Artificial Intelligence In Proactive Road Safety Management

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Introduction

- Road safety is a field with typically high risk of important investments but not matching results.
- Absence of monitoring and accountability limits seriously road safety performance.
- Very often used to look where the data are and not where the problems and solutions are.
- Innovative data-driven solutions could contribute to a proactive approach of addressing urban road safety problems, being a core principle of the Safe System Approach.

Big Data, Broad Horizons

- A wealth of big data becomes available
- Differentiations per road user category and focus on niche analyses (e.g. VRUs, professional drivers, freight vehicles etc.).
- A multitude of data sources:

Mobile Phone geolocation/telematics, Vehicular On-Board Diagnostics, Cameras, CarSharing/BikeSharing, Social Media, Shared Mobility, Digital Maps, Weather, Census etc.

Surrogate Safety Measures (SSMs)

- Big Data → SSMs, e.g. traffic conflicts, harsh driving events, spatial/temporal headways, and many others
- Readily available for proactive analyses before crashes occur or in areas with limited or no crash data availability.
- SSMs show less underreporting; can even aid with crash reporting.
- Research on the validation of surrogate safety metrics is essential…
  1. to reveal which metrics not only are correlated with reported crashes but also have predictive capabilities
  2. to forecast the number of fatalities and/or injuries
  3. to determine how these metrics can integrate crash participant fragility, speed, mass and crash type consequences
- More than before, data must not be misused/misinterpreted.

AI in Telematics & Driver Monitoring

- The insurance industry is heavily investing in telematics-based algorithms, offering reduced premiums for safer driving.
- AI and data fusion technologies used in all stages of road safety data collection, transmission, storage, harmonization, analysis and pattern detection.
- Personalized feedback can be obtained almost instantaneously.

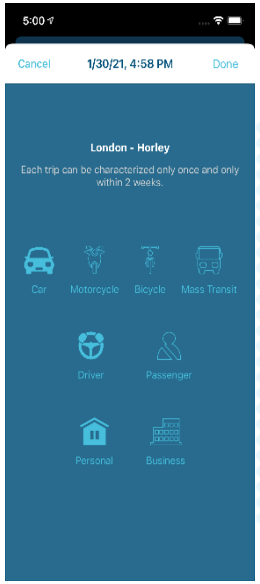
Two proactive examples from smartphone telematics:

A. Driver-based analysis on distraction from mobile use

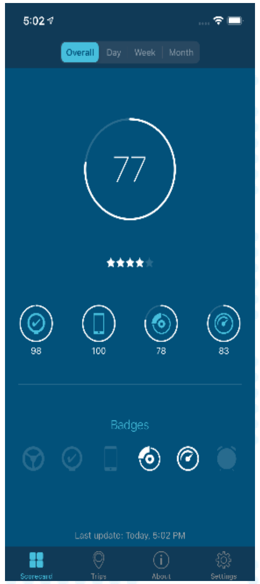
B. Network-based analysis on harsh brakings

Distraction investigation (1/2)

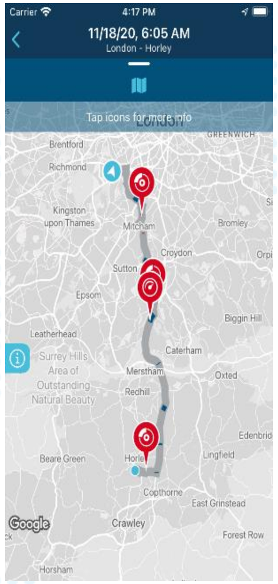
Phase 1 – No feedback



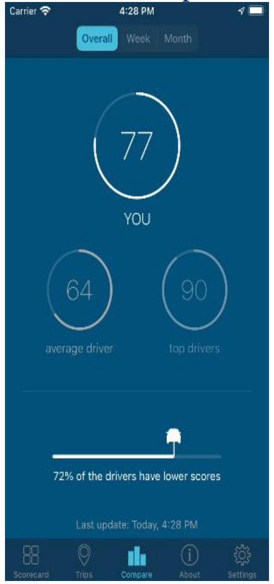
Phase 2 – Scorecard



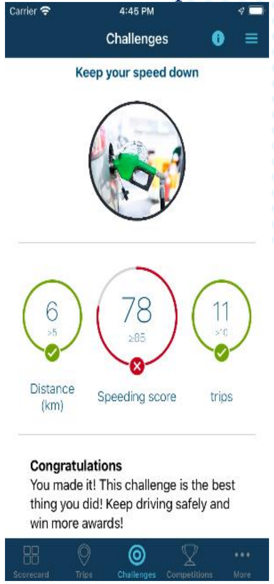
Phase 3 – Maps



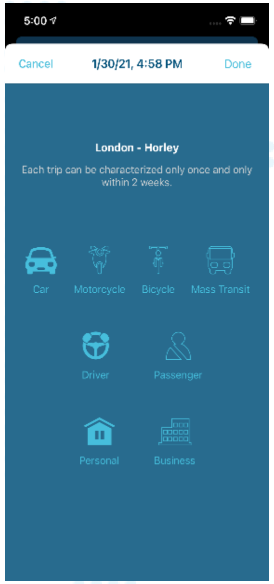
Phase 4 – Comparison



Phase 5 – Competitions

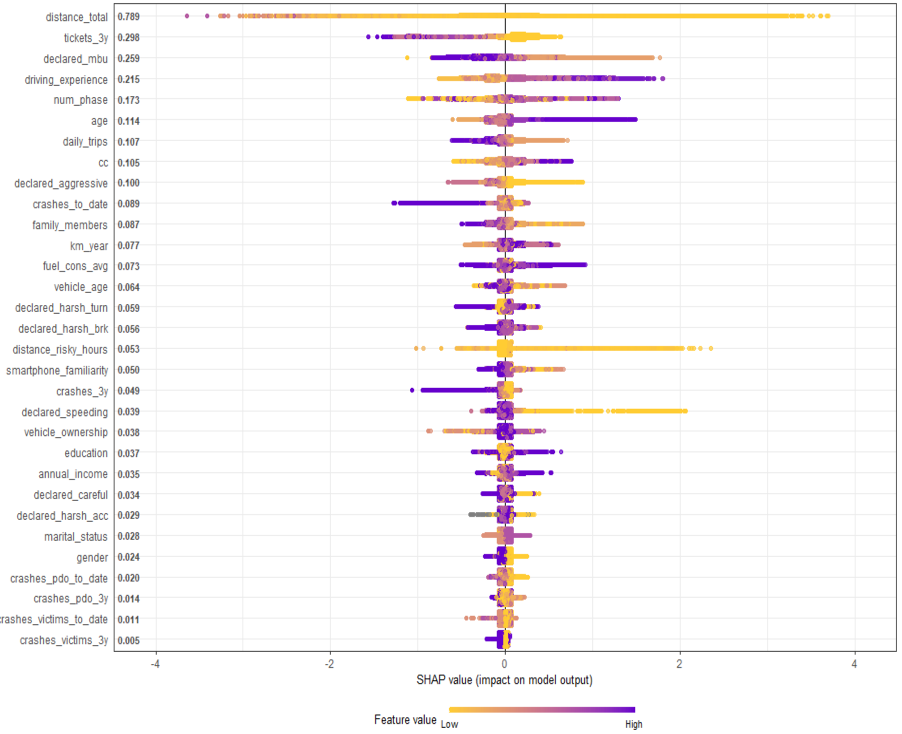


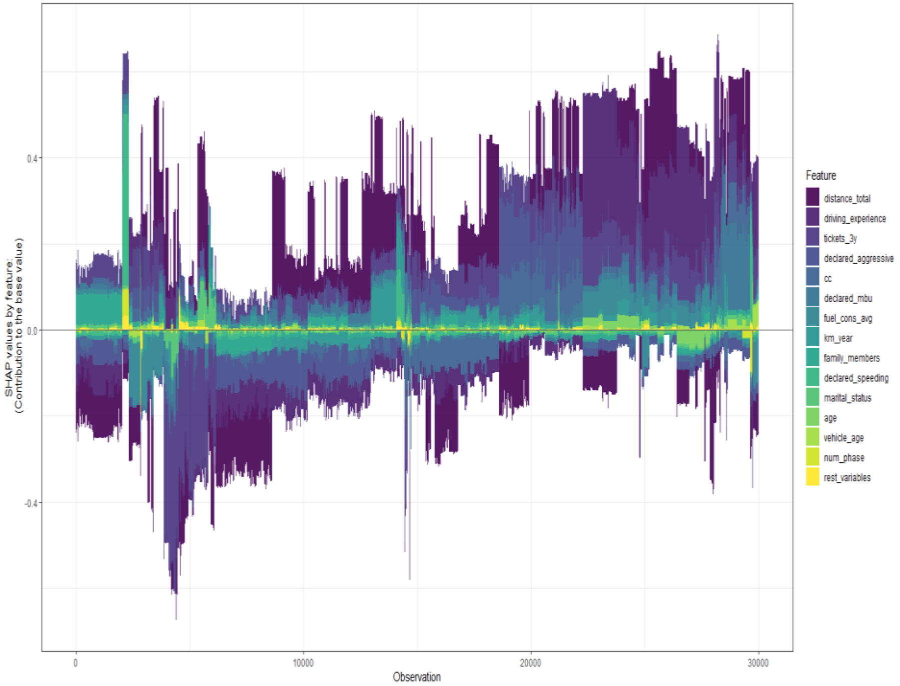
Phase 6 – No feedback



- An investigation of factors influencing distraction from mobile phone use in naturalistic driving
- A smartphone application with 6 feedback phases was the basis for data collection for 87 frequent car drivers
- Developed by OSeven telematics
- Utilizes motion sensors (e.g. accelerometer and gyroscope), position sensors (e.g. magnetometer), global navigation satellite system (GNSS) receivers etc.
- A number of metrics are recorded that can be used as SSMs

Distraction investigation (2/2)

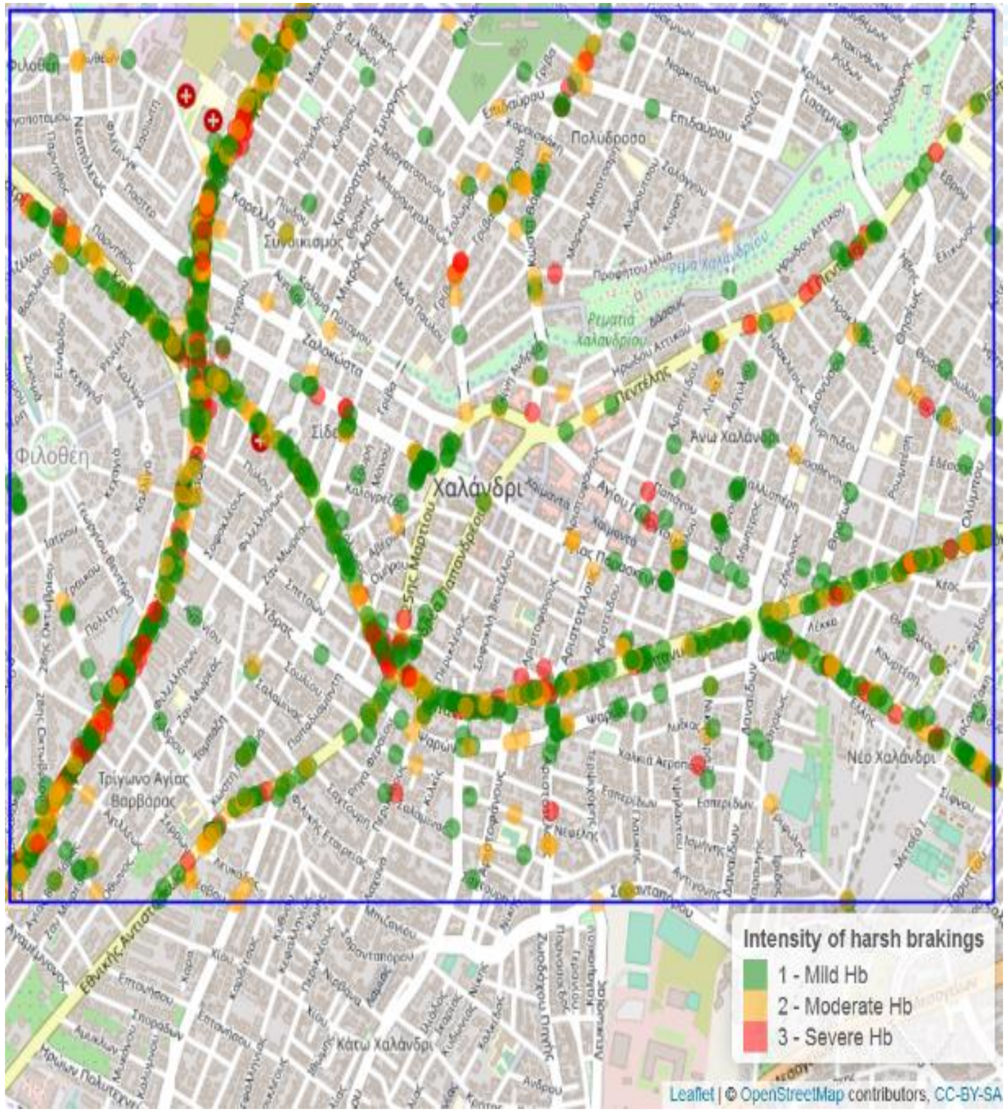




- Explainable XGBoost tree ensemble ML algorithms with SHAP values were trained
- Higher total trip distance, number of tickets & feedback decrease mobile phone use
- Higher driver age & experience, annual kilometers & engine capacity increase mobile phone use

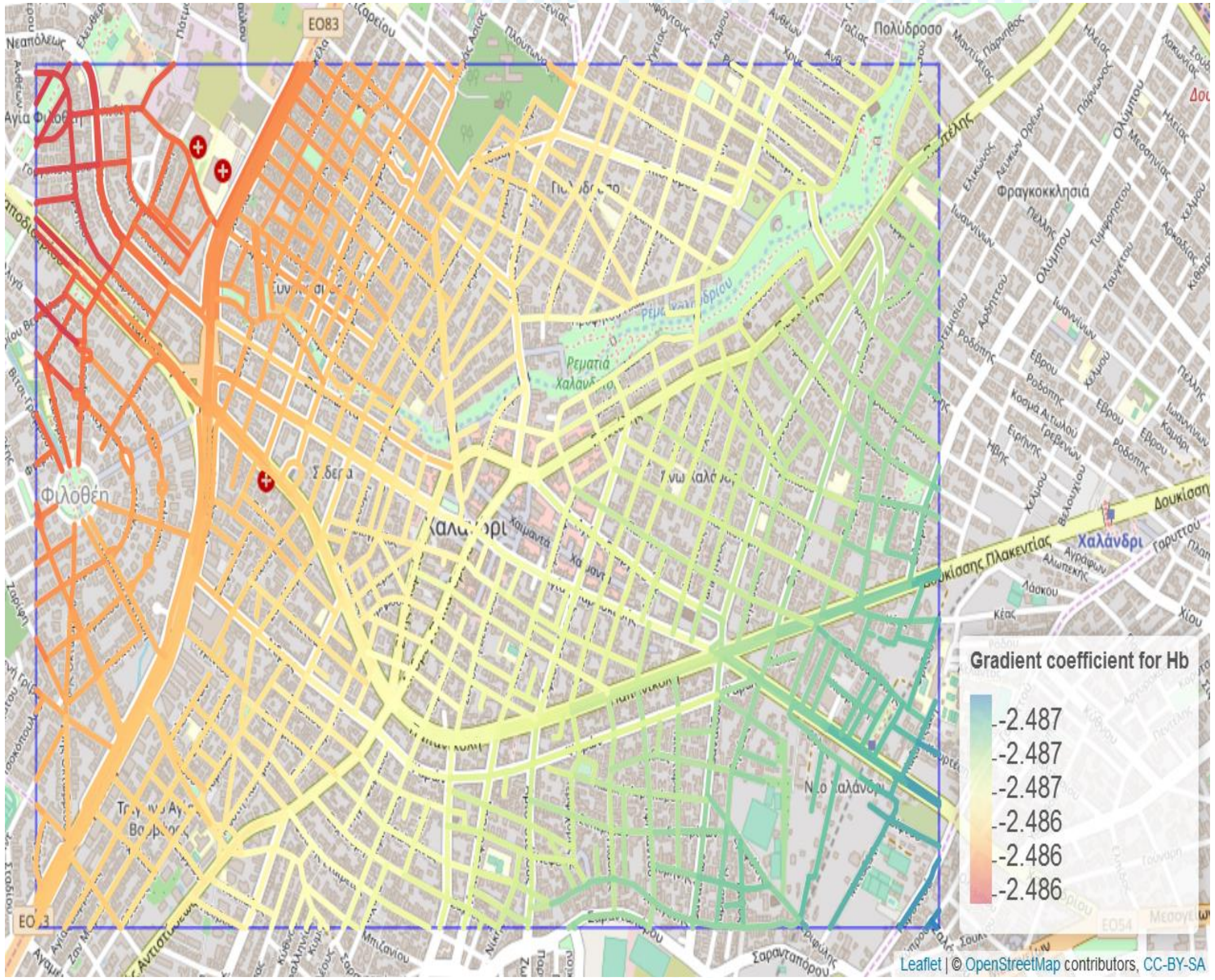
...all in a proactive analysis!

Network Spatial investigation (1/3)



- Smartphone driving behavior data & OpenStreetMap geometric data are exploited and map-matched.
- Harsh braking counts are spatially analyzed in an urban road network.
- 869 road segments (removal of 14 footways) with 4293 nodes (of which, 49 road with traffic lights, 80 with pedestrian crossings)
- Trips between 01-10-2019 & 29-11-2019 – 2 months
- 3294 trips from 230 drivers, 1,000,273 driving seconds (average trip duration 304s)
- 1348 harsh brakings (& 921 harsh accelerations…)

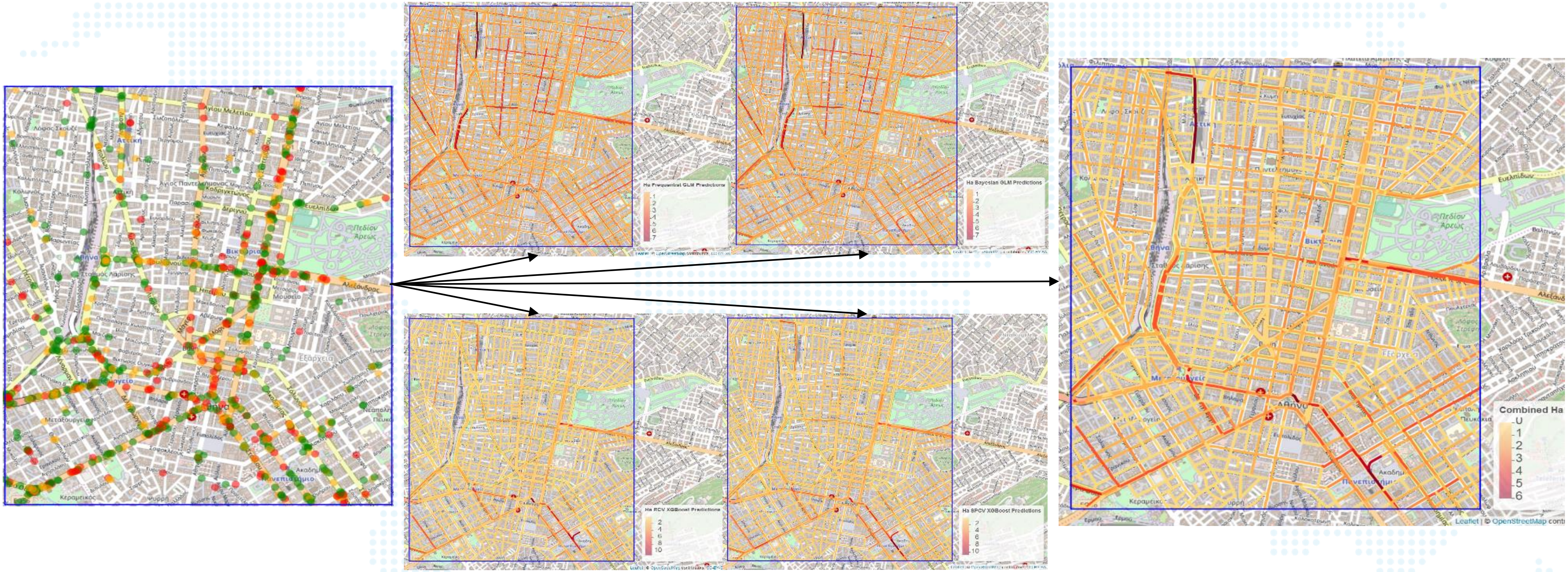
Network Spatial investigation (2/3)



- Statistical models GWPR, CAR, and machine learning XGBoost models (randomly and spatially cross-validated) were trained.
- After adjustments, counts are predicted in another network to assess transferability.
- 87.6% accuracy of harsh braking frequencies was achieved, in a fully proactive analysis.
- Indicative correlations:
  Segment length and pass counts are positively correlated with HBs
  Gradient and neighborhood complexity are negatively correlated with HBs.

Network Spatial investigation (3/3)

Model weaknesses are covered and strengths are enhanced with combined predictions



Conclusions

- Multiple-criteria based exploration and decision analysis to determine the most efficient Surrogate Safety Measures that can be mined or obtained from the available Big Data.
- AI modelling can reveal complex, non-linear relationships such as factors affecting drivers using a mobile – and be distracted.
- Combining high resolution multi-parametric naturalistic driving, geometric and traffic data to conduct meaningful spatial analyses on a road segment basis is very fruitful.
- Road safety practitioners can rapidly gain by copying best practices for data sharing and privacy protection from other fields.
- Research and innovation efforts on the use of AI in computer vision and risk prediction needs more support.
- AI dynamic feedback loops on road safety interventions and countermeasures are a completely unexplored field!

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