14th World Conference on
Transport Research
10-15 July 2016 –> Shanghai, China

Investigation of Texting on Young Drivers Behaviour by Means of Multivariate Copula and Gaussian Mixture Modelling

World Conference on Transport Research – WCTR 2016 Shanghai

10-15 July 2016

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Outline

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Introduction

Introduction

- Around 18.7 billion text messages are sent every day
- Several studies have reported that high percentages of drivers receive, read and compose text messages while driving
- Identifying the exact impact of mobile use on driving behavior is not easy as the use of mobile devices in real-world settings is rarely recorded
- However, texting and driving is considered a hazardous behavior as it is found to cause inattention and distract the driver, resulting in difficulty in lane maintaining and reaction time increases
- While it is impossible(?) to represent this likely crash-inducing situation in real-world settings for safety reasons, driving simulators provide a valid apparatus(?) which enables the investigation of driving behavior with a systematic collection of behavioral response data in real-time

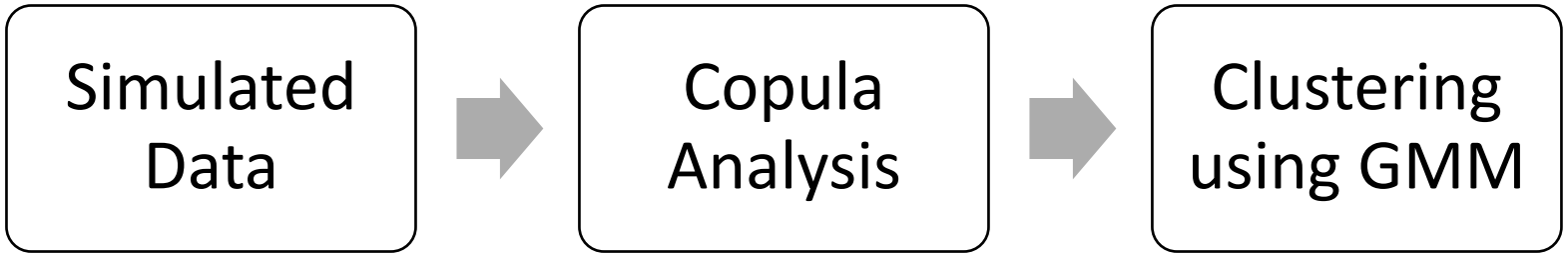
Study Objective

Study Objective

To investigate the effect of texting on driving by means of a driving simulator experiment on a group of young drivers. In particular the aim of the study is to analyse the effect of texting combined with road characteristics (urban & rural network), traffic (normal & increased traffic conditions) and environmental conditions (good weather, rainy weather, nighttime).

Methodological Approach

Methodological Approach



- A **2-step** approach was followed:
- Multivariate Copula Analysis: Describes the interrelation of several random variables → **(1)** Reveals stochastic dependence relationships among variables

$$F(x_1, \ldots., x_d) = C(F_1(x_1), \ldots. F_d(x_d))$$

- Gaussian Mixture Modelling: Used at the events of texting to **(2)** cluster the data in order to investigate stochastic nonlinear patterns in driving

Driving Simulator Experiment

Driving Simulator Experiment

- To capture the phenomenon of distracted driving posed by texting, a driving simulator experiment was employed
- Driving simulators enable the study of hazardous behaviors in a safe environment, without exposing participants and third parties to risk
- Different driving scenarios can be developed to educe behaviors and individual driver characteristics, in situations that could not be investigated in real-word situations, given their safety level or cost
- Simulators systematically generate accurate data in real-time about the driver, the vehicle, and its position in the simulated environment

Experimental Setup

Experimental Setup

- The test group consisted of 34 young drivers aged between 18-28 years old with an average driving experience of 3.5 years
- Participants used their own mobile phones in order to be familiar with the device
- Different scenarios were examined, in order to capture the effect of texting and investigate whether it is stable under different conditions
- Four 5-minute drives were carried out:
    1. Test drive to be familiarized with the simulator
    2. Driving under good weather conditions
    3. Driving under rainy weather conditions
    4. Driving during night time

Experimental Setup (Scenarios)

Road Network

- Urban
- Rural
- Motorway

Traffic Conditions

- Normal
- Increased

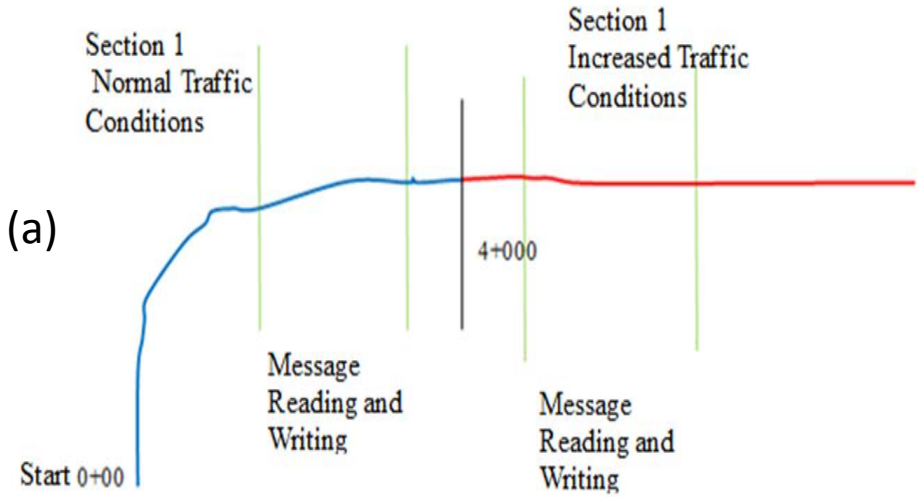
Environmental Conditions

- Good Weather
- Rainy Weather
- Nighttime

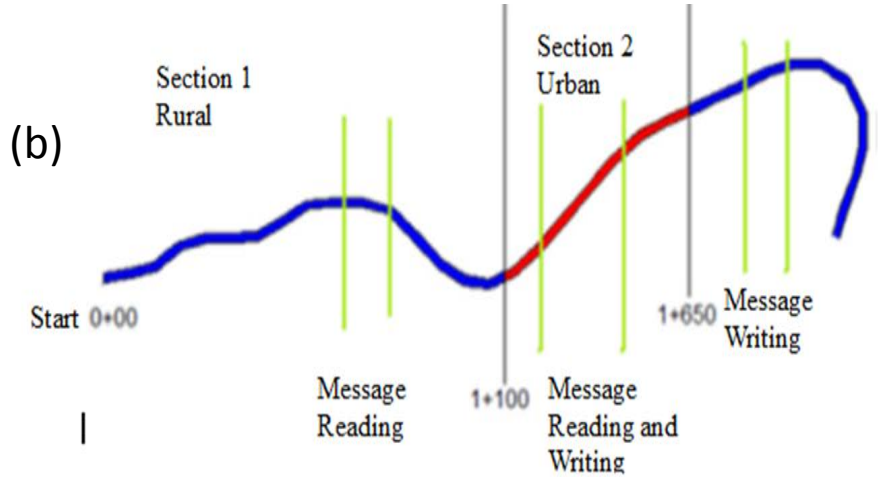
Texting

- Reading SMS
- Composing SMS

Experimental Setup (Drives)



Motorway



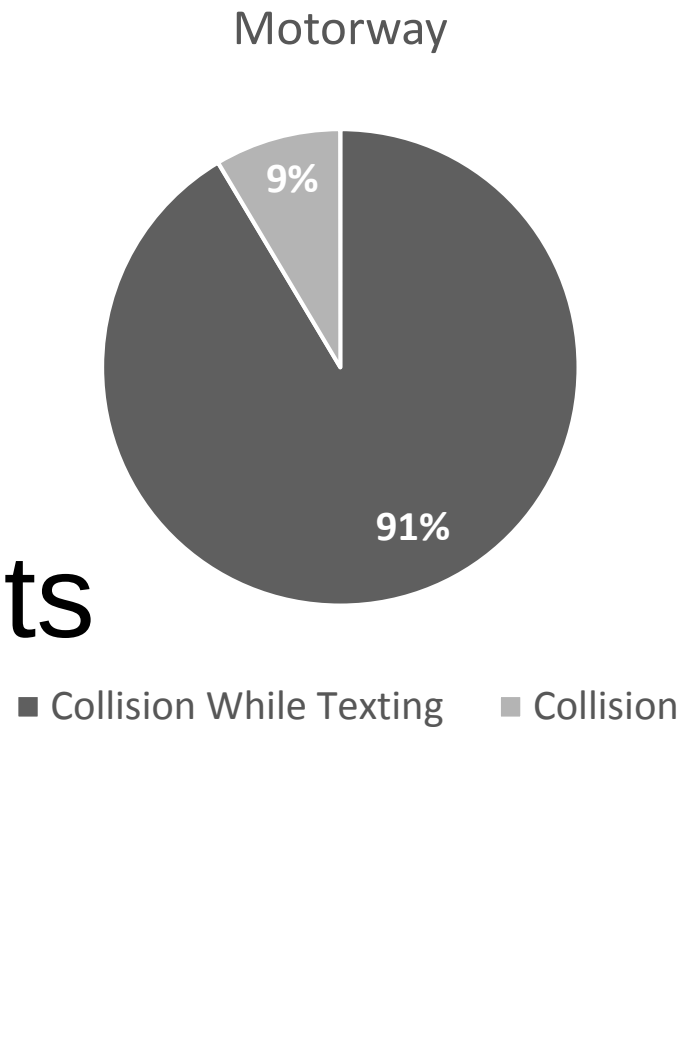
Urban & Rural

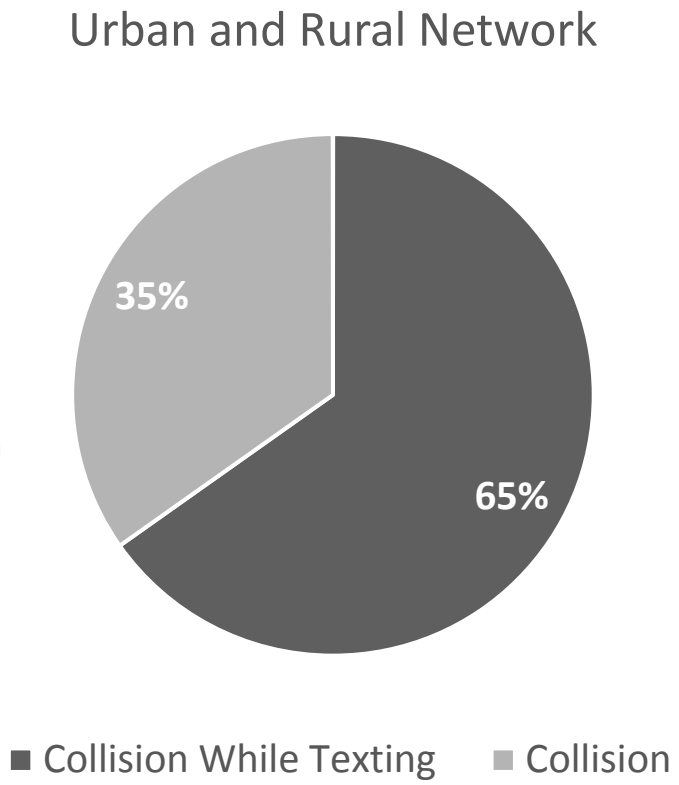
Methodology – Variables Set

Environment	Rainy	Rainy Weather (1: yes, 0:no)
	Good	Good weather conditions (1:yes,0:no)
	Night	Driving During Night (1:yes, 0:no)
Vehicle Position	DLeft	Distance from the left road border (m)
	DRight	Distance from the right road border (m)
	Rspur	Track of the vehicle from the middle of the road (m)
Driver	Speed	Vehicle Speed (km/hr)
	THead	Time to Headway i.e to collision with the ahead driving vehicle (s)
	RT	Reaction Time (s)
Device Type	Touch	Mobile phone with a touch screen (1:yes,0:no)
Driver Actions	In_Free	Free driving in Urban environment (1:yes,0:no)
	In_Read	Reading message in Urban environment (1:yes, 0:no)
	In_Write	Composing message in Urban environment (1:yes, 0:no)
	Out_Free	Free driving in Rural environment (1:yes,0:no)
	Out_Read	Reading message in Rural environment (1:yes, 0:no)
	Out_Write	Composing message in Rural environment (1:yes, 0:no)
	Free_Q1	Free driving in Normal Traffic conditions (1:yes,0:no)
	Read_Q1	Reading message in Normal Traffic conditions (1:yes, 0:no)
	Write_Q1	Composing message in Normal Traffic conditions (1:yes, 0:no)
	Free_Q2	Free driving in Increased Traffic Conditions (1:yes,0:no)
	Read_Q2	Reading message in Increased Traffic Conditions (1:yes, 0:no)
	Write_Q2	Composing message in Increased Traffic Conditions (1:yes, 0:no)

The variable set consists of all the elements required to capture the driving behavior of the young drivers who text while driving

Results


Motorway
9%
91%
Collision While Texting
Collision


Urban and Rural Network
35%
65%
Collision While Texting
Collision

Results – Copula Analysis

- Provided linear correlation (ρ) between variable pairs
- ρ ranges from |0.06| ;no correlation to |0.75| ;strong correlation
- Discretisation between subset of drivers who were engaged in a collision and drivers who were not
- Strongest correlations were presented between lane excursions and speed (**Speed-Dleft, Speed-Dright**)
- Different values of ρ between the same variable pairs when comparing free driving, reading an sms and composing an sms
- Different variable pairs present the strongest correlations in the different conditions examined

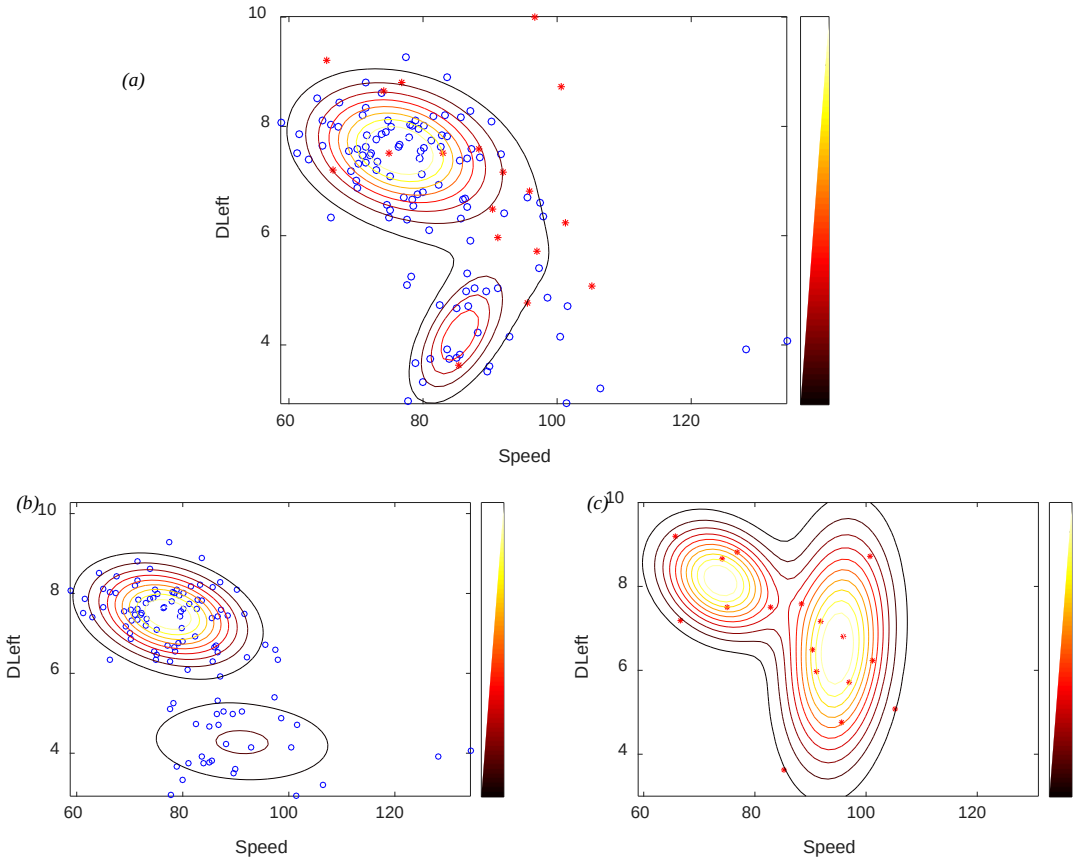
Results – Copula Analysis

		Driver Actions							
		Full Set		Free Driving Subset		Reading Text Subset		Composing Text Subset	
Scenario	Drive Description	Selected Copula	ρ	Selected Copula	ρ	SelectedCopula	ρ	Selected Copula	ρ
No Collision Subset									
Urban Env.	Full Set	Speed/ RT	-0.17	Speed/ RT	-0.16	**Speed/ DLeft**	**-0.17**	**Speed/ DLeft**	**-0.14**
	Good Weather	Speed/ RT	-0.21	RT/ DRight	-0.33	**Speed/ DLeft**	**-0.26**	RT/ DRight	-0.55
	Rainy Weather	RT/ rspur	0.27	RT/ DLeft	0.48	RT/ DLeft	0.35	**Speed/ DRight**	**-0.60**
	Nighttime	Speed/ RT	-0.23	RT/ rspur	-0.20	RT/ DRight	-0.10	**Speed/ DLeft**	**-0.42**
Collision Subset									
Urban Env.	Full Set	Speed/ RT	-0.19	Speed/ DLeft	-0.40	**Speed/ DLeft**	**-0.38**	**Speed/ DRight**	**-0.09**
	Good Weather	Speed/ DLeft	-0.43	--	--	**Speed/ DRight**	**0.58**	**Speed/ DRight**	**0.40**
	Rainy Weather	RT/ DLeft	0.18	--	--	Speed/ rspur	-0.54	RT/ DLeft	0.19
	Nighttime	Speed/ RT	-0.26	--	--	RT/ DRight	0.65	**Speed/ DRight**	**-0.42**

Results – Gaussian Mixture Modelling

- Identified clusters of driving patterns when discretized in the subgroups of drivers who were (a) engaged in a collision; (b) not engaged in a collision
- Presented patterns associated with riskier driving behaviors when engaged in texting while driving, as the use of a mobile phone was associated with poorer driving behaviour

Results- Gaussian Mixture Modelling



Normal Conditions (a) All observations; (b) No collisions; (c) Collisions

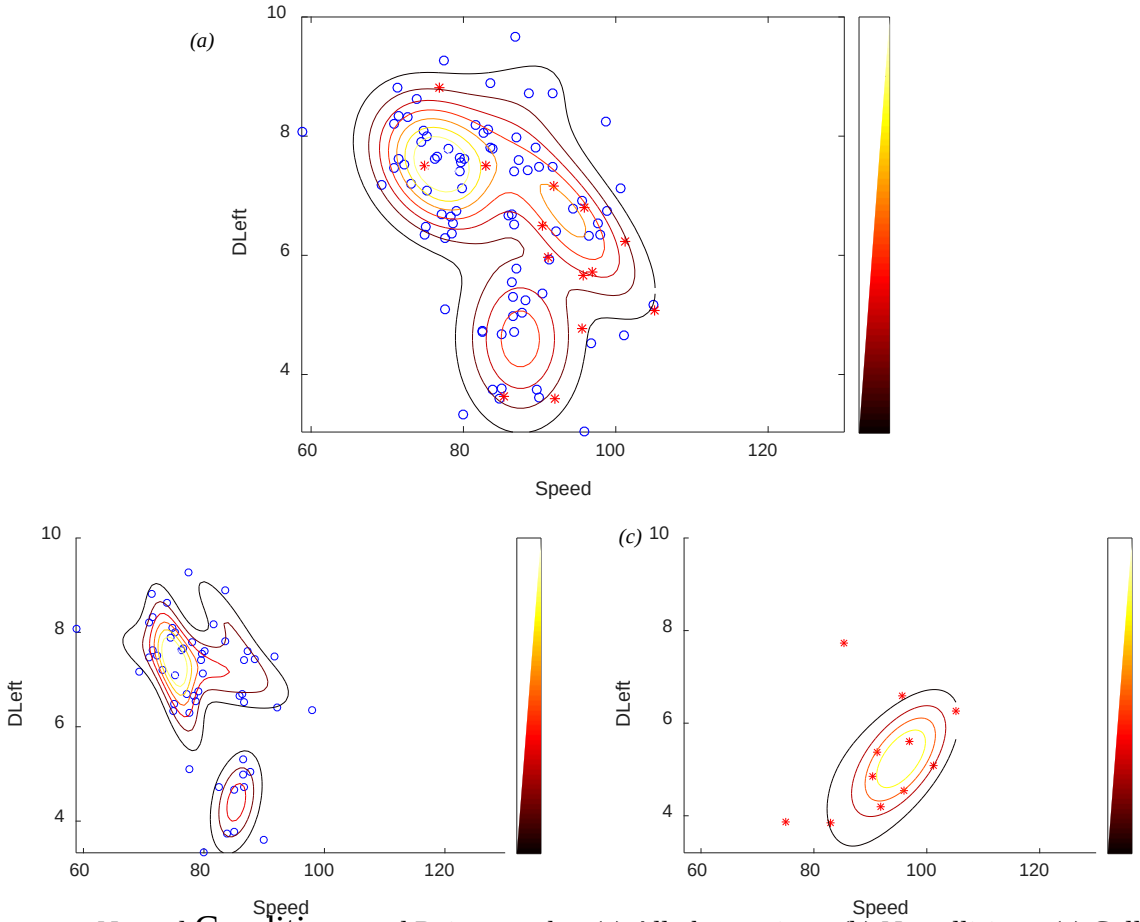
<u>Scenario: Motorway, Drive: Normal Traffic and Good weather conditions → Variable pair: Speed-DLeft</u>

a) When modelling all observations of texters at once, collision events and non-collision events overlap

b) Non-collision events form two main clusters where lower speeds are associated with larger distances from the left border *(slow lane)* and higher speeds with smaller distances from the left boarder *(overtaking lane)*

c) Collision events form two main clusters, where lane maintenance problems are clear

Results- Gaussian Mixture Modelling

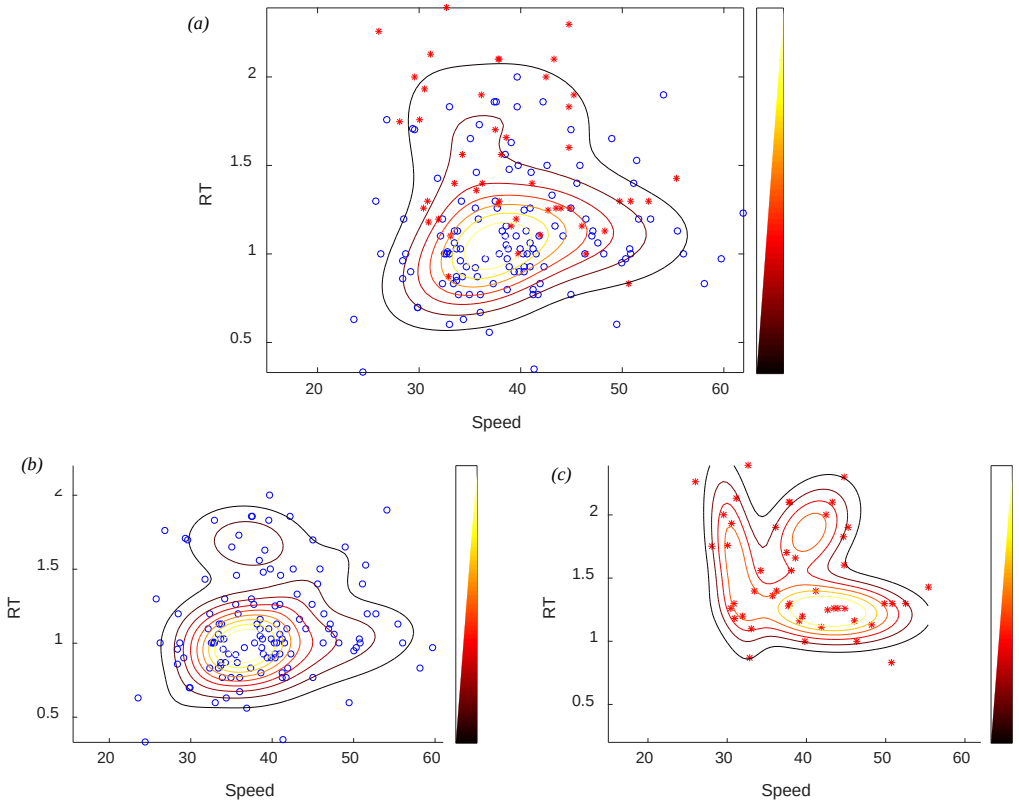


Normal Conditions and Rainy weather (a) All observations; (b) No collisions; (c) Collisions

<u>Scenario: Motorway, Drive: Normal Traffic and Rainy weather conditions → Variable pair: Speed-DLeft</u>

a) When modelling all observations of texters at once, collision events and non-collision events overlap
b) Non-collision events form two main clusters where lower speeds are associated with larger distances from the left border *(slow lane)* and higher speeds with smaller distances from the left boarder *(overtaking lane)*
c) Collision events form one main cluster, where speeds are high and lane maintenance problems are clear

Results - Gaussian Mixture Modelling

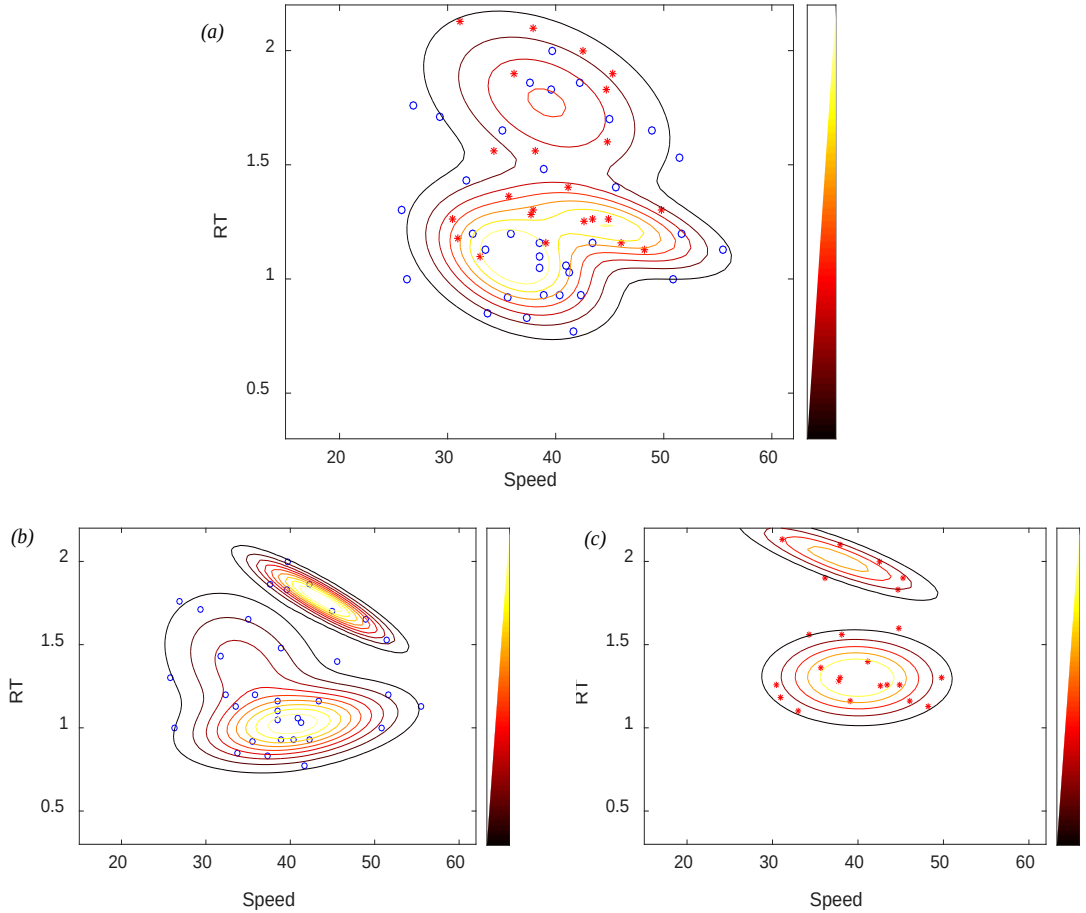


Rural Environment (a) All observations; (b) No collisions; (c) Collisions

<u>Scenario: Rural Network, Drive: Good Weather Conditions → Variable pair: Speed-RT</u>

a) When modelling all observations of texters at once, collision events and non-collision events overlap
b) Non-collision events form one main cluster where the highest pdf is presented at lower speeds and a RT≈1 second
c) Collision events form one main cluster, where both speed and reaction time are higher

Results - Gaussian Mixture Modelling



Rural Environment and Rainy weather (a) All observations; (b) No collisions; (c) Collisions

<u>Scenario: Rural Network, Drive: Rainy Weather Conditions → Variable pair: Speed-RT</u>

a) When modelling all observations of texters at once, collision events and non-collision events overlap
b) Non-collision events form two main clusters where lower speeds are associated with lower reaction times and higher speeds with higher reaction times
c) Collision events form two main clusters, where reaction times are presented to be higher when compared to non-collision events

Conclusions and Outlook

Conclusions and Outlook

- This study provides evidence that texting while driving is a distracting activity and likely crash-inducing driving behavioral patterns are presented
- The analysis is based on simulated data, which are able to represent driving behavior and allow the investigation of behavioural patterns under different scenarios
- The presented 2-step methodological approach followed, captures the stochasticity in the phenomenon but also facilitates the understanding of the phenomenon by identifying the behavioural patterns emerging through the different scenarios investigated
- Copula analysis results present the stochasticity of the data, however findings exhibit that there exists strong correlation between speed and lane maintenance when drivers text and drive
- Clustering using GMMs identified clusters of driving patterns based on whether drivers were engaged in a collision or not
- As a point of outlook, the proposed approach in analysing data can be expanded in models of statistical analysis or artificial intelligence

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