Multimodal Extreme Scale Data Analytics for Smart Cities Environments

MARVEL @ DataWeek 2023

From "Big" to "Extreme", or How to increase the value from data analytics

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Identity Card

Project Consortium
17 partners

Project Name
Multimodal Extreme Scale Data Analytics for Smart Cities Environments

Total Budget
€5 998 086.25

Project Type
RIA

Start Date
1 January 2021

Duration
36 months

Motivation

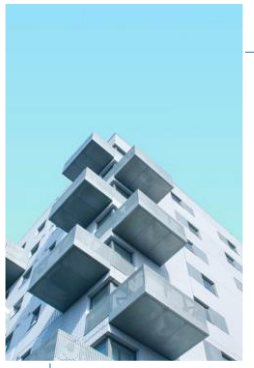
Cities have become actual **“data engines”**

huge variety of IoT urban sensors and devices recording multiple everyday activities producing large scale heterogeneous datasets

Need for accurate **predictions** and better **analytics**

Challenges

1. Valuable **knowledge extraction**
2. **Commercial value** from data

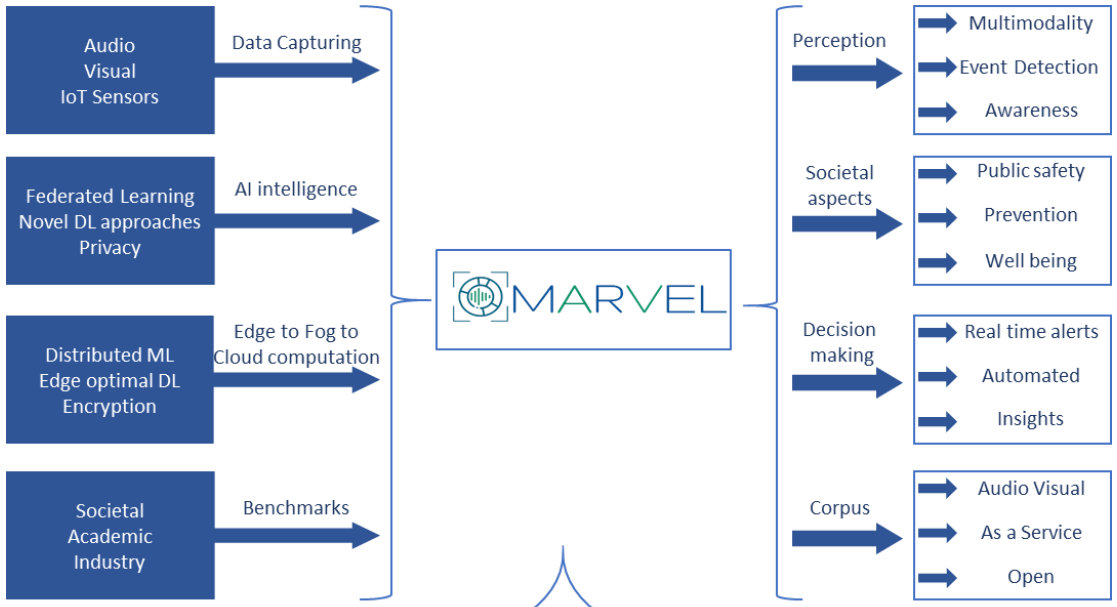


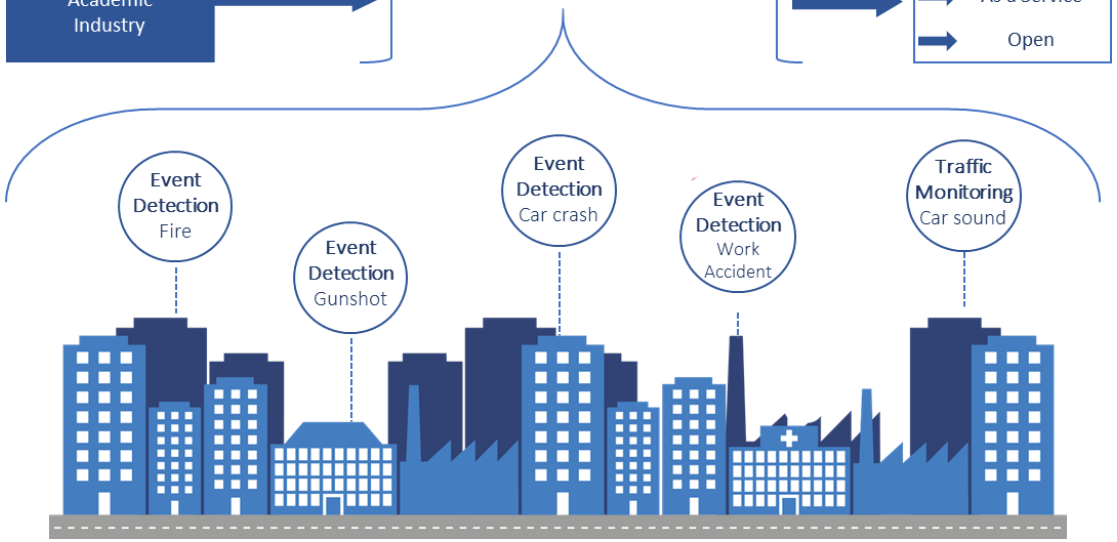
Need to **shift** traditional **methodologies, techniques** and **tools** of information extraction into **new dimensions.**

How?

By cracking the problem of **extreme scale data analytics**

MARVEL in a nutshell



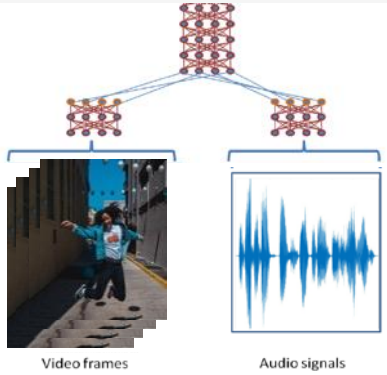


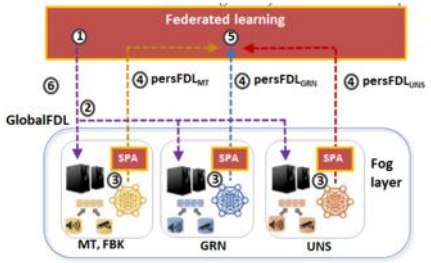
- A privacy-aware solution for revealing valuable insights to improve quality of life
- Event detection and situational awareness in a smart city environment to support decision-making
- Breaking technological silos
- Tested in real-world complex settings for ensuring accurate, cross scale, and in-time predictions
- Contribution of extremely large audio visual processed datasets to support the European Data-driven Economy

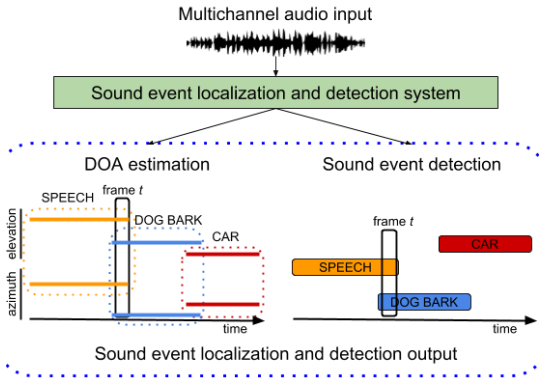
Our mission

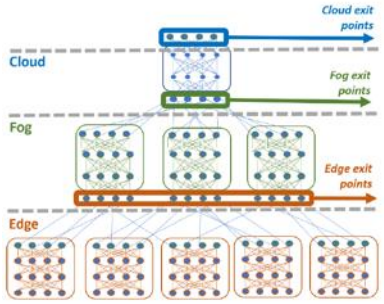
Collect, analyse and data mine
multi-modal **audio-visual data** streams of a Smart City
and **help decision-makers** to improve the quality of life of their citizens and the services they offer to them **without violating ethical and privacy limits** in an AI-responsible manner.

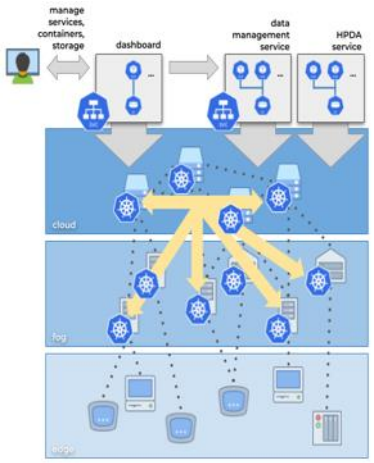
MARVEL Framework - Pillars











1 Real **heterogeneous distributed** Big Data in **smart cities** environments

2 **Edge-to-fog-to-cloud** (E2F2C) distributed ubiquitous computing **architecture**.

3 **AI-based intelligence** for **multi-modal perception** and **situational awareness.**

4 **Quantitative assessment** of **E2F2C** and **Multi-modal AI tools and methods** via societal, academic and industry validated **benchmarks**.

Real Life Experiments in Smart Cities

Inform local authorities and emergency services of potential anomalous events that may lead to dangerous situations:

- Monitoring of crowded areas
- Detecting criminal/anti-social behaviors
- Monitoring of parking places
- Analysis of a specific area for better urban planning

City monitoring in Trento, Italy

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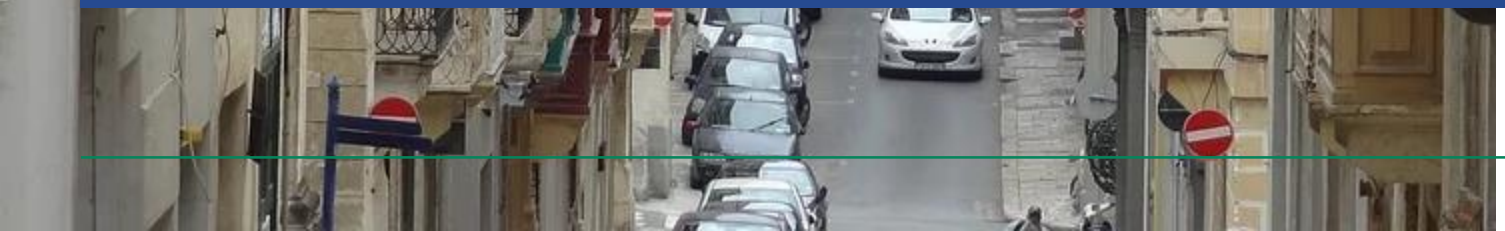
Data monitoring and analysis for planning infrastructure upgrades and implementing mobility management measures:

- balancing the needs of mixed traffic, planning, and use of shared road space
- understanding behavior by mode of transport
- improving perceived safety for active mobility modes; and creating anonymisation tools for road-monitoring cameras.

Road Traffic Management in Malta



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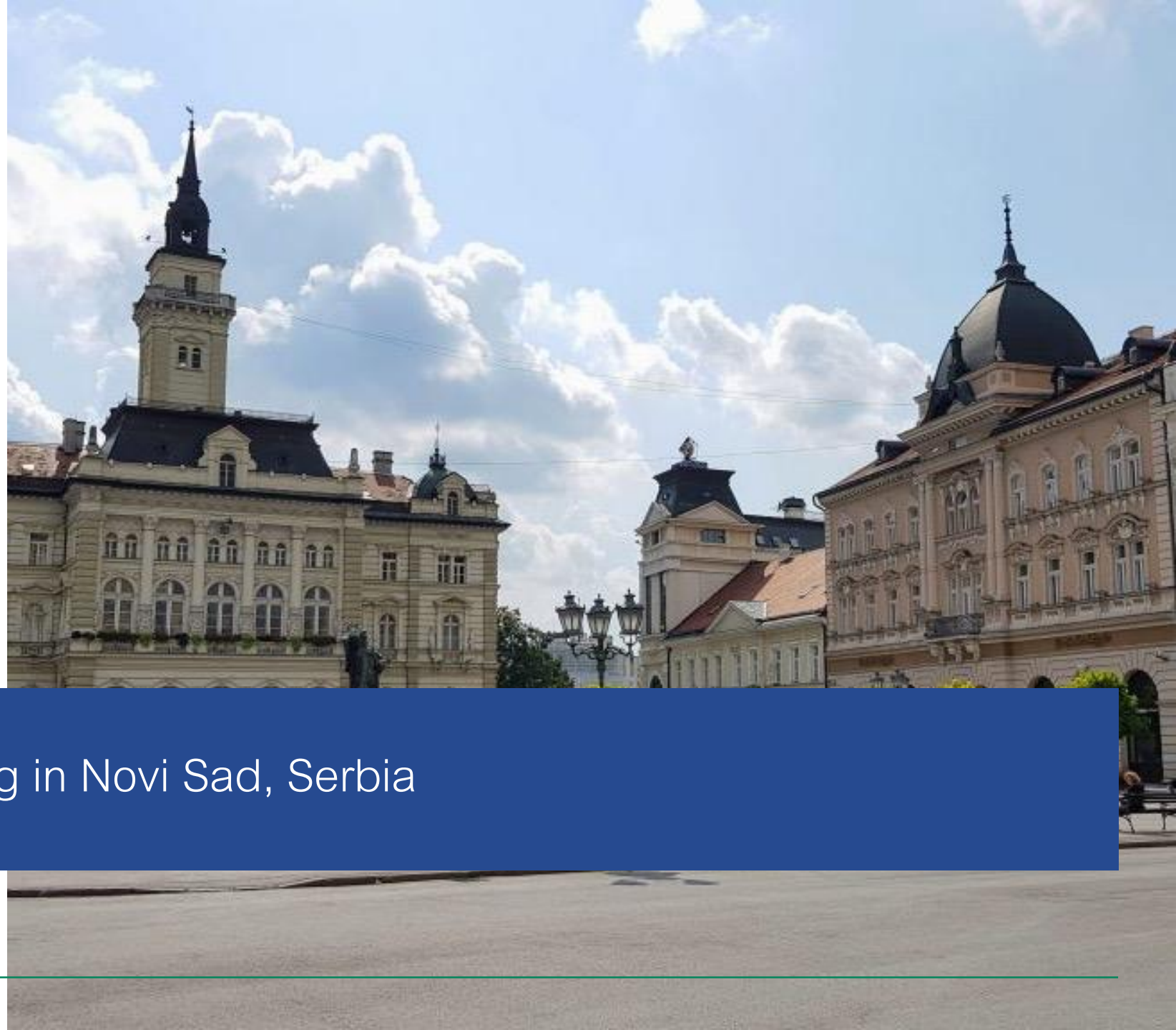
Data collection using drones and experimental evaluation in controlled environments to support the Trento and Malta use cases

- Monitoring of large public events
- Evaluate MARVEL technologies using drones
- Audio-Visual emotion recognition



Crowd behaviour monitoring in Novi Sad, Serbia

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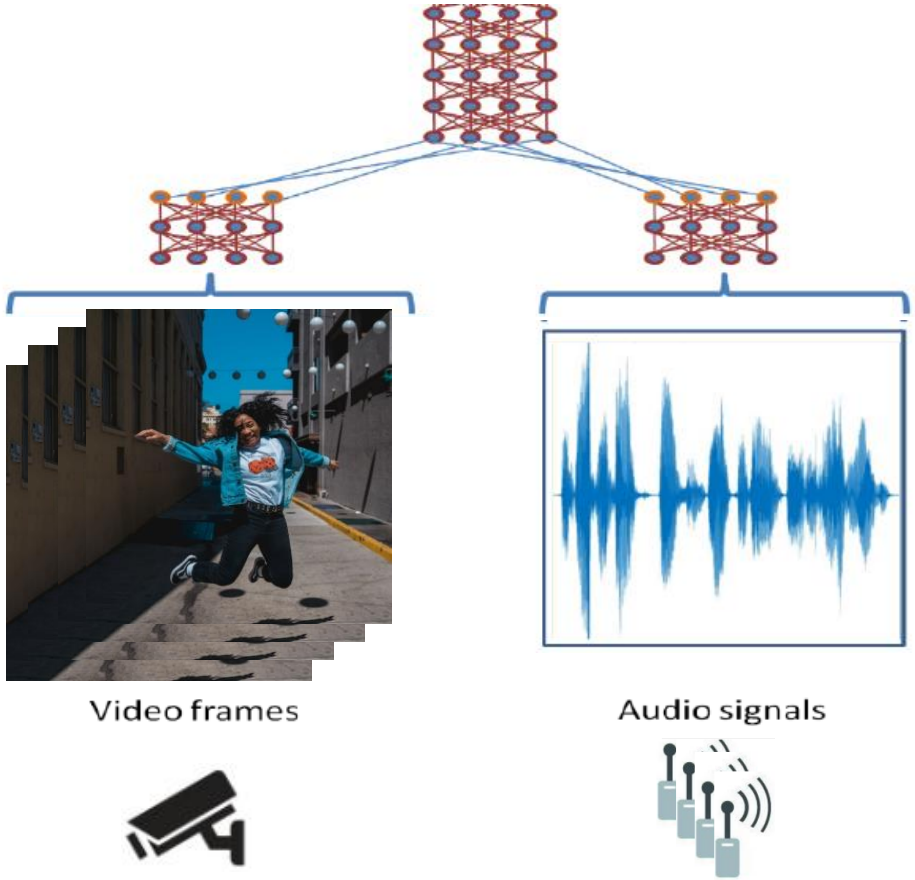
Multimodal perception and intelligence

Project's rationale: *explore hidden correlations in synchronous streams of audio, visual and other data to increase classification accuracy of audio-visual/environmental events.*

- **Audio-visual analytics**



Early fusion – human – like perception!

Challenges: privacy (GDRP) and complexity

Multimodal perception and intelligence

Project's rationale: *explore hidden correlations in synchronous streams of audio, visual and other data to increase classification accuracy of audio-visual/environmental events.*

- **Anomaly detection in smart cities**

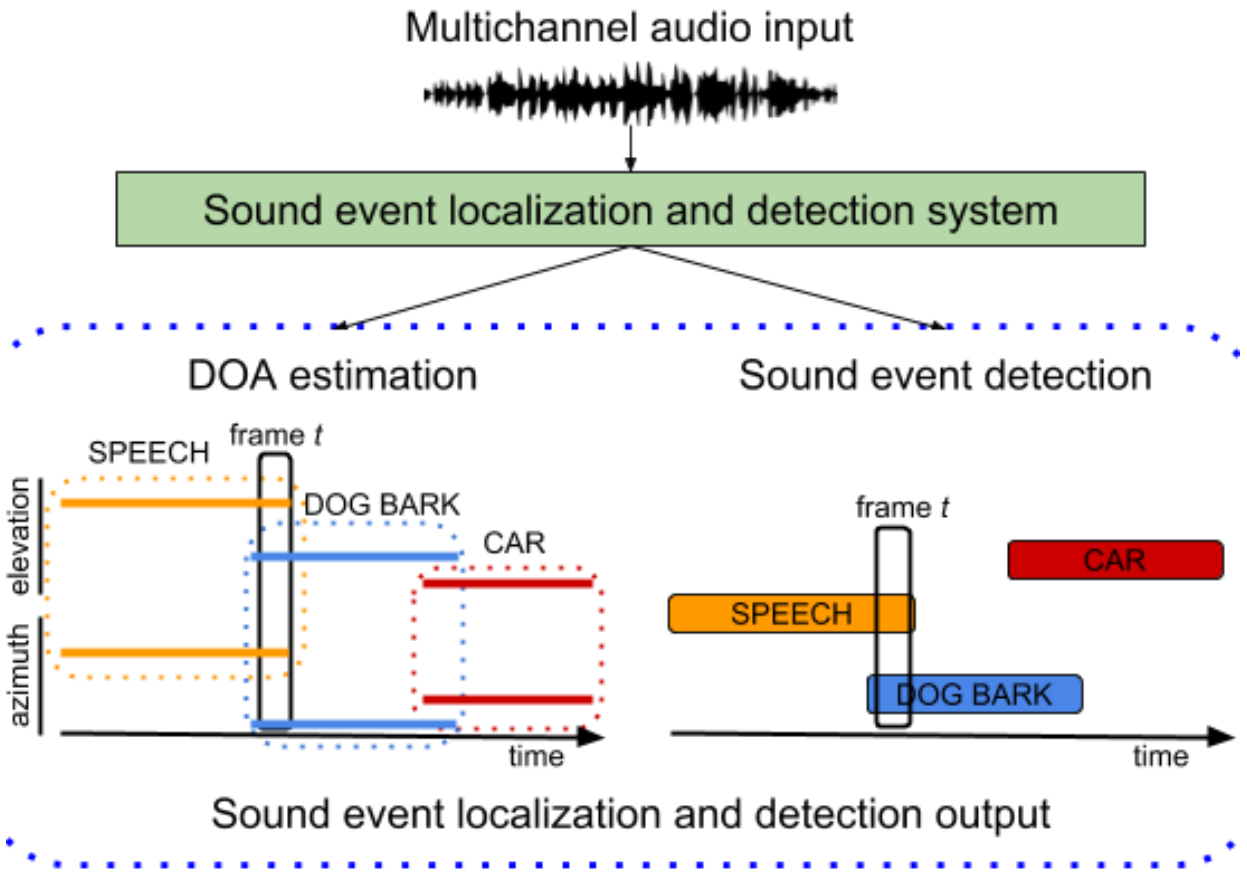
Detect the presence of an unexpected/unseen object, sound, action, etc.

Low visibility conditions: *exploit complementary **audio** information*!

Multimodal perception and intelligence

Project's rationale: *explore hidden correlations in synchronous streams of audio, visual and other data to increase classification accuracy of audio-visual/environmental events.*

- **Audio AI intelligence**



Acoustic analysis and mapping of city scenes!

Multimodal perception and intelligence

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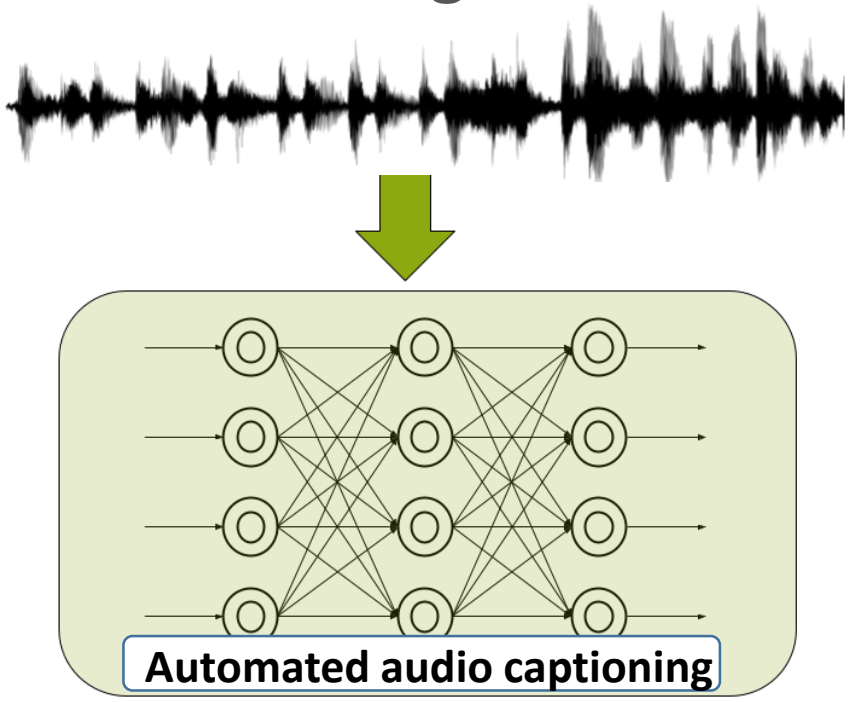
- **Audio AI intelligence**



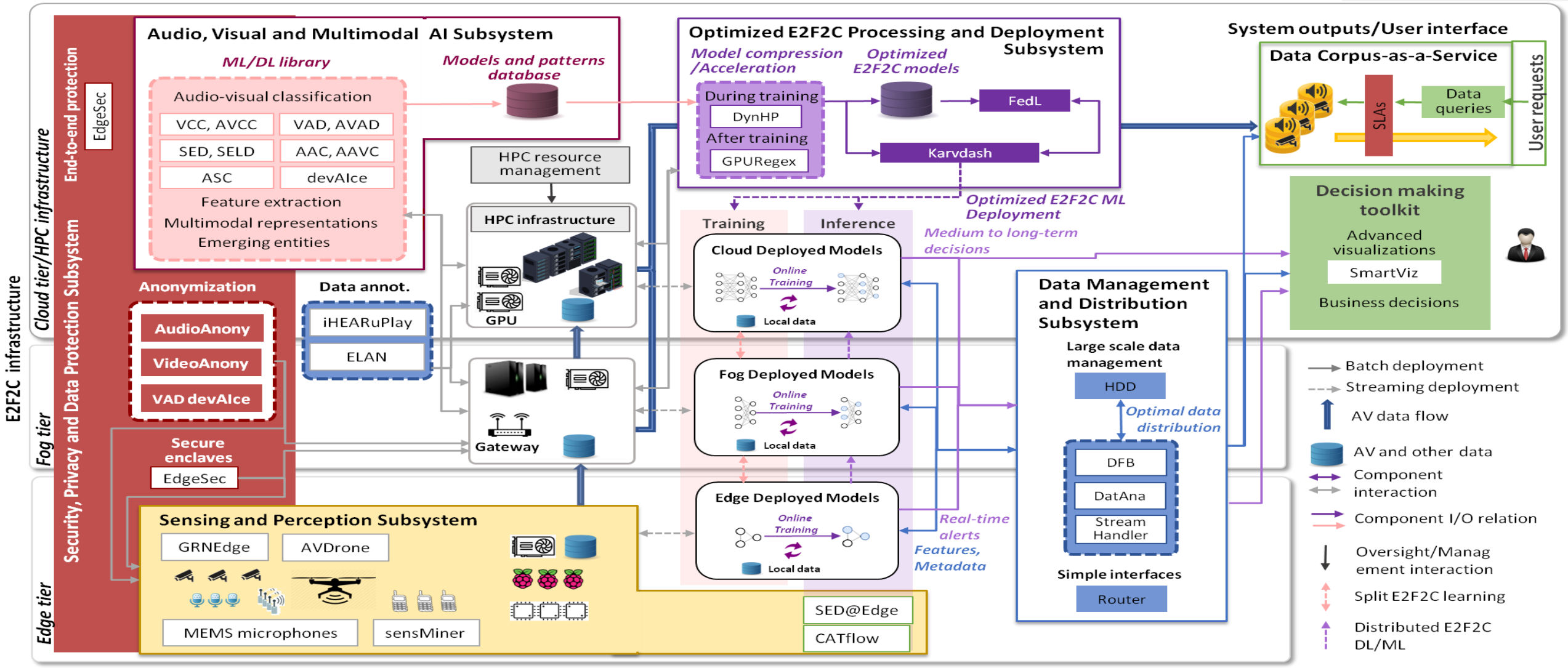
"Two people chatting on a busy street."

Sound-enabled environmental awareness

MARVEL conceptual architecture

- The MARVEL framework consists of 35 technological components of a wide range of functionalities and the associated framework roles.
- The components have been grouped into seven subsystems:
  1. Sensing and perception subsystem
  2. Security, privacy, and data protection subsystem
  3. Data management and distribution subsystem
  4. Audio, visual, and multimodal AI subsystem
  5. Optimised E2F2C processing and deployment subsystem
  6. E2F2C infrastructure
  7. System outputs: User interactions and the decision-making toolkit.

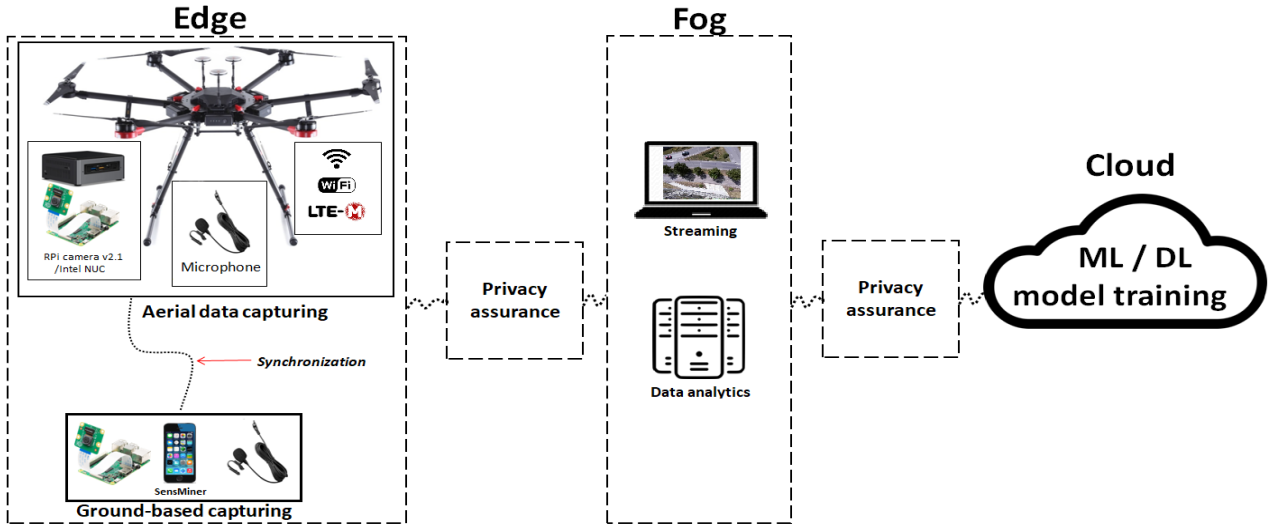
MARVEL conceptual architecture

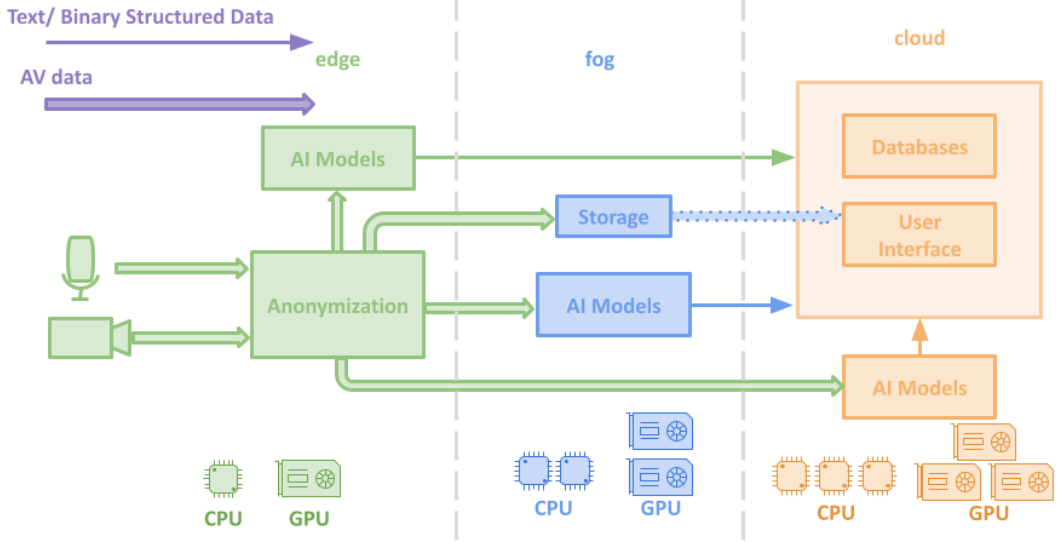


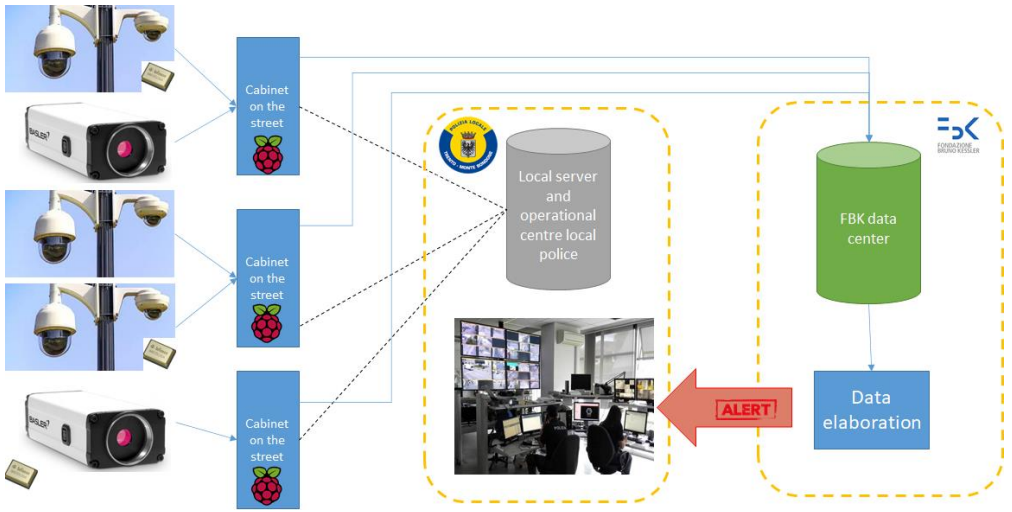
E2F2C infrastructure

Components

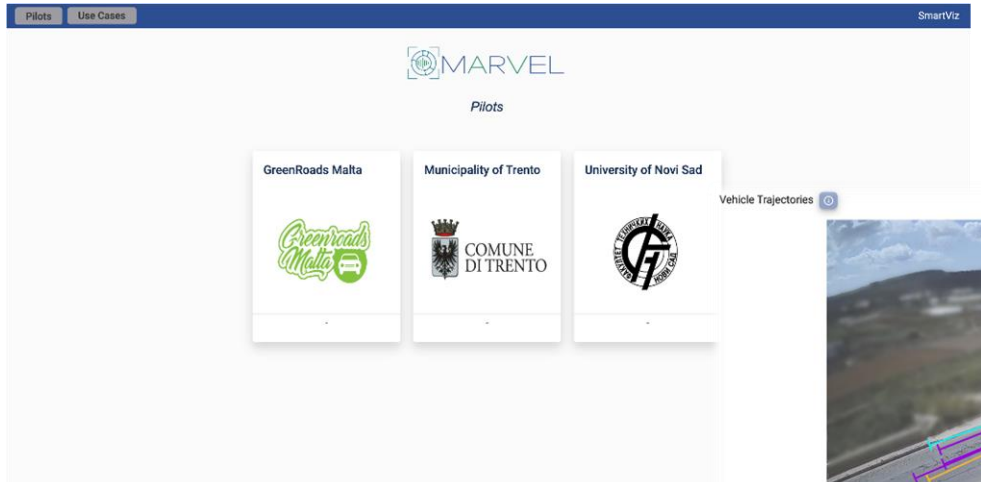
- Consists of the HPC cluster (PSNC), HPC resource management and orchestration (PSNC), together with the three underlying infrastructural tiers – cloud, fog, and edge (GRN, MT, and UNS).

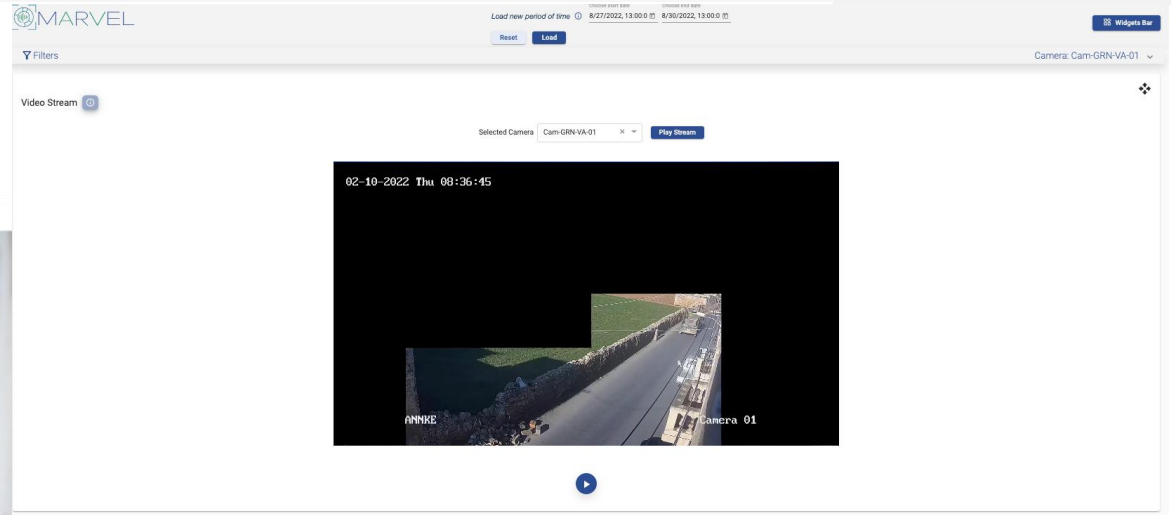


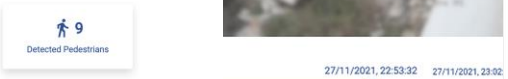


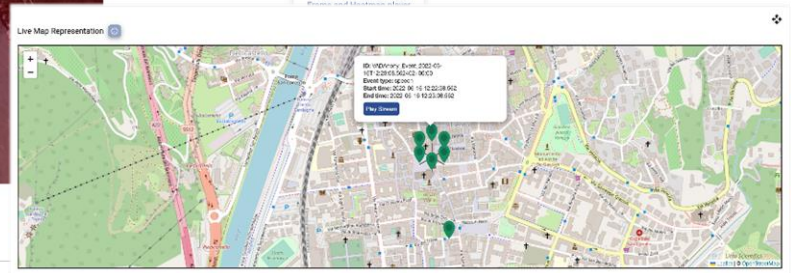


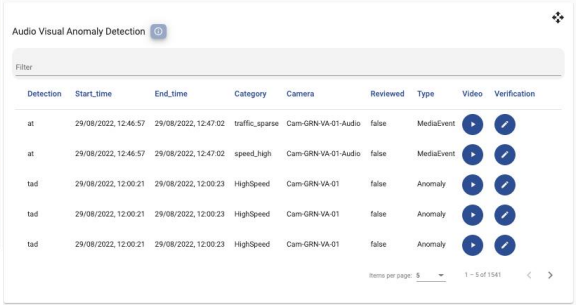
System outputs: User interactions and decision-making toolkit

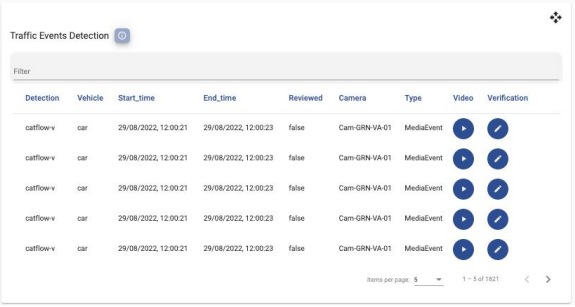


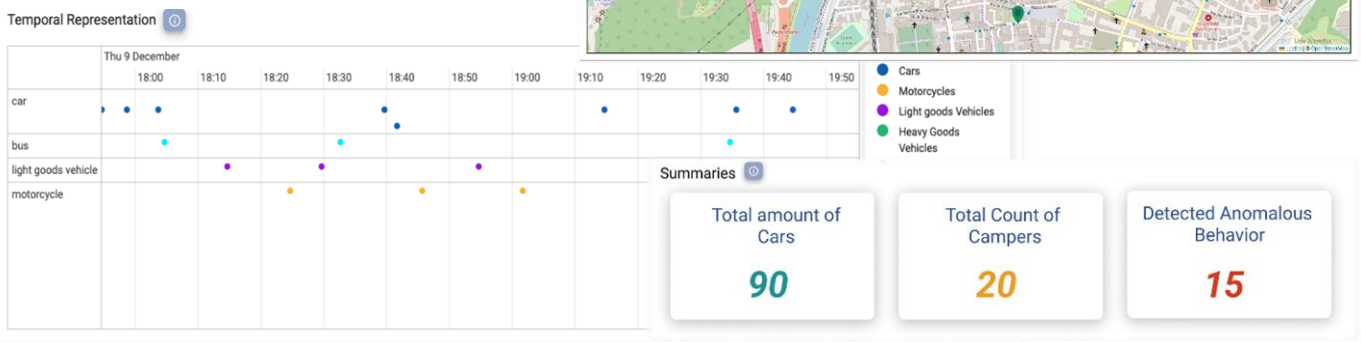












Thank you!

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