Impact of driver feedback on behavior and safety through a smartphone application

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Introduction

- Accurate monitoring of driver behavior has scientific and technical requirements
- The Internet of Things (IoT) constantly offers new opportunities and features to monitor and analyse driver behavior through:
  - Wide use of smartphones and social media
  - Effective data collection and handling
  - Big Data Analysis
The BeSmart project

The objectives of the project:

- Development of an innovative and seamless Internet of Things application
- Assessment and improvement of behavior and safety of all drivers (car drivers, powered two-wheelers, cyclists, professional drivers) along multi-modal trips
- Organization and exploitation of a naturalistic driving experiment of 200 drivers for 12 months
Research Scope

- Identification of the critical driving parameters that affect harsh events using data from:
  - Smartphone devices
  - Naturalistic driving experiment

- Investigation of the impact of driver feedback on driving behavior as expressed by the frequencies of harsh accelerations and harsh brakings
The BeSmart driving experiment

- The experiment consists of 6 different phases differing in the type of feedback provided to drivers.

- The present study refers to the first two phases:
  - Phase 1 - no feedback to drivers - 12 weeks duration
  - Phase 2 - personalized feedback in means of a trip list and a scorecard regarding drivers’ behavior - 10 weeks duration

- A total of 26,619 trips from a sample of 147 car drivers
The BeSmart Application

- Driving behavior characteristics
  - Speeding
  - Harsh braking/acceleration/cornering
  - Seatbelt use
  - Mobile phone use

- Travel behavior characteristics
  - Total distance
  - Road network type
  - Risky hours driving
  - Vehicle type
Smartphone data collection (1/2)

- A mobile application to record user’s driving behavior (automatic start / stop)
- A variety of APIs is used to read mobile phone sensor data
- Data is transmitted from the mobile App to the central database
- Data are stored in a sophisticated database where they are managed and processed
Smartphone data collection (2/2)

- Indicators are designed using:
  - machine learning algorithms
  - big data mining techniques

- The database analyzed was in .csv format
  - Drivers’ trips are stored per row, the characteristics of which are stored in each column’s variables

- State-of-the-art technologies and procedures in compliance with standing Greek and European personal data protection laws (GDPR)
Descriptive statistics

- Both types of harsh events (accelerations and brakings) are reduced in the 2\textsuperscript{nd} phase of the experiment.

- The percentage of driving above the speed limits and driving while distracted by the mobile phone is reduced in the 2\textsuperscript{nd} phase of the experiment.
Theoretical Background

Selection of statistical method:

- Need for event prediction - data counting (data modeling)
- Generalized Linear Models (GLM) - Poisson Regression
- Introduce random effects to capture different driving behaviors and extend GLMs as Generalized Linear Mixed-Effects Models (GLMMs), given by the following formula:

\[ \log(\lambda_i) = \beta_0 i + \beta_j x_{ji} + \beta_{n-1} x_{n-1} + \varepsilon \]
Results (1/2)

- GLMMs for harsh acceleration counts

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GLMM for Phase 1</th>
<th>GLMM for Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>s.e.</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.927</td>
<td>0.091</td>
</tr>
<tr>
<td>Maximum Speed</td>
<td>0.321</td>
<td>0.022</td>
</tr>
<tr>
<td>Percentage of Speeding Duration</td>
<td>0.074</td>
<td>0.013</td>
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<tr>
<td>Percentage of Mobile Use Duration</td>
<td>0.042</td>
<td>0.011</td>
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<tr>
<td>Log(Total Trip Duration)</td>
<td>0.848</td>
<td>0.051</td>
</tr>
<tr>
<td>Log(Total Trip Distance)</td>
<td>-0.231</td>
<td>0.050</td>
</tr>
</tbody>
</table>
Results (2/2)

- GLMMs for harsh braking counts

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GLMM for Phase 1</th>
<th></th>
<th>GLMM for Phase 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>s.e.</td>
<td>p-value</td>
<td>Sig.</td>
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<tr>
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<td>0.067</td>
<td>0.006</td>
<td>**</td>
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<tr>
<td>Maximum Speed</td>
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<td>0.016</td>
<td>0.000</td>
<td>***</td>
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<tr>
<td>Percentage of Speeding Duration</td>
<td>0.097</td>
<td>0.010</td>
<td>0.000</td>
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<tr>
<td>Log(Total Trip Duration)</td>
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<td>0.045</td>
<td>0.000</td>
<td>***</td>
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<tr>
<td>Log(Total Trip Distance)</td>
<td>-0.298</td>
<td>0.036</td>
<td>0.000</td>
<td>*</td>
</tr>
</tbody>
</table>
Conclusions (1/2)

- Impact of detailed trip parameters
  - Maximum speed, the percentage of speeding duration and total trip duration positively correlated with both harsh event frequencies
  - On the other hand, the exposure metric of total trip distance negatively correlated with both harsh event types
  - The percentage of mobile use duration, significant only for harsh accelerations with a small positive correlation
Conclusions (2/2)

- Impact of driver feedback
  - Initial findings suggest drivers’ improvement on their performance regarding all recorded driving behavior metrics
  - Coefficient values change in a similar direction for both types of events between the two experiment phases
  - Feedback effects not easily discernible in macroscopic investigations; driver clusters will be analyzed in the future
Future research

- Analysis of different driving behavior parameters identified by the road safety literature as risk factors (e.g. exceeding speed limit, mobile phone distraction)

- Analyses per gender, age, history of accidents, self-assessment, driving experience and more demographic characteristics

- Investigation of feedback effect on driving behavior and safety of motorcyclists
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