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Advanced driver monitoring using smartphone applications: The BeSmart project

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Introduction

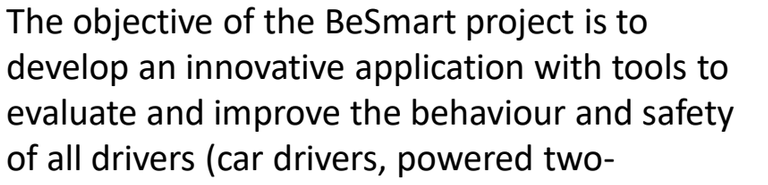
In light of rapid technological advancement during the previous decade, driver monitoring and its potential improvements remain a critical transport challenge. Driver monitoring involves the observation and recording of crucial driving tasks, such as speeding or driver behaviour under distraction factors. However, researchers have been struggling with the difficulty of collecting accurate real-time driving data by adopting low-cost collection and processing methods. In that context, the high penetration rate of smartphones provide new opportunities to monitor and analyze driver behaviour.

Objective

In this environment, the aim of the present study is to showcase the conceptual framework and preliminary results of the BeSmart project. The objective of the BeSmart project is to develop an innovative application with tools to evaluate and improve the behaviour and safety of all drivers (car drivers, powered two-wheelers, cyclists, professional drivers) along multi-modal trips. More specifically, the present study aims to identify the critical driving parameters that affect driving behaviour as expressed by the frequencies of harsh accelerations and harsh brakings while driving.

Methodology

In order to achieve the research objective, an innovative smartphone application is developed by OSeven Telematics (www.oseven.io), aiming to record driver behaviour using the hardware sensors of the smartphone device. The standard procedure that is followed every time a new trip is recorded by the App, is clearly presented in the following figure.



The exposure indicators that are available include indicatively duration (seconds), total distance (mileage) and type(s) of the road network. Moreover, the driving behaviour indicators consist of the following: speeding (distance and time of driving over the speed limit and the exceedance of the speed limit), driver distraction (caused by smartphone use during driving), number and severity of harsh events number and severity of harsh events (braking and acceleration), etc.

Theoretical background

- k-means Clustering

As a preliminary step, clustering is useful in order to divide the trip sample into several categories, which can provide insights as to whether driving behaviour differs systematically on a macroscopic scale.

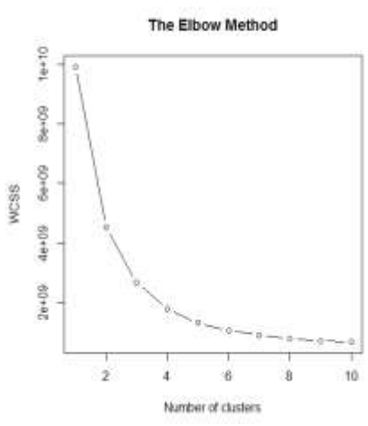
- Generalized Linear Mixed-Effects Models

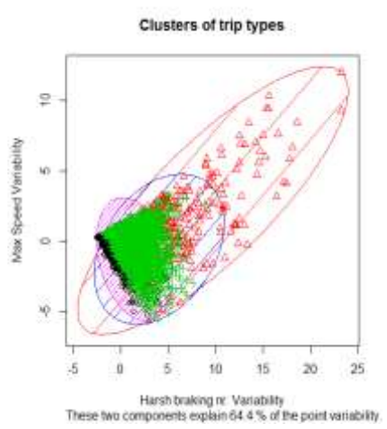
In order to capture personal driver traits that are unobserved, random effects are introduced to GLMs in order to extend them as Generalized Linear Mixed-Effects Models (GLMMs)), given by the following formula:

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

Analysis and Discussion

After establishing the theoretical background, several clustering configurations were tested. 11211 trips from 132 drivers were examined and clustered in three types: Aggressive, Speeding and Average.





Subsequently, Generalized Linear Mixed-Effects Models were fitted to the trips of 76 car drivers who made frequent trips in order to model the frequencies of harsh events. GLMM Results indicate a number of correlations: The parameters of maximum speed, speeding duration and total trip duration have all been determined as statistically significant and positively correlated with both harsh acceleration and harsh event counts. Similarly, total trip distance is statistically significant and negatively correlated with both harsh event types. Mobile use duration was found significant only for harsh accelerations with a small positive correlation.

Parameter	GLMM for harsh acceleration counts					GLMM for harsh braking counts				
	Estimate	s.e.	p-value	Sig.	Rel. Risk Ratio	Estimate	s.e.	p-value	Sig.	Rel. Risk Ratio
Intercept	-0.094	0.098	0.335		0.910	0.655	0.078	0.000	***	**1.925**
Maximum Speed	0.218	0.029	0.000	***	1.244	0.203	0.021	0.000	***	**1.225**
Speeding Duration	0.032	0.009	0.000	***	1.033	0.031	0.007	0.000	***	**1.031**
Mobile Use Duration	0.018	0.008	0.032	*	1.018	–	–	–	–	–
Log(Trip Duration)	0.291	0.042	0.000	***	1.338	0.280	0.030	0.000	***	**1.324**
Log(Trip Distance)	**-0.066**	**0.022**	**0.002**	**	**0.936**	**-0.072**	**0.016**	**0.000**	***	**0.931**

Future Research

As evident from the analysis of car drivers of the initial phase of BeSmart, multi-dimensional results are expected from the project experiment. Future research will also focus on the analysis of different driving behaviour parameters, as well as analyses per gender, age, and more demographic characteristics.

Acknowledgements

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