Driver behaviour KPIs through smartphone telematics

George Yannis, Armira Kontaxi, Apostolos Ziaiopoulos

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Background

Accurate monitoring of driver behaviour has scientific and technical requirements.

The Internet of Things (IoT) constantly offers new opportunities and features to monitor and analyse driver behaviour through:

- Affordable On-board Diagnostics (OBD)
- Widespread use of smartphones and social media
- Effective data collection and handling
- Big Data Analysis
Joint efforts in 3 Research Projects

**BE SMART**
Multi-modal driver behaviour and safety support system on the basis of smartphone applications
www.besmart-project.gr

**smart maps**
Smart city mapping for safer and eco driver behaviour through smartphone sensor big data
www.smart-maps.gr

**i DREAMS**
Safety tolerance zone calculation and interventions for driver-vehicle-environment interactions under challenging conditions
www.idreamsproject.eu

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The BeSmart project

- **Project partners:**
  - National Technical University of Athens, Department of Transportation Planning and Engineering  
    [www.nrso.ntua.gr](http://www.nrso.ntua.gr)
  - OSeven Telematics  
    [www.oseven.io](http://www.oseven.io)

- **Duration of the project:**
  - 42 months (July 2018 – February 2022)

- **Operational Program:**
  - "Competitiveness, Entrepreneurship and Innovation" (EPAnEK) of the National Strategic Reference Framework (NSRF)
The SmartMaps project

➢ Project partners:
   • National Technical University of Athens, Department of Transportation Planning and Engineering
     [www.nrso.ntua.gr](http://www.nrso.ntua.gr)
   • OSeven Telematics
     [www.oseven.io](http://www.oseven.io)
   • Global Link
     [www.globallink.gr](http://www.globallink.gr)

➢ Duration of the project:
   • 30 months (June 2021 – December 2023)

➢ Operational Program:
   • "Competitiveness, Entrepreneurship and Innovation" (EPAnEK) of the National Strategic Reference Framework (NSRF) – 2nd iteration

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The i-Dreams project

- **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:**
  
  - 46 months (May 2019 – February 2023)

- **Framework Program:**
  
  - Horizon 2020 - The EU Union Framework Programme for Research and Innovation – Mobility for Growth
The BeSmart Objectives

- Development of an **innovative and seamless** Internet of Things **application**

- **Assessment and improvement** of behaviour 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

- Acquire and monitor **driver behaviour KPIs:**
  - driving **speed**
  - speeding violations
  - distraction through **usage of mobile phone while driving**
  - harsh driving event frequencies (harsh accelerations and decelerations)

- Investigate the **impact of driver feedback** on driving behavior and safety as expressed by the driver behaviour KPIs
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 behaviour characteristics

- Speeding
- Harsh braking/acceleration/cornering
- Mobile phone use

Travel behaviour characteristics

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

- The BeSmart mobile application to record user’s driving behaviour (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
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 2nd phase of the experiment.

![Average Ha and Hb Counts](image)

- The percentage of driving above the speed limits and driving while distracted by the mobile phone is **reduced** in the 2nd phase of the experiment.
Methodology

- Analysis scope
  - Among the recorded risk factors, the frequency of harsh events is chosen to be investigated in the present study.

- Selection of statistical method:
  - Need for event prediction - data counting (data modeling)
  - Generalized Linear Mixed-Effects Models (GLMMs) to capture different driving behaviors, given by the following formula:
    \[ \log(\lambda_i) = \beta_0 + \beta_j x_{ji} + \beta_{n-1} x_{n-1} + \epsilon \]
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>
</tr>
<tr>
<td>Percentage of Mobile Use Duration</td>
<td>0.042</td>
<td>0.011</td>
</tr>
<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>GLMM for Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>s.e.</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.182</td>
<td>0.067</td>
</tr>
<tr>
<td>Maximum Speed</td>
<td>0.327</td>
<td>0.016</td>
</tr>
<tr>
<td>Percentage of Speeding Duration</td>
<td>0.097</td>
<td>0.010</td>
</tr>
<tr>
<td>Log(Total Trip Duration)</td>
<td>0.885</td>
<td>0.045</td>
</tr>
<tr>
<td>Log(Total Trip Distance)</td>
<td>-0.298</td>
<td>0.036</td>
</tr>
</tbody>
</table>
Findings (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.
Findings (2/2)

- Impact of driver feedback

  - Initial findings highlight **speeding and mobile phone use reduction** when personal feedback is provided to drivers

  - Both types of **harsh events** (accelerations and brakings) are also **reduced** by providing drivers with feedback

  - The present achievements open **new venues for quantifying driver feedback** by measuring its effect on critical driver behaviour **KPIs**
Telematics-based Behaviour KPIs

- Telematics present a very great potential for easy-to-collect and monitor:
  - **risk exposure**: veh-kms, driver-kms
  - **behaviour KPIs** (star-rating drivers): average speed, speeding, mobile phone use, harsh breaking / acceleration
- **Aggregate KPIs** per type of road user, area, vehicle and time.
- Need for **coefficients** to transform telematics drivers population characteristics into a representative drivers population sample
- Need for **business models** for cooperation between Authorities and telematics providers (OEMs also) for data provision.
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