Big Data and Artificial Intelligence for Vision Zero Road Fatalities

George Yannis, Professor
Apostolos Ziaiopoulos, Research Associate

Department of Transportation Planning and Engineering,
National Technical University of Athens
Presentation Outline

1. Background
2. Key Road Safety Big Data Challenges
3. Key Road Safety Artificial Intelligence Challenges
4. AI + Big Data = Road Safety
5. Pending barriers
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Background

- Road transport is responsible for the majority of transport fatalities, with 1,35 million fatalities worldwide each year.

- In 2019, about 22.800 road traffic fatalities were recorded in the 27 EU Member States.
  - Almost 40% of road fatalities occur in urban areas.
  - Vulnerable road users account for 70% of road deaths in urban areas.

- 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.

- The rise of smartphones, sensors and connected objects offers deeper and broader transport data.

- The interpretation of these data can be made possible thanks to progress in computing power, data science and artificial intelligence.
Big Data, Broad Horizons (1/2)

- A wealth of big data becomes available
- This enables differentiations per road user category and focus on niche analyses (e.g. vulnerable road users, professional drivers, freight vehicles etc.).

A multitude of data sources:
- Mobile Phone data
  - Sensor Based Data (e.g. Google Maps, Here, Waze)
  - Cellular Network Data (e.g. mobile phone operators, etc.)
- Vehicular On-Board Diagnostics data (e.g. OEM industry)
- Camera data:
  - On-vehicle (internal, dashcam and peripheral)
  - On the road (cities, operators, police)
- Data from Car Sharing Services (e.g. Uber, Lyft, BlaBlaCar)
- Data from Bike Sharing Services (e.g. 8D Technologies, Mobike)
- Social Media data (e.g. Facebook, Twitter)
Big Data, Broad Horizons (2/2)

- Telematics companies (e.g. OSeven, ZenDrive, Octo)
- Private agency sensor data (e.g. INRIX, Waycare)
- Travel Card data (e.g. Oyster card, Opal card)
- Public authority sensor or traffic measurement data (e.g. Ministries, Public Transport Authorities, Cities, Regions)
- Weather data (e.g. OpenWeatherMap, AccuWeather, etc.)
- Census data (e.g. Eurostat, National Statistics)
- Digital map data (e.g. OpenStreetMap, Google Maps, etc.)
- Shared mobility data (e.g. GPS, routing, etc.)
- Research oriented data (e.g. floating car/instrumented vehicles)
Further New Developments

Several computer science, telematics and societal advancements aid road safety data collection:

- Rollout of 5G/6G technologies facilitates data transmission and manipulation.
- Internet of Things (IoT) progressively brings new opportunities and possibilities (cross-device connectivity).
- Affordable On Board Diagnostic (OBD) systems.
- Wide penetration and adoption of smartphones and social media.
- Powerful cloud computing, computer hardware and analysis tools.
- Competition and a wide market offers sustainable pricing.
Big Data, Big Issues

- The consequences of using data which are not always representative of the whole population (bias towards some user groups) should be assessed and properly corrected.

- It is easy to wrongly consider a dataset as unbiased if it covers a specific dimension in detail (e.g. covering different road users) while it can fail in another (e.g. not covering exposure).

- Desired conclusions should not drive the research approach or outcomes.

- There is a high risk for decision makers to be misled by the opportunistic analysis of seemingly low-cost data in absence of qualified data scientists and statisticians.
How Open are Big Data?

- Fragmentation of data ownership and a lack of interoperability between datasets and platforms.
- Different interests of the various road safety stakeholders in data, creating differing requirements for data access.
- Data ownership varies by who generates and collects the data and they may be not willing to share data due to privacy, legal liability, IP, competition, or cost related issues.
- Road safety data are often ethically or commercially sensitive.
- The diversity of data sources affecting data quality.
- Variations in hardware and software used for collecting the data.
- Lack of expertise in machine learning, data mining, and data management with a road safety context.
Surrogate Road Safety Measures

- **Surrogate road safety measures** (i.e. traffic conflicts, harsh driving events, spatial/temporal headways, and many others) become readily available for **proactive** analyses before crashes occur or in areas with **limited or no crash data availability**.

- Such measures show **less underreporting** and can even aid with crash reporting.

- Research on the validation of surrogate safety metrics is essential...
  - to reveal **which metrics** not only are correlated with reported crashes but also have predictive capabilities
  - to predict the **number of fatalities and/or injuries**
  - to determine how these metrics can **integrate** crash participant **fragility, speed, mass** and crash type consequences

- The adoption of surrogate safety metrics leads to the review of **statistical training needs**, so that data are not misused/misinterpreted.
Crash and Surrogate Data Collection

- Automated data collection is possible through:
  - Instrumented/floating vehicles
  - Smartphone sensors (harsh braking, harsh accelerations, harsh cornering, driving distraction via cellphone use, speeding, poor road surfaces).

- Technologies like automatic crash notification (eCall) and event data recorders enable data-driven responses to post-crash problems.

- Street imagery, also collected by floating vehicles, supports the assessment of road safety performance (star-rating for roads).

- Drones and satellites complement the range of data, capturing solutions with increased market penetration.

- Active safety system activation can also be considered among surrogate safety metrics, for systems such as:
  - Anti-lock Braking System [ABS]
  - Electronic Stability Control/Program [ESC/ESP]
  - Autonomous Emergency braking [AEB]
AI Advances in Crash Risk Estimation

- An array of new AI methods and machine/deep learning or similar algorithmic models available to road safety researchers, stakeholders and authorities for real-time crash risk estimates.

- Big data on crash occurrence and road and traffic characteristics from infrastructure sensors are transformed into multi-dimensional static or dynamic maps of road risk prediction and road & driver star rating.

- Crash datasets are imbalanced, rare event cases which find new approaches and venues of analysis through AI methods.

- Infrastructure assessment frameworks start embracing AI methodologies (e.g. the i-RAP transition to Ai-RAP).

- A large number of model configurations show very promising performance, albeit on specific datasets; transferability capabilities are yet uncertain.
AI Advances in Telematics & Driver Monitoring

➢ The insurance industry is heavily investing in telematics, 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 interpretation from telematics.

➢ Personalized feedback can be obtained almost instantaneously.

➢ Algorithm-based route analysis and personalized hotspot detection features are actively being examined.

➢ During-trip and post-trip interventions are enabled, best administered with gamification and reward systems.
Navigation of complex road environments becomes more attainable at an increasing rate, high-end RADAR/LIDAR and sensor technologies at the forefront of developments.

Several traditional problems are eliminated by RADAR/LIDAR (e.g. reliance on lighting/obstructions).

The decision making process is improved and refined through deep learning.

Purpose-made systems receive purpose-made tools and algorithms, such as grocery delivery or fixed-route public transport.

Most developers design their systems independently and are not reliant on infrastructure adaptations.

Over-the-air AI upgrades become a new reality.
AI Advances in Vehicle Technology (2/2)

- More **physical test areas** and **virtual testbeds** are provided and examined.

- Software **errors** are gradually contained, **reaction times** are minimized.

- **Facial recognition technologies** aid **commercial company claims** with insurance carriers (e.g. Nauto).

- **Vehicle cooperation algorithms**: traffic conflict reduction, efficient traffic management.

- **Additional connectivity byproducts**: increased parking availability, increased fuel efficiency, freight vehicle platooning.

- **Flying vehicles (VTOL) concepts** are co-considered.

*George Yannis*. Big Data and Artificial Intelligence for Zero Vision Road Fatalities – June 2021
AI + Big Data = Road Safety

AI facilitates the proactive management of traffic safety in various ways:

- Collection of data on road infrastructure conditions and traffic events through wide and broad-scale sensors and systems such as real-time computer vision.
- Identification of high risk locations proactively, through predictive multi-layer models.
- Enabled by multiparametric big data, AI pushes the limits of pattern recognition and reaction times beyond human capabilities and may thus uncover new crash-prone road configurations.
- Recent developments in the field of so-called “explainable AI (XAI)” begin to cope with the challenge of the “black box” phenomenon.
Pending Barriers for AI (1/2)

- Safe, road-worthy AI systems face significant challenges that are only hesitantly tackled:
  1. Interfaceability
  2. Interoperability
  3. Timelessness
  4. Scalability

- Absence of monitoring and accountability limits seriously road safety performance. To counter this, increase acceptance and public trust by monitoring and reporting: e.g. operation of the AI Incident Database.

- Legal and operational frameworks are considerably lagging compared to technical developments. Self-updating mechanisms are direly required.
Research and innovation efforts on the use of AI in computer vision and risk prediction needs more support.

Thorough evaluation and assessment criteria must be established across platforms, in research and industry, to deliver robust AI vehicular systems that will actively contribute to fatality reductions.

Cybersecurity/malicious hacking concerns may cause several implications (vehicle manufacturers, software engineers, vehicle owners, automated fleet operators).

AI dynamic feedback loops on road safety interventions and countermeasures: A completely unexplored field!
Pending Barriers for Big Data (1/2)

- Road safety practitioners can rapidly gain by copying best practices for data sharing and privacy protection from other fields.

- More secure alternatives to data exchange, such as the exchange of queries and responses can be explored, instead of raw information.

- Multiple-criteria based exploration and decision analysis to determine the most efficient Key Performance Indicators that can be mined or obtained from the available Big Data.

- Establishment of data harmonization and fusion protocols – Investigation of the best approach to reconcile different data scales (e.g. country, city, city block, road segment, road user).
On a high-level, Governments and Road Safety Authorities can:

- Mandate the sharing of aggregate vehicle data.
- Define a minimum dataset for all vehicle manufacturers to report in an anonymous standard aggregate format.
- Collect data on traffic volume, speed distribution, and locations where vehicles’ active safety systems (ABS/ESP/AEB) are engaged.
- Clarify regulatory frameworks for data protection.
- Governments should also examine how Freedom of Information laws articulate with data protection laws.
Pending Barriers for Road Safety (1/2)

- Road safety cannot be improved based on accurate forecasting alone – causal factors must be determined.

- Therefore, priorities should include the development of “explainable AI (XAI)” – “white box” techniques.

- Emphasis should be placed on collaborations across countries for the integration of all road realities and road safety cultures.

- Funding must also be available to road safety multi-disciplinary professionals to conduct post-intervention assessments and validate or re-calibrate the risk prediction tools.
Pending Barriers for Road Safety (2/2)

- New tools need to be aligned with precise policy objectives.
- Stakeholders should commission research to assess the capability of proxy data and risk mapping tools.

Researchers and practitioners have to:

- Develop new skills and a digital infrastructure.
- Promote a multi-disciplinary approach to road safety that combines expertise from the fields of data science, technology and safety.
- Design user-friendly risk mapping tools to be adopted by road users.
- Update estimates of the benefit/cost ratio of interventions in a dynamic manner, along with accessible user-friendly interfaces.
Conclusions

- Great potential for **seamless big data driven procedures** from safety problem identification to selection and implementation of optimal solutions.

- Newfound **net present value in road safety data**, available for (real-time) early problem detection and prompt and customized decision support on every level.

- Considerable ground remains to be covered for existing road safety AI applications (vehicle, telematics crash analysis).

- Completely unexplored directions remain in several road safety aspects (crowdsourcing options, measure effectiveness, data harmonization).

- Big Data and Artificial Intelligence can become **efficient catalysts** for achieving Vision Zero road fatalities by 2050.
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