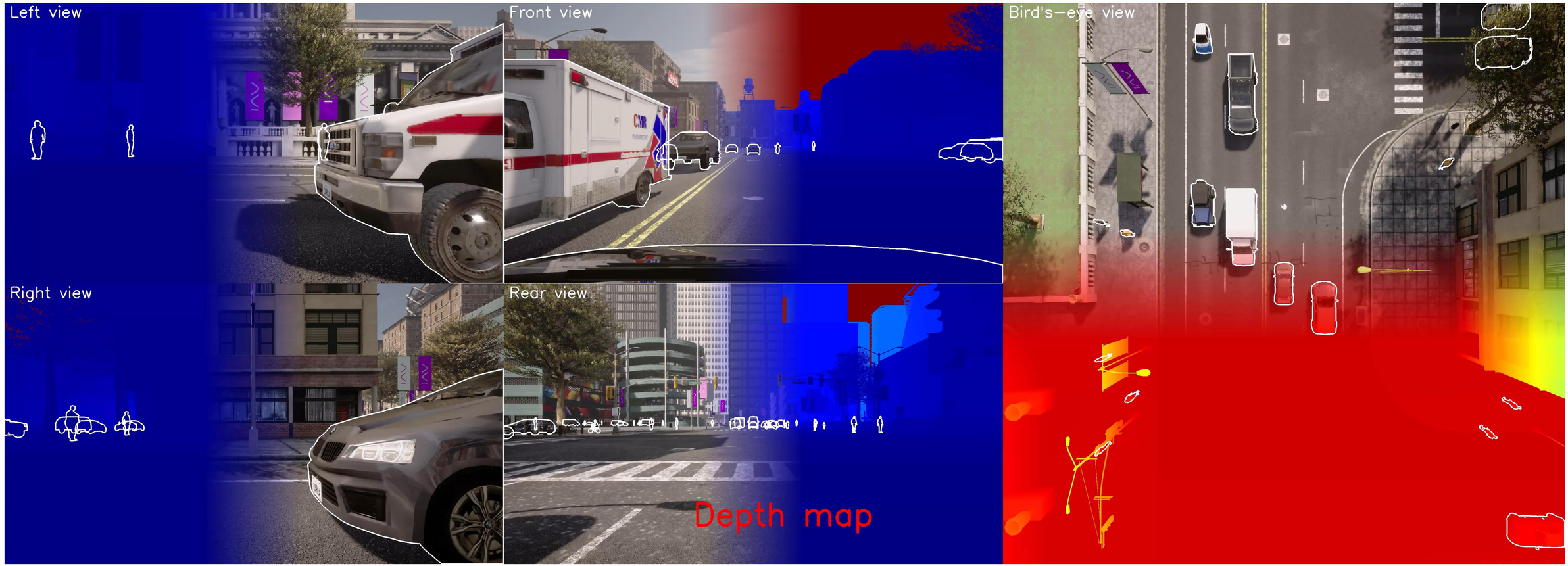


Upcoming: Exploiting Amodality for Various Tasks

Learning amodal panoptic segmentation with

- Depth prediction
- Optical flow
- Vehicle pose estimation
- Multi-object tracking

Upcoming: AmodalSynthDrive Dataset



Thank you for your attention!

http://amodal-panoptic.cs.uni-freiburg.de

SIS 60: Challenges of multi modal ML-based perception development & testing for automated driving applications

Panel Discussion Time

Moderator: Anastasia Bolovinou (ICCS)

Speaker: Abhinav Valada,
Professor (University of Freiburg)
Speaker: Antti Kangasrääsiö,
Head of Research, Sensible 4
Speaker: Eren Aksoy
Professor, Halmstad University

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Thank you!

To Eren

1. One big difference going from robotics to on-road vehicles is the speed. Based on your background on robots' perception how different is the task of semantic scene understanding for AVs in contrast to indoor robotics?
2. In your latest publication you study LIDAR to RGB-D image translation based on semantic segmented scene produced by LIDAR point cloud processing and as pinpointed in the paper this could be extremely useful in solving conflicts between lidar and camera perception (similar to early fusion) but also it can be used to augment the two modalities with information from the other modality (similar to late fusion). In ASAM OSI they standardize the object level representation from different sensors. In a sense what you proposed could also mean that it is important to consider semantic segmented images as a mid-level representation in multi-modal settings. What are your thoughts on these?
3. Based on your experience with vision-based scene understanding, which visual features are most helpful and which methods can be used to understand spatial relationships among objects in a scene? Pose seems as a good feature for action recognition but not so often taken into account in scene understanding. Would that be a good candidate feature for revealing occluded scene objects identity?

To Antti

1. ISO 22737 is the first standard on Low-Speed-ADS and in there we read that the vehicle also needs to be able to observe pedestrians and cyclists approaching the vehicle's path, even if they'd be partly covered. Occlusions could be due to other objects closer to the FoV or even due to environmental particles in the air like rain or snow. Do you think that perception algorithms trained to work well under rain or fog could work equally well for occluded objects due to other objects/road users' presence or are these two problems fundamentally different?
2. Informed motion planning in complex urban intersections is challenging even in low speeds. Does Sensible 4 investigates solutions where perception beyond on-board sensors' FoV is possible via V2X communications?
3. During testing under adverse weather conditions it is expected that deviations from what expected can occur in terms of vehicle behavior. How easy is to know, based on the logged data, whether this was due to a sensor fault, perception sw fault or decision making fault and what is your process to upgrade your vehicle SW/HW before the next open road test is scheduled?

To Abhinav

1. How important do you think it is to be able to train ML/DL modules offline on synthetic datasets, considering also the fact that synthetic data can produce groundtruths that are 100%accurate? Have you tried to compare training only on synthetic dataset versus real-world?
2. What is the progress in research community with designing metrics to quantify the ML/DL modules performance in an interpretable manner? Which expertise does that need? (is it only computer scientists/engineers or human experts too?)
3. How close are we to see these panoptic/amodal segmentation modules running in real time within automotive embedded PCs/ECUs?
4. Starting from the fact that your approach achieves SoA results in image semantic segmentation, have you tried to feed your perception module output to an AD controller to argue about the potential of amodal PS in better AD decision making?