Smart Maps supporting safe driving behavior using multi-source large-scale data

George Yannis

NTUA Professor

Together with:
Dimitrios Nikolaou, Armira Kontaxi, Apostolos Ziakopoulos,
Petros Fortsakis, Elina Frantzola,
Konstantinos Sigalos, George Kouridakis

39th Meeting of the International Road Traffic Safety Data and Analysis Group (IRTAD)

London, 9-10 April 2025

The SmartMaps Project

- Project partners:
  - National Technical University of Athens, Department of Transportation Planning and Engineering www.nrso.ntua.gr
  - OSeven Telematics www.oseven.io
  - Global Link www.globallink.gr
- Duration of the project:
  - 26 months (October 2021 – November 2023)
- Operational Program:
  - "Competitiveness, Entrepreneurship and Innovation" (EPAnEK) of the National Strategic Reference Framework (NSRF) – 2nd iteration

European Union
European Regional Development Fund

ΕΣΠΑ 2014-2020
ανάπτυξη - εργασία - αλληλεγγύη

ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΥΠΟΥΡΓΕΙΟ ΠΑΙΔΕΙΑΣ
ΕΡΕΥΝΑΣ & ΘΡΗΣΚΕΥΜΑΤΩΝ

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ΕΙΔΙΚΗ ΥΠΗΡΕΣΙΑ ΔΙΑΧΕΙΡΙΣΗΣ ΕΠΑνΕΚ

EPAnEK 2014-2020
OPERATIONAL PROGRAMME
COMPETITIVENESS•ENTREPRENEURSHIP•INNOVATION

Objectives

- Exploitation of large-scale **spatio-temporal data** from smartphone sensors.

- **Development of smart driver behaviour maps** with online information on safety conditions and eco-driving (by reducing fuel consumption).

- Creation of a **comprehensive tool to promote safe driving behaviour** with application in Greece and around the world.

Data Collection

- Road Geometry Data (OpenStreetMap)
  Length, Curvature, Slope
- Observed Driving Data – Field (Global Link)
  Seatbelt use, Helmet use, Speeding, Distraction
- Naturalistic Driving Data – Telematics (OSeven)
  Harsh braking, Harsh acceleration, Speeding, Distraction
- Road Crash Data (ELSTAT) – inaccurate location recording → cannot be used in detailed crash prediction modelling
- Emissions and fuel consumption - based on speed and acceleration data (Zhao et al., 2015)
- Covering broad road network areas within the 13 Regions of Greece (NUTS2)

Road Geometry Data

- The data processing and analyses conducted within the road network of Western Greece are presented (same methodology was applied in the remaining Greek Regions).

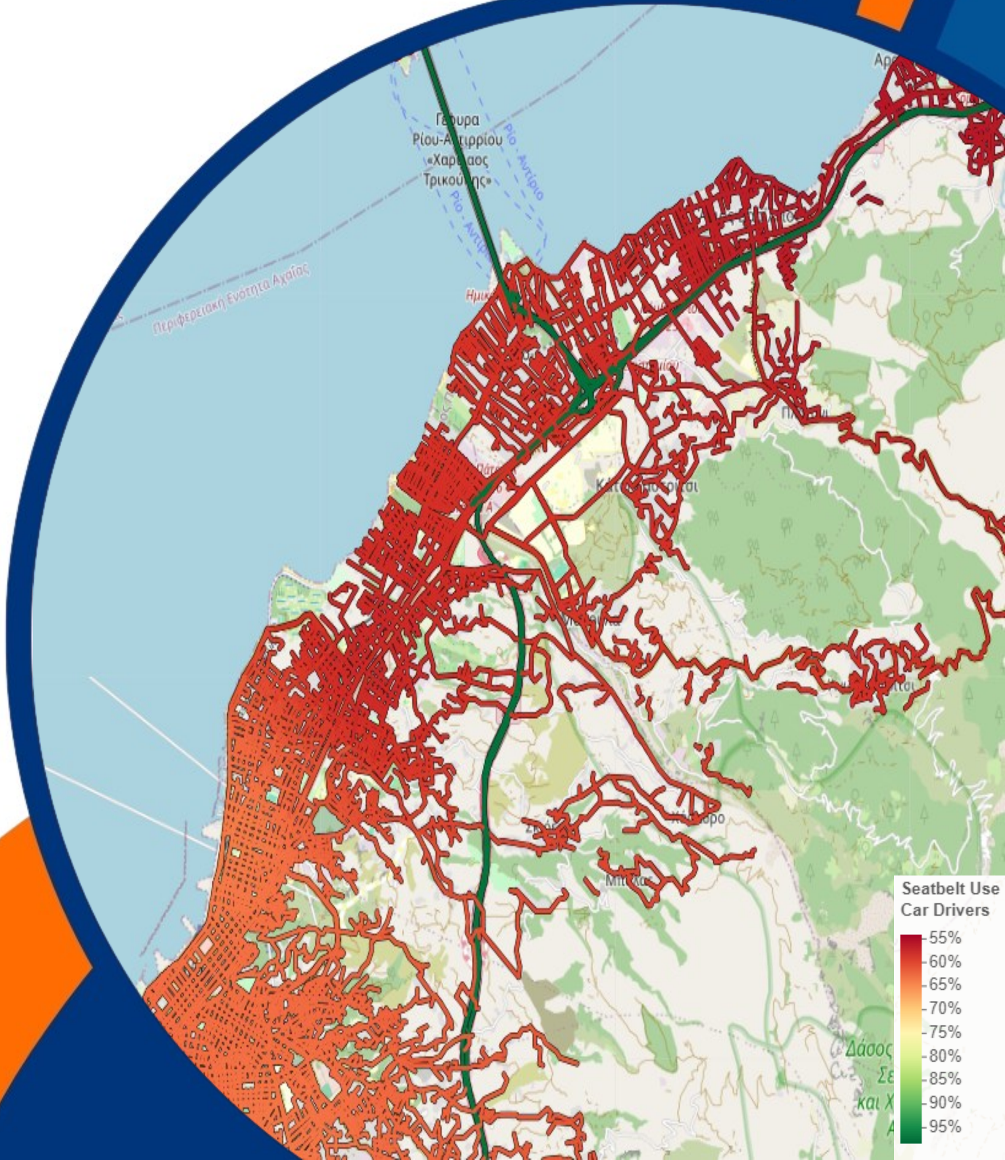
- 9.355 road segments:
  (Mean Length: 223m, Total Length ~2000km).

- Road Types: (74% residential, 7% tertiary, 6% primary, 6% motorway, 5% secondary, 2% other types).

- Slopes: 59% (flat: 0-3%), 18% (mild: 3-5%), 13% (medium: 5-8%), 4% (hard: 8-10%), 6% (extreme: >10%).

Observed Driving Data

- **Field measurements** on road user behaviour indicators in 10 locations (4 motorway, 3 rural, 3 urban).
- **Inverse Distance Weighting (IDW)** was used twice for spatial interpolation in the entire road network (motorways, non-motorways).
- IDW estimates the value of a variable at a given location by using a **weighted average of the surrounding known values**, with weights determined by their distance to the target location, assuming that nearby locations have similar values.
- ~**2.500 observations** of passenger car drivers. (seatbelt, distraction, speeding).
- ~**500 observations** of PTW drivers (helmet).



Naturalistic Driving Data - Telematics

- 14.611 trips in the examined area in 2021.

- Map matching of naturalistic driving data and considered road segments.

Naturalistic Driving Data per segment	Min.	Mean	Max.
Trip count	0	61,3	1.293
Speeding count (sec)	0	30,5	27.279
Mobile usage count (sec)	0	35,2	8.561
Harsh acceleration events	0	0,8	136
Harsh braking events	0	1,3	221

Spatial Error Model - Background

- The spatial error model handles the spatial autocorrelation in the residuals.
- The idea is that such errors (residuals from regression) are autocorrelated in that the error from one spatial feature can be modeled as a weighted average of the errors of its neighbors.
- This model can be expressed as:

$$y = X\beta + u, \quad u = \lambda_{Err} Wu + \varepsilon$$

  - where y is an (N×1) vector of observations on a response variable taken at each of N locations,
  - X is an (N×k) matrix of covariates,
  - β is a (k×1) vector of parameters,
  - u is an (N×1) spatially autocorrelated disturbance vector,
  - ε is an (N×1) vector of independent and identically distributed disturbances
  - λ_{Err} is a scalar spatial parameter.

Spatial Error Model - Results

Dependent variable: **log(harsh_braking_count + 1),** Type: error, Coefficients: (asymptotic standard errors)

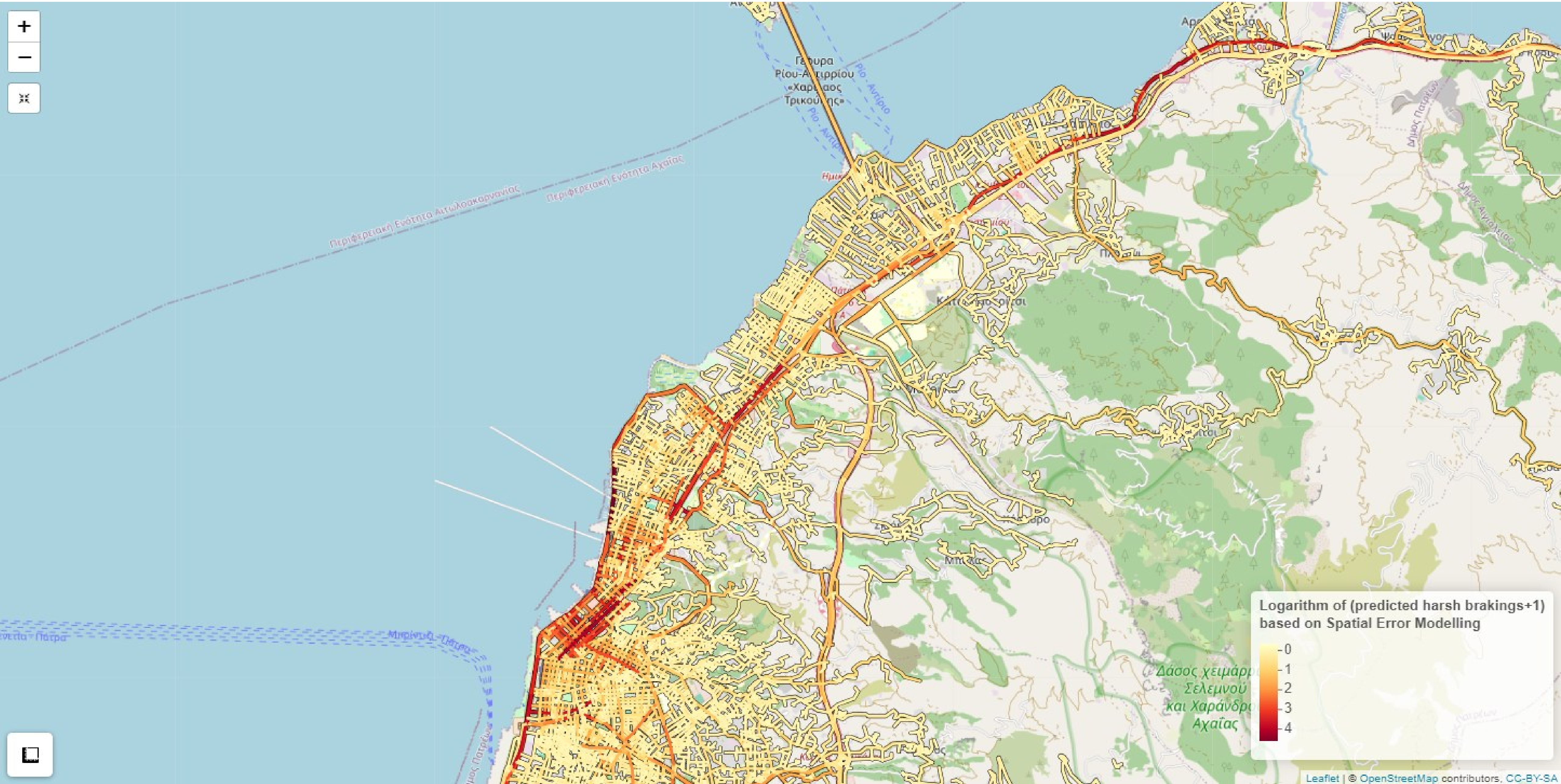
	Estimate	Std. Error	z value	Pr(>|z|)	VIF
(Intercept)	-0.7556	0.0627	-12.052	**<0.001**	-
trip_count	0.0029	0.0000	72.678	**<0.001**	1.35
log(1 + length)	0.0986	0.0048	20.595	**<0.001**	1.21
log(1 + speeding_count)	0.1151	0.0047	24.437	**<0.001**	1.45
log(1 + efficiency)	0.4674	0.0774	6.042	**<0.001**	1.16
mobile_usage_rate	0.0119	0.0018	6.338	**<0.001**	1.03
motorway	-0.1673	0.0209	-8.012	**<0.001**	1.05

Lambda: 0.0164, LR test value: 4.1966, p-value: 0.040

AIC: 11824, (AIC for lm: 11826)

- Lambda value of 0.0164 is statistically significant, suggesting the error term is spatially autoregressive.
- From the AIC, the spatial error model performs much better than the linear model, as lower AIC indicates better fit.
- Spatial Error Model led to non-statistical significant spatial autocorrelation in the residuals (Moran I: <0.001, p_value = 0.503), while the opposite is the case for the non-spatial model (Moran I: 0.027, p_value = 0.019).

Visualization of Model Predictions - Crash Risk



Key Analysis Conclusions

- Road geometry characteristics, naturalistic driving data, observed driving data and historical road crashes were combined for:
  - the development of a smart mapping tool for safer and eco driver behaviour,
  - road safety modelling.

- Significant positive effects of segment length, speeding events, and trip count on harsh braking events count.

- Spatial models provide a better fit to the data than non-spatial models and reduce spatial autocorrelation in the residuals.

Scientific and Societal Impact

- **Innovative and intuitive tools** for individual road users and decision makers.
- Exploitation of **multidisciplinary data** to assess **multidimensional** impacts.
- Novel scope of **scientific** approach and analysis.
- Exploration of the **influence** of different policies on safety and environment.
- Contribution towards UN and EU SDG goals for **crash and fuel consumption reductions** (SDGs 9&13).

The Smart Mapping Tool

smartmaps SMART MAPPING TOOL FOR SAFER AND ECO DRIVER BEHAVIOUR

https://www.saferoadsmap.com/

Areas

- Athens
- East Attica
- Central Greece
- Crete
- Eastern Macedonia-Thrace
- Epirus
- Ionian Islands
- North Aegean
- Peloponnese
- South Aegean
- Thessaly
- Western Greece
- Western Macedonia

Metrics

- Crash Risk (statistical modelling)
- Fuel Consumption
- Seatbelt Use
- Helmet Use
- Distraction (Telematics)
- Speeding (Telematics)
- Harsh Braking (Telematics)
- Harsh Acceleration (Telematics)
- Crashes (Area Index)
- Fatalities (Area Index)
- Emissions: CO_2, CO, HC, NO_x
- Road Segment: Slope, Linearity, Length, OSM ID

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oseven DRIVING FORWARD>

global link International Marketing Research

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OECD
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