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

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OPERATIONAL PROGRAMME
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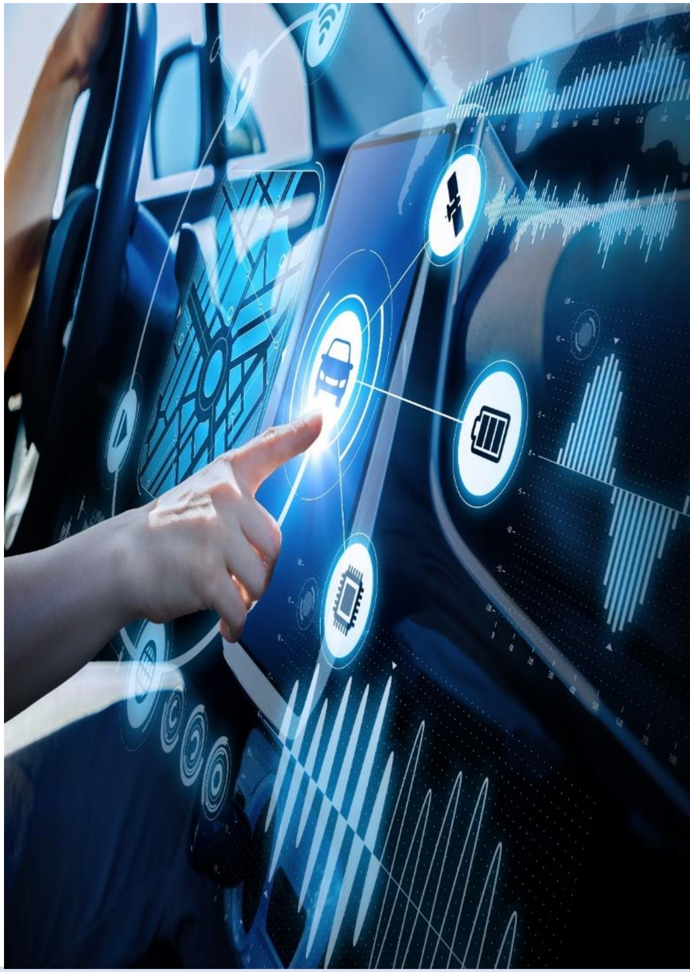
Research Scope

- 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

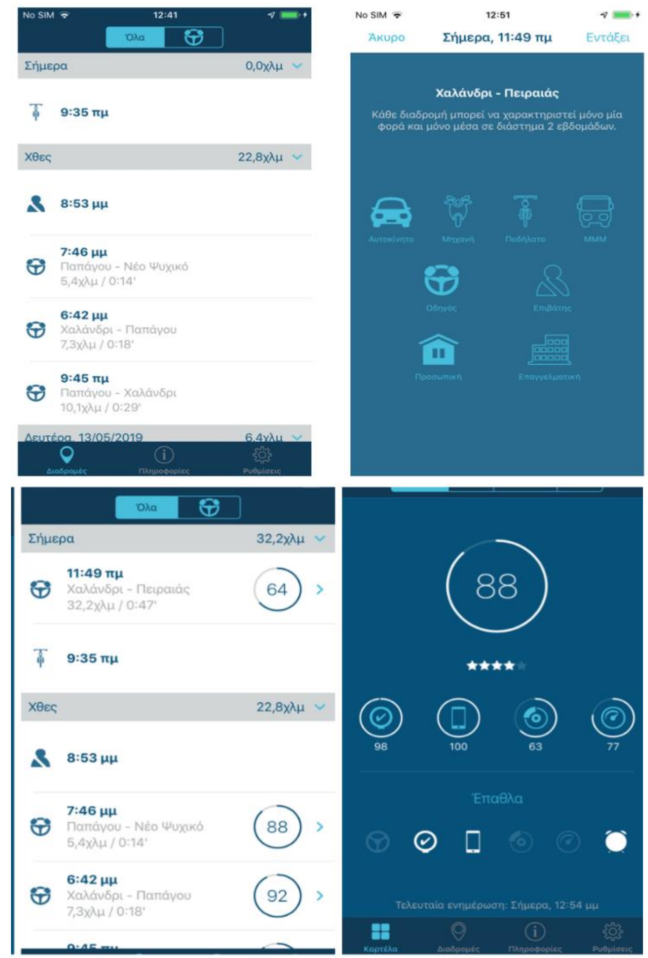
The BeSmart driving experiment

- 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



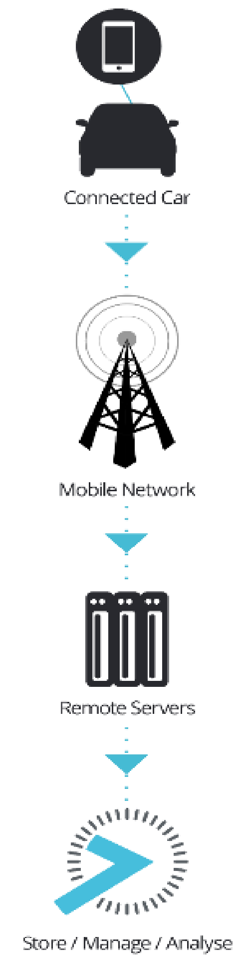
The BeSmart Application

- 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



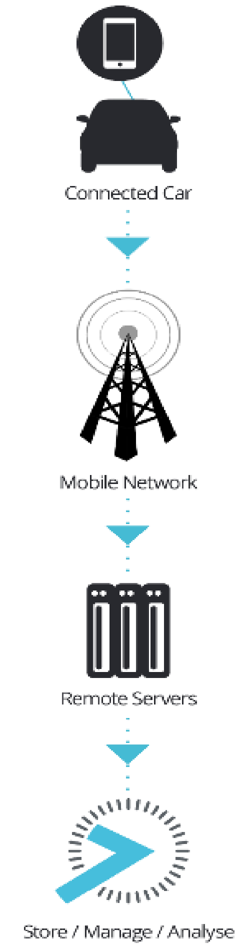
Smartphone data collection (1/2)

- 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



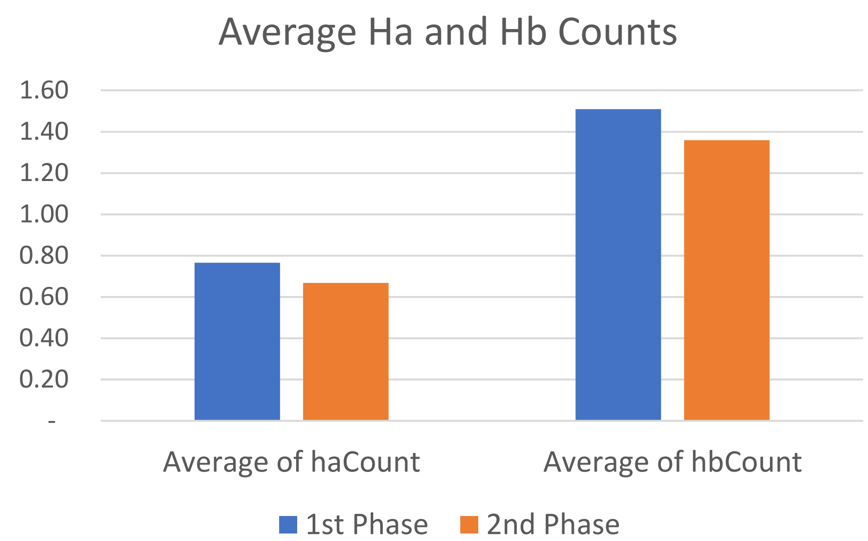
Smartphone data collection (2/2)

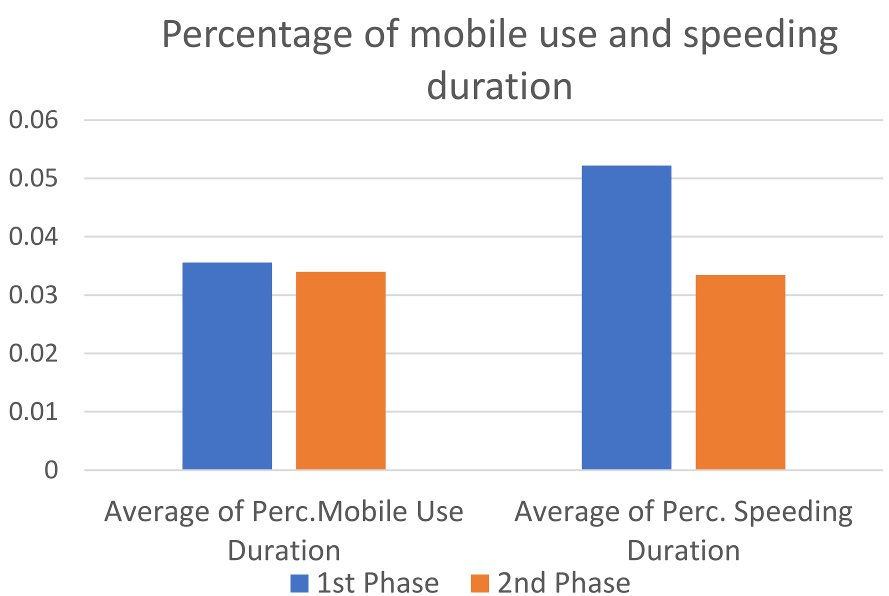
- Indicators are designed using:
  - machine learning algorithms
  - big data mining techniques
- The database analyzed was in .csv format
  - Drivers' trips are stored per row, the characteristics of which are stored in each column's variables
- State-of-the-art technologies and procedures in compliance with standing Greek and European personal data protection laws (GDPR)



Descriptive statistics

- Both types of harsh events (accelerations and brakings) are reduced in the 2nd phase of the experiment





- 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

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:

$$log(\lambda_i) = \beta_{0i} + \beta_{ji}x_{ji} + \beta_{n-1}x_{n-1} + \varepsilon$$

Results (1/2)

- GLMMs for harsh acceleration counts

Parameter	GLMM for Phase 1					GLMM for Phase 2				
	Estimate	s.e.	p-value	Sig.	Relative Risk Ratio	Estimate	s.e.	p-value	Sig.	Relative Risk Ratio
Intercept	-0.927	0.091	0.000	***	0.395	-1.127	0.085	0.000	***	0.324
Maximum Speed	0.321	0.022	0.000	***	1.378	0.412	0.021	0.000	***	1.509
Percentage of Speeding Duration	0.074	0.013	0.000	***	1.076	0.035	0.012	0.003	**	1.035
Percentage of Mobile Use Duration	0.042	0.011	0.000	***	1.042	-	-	-	-	-
Log(Total Trip Duration)	0.848	0.051	0.000	***	2.334	0.729	0.050	0.000	***	2.073
Log(Total Trip Distance)	-0.231	0.050	0.000	***	0.793	-0.087	0.046	0.047	*	0.916

Results (2/2)

- GLMMs for harsh braking counts

Parameter	GLMM for Phase 1					GLMM for Phase 2				
	Estimate	s.e.	p-value	Sig.	Relative Risk Ratio	Estimate	s.e.	p-value	Sig.	Relative Risk Ratio
Intercept	-0.182	0.067	0.006	**	0.833	-0.313	0.075	0.000	***	0.731
Maximum Speed	0.327	0.016	0.000	***	1.387	0.331	0.015	0.000	***	1.395
Percentage of Speeding Duration	0.097	0.010	0.000	***	1.102	0.081	0.009	0.000	***	1.084
Log(Total Trip Duration)	0.885	0.045	0.000	***	2.423	0.723	0.038	0.000	***	2.061
Log(Total Trip Distance)	-0.298	0.036	0.000	*	0.742	-0.082	0.033	0.015	*	0.921

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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