VORTEX-COLAB

Perception of a vehicle: use case and possible routes

Jornadas de Mobilidade Elétrica

29 de setembro de 2023

VORTEX CoLab

COLLABORATIVE LABORATORY IN CYBERPHYSICAL SYSTEMS AND CYBERSECURITY

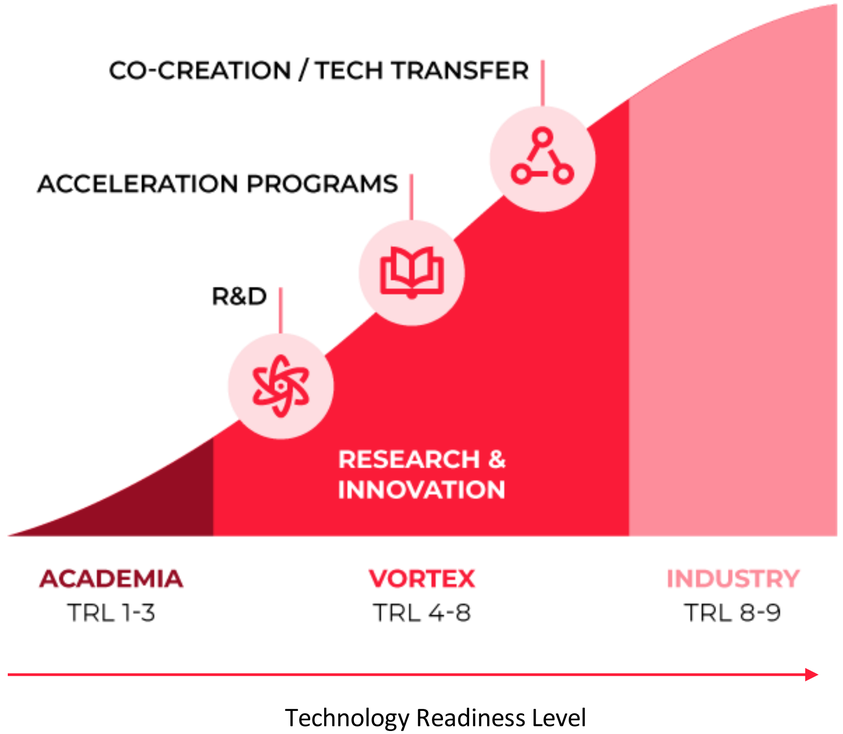
www.vortex-colab.com

WHO WE ARE

VORTEX-CoLab

VORTEX-COLAB is where the application of research is accelerated, where new technologies are further developed, scaled up and realized.

Our primary tasks are to support and assist trade and industry including SME's, governments and others in technological innovation and in solving problems by rendering services and transferring knowledge and expertise.



THE ASSOCIATES

An ecosystem for excellence and research

Capgemini engineering

beta-i

CISTER Research Center in Real-Time & Embedded Computing Systems

NOVALINCS

INESCTEC

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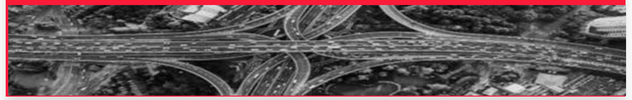
WHAT WE DO

Projects

CYBERSECURITY AND DISTRIBUTED SYSTEMS



+ Cybersecure Cyber Physical Systems for Automotive and Unmanned Robotic Systems
+ Verification and Validation of V2X Apps
+ Secure Over-the-Air (OTA) updates
+ Trust / Privacy
+ Design of secure and resilient distributed architectures
+ Device-edge-cloud computation distribution

SAFETY FOR EMBEDDED SYSTEMS

+ Embedded Virtualization (ARM and RISC-V)
+ Safety of mixed-criticality systems
+ Continuous observation
+ Hardware accelerators
+ Lightweight formal verification methods
+ Data-centric computing architecture

PERCEPTION ON THE EDGE

+ Embedded AI
+ Real-Time Perception
+ World Model integration
+ V2X Data fusion for extended horizon
+ Advanced Visualization
+ Interaction for fomenting Human-Machine trust

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CYBERSECURITY AND DISTRIBUTED SYSTEMS – Reference Use Cases

SECURE OVER THE AIR (OTA) updates

Secure update distribution &

Secure and safe update installation

Support for remote software updates is inevitable for effective operations. Industries such as transportation, energy, consumer, smart building and manufacturing rely heavily on a potent IoT ecosystem for best possible outcomes.

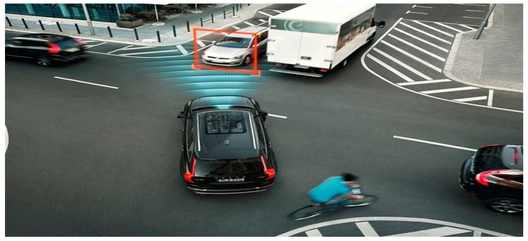
This approach allows to **harden the chain of trust** for the download and verification process. Extend the **trust to the installation process**. Also, by making **OTA directly on hypervisor level**, gives further security guarantees because **any compromised container is reset** . All this processes are if fully **auditable**.

SECURE STORAGE

In-vehicle auditable storage for ECUs or IoT Devices, IDSs

With the digital transformation, the **Electronic Devices** become **software element**s that generate logs of their actions. These logs give us a trace of everything that happened, however, reduced storage means only a reduced amount of data can be kept. In this project we propose a dedicated device for **log storage** deployed in a primary device or gateway. This way we ensure **immutable** storage for logging data for **auditability** purposes.

This solution **provides long term log storage**, **auditable logs and** allows for long term storage to **feed to security systems**.

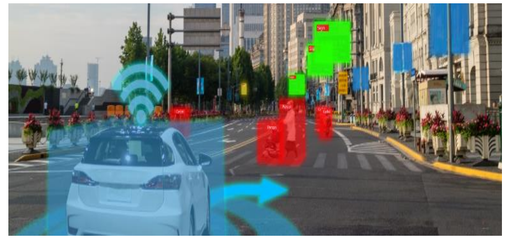


V2X SOLUTIONS FOR THE EDGE

Distributed data management and V2X PKI security/privacy

Pushing sensed data to the cloud is costly, slow and centralized. By having a lightweight computation and **sensor fusion across the Edge-Cloud** by using road infrastructure and reducing the amount of data that needs transfer to the cloud. This solution uses a **cloudless distributed** data management as close as possible to vehicles. Using Optimistic Replication and **data convergence**. Supports C-ITS PKI security for V2.

This solution provides Lowest latency possible and consistency, Edge computation - no cloud dependency. **Secure end-to-end** communication **via C-ITS compliant security**



SAFE COLABORATIVE MANEUVERS

Lightweight formal methods for maneuver design and validation

Current autonomous driving solutions are based on vehicles acting independently of others, receiving only some data from infrastructure elements and possibly some control messages.

This solution allows to create a safe and **correct-by-design maneuvers** based on **lightweight formal methods**. Maneuvers become collaborative via orchestration and execution monitoring to guarantee correctness in **(soft) real-time**.

This solution provides **Correct-by-design**, **Collaborative-by-design** and is extensible to **any kind of road or vehicle scenarios**

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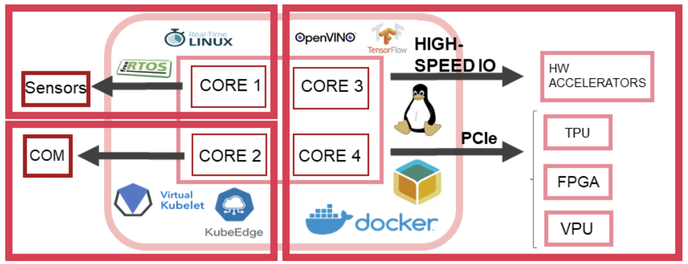
SAFETY FOR EMBEDDED SYSTEMS – Reference Use Cases



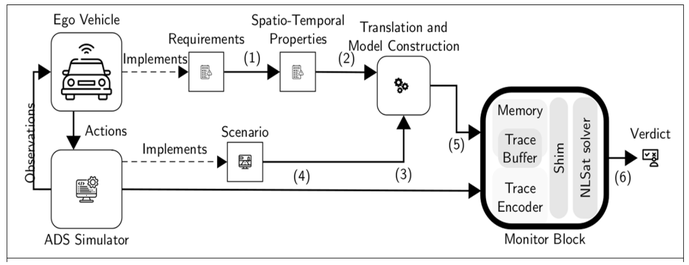
HYPERVISOR ON THE EDGE

Next Generation static-partitioning Hypervisor solution supporting flexible resource management and control for mixed-criticality systems

The increase adoption of virtualization technologies in industrial domains, such as railways, avionic, automotive, Industrial Internet of Things (IIoT), but also in telco systems with the recent development of 5G.

By using **Low-level Hypervisor** supporting **AI-based hardware** accelerators and flexible management of resources for **mixed-criticality systems**. We allow to focus on software-defined and hardware-implemented **resource isolation** for enhanced **safety of future** embedded edge devices.

This solution allows to avoid deployment issues on different hardware platform. Also, by leveraging economic **AI-based bricks** we can **support high performance task** required for the **Industry 4.0**



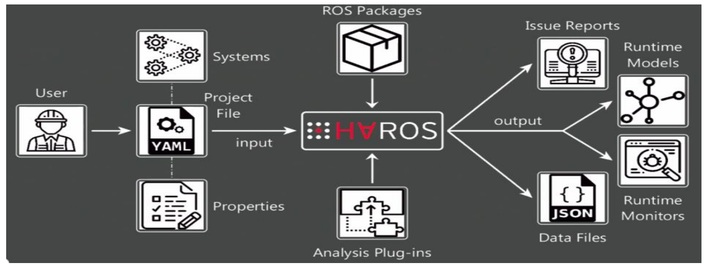
STEM

Automatically generates binary code monitors from a high-level specification language

Conducting autonomous driving tests on the road is very expensive, strong regulatory constraints, time and road traffic laws are complex having a wide topology variety. To validate these systems in safety-critical situations poses a risk to drivers and bystanders.

By **formalization of traffic laws** and **rules as spatio-temporal properties**. Also, verification via **automatic binary monitor generation** to increase confidence in future autonomous driving systems. **Runtime monitoring of spatio-temporal behaviors**.

We designed it for non-experts in software engineering. Allowing **verification of ADAS and AD systems** components with **correct-by-construction monitors generated via automatic tooling**. The technology used also allows for **easy extension**.



HAROS

Automated Analyses Tools for Robotic Applications

A current trend in robotics systems is to develop modular components that can be used off-the-shelf in a variety of applications. This flexibility is often achieved with extensive parameterization and configuration, not always fully understood or documented.

By Applying automatic verification techniques to extract runtime models from source code, **extended runtime monitoring** of **communications safety** requirements, and provide **quality analysis reports** for robotic applications. By detecting problems early in the **SDLC one can avoid issues on the later stages** or even in production

Lightweight formal methods are automatic or **semi-automatic verification techniques** suitable for cases involving non-experts in Software Engineering.

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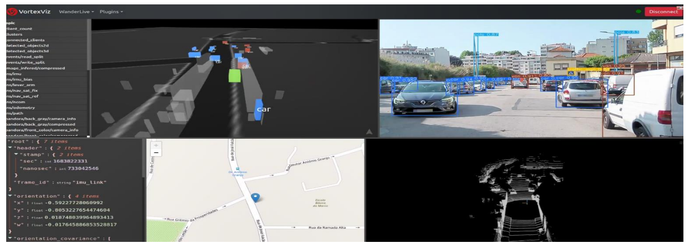
PERCEPTION ON THE EDGE – Reference Use Cases



VORTEX VIZ

ADAS/AD & AGV DATA VISUALIZATION

The development of software for perception requires a huge effort in debugging and analysis of collected data. Visualization platforms require **a hard and specialized setup**, which limits the data analysis of the development teams. This platform aims to **reduce** the need for **specific setups** by providing a **no installation web application**.

We produced **a computer/mobile** version, as well as a **VR** version, that allows a **quick and easy access** to all data through a **web browser** in a fluid, **synchronized** and **real-time** fashion**. Multisource data** and **simultaneous visualization**.

This solution provides a **quick** and **easy** access to compatible data anywhere, in any OS. Provides the ability for customization with **multiple versions & technologies**.

WANDER LIVE

Real Time Perception – Automotive Use Case

Perception is an increasing need in several industries. In this project we worked with our partner to demonstrate the ability to **display classified and identified data** in a live environment using Perception capabilities in a vehicle.

In this project we create a **3D world model with data tracking**. Via data fusion of data retrieved via Cameras, 3D Lidar and INS. With the usage of **image classification** and **point cloud object clustering** enables tracking or correct 3D object tracking, also ensuring that the **data was synchronized** to the sensors data acquisition rate. Finally, all the data was transformed for the vehicle perspective.

This solution allowed for a baseline **software for Perception**, with an automotive use-case. Enhanced knowledge in **sensor processing** and **information fusion**.

AD SHORTY

Scaled Down Car for Predictive Maintenance

Perception and **Autonomous** navigation are not only an issue for automotive but is now becoming a need for AGVs either on a factory floor or on a pipeline monitoring.

In this project we worked with our partner to create a base platform to replicate the behavior of a normal car in a scaled down way as to proper validate **going back to safety in AD**. Then we identified the possible usage for Predictive Maintenance use-cases. With the ability **to plan missions**, **set actions on waypoints** (e.g., collecting video, pictures) thus allowing for **cloud offloading** in domain specific processing.

This solution allowed to replicate our **perception stack** from a real size environment to a scaled down one. Allowing at the same time to strengthen the scope of our use-cases.

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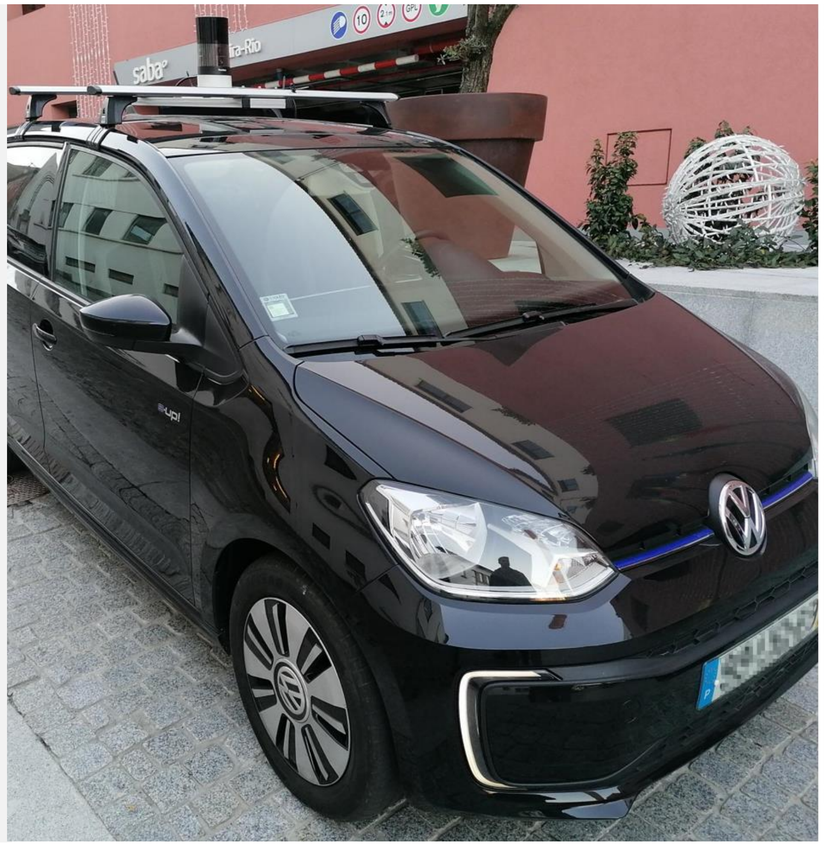
Wander Live – A perception testbed

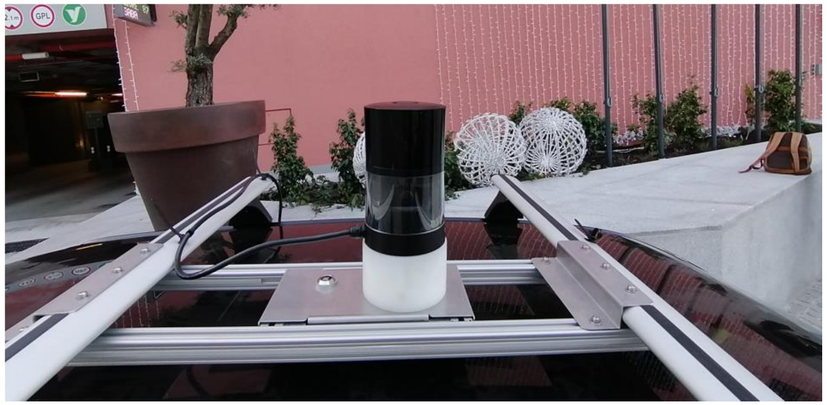
A platform for vehicle perception use cases

Electric VW Up: Standard vehicle

OXTS RT500: Inertial Navigation System (INS) providing gnss localization, reference and inertial and odometry data.

Hesai Pandora: Sensor unit comprising 40 channel 360º LiDAR and multiple cameras: 1 front RGB camera + 4 orthogonal wide angle greyscale cameras

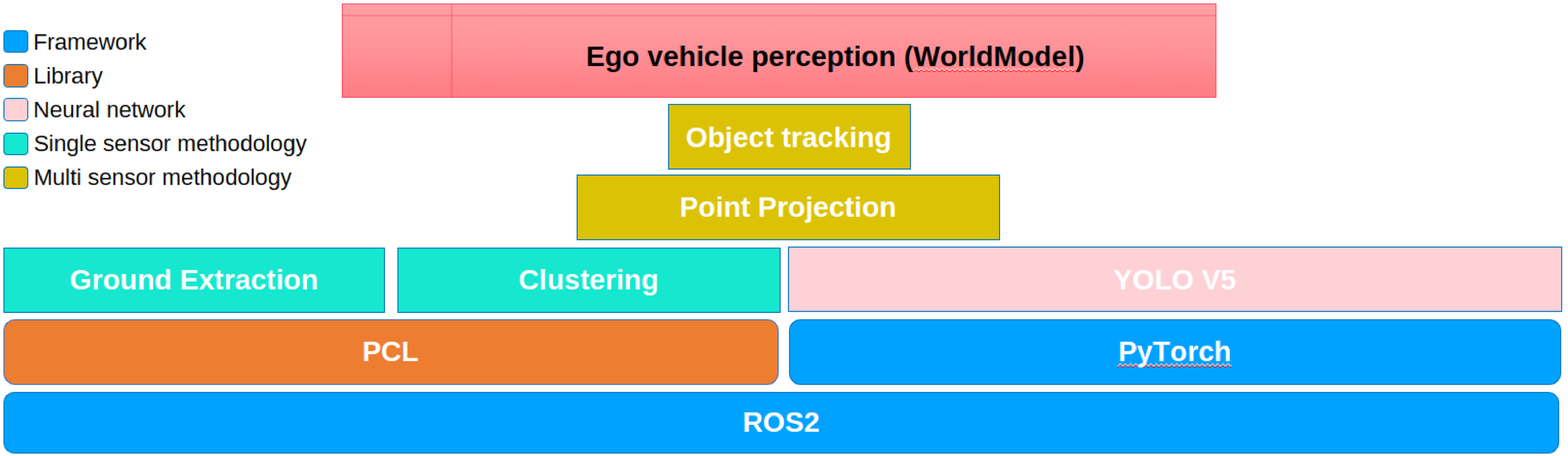




Wander Live – High level architecture

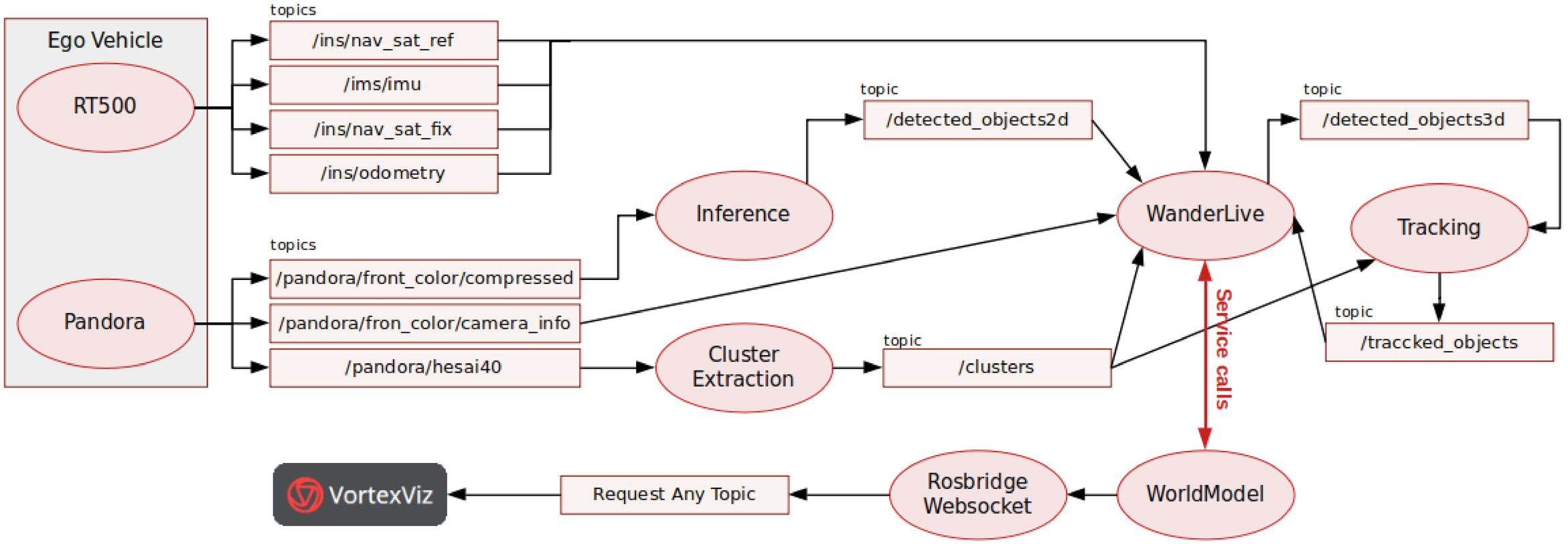
The goal: to achieve a representation of all knowledge of the ego vehicle

Overview of the most prominent frameworks and methodologies to create the representation (WorldModel)

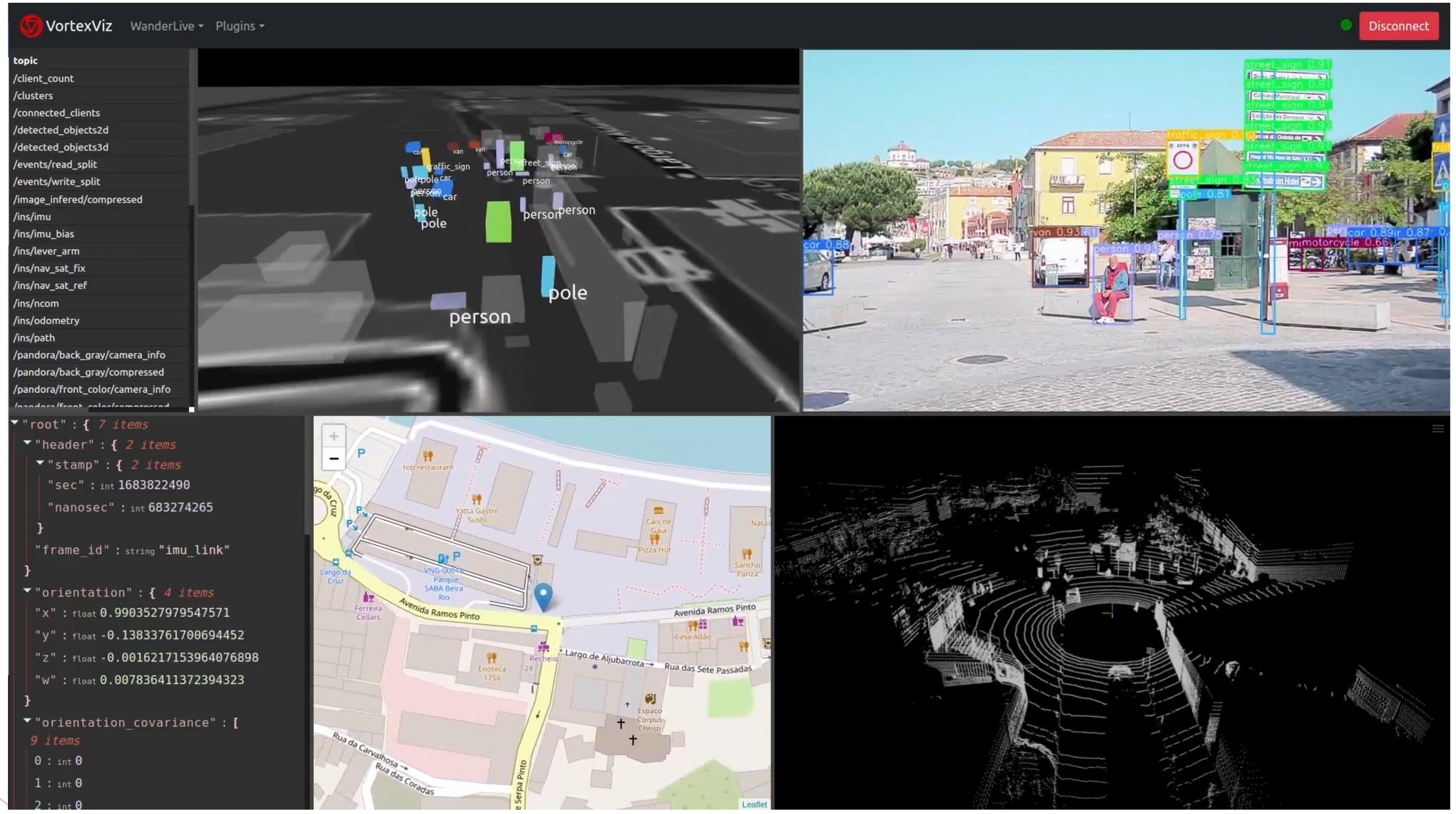


Wander Live – Workflow

Data flow and main modules involved in the process



Wander Live – Results



Wander Live – Results (video)

Wander Live – What next?

Look at the road!!!

Integration of road / lane / free space detection and its harmonization within our WorldModel

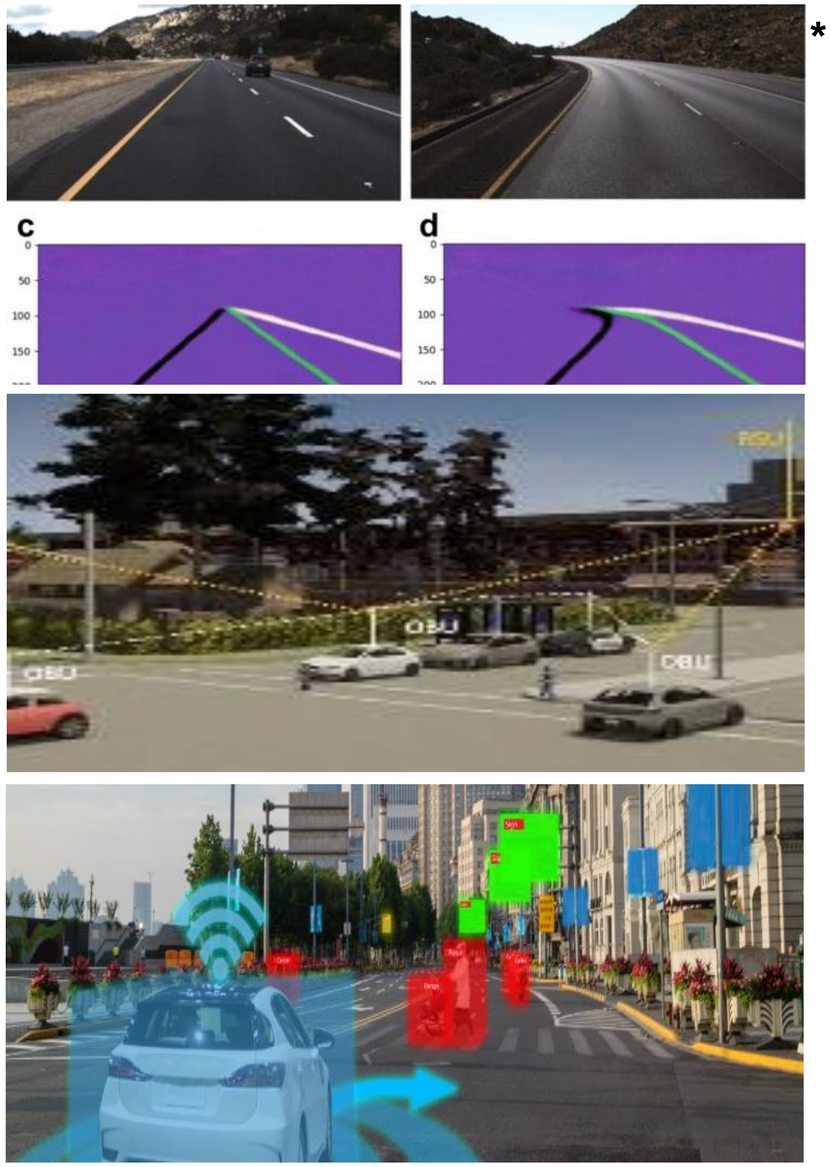
We are not alone!

Integration of V2X

- V2X => Vehicle to X, with X being anything.
- Infrastructure (one of the anythings) is an integral part of Smart Cities concept
- Small (or not so small) sensory and/or processing modules connected to the internet (IoT) is the base of a Smart City

Diversity promotes redundancy

Integration of more sensor types / technologies, promoting redundancy and mitigation of each one's shortcomings



* Wei Wang et.al., CNN based lane detection with instance segmentation in edge-cloud computing

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Thank you

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