TRANSPORT RESEARCH ARENA

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How to Define a Safety Tolerance Zone for Speed? Insights from the i-DREAMS project

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Together with:

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Introduction

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- Approximately, **1.25 million people die every year** on roads worldwide, with millions more sustaining serious injuries and living with long-term adverse health consequences

- Several **factors that affect the likelihood of a road traffic crash** or a serious injury (e.g. distraction, fatigue) have been identified

- **Technological developments** make massive and disaggregated operator performance data easily available, through new in-vehicle sensors that capture detailed driving style

- This creates new opportunities for the detection and design of **customized interventions** to mitigate risks, increase awareness and upgrade driver performance

Background

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- The i-DREAMS project aims to establish a framework for the definition, development, testing and validation of a context-aware safety envelope for driving in a **Safety Tolerance Zone (STZ)**, within a smart Driver, Vehicle and Environment Assessment and Monitoring System
- Taking into account driver background factors and risk indicators associated with driving performance as well as the driver state and driving task complexity parameters, a **continuous real-time assessment** is made in order to monitor and determine if drivers are within acceptable boundaries of safe operation
- Delayed safety-oriented interventions and **post-trip feedback** are provided so as to enhance driver's knowledge, attitudes and perceptions

The i-DREAMS project

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- **13 Project partners:**
  National Technical University of Athens
  Universiteit Hasselt, Loughborough University, Technische Universität München, Kuratorium für Verkehrssicherheit, Delft University of Technology, University of Maribor, OSeven Telematics, DriveSimSolutions, CardioID Technologies, European Transport Safety Council, POLIS Network, Barraqueiro Transportes S.A.
- **Duration of the project:**
  48 months (May 2019 - April 2023)
- **Framework Program:**
  Horizon 2020 - The EU Union Framework Programme for Research and Innovation - Mobility for Growth

Objectives

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- The aim of this work is to define a Safety Tolerance Zone (STZ) for speed, and integrate crash prediction and risk assessment under a **Neural Network framework**

- Explanatory variables of risk and the most reliable indicators of **task complexity and coping capacity**, such as time headway, distance travelled, speed, forward collision, time of the day or weather conditions were assessed

- As the key output of the i-DREAMS project is an integrated set of monitoring and communication tools for intervention and support, **state-of-the-art technologies and systems** were utilized in order to monitor driving performance indicators

Data Collection

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- A **naturalistic driving experiment** was carried out involving 20 drivers from Belgium, during a 3-month timeframe (from 21/07/2021 to 30/10/2021) and a large database of 757 trips was created
- Data from the **Mobileye system, a dash camera and the Cardio gateway** which records driving behavior along with GNSS signals were used
- Information about the current warning stage were also collected for comparison with the **i-DREAMS warning stage** (i.e. normal driving, danger phase, avoidable accident phase)

Variable	Description
ME_AWS_hw_measurement_mean	Headway measurement (seconds)
ME_AWS_fcw_mean	Forward collision warning
ME_AWS_pcw_mean	Pedestrian collision warning
GPS_distances_sum	Distance travelled (km)
DEM_evt_ha_lvl_M_mean	Medium level harsh acceleration events
DEM_evt_hb_lvl_M_mean	Medium level harsh braking events
ME_AWS_time_indicator_median	Indicates lighting conditions (day, dusk, night)
ME_Car_wipers_median	Indicates weather conditions (wipers on/off)

Methodological Overview

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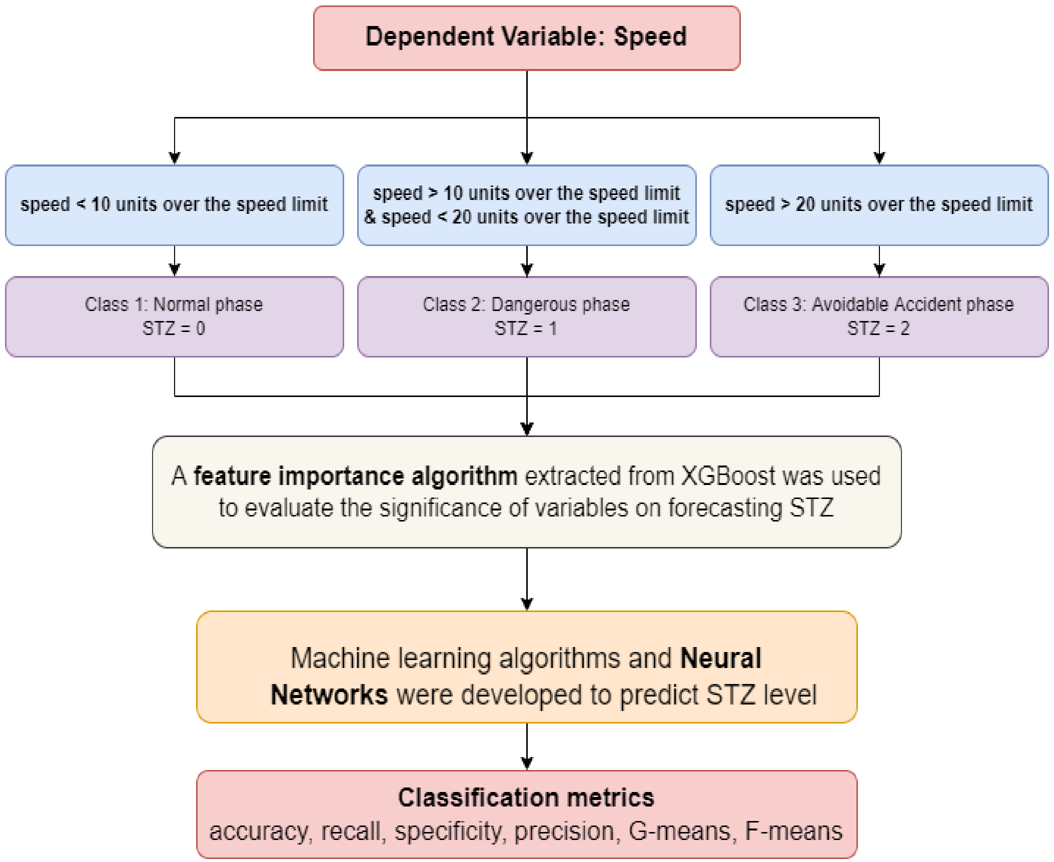
- A feature selection **algorithm** was applied in order to identify the most important features for predicting the STZ level
- These features were then fed into a **Neural Network classifier** to identify the STZ level
- In order to compare the **classification performance** of the several configurations (hyperparameters and mix of considered inputs), well-established machine learning error metrics were calculated
    - Accuracy
    - Precision
    - Recall



Feature Importance

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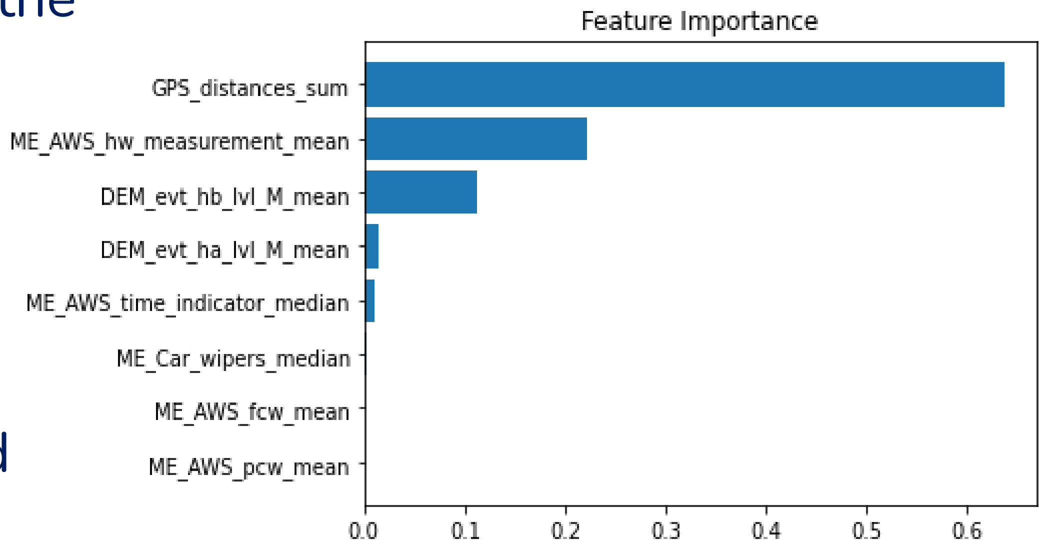
- A feature importance algorithm extracted from **Extreme Gradient Boosting (XGBoost)** was used to evaluate the significance of variables on forecasting STZ and select the most appropriate independent variables

- GPS distance travelled, headway measurement and medium level harsh braking events were the **most important factors** of all examined indicators

- The **parameters of task complexity** (i.e. car wipers and time indicator) were less significant, while forward collision warning and pedestrian collision warning variables had a negligible impact on STZ speed



Neural Network Models

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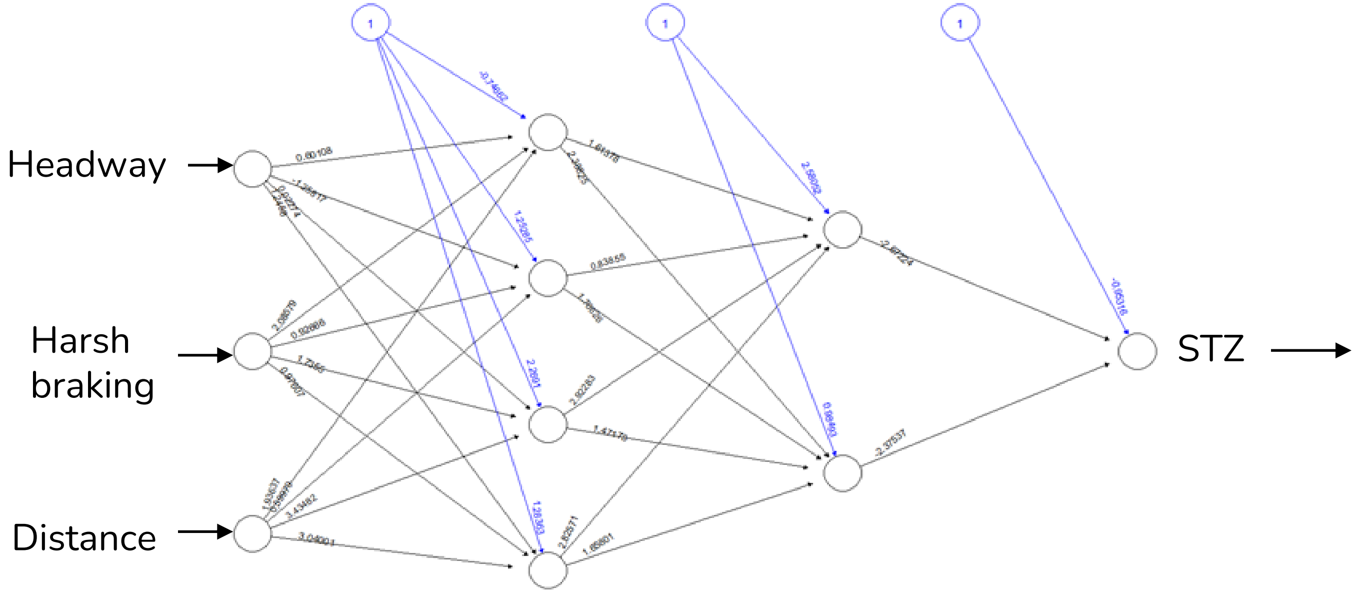
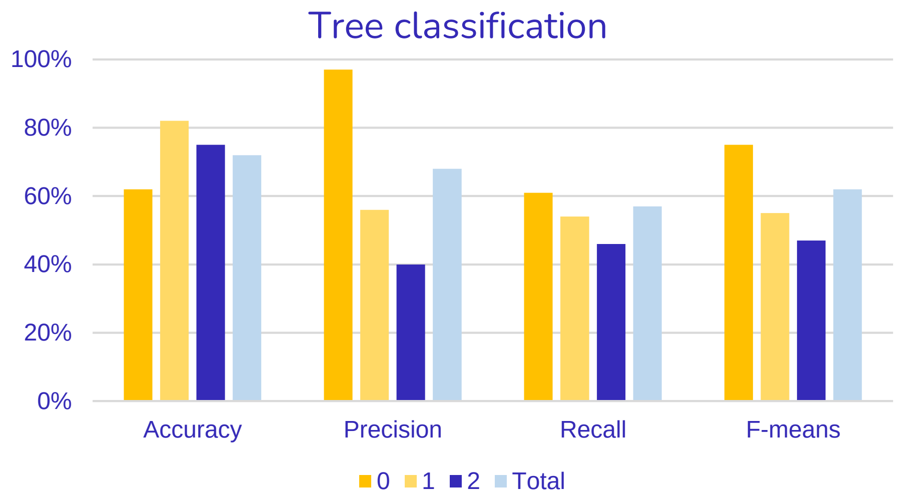
- A feed-forward multilayer perceptron **Neural Network model** was implemented
- Based on the feature importance and the significance of the relevant indicators, there were **three neurons in the input layer** (i.e. headway measurement, medium level harsh braking events and distance travelled) and **one neuron in the output layer** (i.e. STZ)





**0 refers to normal phase, 1 refers to dangerous phase, 2 refers to avoidable accident phase*

Discussion

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- **Normal Driving** included the majority of available data and thus was predicted with 97% precision and 61% recall, while **Dangerous Driving classification** presented 56% precision and 54% recall

- The **Avoidable Accident phase**, which included only the 4% of the test set, presented the lowest rates, i.e. 40% precision and 46% recall in STZ

- Overall, findings indicated that both methods **could predict adequately the Safety Tolerance Zone** but the imbalance of the dataset posed difficulties in correctly identifying all classes

Conclusions

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- A **strong relationship** between STZ speed and the independent variables of headway, distance travelled and medium harsh braking events was observed

- Imbalanced learning could **enhance classification results**, in order for all three STZ levels to be correctly identified in real-time

- The presence of a **passenger, the drug abuse, the alcohol consumption or the seat belt** use constitute some of the high risk factors that cause road crashes could be also included

- **Factor analysis and microscopic data** analysis of the database collected could be implemented through econometric techniques, and deep learning

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Thank you!

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