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HIT- HELLENIC INSTITUTE OF TRANSPORT

HELLENIC INSTITUTE OF TRANSPORTATION ENGINEERS

11th INTERNATIONAL CONGRESS on TRANSPORTATION RESEARCH

Clean and Accessible to All Multimodal Transport

Heraklion, Crete, September 20th - 22nd 2023

Spatial analysis of telematics surrogate safety measures across road environments

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The SmartMaps project

smartmaps

- **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:**
  - 30 months (June 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

ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
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ΟΙΚΟΝΟΜΙΑΣ & ΑΝΑΠΤΥΞΗΣ
ΕΙΔΙΚΗ ΓΡΑΜΜΑΤΕΙΑ ΕΤΠΑ & ΤΣ
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

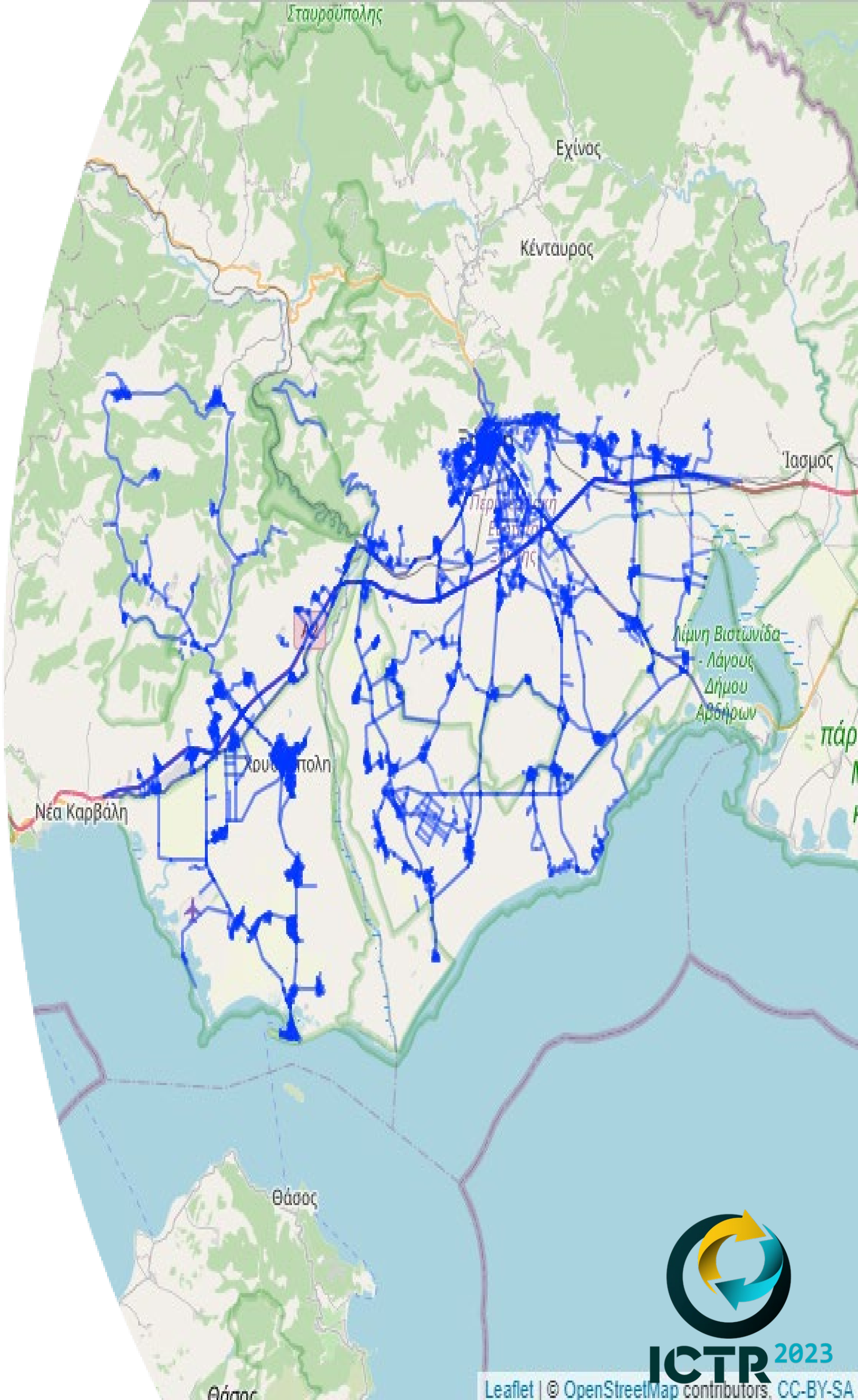
Naturalistic Driving Data – Telematics (OSeven)

- Harsh braking
- Harsh acceleration
- Speeding
- Distraction

Road Crash Data (ELSTAT)

Road Geometry Data

- The area of East Macedonia & Thrace was chosen as a challenging area in terms of data availability for the initial investigations.
- The process of data collection and analysis carried out in East Macedonia & Thrace area will be replicated in the remaining Greek Regions.
- 6099 road segments:
  (Mean Length: 290m, Mean Angle Rate: 0.50 [1/m], Total Length 1700km)
- Road Types: (68% residential, 12% tertiary, 7% secondary, 3% motorway, 10% other types)
- Slopes: 76% (flat: 0-3%), 10% (mild: 3-5%), 7% (medium: 5-8%), 3% (hard: 8-10%), 4% (extreme: >10%).



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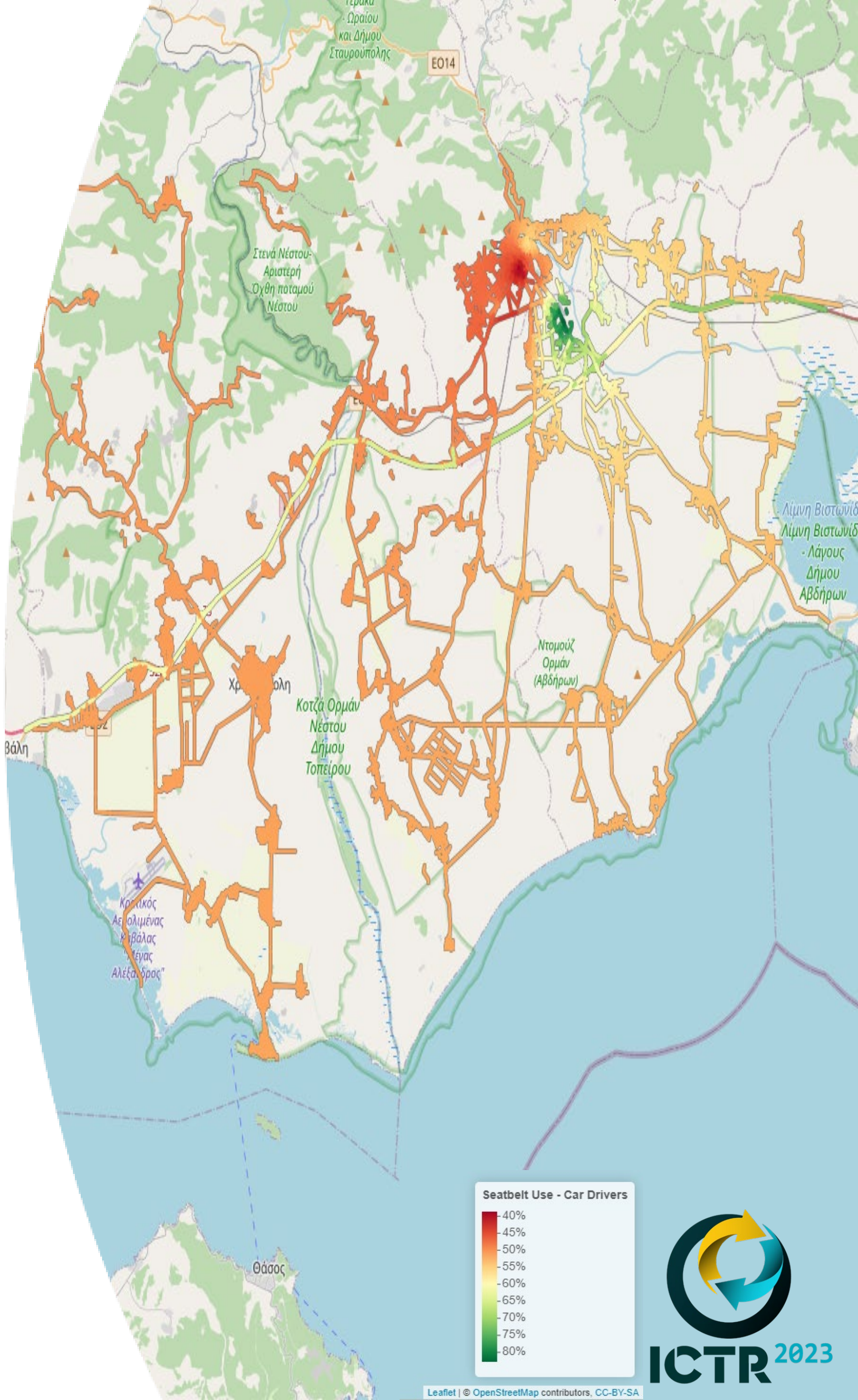
Observed Driving Data

- **Field measurements** on road user behaviour indicators in 10 locations (3 motorway, 4 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.
- ~**3500 observations** of passenger car drivers. (seatbelt, distraction, speeding)
- ~**260 observations** of PTW drivers (helmet).



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Naturalistic Driving Data - Telematics

- 5129 trips in the examined area in 2021.
- Map matching of naturalistic driving data and considered road segments.

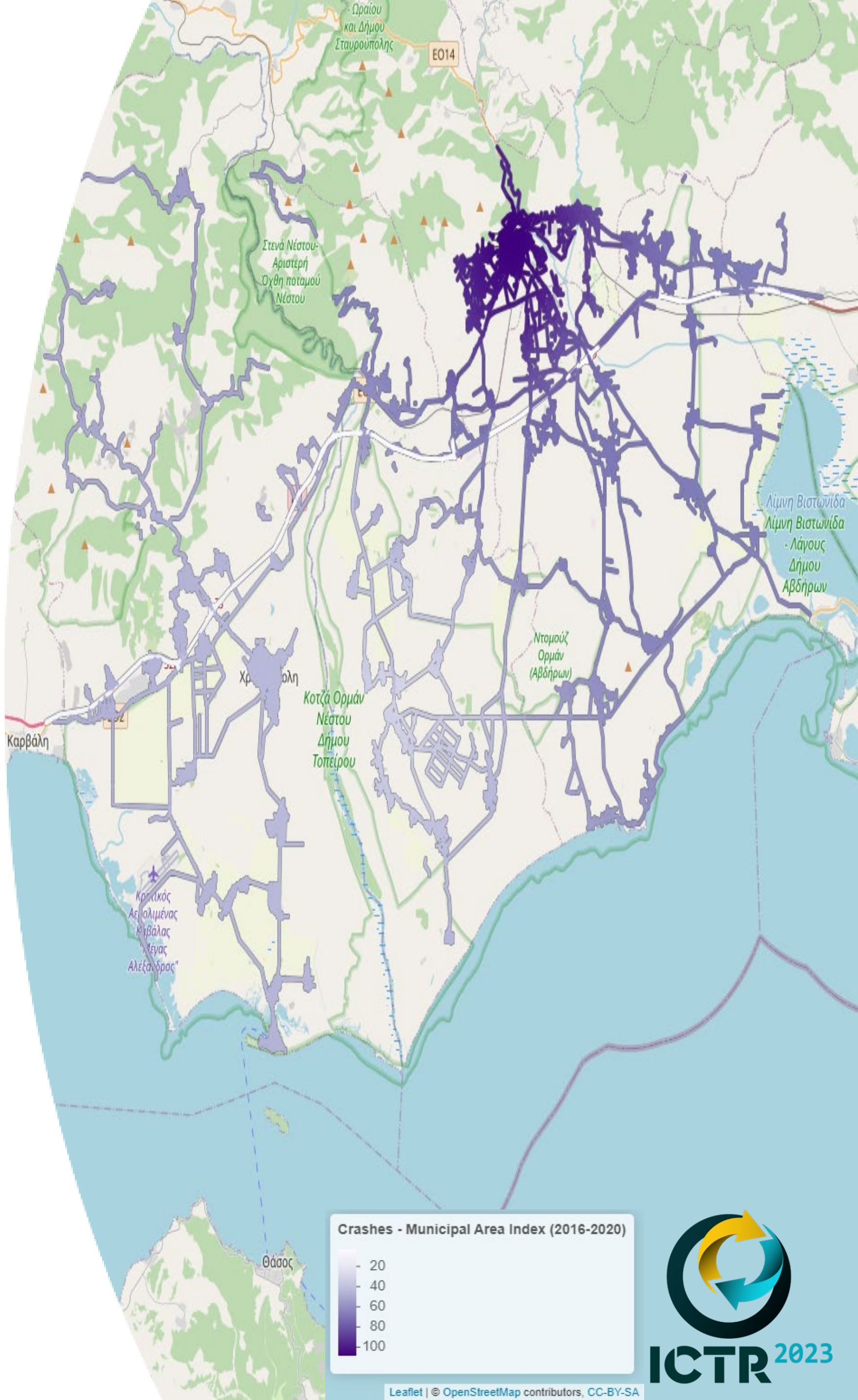
Naturalistic Driving Data per segment	Min.	Mean	Max.
Trip count	0	32	1272
Speeding rate (sec/trips)	0	0.26	110
Mobile usage rate (sec/trips)	0	0.34	133
Harsh acceleration rate (sec/trips)	0	0.004	1.00
Harsh braking rate (sec/trips)	0	0.007	1.42

Road Crash Data

- **Inaccurate recording** of crash locations (lack of coding with geographical coordinates in the national database).
- Aggregate crash data for **5 municipalities** (Xanthi, Avdira, Myki, Topeiros, Nestos)

Municipality	Motorway	Crashes (2016-2020)	Fatalities (2016-2020)	Serious Injuries (2016-2020)	Slight Injuries (2016-2020)	KSI (2016-2020)
Xanthi	No	108	10	15	128	25
Xanthi	Yes	1	0	2	0	2
Avdira	No	70	12	20	73	32
Avdira	Yes	5	1	2	10	3
Myki	No	20	4	6	16	10
Myki	Yes	0	0	0	0	0
Topeiros	No	32	7	7	36	14
Topeiros	Yes	4	3	4	7	7
Nestos	No	44	12	9	49	21
Nestos	Yes	12	3	4	15	7

- Spatial interpolation of "**area crash-related indexes**" based on the total numbers using IDW twice (motorways, non-motorways). (Crashes, Fatalities, Killed and Seriously Injured (KSI)).



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 $(N\times1)$ vector of observations on a response variable taken at each of N locations,
  - X is an $(N\times k)$ matrix of covariates,
  - β is a $(k\times1)$ vector of parameters,
  - u is an $(N\times1)$ spatially autocorrelated disturbance vector,
  - ε is an $(N\times1)$ 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|)
(Intercept)	-0.3077	0.0849	-3.6229	**0.0003**
log(1 + length)	0.0360	0.0039	9.3512	**< 2.2e-16**
log(1 + slope)	-0.0055	0.0059	-0.9399	0.3473
log(1 + efficiency)	0.1067	0.0580	1.8408	**0.0657**
log(1 + speeding_count)	0.0847	0.0046	18.4841	**< 2.2e-16**
mobile_usage_rate	0.0064	0.0015	4.3898	**<0.001**
PC_D_Seatbelt_Yes_p	-0.0237	0.0951	-0.2493	0.8031
log(Crashes2016_2020)	0.0233	0.0085	2.7405	**0.0061**
trip_count	0.0024	0.0000	52.0655	**< 2.2e-16**

Lambda: 0.022785, LR test value: 5.1845, p-value: 0.022789
AIC: 3891.5, (AIC for lm: 3894.7)

- Lambda value of 0.022 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 Lag Model - Background

- A spatial lag is a variable that essentially averages the neighboring values of a location (the value of each neighboring location is multiplied by the spatial weight and then the products are summed).

- It can be used to compare the neighboring values with those of the location itself.

- For these spatial lags, we can use the spatial lag model to address the spatial autocorrelation in the dependent variable:
  $y = \rho_{Lag} W y + X\beta + \varepsilon$

  - Where ρ_{Lag} is a scalar spatial parameter, indicating how much a spatial feature is influenced by its neighbors..

Spatial Lag Model - Results

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

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-0.2929	0.0845	-3.4657	**0.0005**
log(1 + length)	0.0356	0.0038	9.2738	**< 2.2e-16**
log(1 + slope)	-0.0061	0.0059	-1.0367	0.2999
log(1 + efficiency)	0.1048	0.0579	1.8093	**0.0704**
log(1 + speeding_count)	0.0846	0.0046	18.4784	**< 2.2e-16**
mobile_usage_rate	0.0064	0.0015	4.4202	**<0.001**
PC_D_Seatbelt_Yes_p	-0.0371	0.0944	-0.3927	0.6945
log(Crashes2016_2020)	0.0218	0.0085	2.5734	**0.0101**
trip_count	0.0024	0.0000	51.9864	**< 2.2e-16**

Rho: 0.016061, LR test value: 3.8597, p-value: 0.04946
AIC: 3892.8, (AIC for lm: 3894.7)

- Rho value of 0.016 is statistically significant, suggesting there is positive spatial autocorrelation.
- Similarly, the spatial lag model is much better than the linear model, even though it is not as good as the spatial error model.

Key Conclusions

- Road geometry characteristics, naturalistic driving data, observed driving data and historical road crashes were combined for 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.
- Methodology applied in East Macedonia & Thrace area can be extended to other Greek regions and national road network.

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