Road Safety on Five Continents
20th international RS5C conference,
Leeds, UK from 3–5 September 2025

Advanced Analytics for Traffic Safety: Key Metrics, Predictive Insights, and High-Risk Junction Identification

Dr. Paraskevi Koliou[1], Prof. George Yannis[1]

[1] National Technical University of Athens, Department of Transportation Planning and Engineering, Athens, Greece

Introduction

Road safety remains a critical global issue, with over **1.19 million deaths** annually. In Europe, progress is uneven, despite initiatives such as the EU Vision Zero, which aims to halve road deaths by 2030.

Traditional crash-based analyses are retrospective and limited by **underreporting** and low **data granularity**, requiring crashes to occur before action is taken.

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 can be easily **identified** using smartphone app data.

Leveraging real-time data from smartphone sensors offers a **proactive approach to traffic safety analysis and intervention.**

Objectives

1. **Identify** high-risk urban junctions using smartphone driving data and traffic metrics.
2. **Evaluate** the impact of speed variability, braking, and traffic volume on crash risk.
3. **Develop** a predictive framework to guide proactive traffic safety interventions.

Methodology

1. Study Area

- Location: Central Athens, Greece

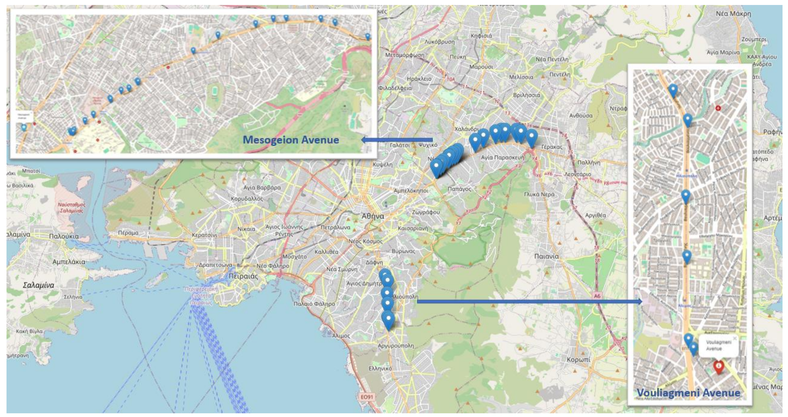


Figure 1: *Study network of Athens*

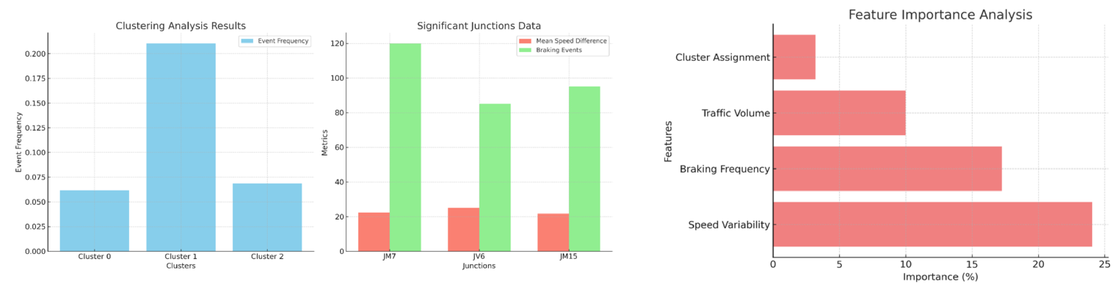
2. Data Sources

- **Telematics Data:** Collected via **OSeven smartphone app** (unsafe driving behaviors).
- **Traffic Management Center & Google Maps** (traffic volume, road characteristics).
- Spatial mapping via **QGIS**.

3. Data Processing

- **Statistical Modelling:** GLM & GLMM for crash–event association.
- **Clustering:** K-Means, DBSCAN to group high-risk junctions.
- **Predictive Modelling:** Random Forest for crash predictors (feature importance).
- **Spatial Analysis:** Moran's I, Geary's C for unsafe event hotspots.
- **Dimensionality Reduction:** PCA to optimize performance.

Results



Junctions	Traffic Volume (Veh/h)	Mean Speed Difference (km/h)	Braking Events (Count)	Occupancy (%)
JM7	3001	22.3	120	9.74
JV6	2589	25.1	85	8.51
JM15	2750	21.7	95	7.8

Figure 2: *Results of analysis*

1. **Clustering Analysis:** 3 groups identified → Cluster 1 = highest risk (high speed variability, frequent braking).

2. **Significant Junctions:**
   - JM7, JV6, JM15 → high traffic volume, speed differences, and braking events (see figure).

3. **Feature Importance:**
   - **Top predictors:** Speed variability (24%), braking frequency (18%), traffic volume (10%).
   - **Spatial Hotspots:** Unsafe driving clusters overlapped with crash-prone areas.

Conclusions

1. **Unsafe driving behaviours** (especially harsh braking & speed fluctuations) are **strong predictors of crash risk.**
2. **Smartphone** app data combined with ML provides a **proactive safety monitoring tool.**
3. **Recommendations:**
   - Speed management enforcement.
   - Driver education via feedback apps.
   - Infrastructure improvements (clearer signage, optimized junction designs).
4. **Future work:** Extend to broader regions, integrate weather and real-time traffic updates.

Contact Information:
Dr. Paraskevi Koliou, Research Associate, NTUA
Department of Transportation Planning and Engineering
Email: evi_koliou@mail.ntua.gr
Website: https://www.nrso.ntua.gr/p/evikoliou/