Measuring the impact of driver behavior telematics in road safety

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Abstract

The Internet of Things offers constantly updating opportunities and features to monitor and analyze driver behavior through smartphone recording and big data analytics. The objective of the present proposal is to present the capabilities of an innovative smartphone application developed by OSeven telematics to automatically record driver behavior. A naturalistic experiment was carried out between July and December 2019, and daily trips of 200 drivers were automatically recorded. Two main pillars of analysis were examined: The first pillar concerned the investigation of detailed trip characteristics on harsh acceleration and harsh braking events counts as they were recorded through the OSeven app. The second pillar explored the riding behavior of motorcyclists while speeding, based on detailed riding analytics from the OSeven app. The present findings are a quantitative documentation of the impact of personalized driver feedback on two of the most important human risk factors, i.e. harsh events and speeding.

Keywords

Road safety; driver behavior; telematics; smartphone application; naturalistic driving experiment

Introduction

The Internet of Things (IoT) constantly offers new opportunities and features to monitor and analyze driver behavior through wide use of smartphones, effective data collection and Big Data analysis, resulting in assessment and improvement of driver behavior and safety. More precisely, technological advancements in driver behavior telematics are exploited by the insurance industry which is is growing and changing rapidly the last two decades. In addition, the high penetration rate of smartphones has offered new possibilities for faster, more accurate and low price driver behavior data collection. The interpretation of these data can be made possible thanks to progress in computing power, data science and artificial intelligence.

Previous studies have concluded to several interesting and useful results regarding the effect of various types of telematics on driving performance and safety. More specifically, recent review studies have examined the utility of telematics data for road safety showcasing promising results with respect to crash risk reduction and improvement of driving behavior (Kirushanth & Kabaso, 2018; Tong et al., 2015; Szpytko & Agha, 2020). It is also highlighted that incentives within a social gamification scheme, with personalized target setting, benchmarking and comparison with peers may have a greater impact (Tselentis et al., 2020).

In light of the aforementioned, the objective of the present study is to present the capabilities of an innovative smartphone application developed by OSeven telematics to automatically record driver behavior using hardware sensors of smartphone devices, such as orientation, GPS and gyroscope and investigate the impact of driver behavior telematics in driver behavior and road safety.

Methodology

In order to achieve the research objective, an innovative smartphone application was developed aiming at the assessment and improvement of driver behavior and safety. The application is developed by OSeven (www.oseven.io), aiming to record driver behavior using the hardware sensors of the smartphone device. Furthermore, a variety of APIs is exploited to read sensor data and temporarily store them to the smartphone's database before transmitting them to the central (back-end) database.

The standard procedure that is followed every time a new trip is recorded by the application is clearly presented in Figure 1. The data collected are highly disaggregated in space and time. Once stored in the backend cloud server, they are converted into meaningful driving behavior and safety indicators, using signal processing, Machine Learning (ML) algorithms, Data fusion and Big Data algorithms. This is achieved by using state-of-the-art technologies and procedures, which operate in compliance with standing Greek and European personal data protection legislation (GDPR).

Fig. 1. The OSeven data flow system.

The available exposure indicators include indicatively trip duration (seconds), total distance (mileage), type(s) of the road network used, given by GPS position and integration with map providers e.g. Google, OSM, (highway, rural or urban environment) and time of the day when riding. Moreover, the riding indicators associated with riding behavior consist of the following: speeding (distance and time of riding over the speed limit and the exceedance of the speed limit) and riding aggressiveness, measured in the present approach by the number and severity of harsh events (harsh brakings/accelerations).

Within the framework of the present research, a naturalistic experiment was conducted with different participating driver types: 65 car drivers and 13 motorcyclist riders, who all installed the respective OSeven driver / rider application on their smartphone devices. The experiment was carried out between July and December 2019, and daily trips of the participants were automatically recorded.

Two main pillars of analysis were examined: The first pillar concerned the investigation of detailed trip characteristics on harsh acceleration and harsh braking events counts as they were recorded through the OSeven app. During the first two months, participants drove their cars as usual, referring as Phase A. Over the subsequent two months, referring as Phase B, participants were provided with personalized feedback, a trip list and a scorecard regarding their driving behavior, allowing them to identify their critical deficits or unsafe behaviors. The second pillar explored the riding behavior of motorcyclists while speeding, based on detailed riding analytics from the OSeven app and investigated whether personalized feedback can improve motorcyclist behavior.

Results

In order to model the expected frequency of events per trip for the participant drivers and the percentage of speeding per trip for the participant riders, mixed-effect models in a GLM framework (GLMMs) were calibrated. Specifically, GLMMs were fitted in R-studio (with the lme4 package) via maximum likelihood and using z-factor scaling. A number of models were tested with different configurations in the collected parameters in both fixed effects and random effects.

Modelling Harsh Events of car drivers

The key indicator, and response variable for the purpose of this research is the frequency of harsh acceleration and harsh braking events during the two first experiment phases. Table 1 provides a description of the variables selected. Regarding the harsh event frequencies, it is noted that both during Phase A and Phase B drivers seem to incur more harsh brakings than harsh accelerations during their trip.

Table 1. Description of the variables used in the analysis

Variable	Description
Total Trip Duration [s]	Total trip duration [sec]
Total Trip Distance [km]	Total trip distance [km]
Average Speed [km/h]	Mean driving speed per trip [km/h]
Maximum Speed [km/h]	Maximum of driving speed per trip [km/h]
Percentage of Mobile Use Duration [%]	Share of mobile use per trip [%]
Percentage of Speeding Duration [%]	Share of time over the speed limit per trip [%]
Harsh accelerations [count]	Harsh acceleration events per trip [count]
Harsh brakings [count]	Harsh braking events per trip [count]

Modelling results regarding the harsh acceleration frequencies reveal some interesting findings; the parameters of maximum speed, percentage of speeding duration and total trip duration have all been determined as statistically significant and positively correlated with harsh acceleration frequencies for both experiment phases. In the same context, total trip distance is statistically significant and negatively correlated with harsh acceleration frequencies for both experiment phases as well. Mobile use duration was found statistically significant only for Phase A with a small positive correlation. For furhter details we refer the reader to Kontaxi et al. (2021a).

Modelling speeding behavior of motorcyclists

As for the riding behavior of the participants, using risk exposure and riding behavior indicators calculated from the app, models were calibrated to correlate the percentage of riding time over the speed limit with other riding behavior indicators. An overall model for all trips and separate models for urban and rural trips were developed. Table 2 provides a description of the parameters of the models.

Table 2. Description of the variables used in the analysis

Variable	Description
Rider Feedback	Provision of rider feedback through the application [yes/no]
Trip Duration [sec]	Total trip duration [sec]
Harsh Accelerations [count]	Number of harsh accelerations per trip
Risky hours	Hours with high risk rate 00:00-05:00 [yes/no]
Morning Rush	Morning rush hour 06:00-10:00 [yes/no]
Afternoon Rush	Afternoon rush hour 16:00-20:00 [yes/no]

Modelling results regarding the speeding behavior of motorcyclists, also reveal some interesting findings: The parameters of trip duration, the distance driven during risky hours, morning peak hours and the number of harsh accelerations have all been determined as statistically significant and positively correlated with the percentage of speeding. In the same context, riding during the feedback phase of the experiment, as well as afternoon peak hours are statistically significant and negatively correlated with speeding percentage. For furhter details we refer the reader to Kontaxi et al. (2021b).

Discussion

The present findings are a quantitative documentation of the impact of personalized driver feedback on two of the most important human risk factors, i.e. harsh events and speeding. The ultimate objective when providing feedback to drivers is to trigger their learning and self-assessment process, enabling them to gradually improve their performance and monitor the shift of driving behavior. The present results offer impetus for larger-scale applications and relevant policy interventions. Naturally, the present research encountered curtained limitations. These analyses are macroscopic overall, and should be treated as a high-level behavioral investigation. Through the present approach, there is no option to statistically examine if mobile phones were used at the moments of harsh events, but rather the choice was simply to verify that they both occurred within the same trip; thus the temporal coincidence of data was not considered. Addressing these limitations will require the development of additional dedicated methodologies in the future, and the examination of in-depth datasets analyzing each trip per trip-second.

Moreover, future research will also focus on the analysis of different driving behavior parameters identified by the road safety literature as risk factors (e.g. exceeding speed limit, mobile phone distraction) and their effect on driving performance and road safety. Furthermore, analyses per driving experience, crash history, self–assessment and more demographic characteristics could be undertaken in order to capture any particular trends found in the categories of these parameters, possibly improving feedback processes, on the condition that this information can be provided while observing data protection laws.

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