Actionable Human in the Loop Traffic Forecasting for CCAM – ACUMEN

Panagiotis Fafoutellis
Civil & Transportation Engineer, PhD

Together with:
Katerina Papadatou, Eleni Vlahogianni

Department of Transportation Planning and Engineering
National Technical University of Athens

Artificial Intelligence for Road Safety and Mobility Workshop

8th UN Global Road Safety Week

Athens, 15 May 2025

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The ACUMEN project

Acumen

- **ACUMEN:**

  "Ai-aided deCision tool for seamless mUltiModal nEtwork and traffic management"
  acumen-project.eu

- **Partners:**
  17 partners from 9 countries,
  including the National Technical University Of Athens

- **Duration of the project:**

  36 months (June 2023 – May 2026)

- **Framework Program:**

  ACUMEN project is co-funded by the EU Horizon Europe Research and Innovation Programme under Grant Agreement No. 101103808

Co-funded by the European Union

Objectives Overview

Main objective: to support the transition to **seamless**, **sustainable**, **connected**, and **automated** mobility by proposing a **generic, modular** digital paradigm for advanced network management, leading to

i. more efficient and reliable door-to-door journeys for people and goods
ii. increased safety and resilience at the network level
iii. critical contribution to the Green Deal

Specific Objectives

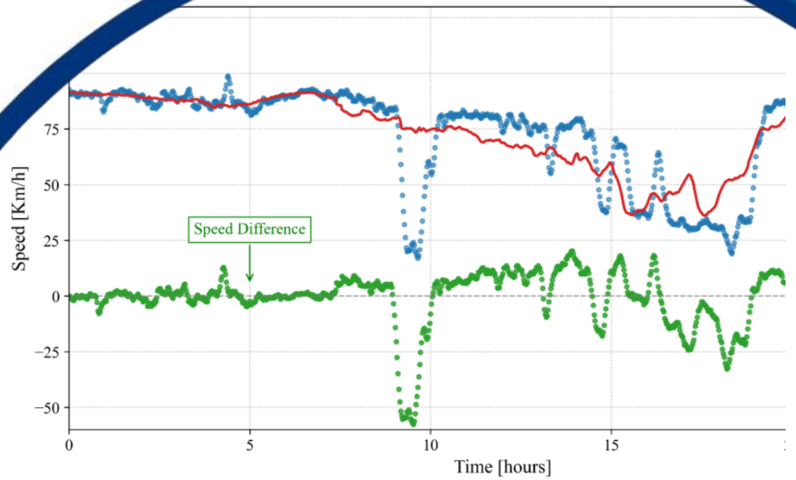
- Design a safe, secure, privacy-preserving, decentralized **data handling and sharing framework**
- Develop **monitoring and forecasting tools** based on explainable AI and hybrid intelligence
- Develop **decision-making and management** solutions
- Integrate the above in **digital twins** and test in **pilots** for 4 cities

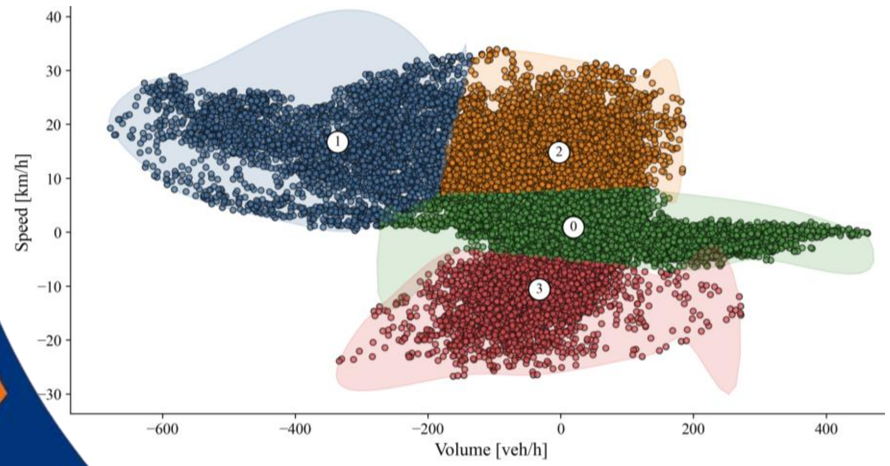
NTUA's contribution

- Real-time incident detection framework
- Trustworthy traffic forecasting models
- Hybrid forecasting model/human in the loop
- AI-driven traffic management framework
- Athens pilot and digital twin

Incident detection

- Two-step Unsupervised Learning framework
  1. Recognize a daily typical/expected traffic conditions pattern (using an LSTM Autoencoder to filter out incidents in historical data)
  2. Detect clusters of measurements that correspond to different traffic conditions, using their deviations from the expected pattern as input variables
- Identified 4 clusters of traffic conditions and introduced a new taxonomy, according to their "recurrency" (deviation from expected conditions)
  - [0] Recurrent conditions (close to expected mean)
  - [1] Low demand (weekend, holiday)
  - [2] Boundary conditions (before or after congestion)
  - [3] Incident (unexpected heavily congested conditions)
- High resolution data (90 seconds) → Real time incident detection





Human in the loop framework

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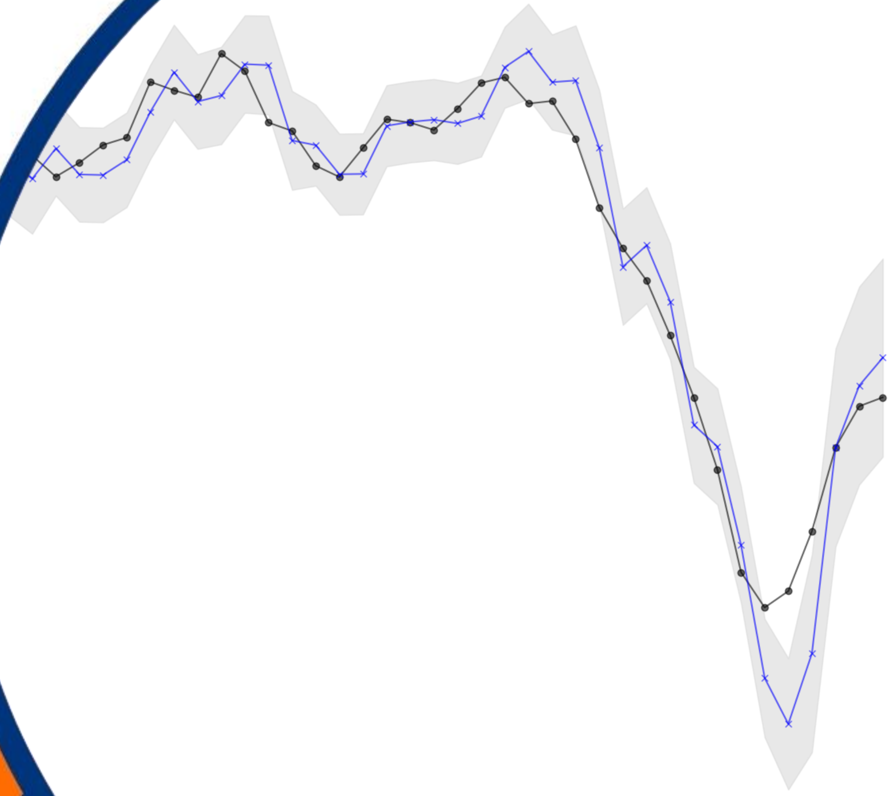
- Deep Learning models provide reliable predictions in general but may fail during non-recurrent conditions/incidents – When we need them the most!
- Non-recurrent incidents (≠ recurrent congestion) correspond to ~5% of the traffic measurements, imbalanced datasets

AI performance auditing in real time: a human user intervenes to improve prediction
When? In risky situations: (i) uncertainty for next prediction exceeds a certain threshold (ii) during incidents
How? Opt for alternative prediction model – trained for extreme conditions

Next step: Is the process learnable? Can a model learn to make the optimal decision in each case?



Human-in-the-loop Graphic User Interface

Main functionality

- Simulates real-world data streaming (traffic measurements), models provide predictions in real time, predictions of a very reliable model are used during recurrent conditions (including expected congestion, e.g. during peak hours)
- If (**High Uncertainty Interval** or **Non-Recurrent Traffic Conditions**)
  - Warning alert
  - Human's decision to select alternative forecasting model
- User's response is saved to be analysed
- Expect total prediction performance improvement

Support users' decision-making:

- Metrics of prediction uncertainty and errors
- Fundamental diagram
- Visualization of residuals for the past timesteps
- A legend for the traffic conditions classes

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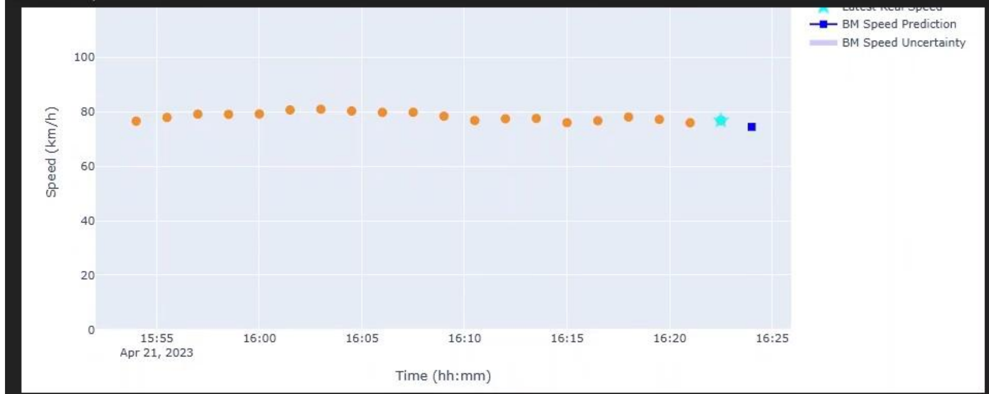
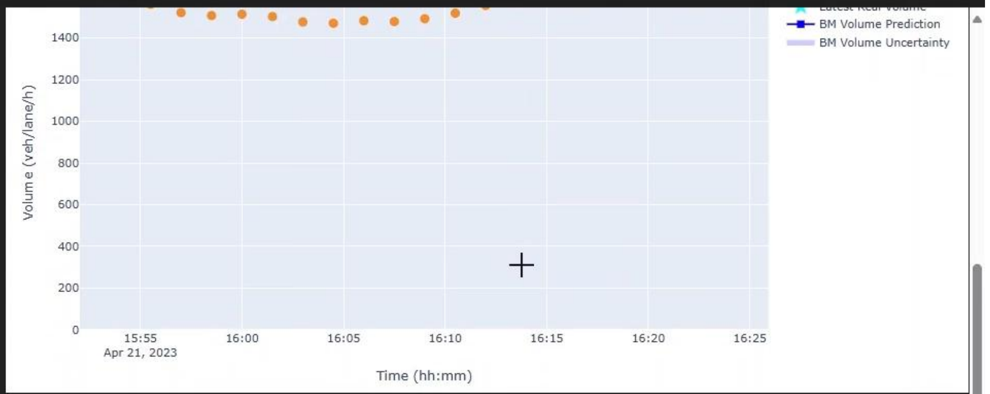
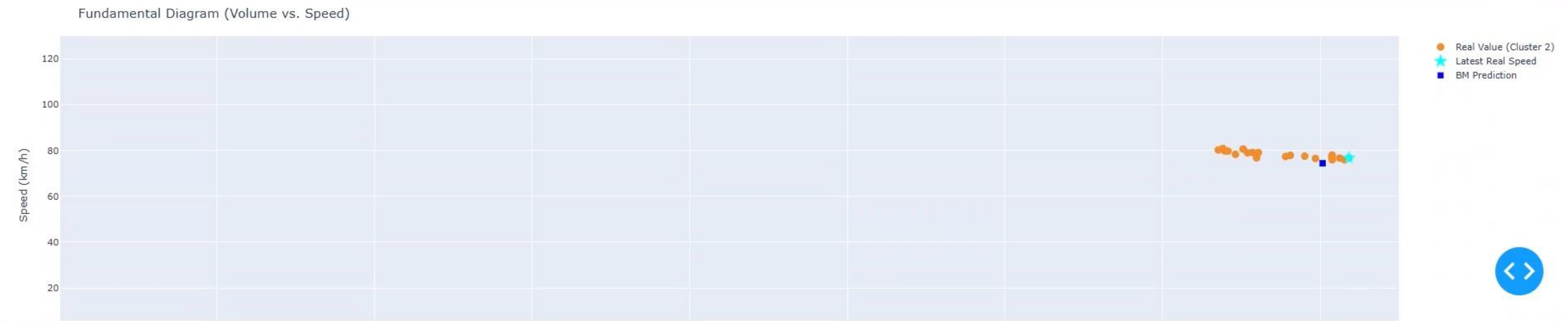
Dash





Metric	Value
Day of the Week	Friday
Real Speed	76.80
MAPE (Speed)	2.55%
Residual (Speed)	1.96
PICP (Speed)	100.00%
Sharpness (Speed)	7.46

Metric	Value
Day of the Week	Friday
Real Volume	1636.68
MAPE (Volume)	2.94%
Residual (Volume)	48.11
PICP (Volume)	100.00%
Sharpness (Volume)	122.04



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Timely incident detection and more accurate predictions

- Better information systems for all road users
- Informed (predictive) traffic management: decision-making to prevent traffic congestion, response
- Response to incidents (accidents, weather, road closures, etc.)
- Better conditions → More sustainable, environmentally friendly and safer mobility

Scientific and Social Impact

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- Propose a more actionable traffic conditions taxonomy

- Enhance performance and transparency of DL models

- Integration into CCAM environments → collect data from individual vehicles, more detailed information, better information flow

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Future Challenges

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- In CCAM environments, further increase the accuracy of predictions and incident detection

- Improve traffic conditions and effectiveness of traffic management strategies

- Increase trust to AI models by making them more interpretable

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