Technical University of Munich

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Artificial Intelligence, Big Data & Road Safety

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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
6. Conclusions

Background

- ➢ Road transport is responsible for the majority of transport fatalities, with 1,3 million fatalities worldwide each year.
- ➢ In 2022, about 20.600 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.

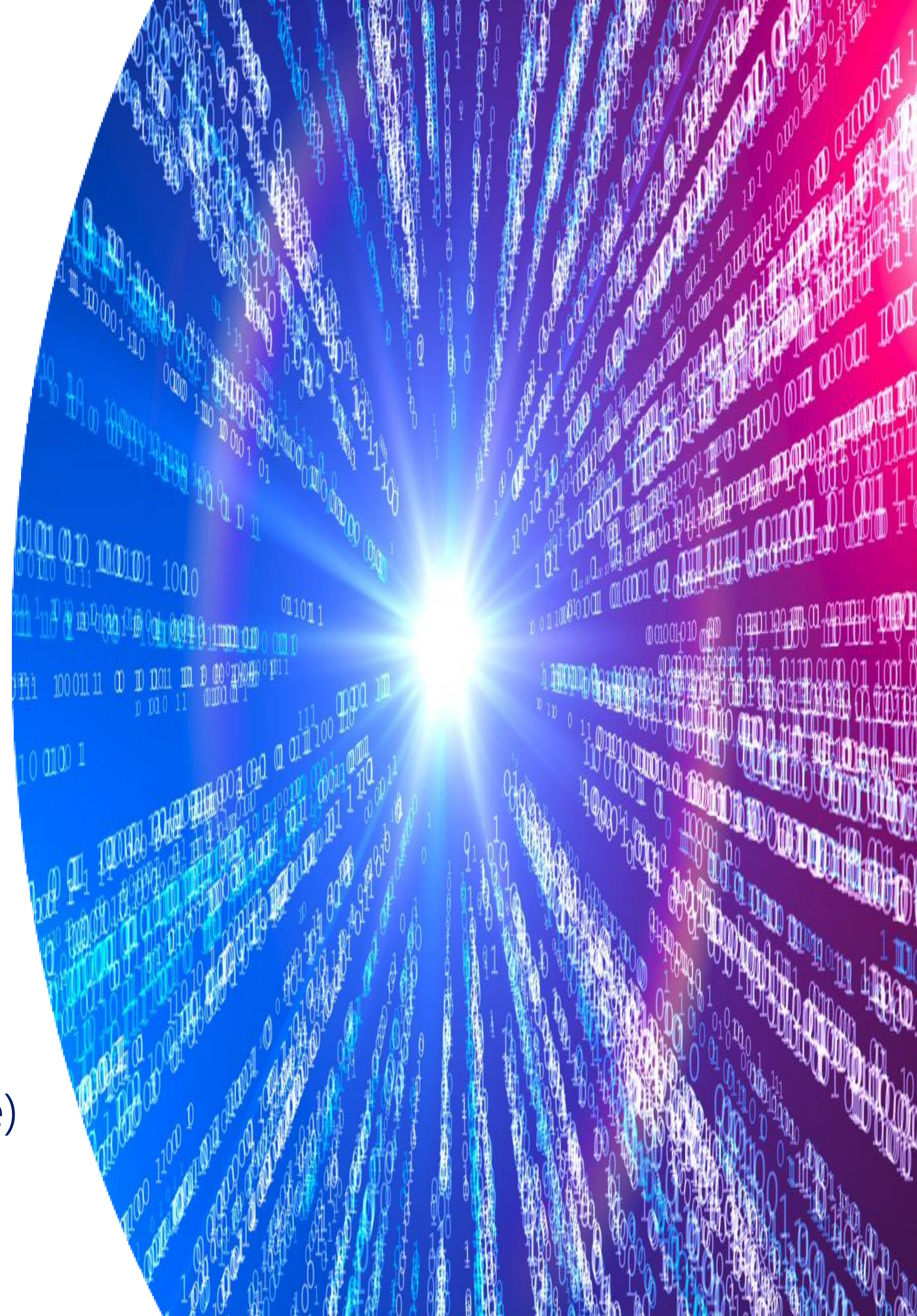
Big Data, Broad Horizons (1/2)

- 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, dash-cam 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)
- Data from Micromobility Operators (e.g. Bolt, Lime)



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.)
- Social Media data (e.g. Facebook, Twitter)
- 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.
- Wider 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

- 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-dimension 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 Road Safety Risk Estimation

- Methods related to Artificial Neural Networks are the most promising for road safety, contributing to ADAS

- Apart from incident detection, all other problems addressed are mode-specific.

- Knowledge could be transferred from the safety field of AVs to other modes.

- Pattern recognition has received heightened attention (e.g. 84% accuracy of pedestrian detection from video recording using Convolutional Neural Networks).

- However, it remains a challenge to detect and block intentional malicious manipulation of training datasets.

AI Advances in Telematics & Driver Monitoring

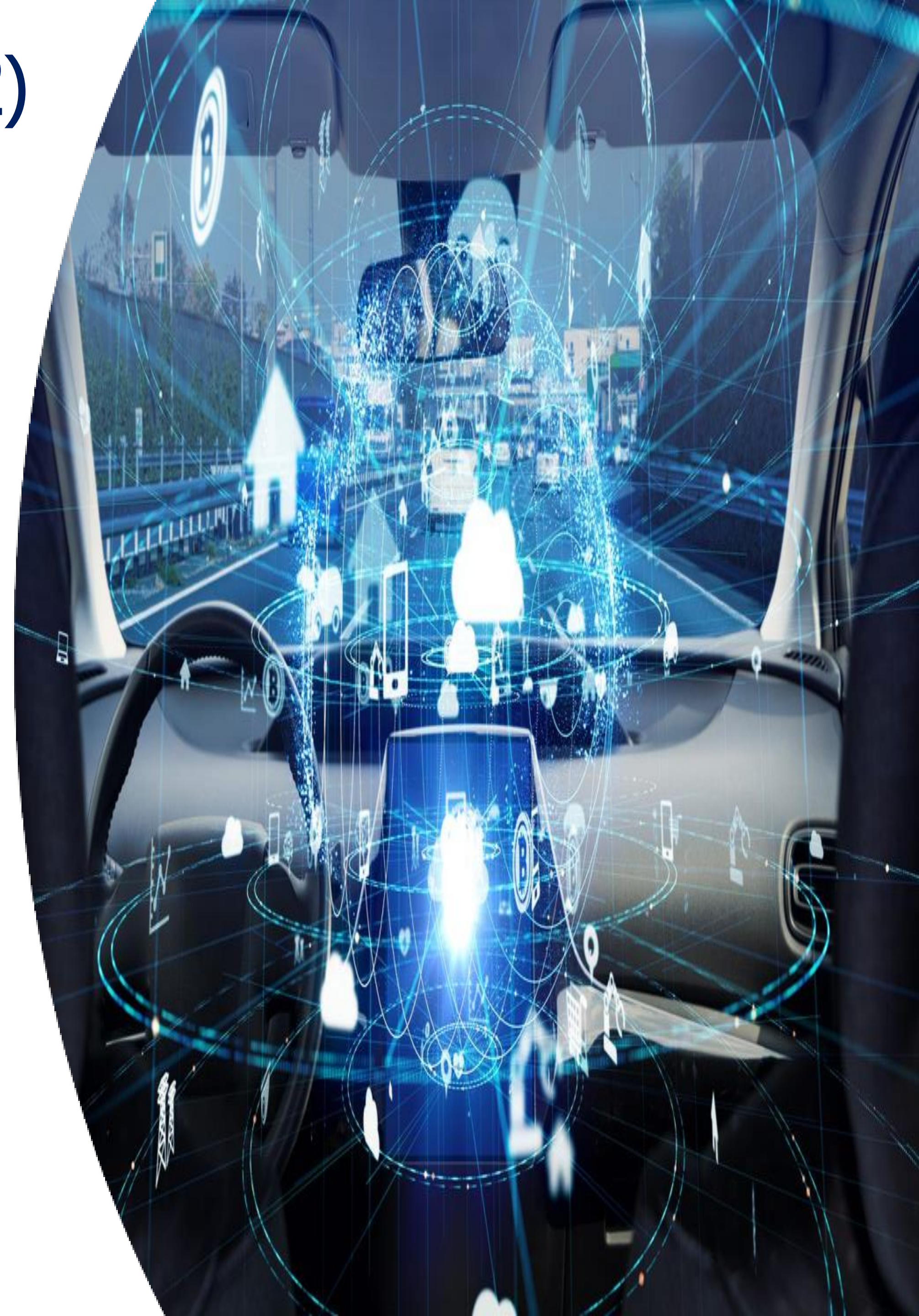
- The insurance industry is heavily investing in telematics, offering reduced premiums for safer driving.
- AI and data fusion technologies used in all stages of road safety data collection, transmission, storage, harmonization, analysis and interpretation from telematics.
- Personalized feedback can 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.

AI Advances in Vehicle Technology (1/2)

- 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.



AI + Big Data = Road Safety

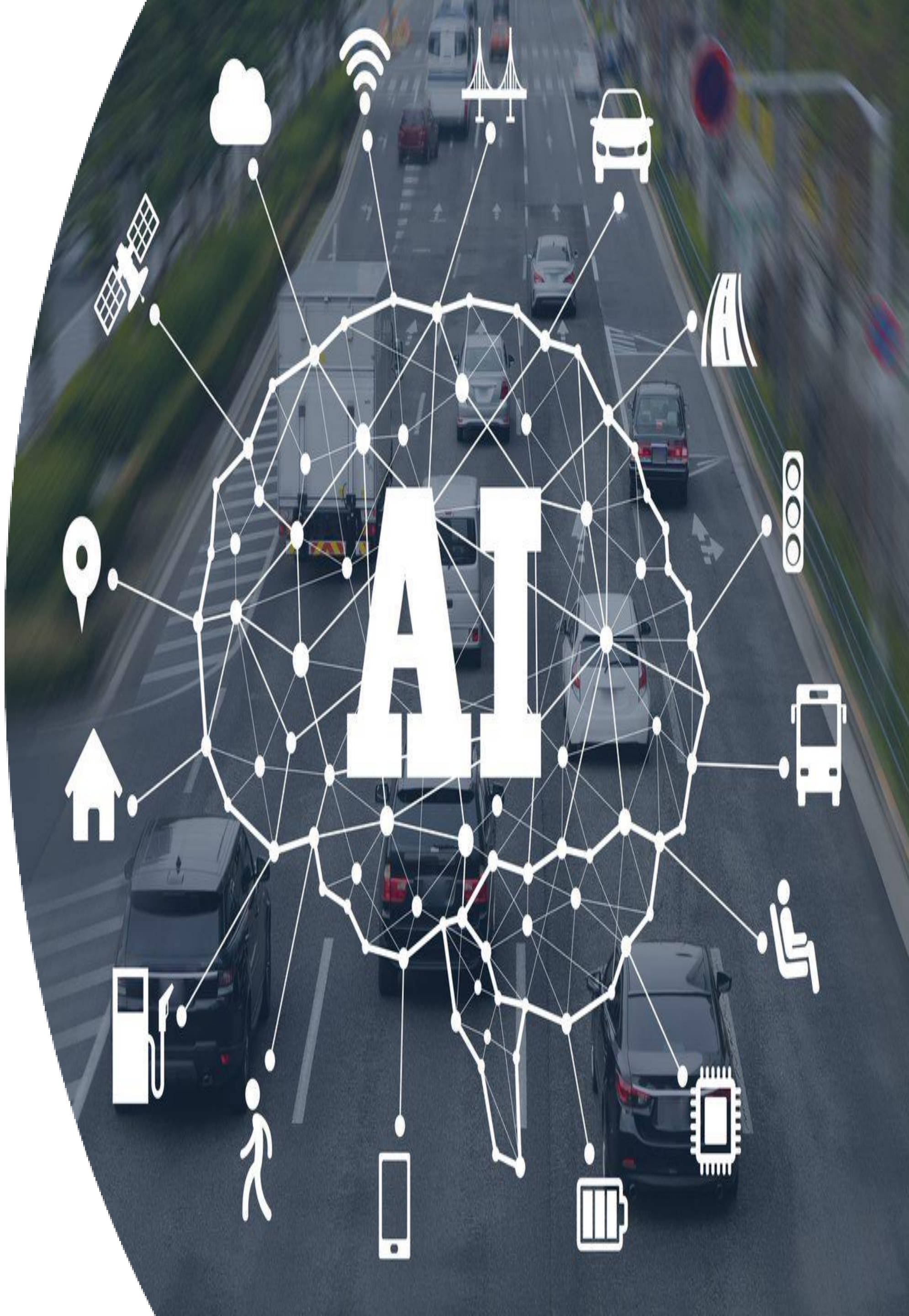
AI facilitates the proactive management of traffic safety in various ways:

- 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.

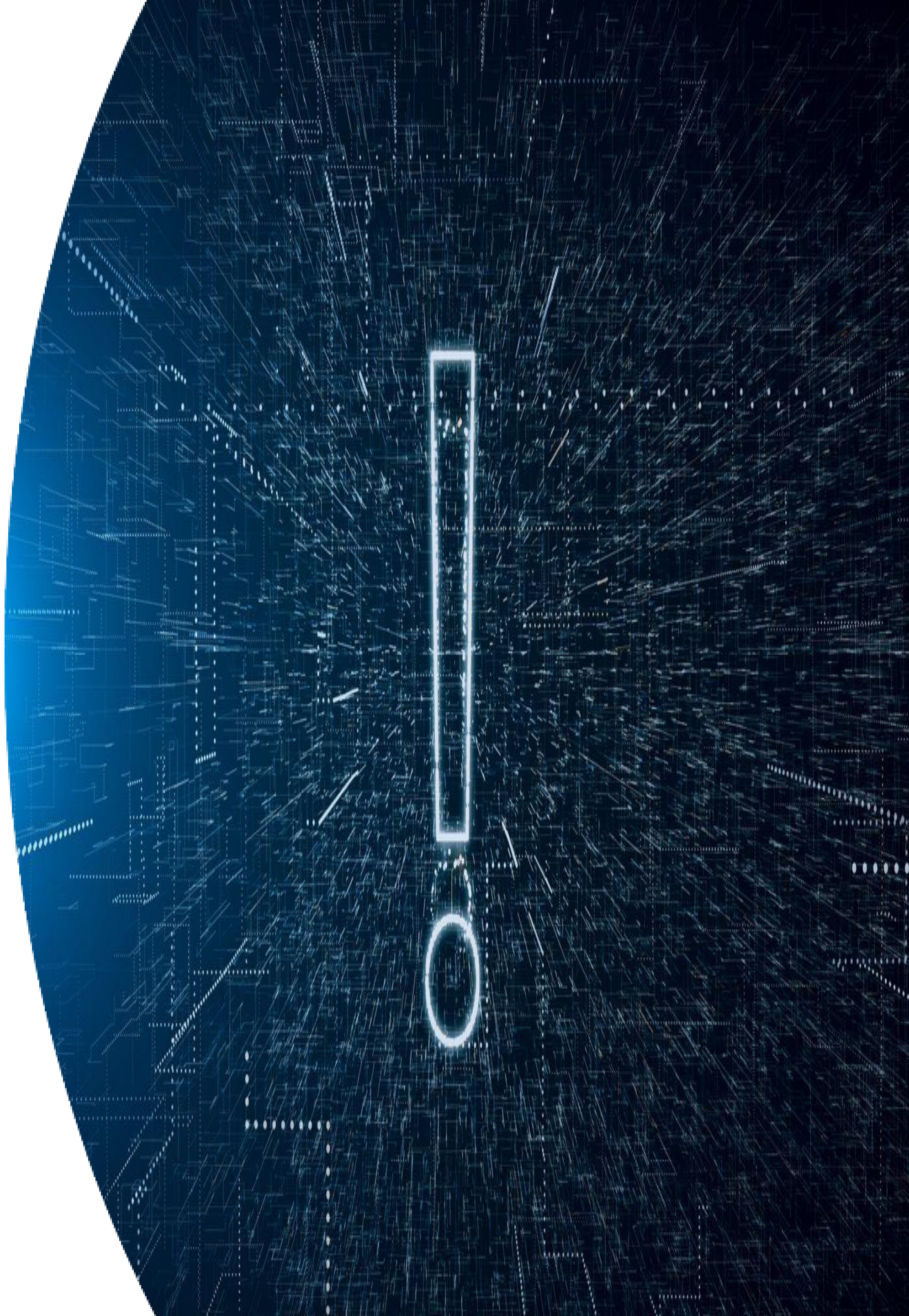
Pending Barriers for AI (2/2)

- 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).

Pending Barriers for Big Data (2/2)

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, and enable, 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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