Correlation of driver behaviour and fuel consumption using data from smartphones

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Objective

• Investigate the effect of driver behaviour on fuel consumption using data from smartphones

• Determine the various parameters that affect driving performance and how they interact with each other in order to predict fuel consumption
Outline

• Background
• Past Limitations
• Data Flow
• Risk Exposure Indicators
• Risk Driving Indicators
• Experimental Process
• Data Collection
• Methodology
• Analysis Results
• Conclusions
• Future Challenges
Background

Driver

- Aggressive driving style affects fuel economy and consumption
- Eco-driving knowledge and reward are the most effective incentives for encouraging improved driver performance

Vehicle

- In-vehicle driver behaviour monitoring systems increase road safety and reduce fuel consumption

Environment

- Up to 30% less fuel consumption
- Significant reduction of pollutants emissions (CO, CO₂, NOₓ)
- 10-25% less accidents
Past Limitations

**Limiting barriers** existed so far:

- Mobile phone technology
- High cost of in-vehicle data recording systems (i.e. OBD)
- Low penetration rate of smartphones and social networks
- Inability to manage and exploit Big Data

Current **technological advances** make it substantially easier for experts to collect and exploit data easier and more accurately through smartphones.
Data Flow (1/2)

• A **user-friendly smartphone App** recording driver’s behaviour using mobile phone sensors, without any user involvement (automatic start / stop)

• A **variety of APIs** reading sensor data recorded and temporarily store it to mobile phone

• **Data transmission** from the mobile App to the central database via an appropriate communication channel such as:
  - Wi-Fi network (online)
  - Cellular network such as a 3G/4G network (online)
  - Bluetooth (offline)
Data Flow (2/2)

• Data is stored in a sophisticated **database** where managed and processed

• **Indicators** result from the mobile phone data process using:
  - Machine Learning algorithms
  - Big data mining techniques

• **Visualization** of the metrics and scores for the evaluation of the driving behaviour through:
  - Mobile App
  - Web Portal

• All the aforementioned procedures use the latest technologies in compliance with **GDPR**
Risk Exposure Indicators

- Total driving **duration** (seconds)
- Total **distance** travelled (mileage)
- **Type of the road** network used (highway, rural or urban)
- **Time of the day** driving (rush hours, risky hours)
- **Weather** conditions (fog, rain, snow)
Risk Driving Indicators

• **Speeding** (distance and time of driving over the speed limit, speed limit exceedance)

• Number of **harsh events** (braking and acceleration)

• Driving **aggressiveness**

• Driver **distraction** (caused by mobile phone use during driving)

• **Eco-driving** (smooth use of the accelerator, steering, transmission and brakes)
Experimental Process

• Naturalistic driving experiment

• The sample of the analysis consists of 17 participants, aged 20-35

• 2 different driving scenarios
  - 2 months normal driving (before)
  - 2 months eco-driving (after)

• A large database of thousands trips
Data Collection

- OSeven backend office
- Fuel Consumption Log Template
- Driving Behaviour Questionnaire
Methodology (1/2)

4 Lognormal Regression models were developed to identify driving characteristics influencing the fuel consumption:

- Model 1: Predicting fuel consumption – overall model
- Model 2: Predicting fuel consumption driving on highway
- Model 3: Predicting fuel consumption driving on rural road
- Model 4: Predicting fuel consumption driving on urban road
Methodology (2/2)

Independent parameters included in the statistical models:

- Before-after
- Average speed
- Harsh acceleration
- Average deceleration
- Mobile phone use
- Risky hours distance
- Gender
- Educational level

<table>
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<tr>
<th>Variables</th>
<th>Model 1 (overall model)</th>
<th>Model 2 (highway road)</th>
<th>Model 3 (rural road)</th>
<th>Model 4 (urban road)</th>
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Analysis Results (1/2)

- The higher the **average speed**, the higher the fuel consumption
- **Male** drivers after getting improved appeared similar behaviour to **female** drivers before getting improved
- The higher the number of **harsh accelerations** occurred while driving, the higher the fuel consumption
- **Male drivers** tended to **accelerate more frequently** than female drivers
Analysis Results (2/2)

- In urban driving, **acceleration** had the highest impact on fuel consumption.
- **Deceleration** was identified as the second most influential variable.
- In highways where speed limits are high enough, fuel consumption elevated considerably as the **speed** increased.
- **Mobile phone** usage had the slightest influence on motorways.
- **Night-time driving** was positively correlated with fuel consumption.

<table>
<thead>
<tr>
<th>Independent Variables</th>
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<th>Model 2 (highway)</th>
<th>Model 3 (rural road)</th>
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Conclusions (1/2)

• A remarkable **15% reduction** in fuel consumption

• By improving the way participants were considering the task of driving, a **smoother and greener** driver behaviour was achieved

• The higher the **acceleration**, the higher fuel consumption, especially in urban roads

• As the **average speed** increases, the fuel consumption increases, especially in highways. Eco-driving behavior significantly reduced average speed on all types of road

• The higher the **average deceleration**, the higher fuel consumption. Drivers managed to reduce unnecessary braking and saved fuel
Conclusions (2/2)

- The higher the **mobile phone use**, the lower the fuel consumption
- As the **night-time driving** increases, the fuel consumption increases
- **Driver characteristics** played a crucial role in driving performance (gender, age, experience)
- The vast majority of male drivers displayed **less cautious behaviour** during their trips and consumed more fuel than females
- **Experienced** drivers and **most educated** road users adopted a more conservative and ecological driving performance
Future Challenges

- **Larger** and more representative sample of drivers with different age groups
- Investigation of the effect of other **driving factors** (psychological status, fatigue or driving under influence of alcohol)
- Investigation of fuel economy performance with regards to **vehicle characteristics** (tire pressure, driving force, horse power, cubic capacity, weight or age)
- Investigation of the effect of **type of fuel** (gasoline, diesel, liquid petrol or compressed natural gas)
Correlation of driver behaviour and fuel consumption using data from smartphones

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