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Integrating Telematics and Video-Based Recognition for Vehicle Behavior Analysis in Athens

Stella Roussou[1], Apostolos Ziakopoulos[1], Roberto Ventura[2], Dimitris Oikonomopoulos[3], Haris Sideris[3], George Yannis[1]

[1] National Technical University of Athens, Department of Transportation Planning and Engineering, Athens, Greece
[2] Department of Civil, Environmental, Architectural Engineering and Mathematics (DICATAM), University of Brescia, Brescia
[3] OSeven Single Member Private Company, Greece

Introduction

Understanding how vehicles behave in complex urban environments is essential for improving road safety and mobility management. Recent developments in telematics and computer vision have made it possible to **continuously collect and analyze driving data** at both large and small spatial scales.

Telematics systems provide real-time information on speed, acceleration, and vehicle trajectories across large networks, while artificial intelligence and deep learning techniques applied to **video data enable the detection, classification, and tracking of road users** and traffic events such as red-light violations, near-misses, and harsh braking.

Despite their complementary advantages, **telematics and video data have rarely been systematically integrated**. Telematics provide extensive spatiotemporal coverage but limited detail on all road users, whereas video data offer detailed behavioural information but for shorter time periods and smaller areas.

Objectives

This research addresses this gap by developing a framework that **combines telematics and video data** to analyze vehicle speed behaviour and identify high-risk driving patterns. The study focuses on three major urban corridors in Athens and aims to **support the development of proactive road safety indicators** beyond traditional crash-based analysis.

Study Area

The study was conducted in the city center of Athens at three signalized intersections (Vas Amalias-Spot 3, Vas. Sofias-Spot 5, and Panepistimiou-Spot 8).

Two complementary datasets were used:

- ❑ **telematics data** collected from 2019 to 2023 and
- ❑ **video-based data** collected in June 2024 using smartphone cameras and AI-based object tracking.

The telematics dataset includes speed, speeding rate, and harsh events, while the video dataset includes vehicle trajectories, speeds, and Time-to-Collision (TTC) indicators. These datasets provide both long-term network-level information and detailed local traffic behaviour at intersections.

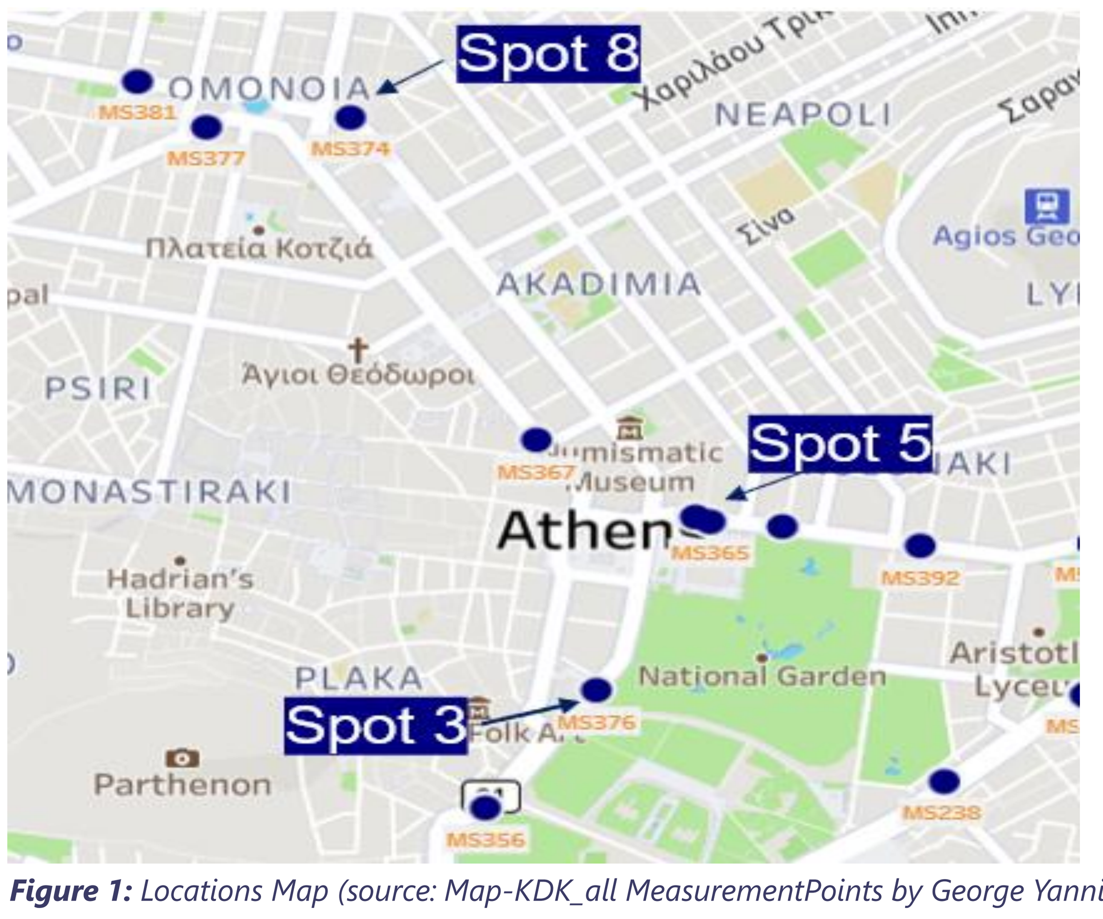

Figure 1: Locations Map (source: Map-KDK_all MeasurementPoints by George Yannis)

Methodology

The integration framework consisted of four main steps:

- ❑ data preprocessing,
- ❑ harmonization of telematics and video datasets,
- ❑ comparative speed analysis, and
- ❑ safety analysis using Time-to-Collision (TTC).

- ➢ Speeds were filtered between 5-60 km/h, and trimmed means were calculated to remove extreme values.
- ➢ Critical TTC events were defined as TTC < 1.5 s and aggregated in 10-second intervals.

The analysis included comparison of mean speeds between datasets, spatial comparison of TTC rates across locations, rolling time-window analysis to detect short-term conflict peaks, and correlation analysis between speed and TTC indicators.

***Table 1:** Sample of Telematics Data (Spot 3 - From 2019 to 2023)*

Timestamp	spot_number	Average_speed (km/h)	speeding_rate
2019-06-01 17:00:00	Vas.Amalias-Panepistimiou-MS376	32.637	0.295
2019-06-01 18:00:00	Vas.Amalias-Panepistimiou-MS376	35.775	0.297
2019-06-02 17:00:00	Vas.Amalias-Panepistimiou-MS376	41.669	0.238

***Table 2:** Sample of Video-Based Data (Spot 3 - June 2024)*

Timestamp	spot_number	Average_speed (km/h)	median_speed_mps
2024-06-01 17:00:00	Vas.Amalias-Panepistimiou-MS376	24.144	6,744
2024-06-01 18:00:00	Vas.Amalias-Panepistimiou-MS376	33.869	9.70
2024-06-02 17:00:00	Vas.Amalias-Panepistimiou-MS376	30.371	8.478

Results

Table 3 presents the comparison between mean speeds derived from telematics and video data for the three study locations.

- In all cases, **telematics speeds were higher than video-based speeds**.
- This difference is explained by the **spatial coverage of the datasets**, as video recordings were focused near signalized intersections where vehicles decelerate, while telematics data represent entire trips, including free-flow segments.

Despite these differences, both datasets showed consistent spatial patterns across the three locations.

***Table 3:** Comparison of Mean Speeds*

Recording location	Mean (km/h)	Telematics Mean (km/h)	Δ (Video – Telematics)	Description
Spot #3	24.8	31.6	-6.8	Intersection approach near Vas. Amalias
Spot #5	13.8	22.8	-8.9	Moderate flow on Vas. Sofias
Spot #8	13.8	29.0	-15.1	Dense intersection at Panepistimiou

The comparison of speed distributions between telematics and video datasets showed that **video speeds were concentrated at lower values** (approximately 10–25 km/h), while telematics speeds presented wider variability, reaching higher values. This confirms that **telematics data capture broader driving conditions, while video data capture localized driving behaviour near intersections**.

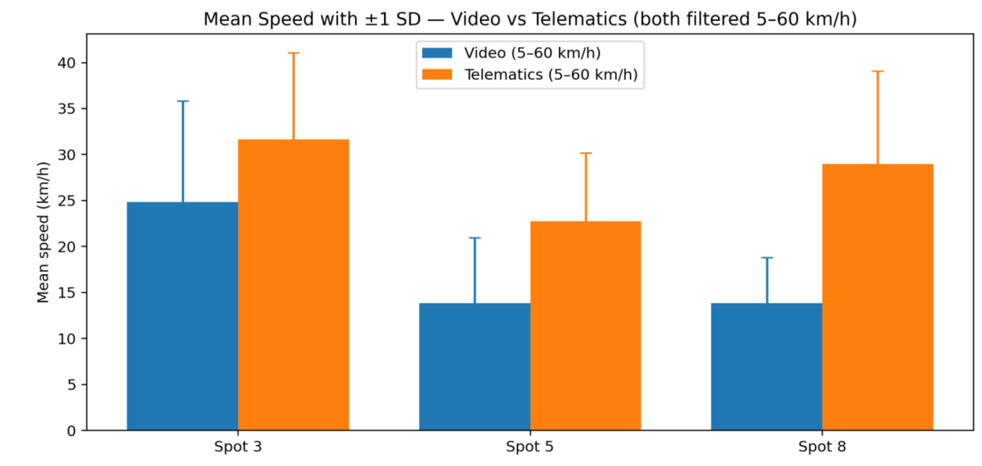

Figure 2: Telematics and Video-recognition extracted speeds

The TTC analysis revealed significant **spatial and temporal differences in traffic conflict** intensity across the three locations.

- ❑ Spot 3 showed the highest number of critical TTC events, indicating higher interaction intensity and unstable traffic conditions.
- ❑ Spot 5 showed moderate conflict levels, while
- ❑ Spot 8 remained relatively stable with very few critical events.

The temporal analysis demonstrated that **conflicts occur in short bursts** rather than continuously, often associated with signal phase changes, pedestrian crossings, or sudden deceleration events.

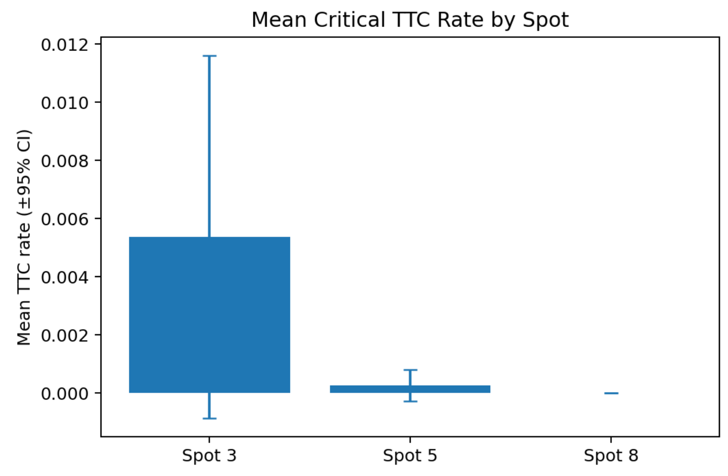

Figure 3: Mean TTC rate per spot

Conclusions

- ➢ The comparison of telematics and video data showed that the two data sources provide **complementary information on vehicle behaviour** and traffic conditions.
- ➢ Telematics data describe speed patterns and variability at the network level, while **video data provide detailed behavioural information and interaction conditions** at specific locations.
- ➢ The results indicate that speed variability, acceleration and braking behaviour are **important indicators of risky driving behaviour**, rather than average speed alone.
- ➢ The integration of telematics and video data improves the identification of **high-risk locations and supports proactive road safety analysis**.
- ➢ The combined framework can support data-driven road safety policies, traffic management strategies, and smart urban mobility planning.
- ➢ Future work should expand the analysis to **more locations and longer time periods** and further develop integrated safety indicators.

Acknowledgments

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Contact Information:
Stella Roussou, PhD Candidate, Research Associate NTUA
Department of Transportation Planning and Engineering
Email: s_roussou@mail.ntua.gr
Website: https://www.nrso.ntua.gr/p/s_roussou/