What is your driving identity? Some empirical findings using large-scale smartphone sensors' data

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Understanding driving behavior

- Helps to identify the circumstances under which abnormal and unsafe driving events take place

- Is useful for the development of advanced driving assistance and recommendation systems

> Real-time recommendations for safer and more efficient driving

- Remains vital even in the era of autonomous and connected vehicles.

> Development of acceptable and user friendly "machines"

Benefits of improved driving behavior

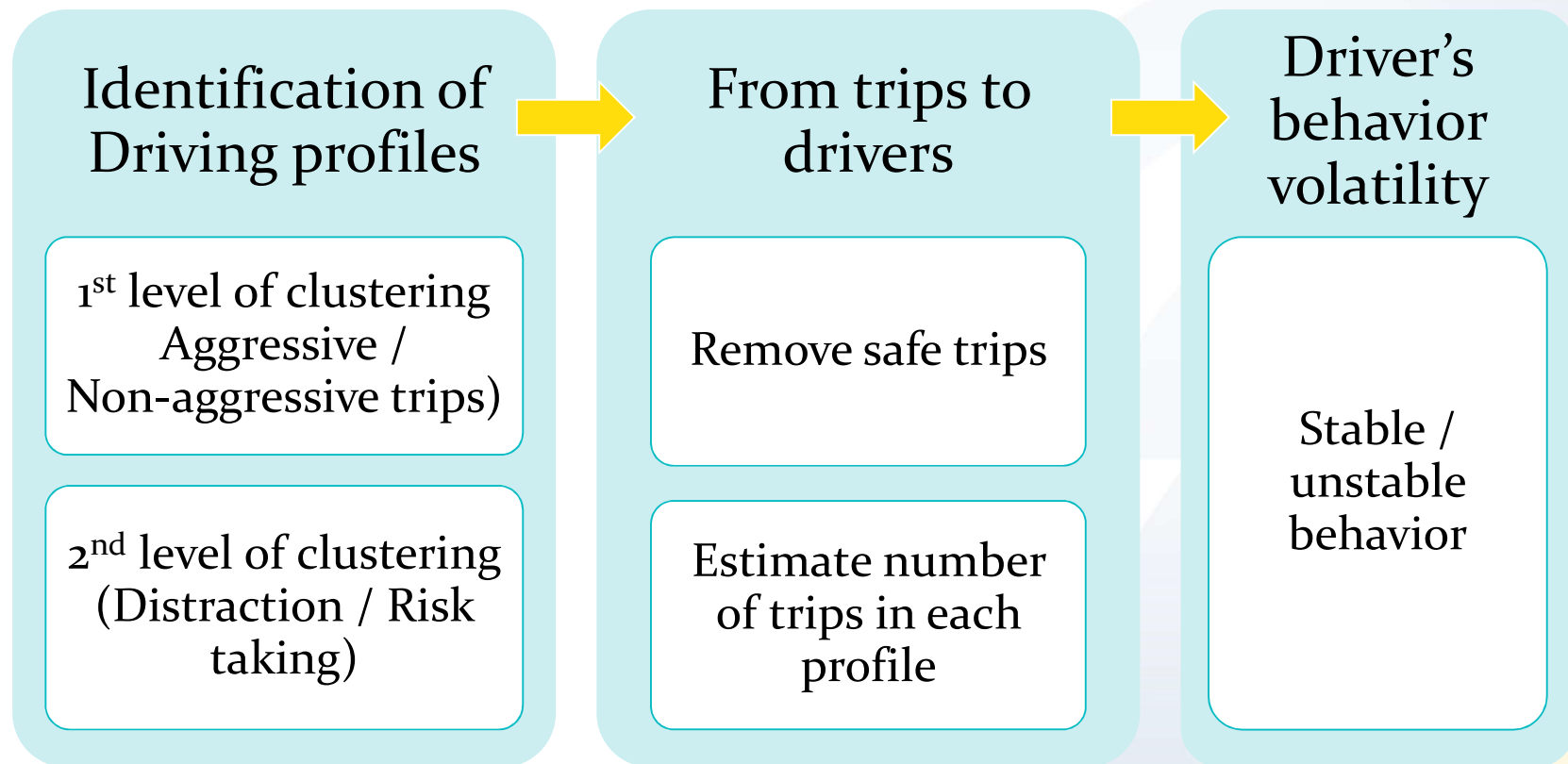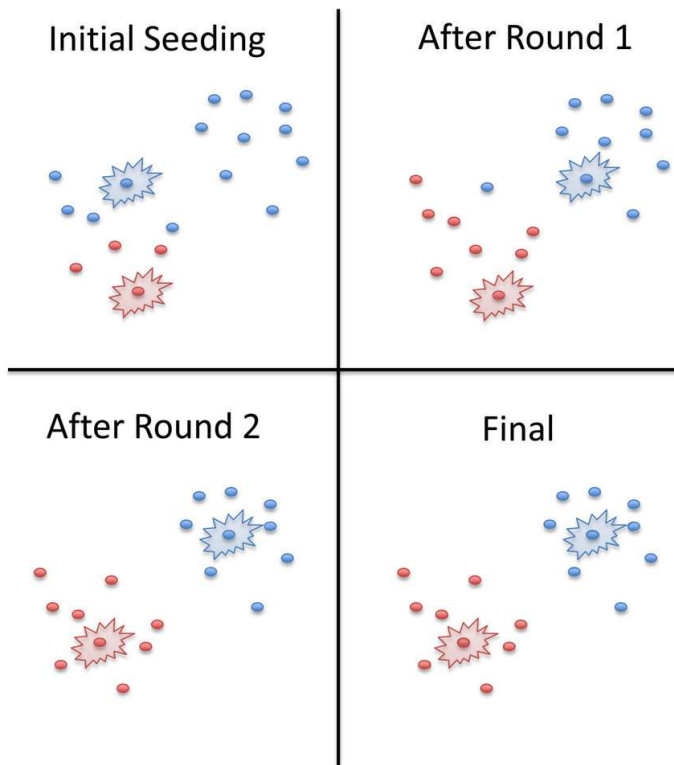|		
🚧	**Road safety & Traffic**	Less car accidents Improved traffic conditions
🌳	**Environment**	Air pollution
🔊	**Public health**	Emissions Noise

What do we aim to do?

- Identify different driving behaviors

- Distinguish safe from unsafe driving styles

- Rank driving behaviors with regards to road safety

- Investigate each driver's behavior volatility in terms of unsafe driving habits

Methodological approach

Identification of Driving profiles

> 1st level of clustering Aggressive / Non-aggressive trips)

> 2nd level of clustering (Distraction / Risk taking)

From trips to drivers

> Remove safe trips

> Estimate number of trips in each profile

Driver's behavior volatility

> Stable / unstable behavior

Methodology: K-means Clustering

Initial Seeding | After Round 1

After Round 2 | Final

- Aims to partition *n* observations into *k* clusters

- Each observation is assigned to the cluster with the nearest mean

- Number of clusters is chosen using the Elbow method

Methodology: Self-Organizing Maps

Output layer
(Competitive layer)

Input layer

x_1 x_2 x_n

X
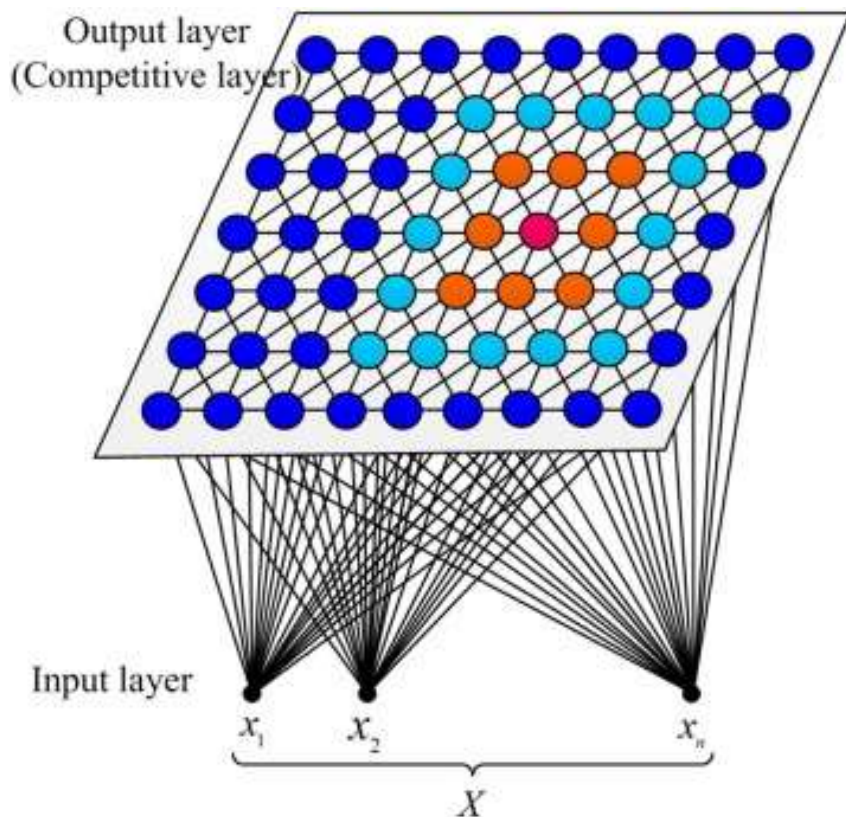
- A type of Artificial Neural Network (ANN)

- Is trained using unsupervised learning

- Two-dimensional, discretized representation, called a **map**

Smartphone data

Data used are collected through the Oseven app (www.oseven.io)

Connected Car — Mobile Network — Remote Servers — Store / Manage / Analyse
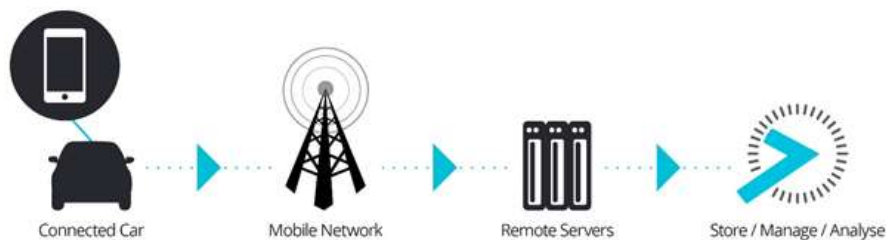
More than **240000 trips** were available, performed by more than **200 drivers** in Attika Region.

Variables

Harsh acceleration events
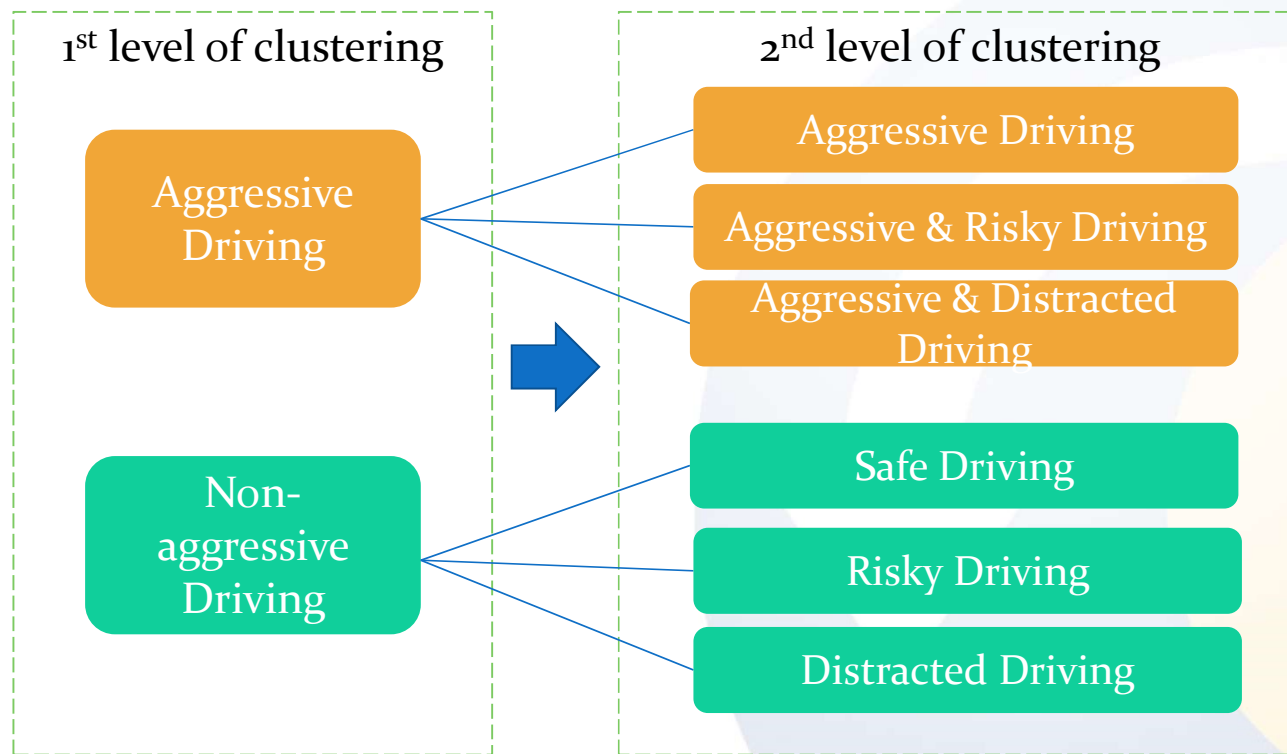
Percent of trip duration over the speed limit

Harsh braking events

Percent of mobile usage

Acceleration

Smoothness indicator

Clustering Results: Driving profiles

1st level of clustering	2nd level of clustering
Aggressive Driving	Aggressive Driving
	Aggressive & Risky Driving
	Aggressive & Distracted Driving
Non-aggressive Driving	Safe Driving
	Risky Driving
	Distracted Driving

Clustering Results: 1ˢᵗ level of clustering

Variable / Cluster	Cluster centers for Aggressive and Non-aggressive trips				
	Harsh Acceleration/km	Harsh Brake/km	Smoothness Indicator	Standard Deviation of Acceleration	Number of trips
Aggressive trips	0.281	1.801	0.455	0.509	25731
Non-aggressive trips	0.038	1.169	0.299	0.093	63212

- 71% of trips are not featured by aggressiveness

- In case of aggressive trips the number of harsh acceleration events are almost 7 times more than in the case of non-aggressive, while the same number for the harsh brake events is less than 2.
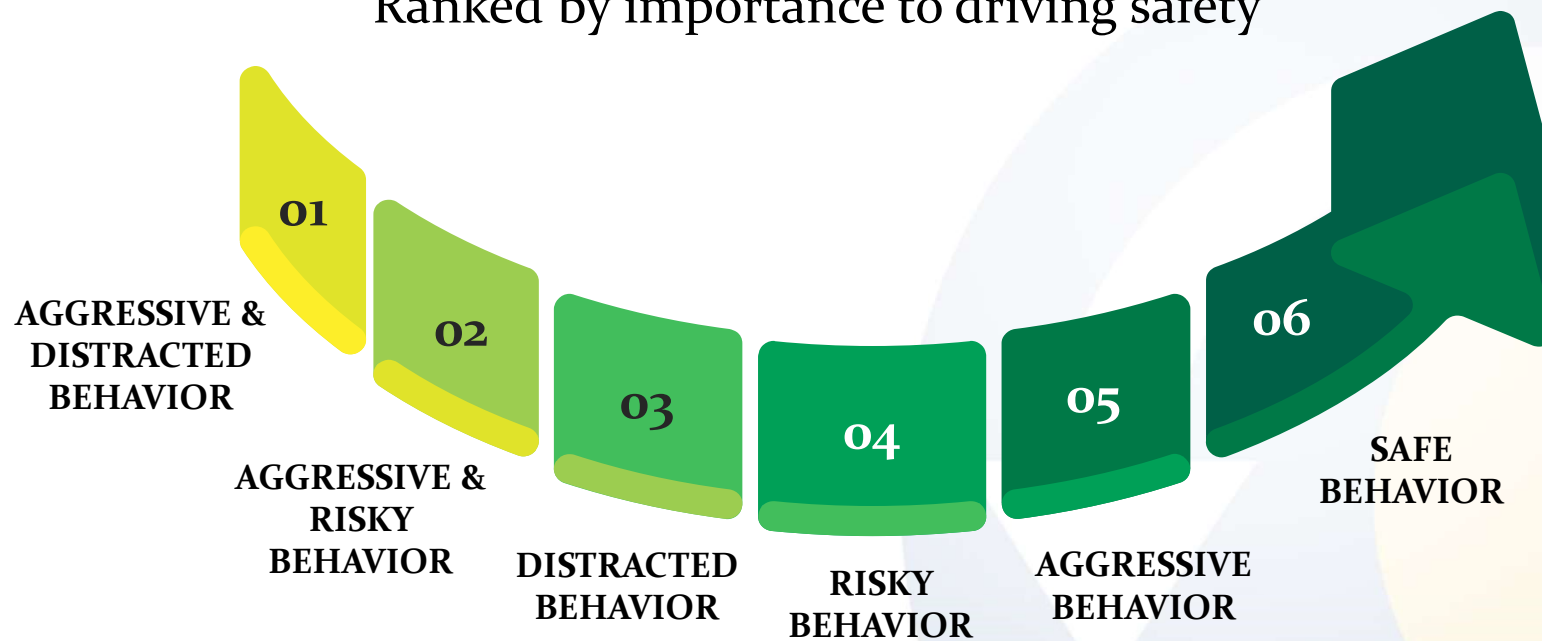
Clustering Results: 2nd level of clustering

Variable / Driving profile	Percentage of mobile usage	Percent of speeding
NON-AGGRESSIVE TRIPS		
Distracted	0.540	0.065
Risky	0.029	0.289
Safe	0.013	0.024
AGGRESSIVE TRIPS		
Risky	0.038	0.292
Aggressive	0.20	0.032
Distracted	0.547	0.100

- The percent of speeding in case of non-aggressive distracted trips is almost 2 times greater than the corresponding percentage for aggressive distracted trips.

- In both aggressive and non-aggressive trips distracted trips constitute less than 8% of the sample

Ranking of driving behavior

Ranked by importance to driving safety

01 — AGGRESSIVE & DISTRACTED BEHAVIOR

02 — AGGRESSIVE & RISKY BEHAVIOR

03 — DISTRACTED BEHAVIOR

04 — RISKY BEHAVIOR

05 — AGGRESSIVE BEHAVIOR

06 — SAFE BEHAVIOR

SOM for unsafe driving

SOM component	Driving profiles				
	Distracted	Risky	Aggressive-Risky	Aggressive	Aggressive-Distracted
V_1	0.044	0.107	0.059	0.759	0.030
V_2	0.168	0.397	0.110	0.267	0.057
V_3	0.045	0.099	0.059	0.770	0.027
V_4	0.042	0.114	0.058	0.757	0.029
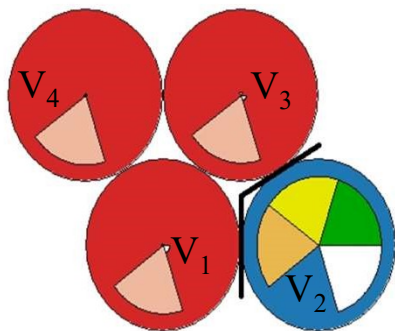
- ☐ Risky
- ☐ Distracted
- ☐ Aggressive & Risky
- ☐ Aggressive
- ☐ Aggressive & Distracted

Components V_1, V_3, V_4:
- ≈75% of aggressive trips

Component V_2:
- 17% distracted trips
- 40% risky trips
- 27% of them were clustered as aggressive trips

Conclusions

- Most of the trips (71%) did not have aggressive driving features, such as harsh accelerating and abnormal braking

- Aggressive driving behavior does not necessarily imply risk taking or distracted driving

- Drivers do not have a stable driving profile, but instead they change the way they drive on every trip

- In terms of unsafe driving behavior there are two groups of drivers:

  o those who drive only aggressively

  o those who perform several abnormal behaviors (aggressiveness, speeding, distraction)

Future research steps

❑ Does an eco driving profile exist?

❑ Identify additional unsafe behavior while driving (Inappropriate lane changing, Overtaking, Abnormal steering)

❑ Impact of external factors (traffic, road conditions, adverse weather)

❑ Causes of distraction: conversations with passengers, listening to music, out of vehicle incidents etc.

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Thank you Oseven for providing the data!