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Correlation of driver behaviour and fuel consumption using data from smartphones

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Objective

- Investigate the **effect of driver behaviour on fuel consumption** using data from smartphones
- Determine the various parameters that affect driving performance and how they interact with each other in order to **predict fuel consumption**

Outline

- Background
- Past Limitations
- Data Flow
- Risk Exposure Indicators
- Risk Driving Indicators
- Experimental Process
- Data Collection
- Methodology
- Analysis Results
- Conclusions
- Future Challenges

Background

Driver

- Aggressive driving style affects fuel economy and consumption
- Eco-driving knowledge and reward are the most effective incentives for encouraging improved driver performance

Vehicle

- In-vehicle driver behaviour monitoring systems increase road safety and reduce fuel consumption

Environment

- Up to 30% less fuel consumption
- Significant reduction of pollutants emissions (CO, CO_2, NO_x)
- 10-25% less accidents

Past Limitations

Limiting barriers existed so far:

- Mobile phone technology
- High cost of in-vehicle data recording systems (i.e. OBD)
- Low penetration rate of smartphones and social networks
- Inability to manage and exploit Big Data

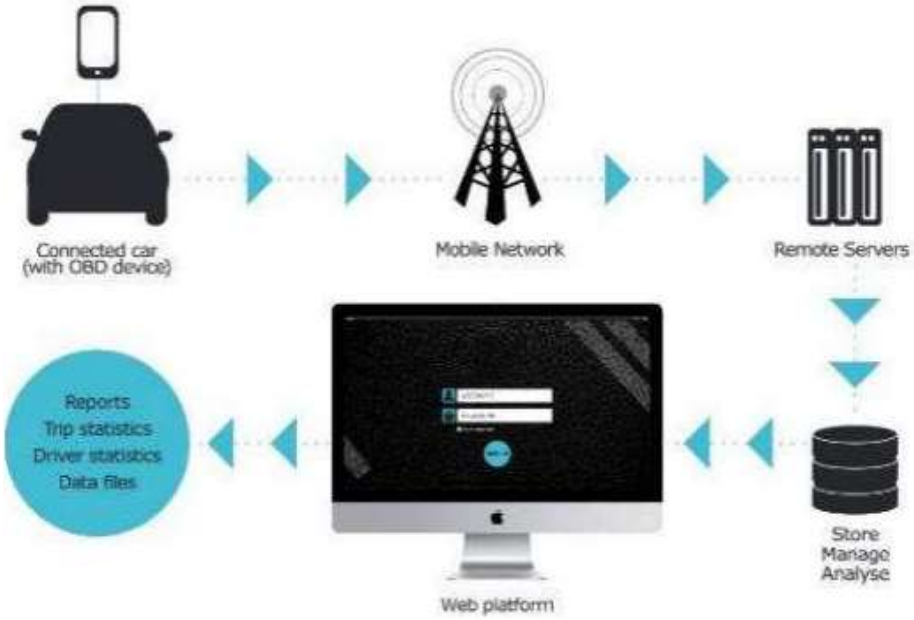
Current **technological advances** make it substantially easier for experts to collect and exploit data easier and more accurately through smartphones

Data Flow (1/2)

- A **user-friendly smartphone App** recording driver's behaviour using mobile phone sensors, without any user involvement (automatic start / stop)

- A **variety of APIs** reading sensor data recorded and temporarily store it to mobile phone

- **Data transmission** from the mobile App to the central database via an appropriate communication channel such as:
  - Wi-Fi network (online)
  - Cellular network such as a 3G/4G network (online)
  - Bluetooth (offline)



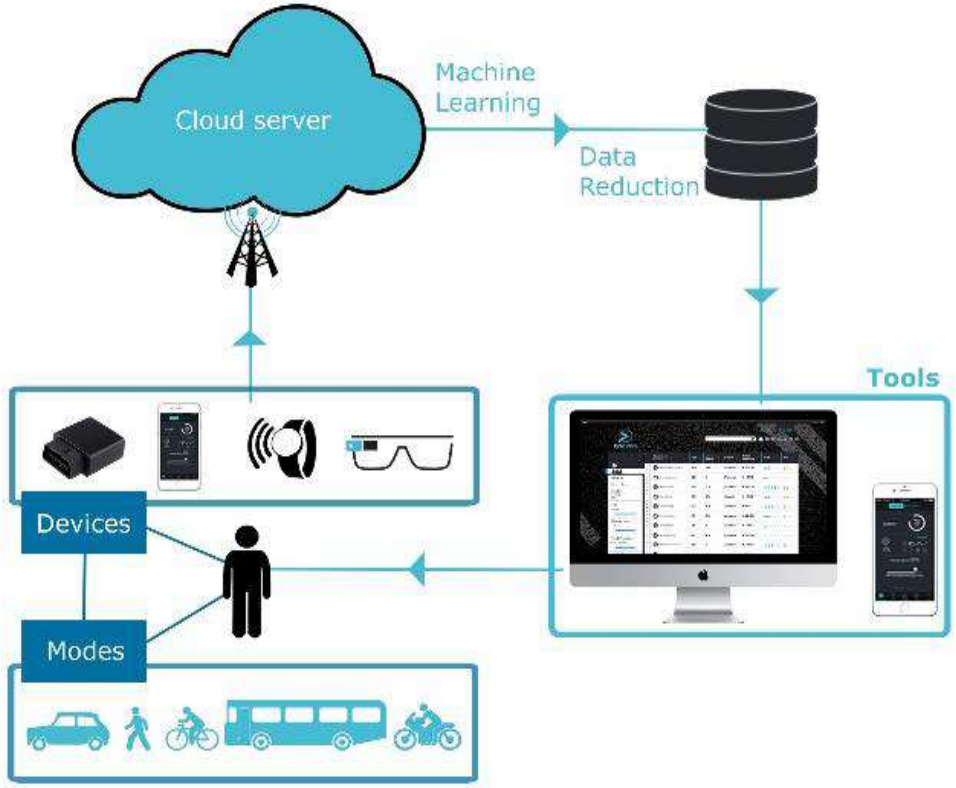
Data Flow (2/2)

- Data is stored in a sophisticated **database** where managed and processed

- **Indicators** result from the mobile phone data process using:
  - Machine Learning algorithms
  - Big data mining techniques

- **Visualization** of the metrics and scores for the evaluation of the driving behaviour through:
  - Mobile App
  - Web Portal

- All the aforementioned procedures use the latest technologies in compliance with **GDPR**

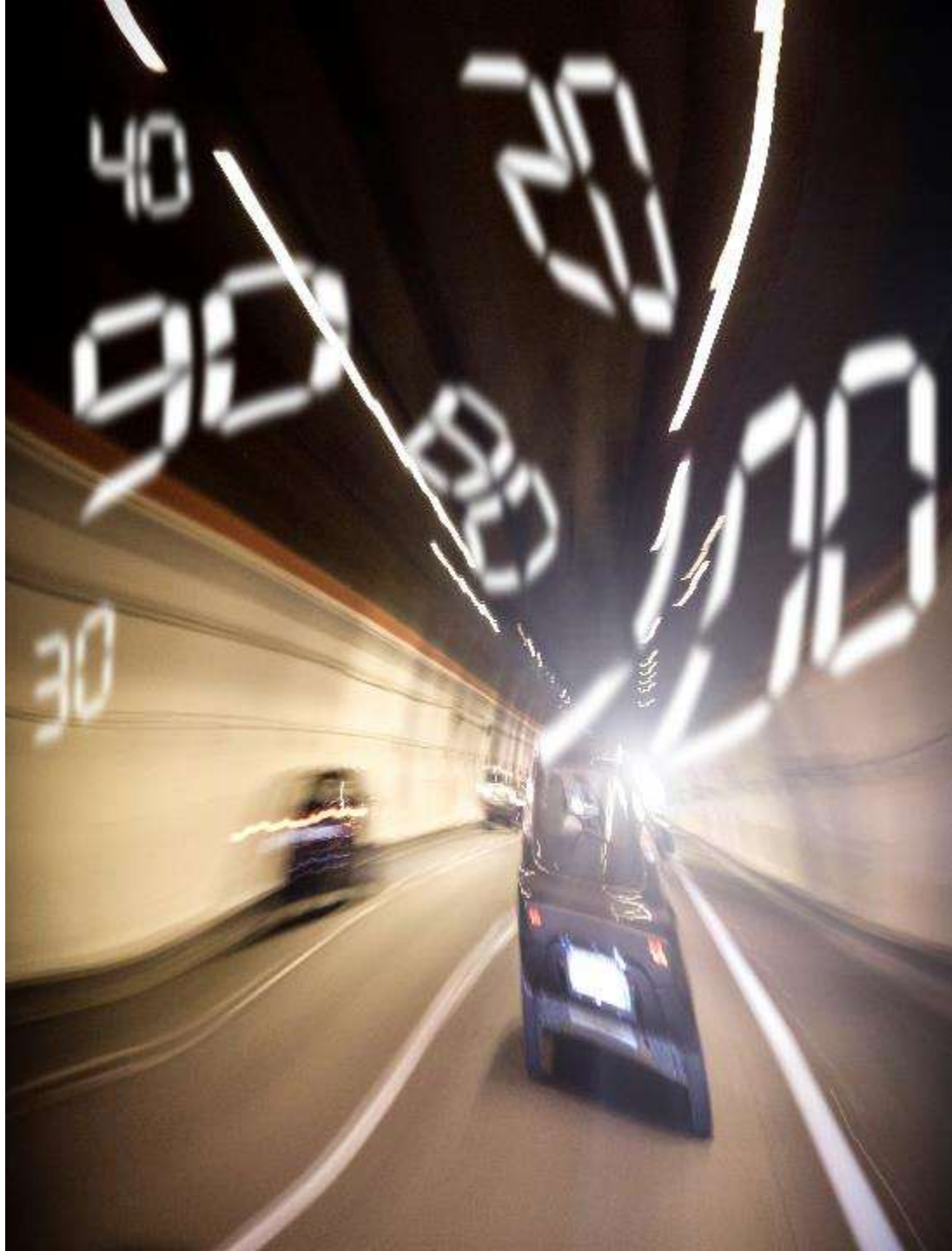


Risk Exposure Indicators

- Total driving **duration** (seconds)
- Total **distance** travelled (mileage)
- **Type of the road** network used (highway, rural or urban)
- **Time of the day** driving (rush hours, risky hours)
- **Weather** conditions (fog, rain, snow)

Risk Driving Indicators

- **Speeding** (distance and time of driving over the speed limit, speed limit exceedance)
- Number of **harsh events** (braking and acceleration)
- Driving **aggressiveness**
- Driver **distraction** (caused by mobile phone use during driving)
- **Eco-driving** (smooth use of the accelerator, steering, transmission and brakes)



Experimental Process

- Naturalistic driving experiment
- The sample of the analysis consists of **17 participants**, aged 20-35
- **2 different driving scenarios**
  - 2 months normal driving (before)
  - 2 months eco-driving (after)
- A **large database** of thousands trips

Data Collection

OSeven backend office

Fuel Consumption Log Template

Driving Behaviour Questionnaire

Methodology (1/2)

4 Lognormal Regression models were developed to identify driving characteristics influencing the fuel consumption:

Model 1: Predicting fuel consumption – **overall model**

Model 2: Predicting fuel consumption driving on **highway**

Model 3: Predicting fuel consumption driving on **rural road**

Model 4: Predicting fuel consumption driving on **urban road**

Methodology (2/2)

Independent parameters included in the statistical models:

- Before-after
- Average speed
- Harsh acceleration
- Average deceleration
- Mobile phone use
- Risky hours distance
- Gender
- Educational level

Variables	Model 1 (overall model)				Model 2 (highway road)				Model 3 (rural road)				Model 4 (urban road)			
	b_i	t	e_i	e_i*	b_i	t	e_i	e_i*	b_i	t	e_i	e_i*	b_i	t	e_i	e_i*
Constant	1,335	16,182			1,413	15,990			1,371	21,930			1,365	22,210		
Before-After	-0,056	-2,971	-0,016	1,000	-0,042	-2,271	-0,012	1,696	-0,057	-2,764	-0,008	1,000	-0,056	-2,868	-0,007	1,000
Avgspeed	0,001	1,787	0,054	3,404	0,001	2,033	0,105	14,756	0,001	2,496	0,046	5,510	0,002	3,267	0,030	4,596
Ha	0,001	2,613	0,096	6,125	0,007	2,072	0,028	3,900	0,002	2,776	0,050	6,095	0,002	5,398	0,116	17,736
Avdecel	0,029	1,986	0,070	4,440	0,021	2,037	0,024	3,313	0,020	1,910	0,042	5,126	0,043	2,907	0,106	16,286
MobileUse	-0,158	-2,056	-0,038	2,424	-0,047	-1,829	-0,007	1,000	-0,149	-2,630	-0,038	4,646	-0,079	-1,736	-0,026	3,983
Riskyhours	0,003	2,581	0,041	2,592	0,002	2,036	0,029	4,074	0,003	2,465	0,030	3,660	0,003	2,498	0,035	5,371
Duration					0,000	-3,371	-0,082	11,432								
Gender	-0,087	-4,996	-0,023	1,479	-0,114	-5,607	-0,031	4,299	-0,087	-5,121	-0,026	3,181	-0,091	-5,995	-0,024	3,733
Educ_level	-0,101	-7,386	-0,023	1,456	-0,113	-6,880	-0,026	3,585	-0,107	-7,500	-0,026	3,108	-0,102	-8,495	-0,023	3,550
Years_drv									-0,016	-2,330	-0,017	2,000	-0,024	-3,634	-0,016	2,411
R^2	**0,620**				**0,637**				**0,656**				**0,704**			

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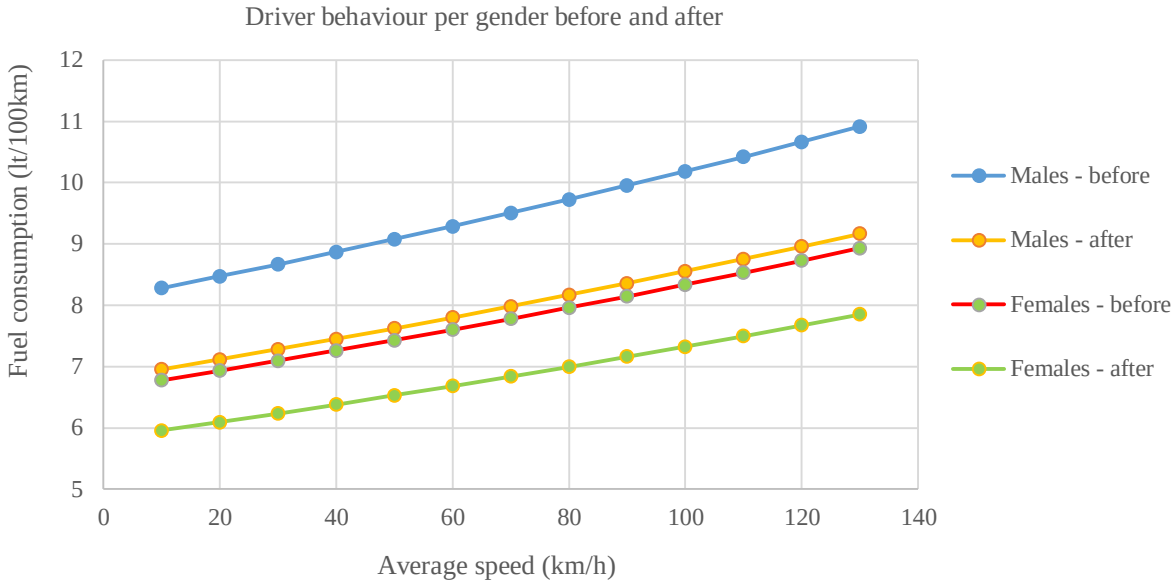
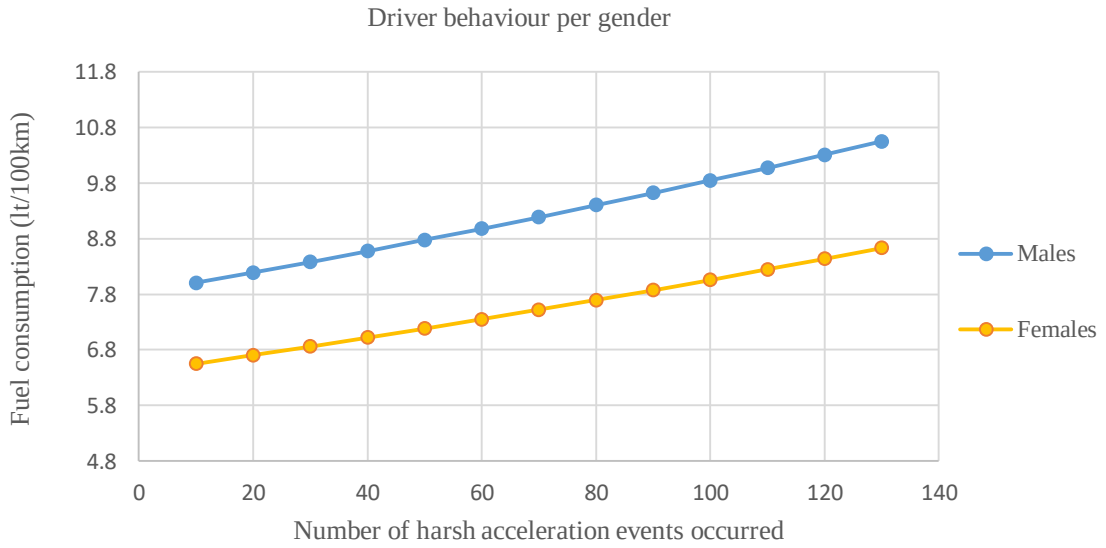
Analysis Results (1/2)

- The higher the **average speed**, the higher the fuel consumption
- **Male** drivers after getting improved appeared similar behaviour to **female** drivers before getting improved
- The higher the number of **harsh accelerations** occurred while driving, the higher the fuel consumption
- Male drivers tended to **accelerate more frequently** than female





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Analysis Results (2/2)

- In urban driving, **acceleration** had the highest impact on fuel consumption
- **Deceleration** was identified as the second most influential variable
- In highways where speed limits are high enough, fuel consumption elevated considerably as the **speed** increased
- **Mobile phone** usage had the slightest influence on motorways
- **Night-time driving** was positively correlated with fuel consumption

Independent Variables	Model 1 (overall model)	Model 2 (highway)	Model 3 (rural road)	Model 4 (urban road)
Before-after	1,000	1,696	1,000	1,000
Average speed	3,404	14,756	5,510	4,596
Harsh acceleration	6,125	3,900	6,095	17,736
Average deceleration	4,440	3,313	5,126	16,286
Mobile usage	2,424	1,000	4,646	3,983
Risky hours distance	2,592	4,074	3,660	5,371
Gender	1,479	4,299	3,181	3,733
Educational level	1,456	3,585	3,108	3,550

Conclusions (1/2)

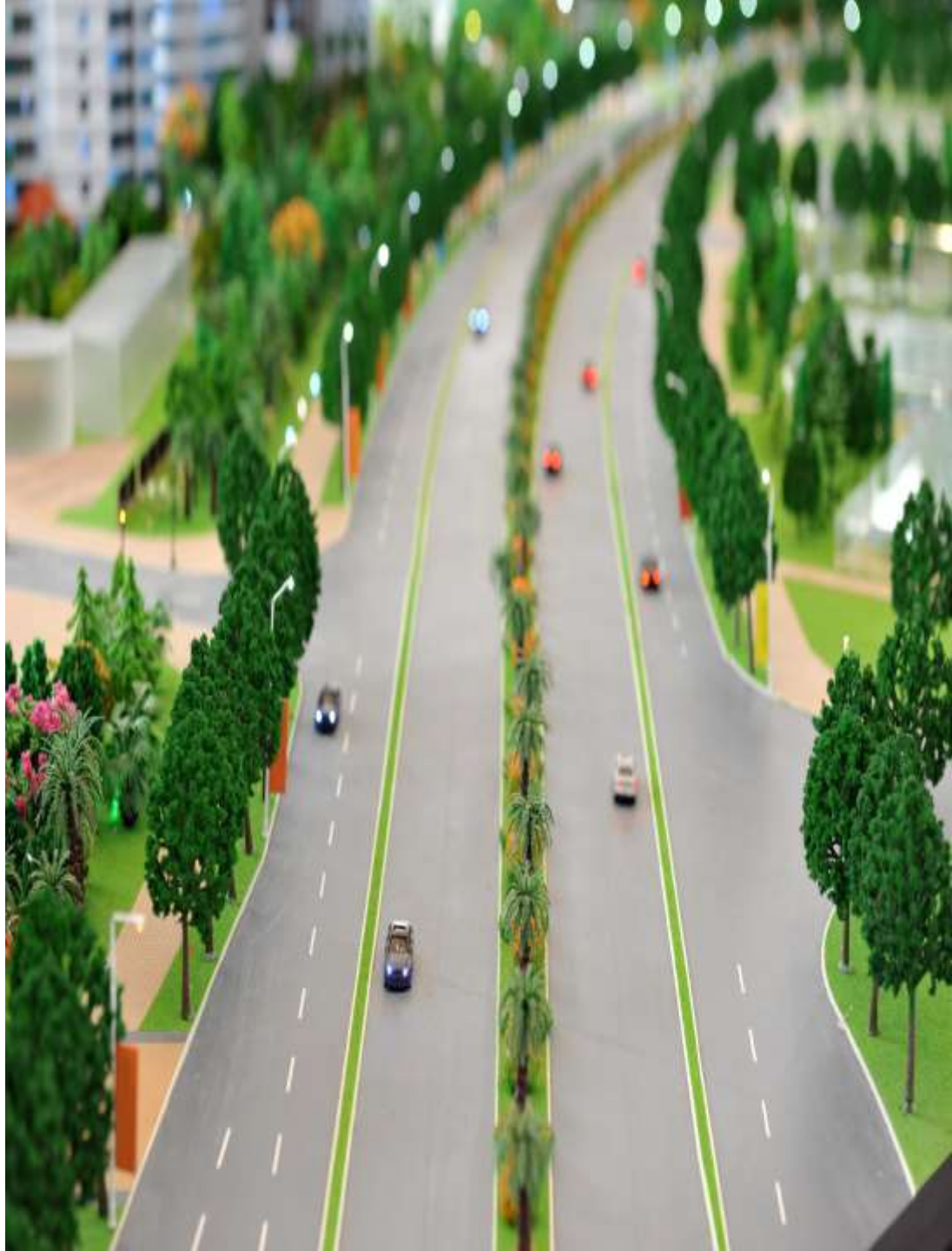
- A remarkable **15% reduction** in fuel consumption
- By improving the way participants were considering the task of driving, a **smoother and greener** driver behaviour was achieved
- The higher the **acceleration**, the higher fuel consumption, especially in urban roads
- As the **average speed** increases, the fuel consumption increases, especially in highways. Eco-driving behavior significantly reduced average speed on all types of road
- The higher the **average deceleration**, the higher fuel consumption. Drivers managed to reduce unnecessary braking and saved fuel

Conclusions (2/2)

- The higher the **mobile phone use**, the lower the fuel consumption
- As the **night-time driving** increases, the fuel consumption increases
- **Driver characteristics** played a crucial role in driving performance (gender, age, experience)
- The vast majority of male drivers displayed **less cautious behaviour** during their trips and consumed more fuel than females
- **Experienced** drivers and **most educated** road users adopted a more conservative and ecological driving performance

Future Challenges

- **Larger** and more representative sample of drivers with different age groups
- Investigation of the effect of other **driving factors** (psychological status, fatigue or driving under influence of alcohol)
- Investigation of fuel economy performance with regards to **vehicle characteristics** (tire pressure, driving force, horse power, cubic capacity, weight or age)
- Investigation of the effect of **type of fuel** (gasoline, diesel, liquid petrol or compressed natural gas)



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