Exploring the relationship between unsafe traffic events and crash occurrence

Stelios Peithis

Transportation Engineer, PhD Candidate

Together with:
Evi Koliou, Stella Roussou, George Yannis

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

ROAD SAFETY

Streets for Life
#MakeCyclingSafe

Exploring the relationship between unsafe traffic events and crash occurrence

➢ Project partners:

- National Technical University of Athens
  Department of Transportation Planning & Engineering
  www.nrso.ntua.gr

➢ Duration of the project:

- 30 months (June 2022 – December 2024)

➢ Framework Program:

- NTUA – Basic Research Programme 2021

H.F.R.I.
Hellenic Foundation for Research & Innovation

Greece 2.0 NATIONAL RECOVERY AND RESILIENCE PLAN
Funded by the European Union NextGenerationEU

Why does it matter?

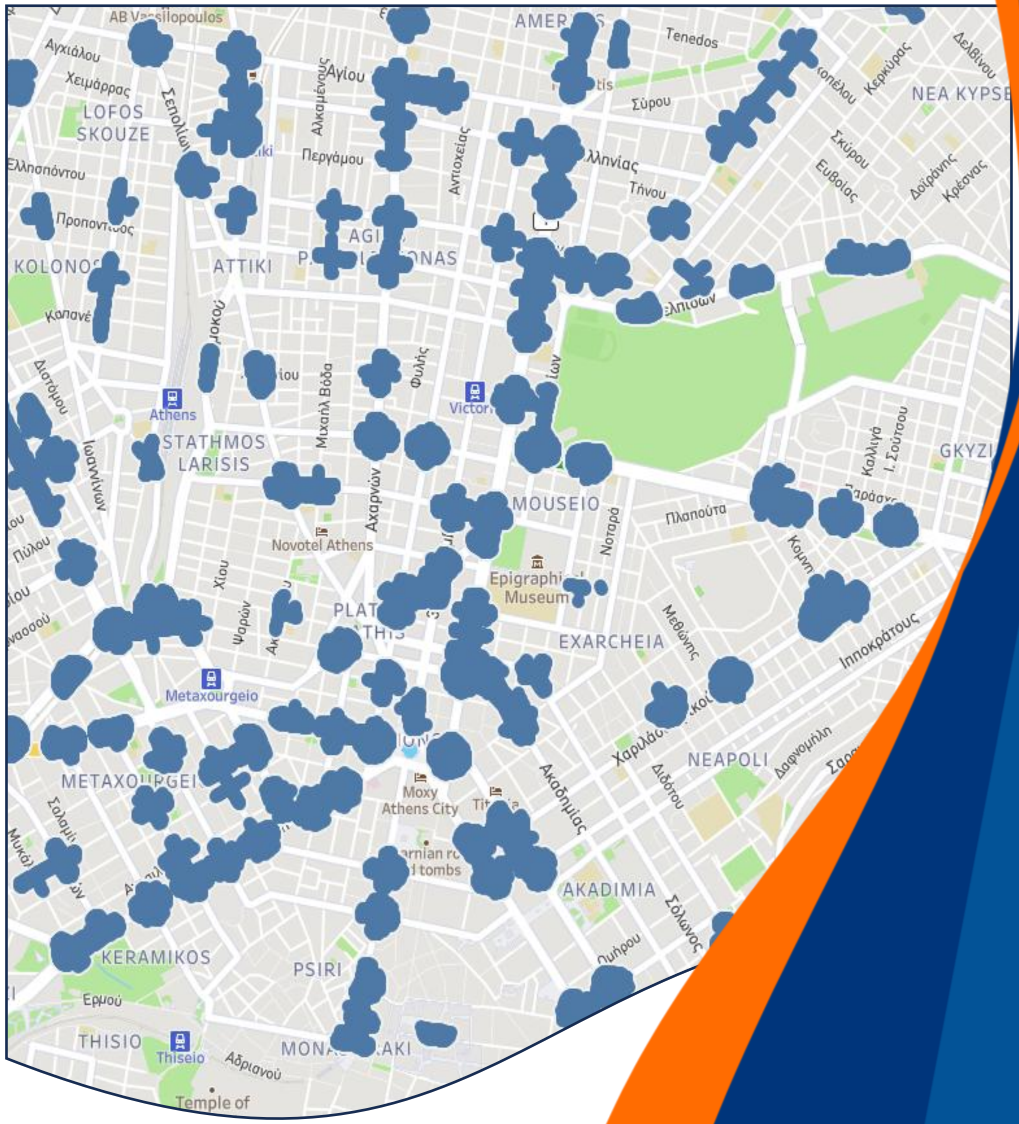
- Road crashes are a significant public health issue, with over 1.19 million annual fatalities worldwide
- Current road safety measures show slow progress, necessitating new approaches for crash prediction and prevention.
- Unsafe traffic events, such as harsh accelerations and braking, occur more frequently and are easily obtainable using smartphone app data.
- Leveraging real-time data from smartphone sensors offers a proactive approach to traffic safety analysis and intervention.

Objectives

- **Identify correlations** between unsafe traffic events (e.g., harsh braking, illegal crossings) and crash occurrences.
- **Develop predictive models** to forecast crash risk using telematics and video data.
- **Integrate multi-source data** (smartphone, camera, crash reports) for comprehensive safety analysis.
- **Compare event types** to determine which are most effective for crash prediction.
- **Evaluate data efficiency** by identifying the minimum data needed for reliable safety assessments.
- **Support proactive safety** strategies by shifting from crash-based to event-based analysis.

Data Collection

- **Driving Behaviour (Telematics) Data:** Data from ~300 drivers in Athens using the OSeven smartphone app, recording instances of harsh acceleration and braking.
- **Traffic Metrics:** Obtained from the Attica Traffic Management Center, including traffic volume, average speeds, and occupancy rates.
- **Road Characteristics:** Leveraging Google Maps and OpenStreetMap Overpass API to construct a graph of nodes and edges of the road network.
- **Crashes Data:** Collected from the Greek Traffic Police, crash records across 478 intersections in central Athens. The dataset contains information on crash type, severity, involved road users, time of occurrence.
- **Camera Data:** Collected from fixed video cameras installed at eight key intersections in central Athens, focused on the Omonoia Square location. The dataset includes illegal pedestrian crossings, red-light violations, vehicle behaviour, and Time-to-Collision (TTC) metrics.



Streets for Life
MakeCyclingSafe

Results - Key Findings from Telematics & Crash Data

- **Harsh Events as Crash Predictors**
  Harsh acceleration and braking events strongly correlate with crash occurrences, especially at urban intersections.
- **High-Risk Junctions Identified**
  Junctions with high-speed variability and frequent braking were flagged as crash-prone areas.
- **GLM & GLMM Statistical Models**
  These models confirmed that variables like speed difference, right exits, and pedestrian infrastructure significantly influence crash frequency.
- **Machine Learning Models (Random Forest, XGBoost)**
  Achieved up to 80% accuracy in classifying crash risk levels across 478 intersections using harsh event ratios and lane data.
- **Important Predictive Features**
  Mean speed difference, braking probability, and harsh braking frequency were top contributors to crash risk.
- **Spatial Hotspots Mapped**
  Tools like Local Moran's I and Geary's C highlighted clusters of unsafe behaviours and crash hotspots in central Athens.

Results - Camera Data & Behaviour Analysis

- **Illegal Crossings Detected**
  Cameras at 8 key intersections recorded frequent **illegal pedestrian and vehicle crossings**, especially during long red-light phases.
- **Automated Detection Accuracy**
  The detection system achieved up to **70% accuracy** in recognizing traffic light states and identifying violations.
- **Time-to-Collision (TTC) Analysis**
  Lower TTC values were consistently linked to illegal crossings and speeding, indicating higher collision risk.
- **Predictive Behaviour Models (LSTM & GRU)**
  Neural networks successfully predicted pedestrian violations based on light phases and traffic patterns:
  - **LSTM**: Higher recall, good for capturing more violations.
  - **GRU**: Better precision, fewer false positives.
- **Key Insight**
  Pedestrian behaviour is strongly influenced by signal timing and vehicle speed—long red lights and low traffic often lead to risky crossings.

Streets for Life

This research supports that vision by:

- Identifying where unsafe driver behaviour threatens vulnerable users (e.g., pedestrians).
- Enabling targeted, proactive interventions - like speed calming, better signal timing, and pedestrian-friendly design.
- Promoting data-informed policy to prioritise human life over traffic flow.

Using unsafe event data helps transform roads into safe, livable spaces, supporting the global call for StreetsForLife that protects everyone, especially the most vulnerable.

Streets for Life
#MakeCyclingSafe

Scientific and Social Impact

- **Multisource Data Integration:** Combines telematics, camera footage, and crash records, showcasing a novel, interdisciplinary approach to traffic safety research, using Machine Learning and Spatiotemporal Risk Mapping.
- **Proactive Protection of Vulnerable Road Users:** Identifies unsafe conditions before crashes occur, helping protect pedestrians, cyclists, and children—those most at risk in urban traffic.
- **Supports Safer, People-Centric Urban Design:** Provides data to inform lower speed zones, improved crossings, and infrastructure that prioritizes human life over vehicle flow.
- **Enables Data-Driven Public Policy:** Empowers local governments to implement evidence-based safety interventions instead of waiting for crashes to happen.

Streets for Life
#MakeCyclingSafe

Future Challenges

- Data Limitations and Generalizability: The current study focuses on Athens; applying the same methodology to different cities or rural areas may require adjustments due to varying infrastructure and driver behaviour.
- Incomplete Data Sources: Some unsafe events may go undetected due to sensor limitations, camera occlusions, or missing telematics coverage.
- High Computational Demands: Machine learning models, especially deep learning (e.g., LSTM, GRU), require significant processing power and clean, well-structured data.
- Policy and Integration Barriers: Integrating these systems into existing traffic management frameworks may face institutional resistance, funding issues, or lack of technical expertise.
- Behavioural Adaptation: Drivers and pedestrians may change behaviour in response to monitoring, affecting model accuracy and requiring continuous system updates.

Exploring the relationship between unsafe traffic events and crash occurrence

Stelios Peithis

Transportation Engineer, PhD Candidate

Together with:
Evi Koliou, Stella Roussou, George Yannis

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

DECADE OF ACTION FOR ROAD SAFETY

Streets for Life
#MakeCyclingSafe