Driver Response to Gear Shifting System in Motion Cueing Driving Simulator

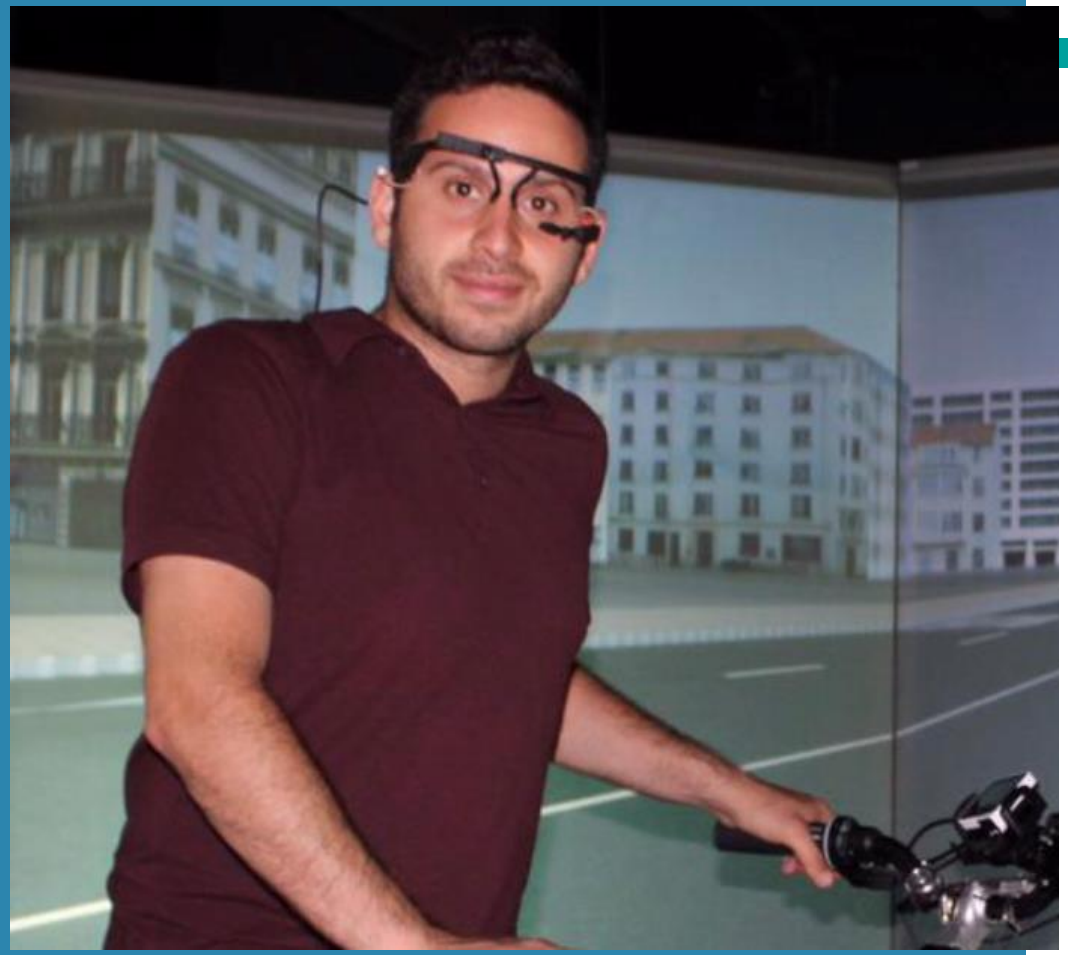
Navid Ghasemi [1], Hocine Imine[2], Claudio Lantieri [1], Andrea Simone[1], Valeria Vignali[1] , Roland Brémond[2]

[1]Department of Civil, Chemical, Environmental and Materials Engineering (DICAM),

University of Bologna

[2]The Perceptions, Interactions, Behaviours & Simulations Lab for road and street users (PICS-L),
Gustave Eiffel University

Contact Email: navid.ghasemi3@unibo.it

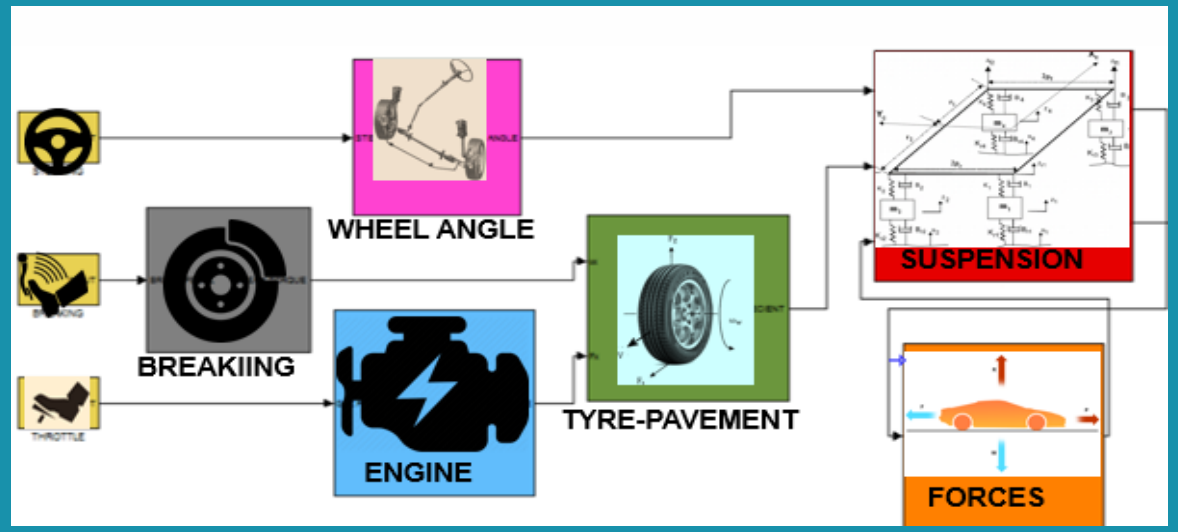


Navid Ghasemi

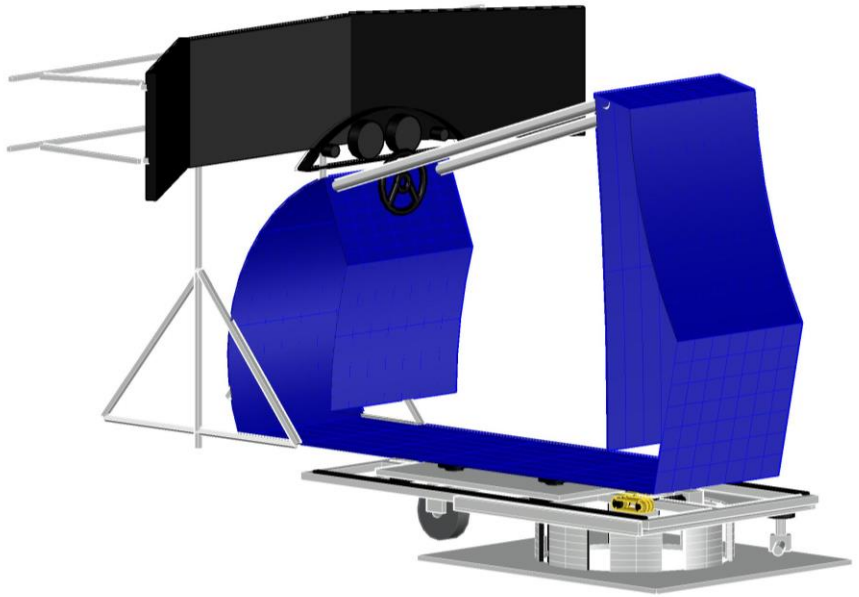
Navid Ghasemi is a Postdoctoral Researcher at the Department of Civil, Chemical, Environmental and Materials Engineering (DICAM) in the University of Bologna. He received his co-tutelle Ph.D. in signal, Image and Automatic from Pairs-Est University and in Civil Engineering from road department (DICAM) at University of Bologna.

His research interests includes Driver Behaviour, Road Safety and Sustainable Mobility.

Motion Cueing in Driving Simulation



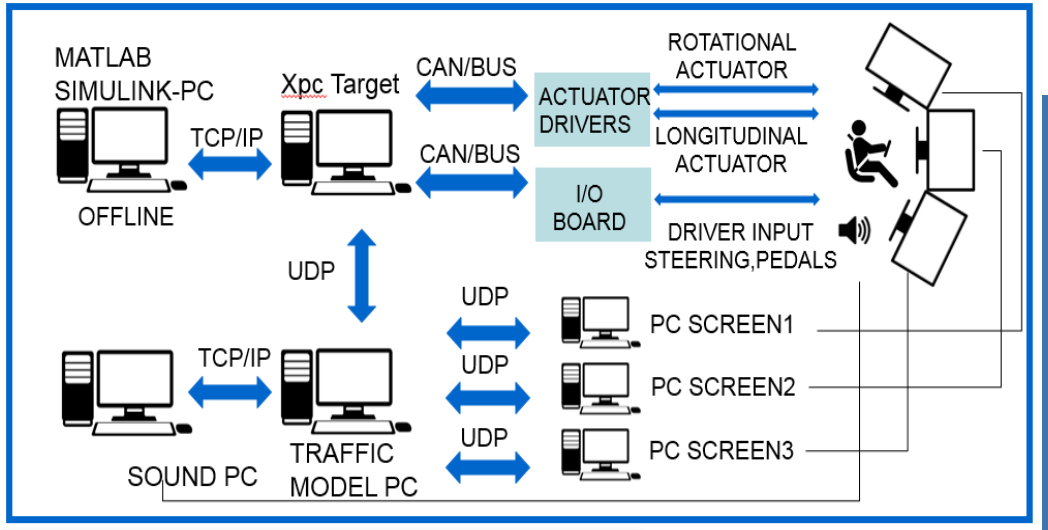
Vehicle dynamic model is essential!



- Produce accurate vehicle dynamics
- Provides Necessary input for motion cueing
- Comparable results with the real road

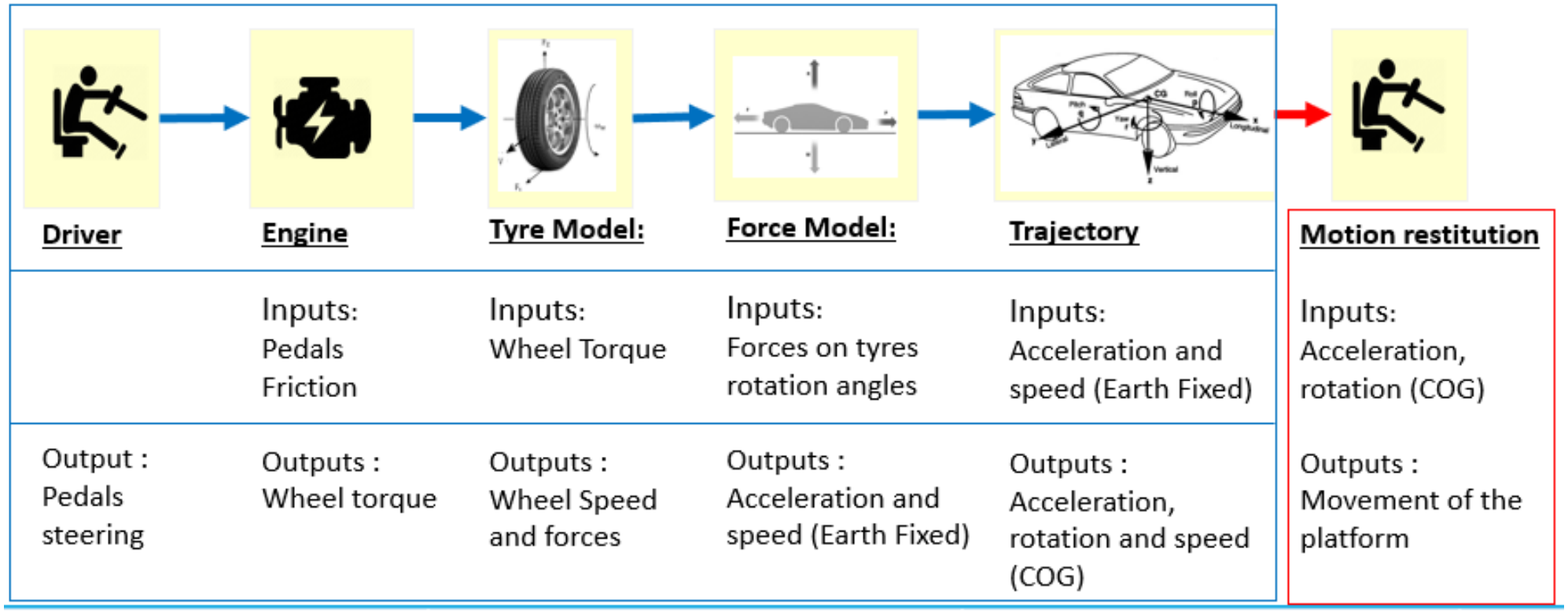
Simulacet Driving Simulator Architecture

- The “Simulacet” driving simulator is designed with a 2 DOF motion platform.
- The visual image is provided by the means of three HD fixed LED screens.
- Sound cues are provided with speaker



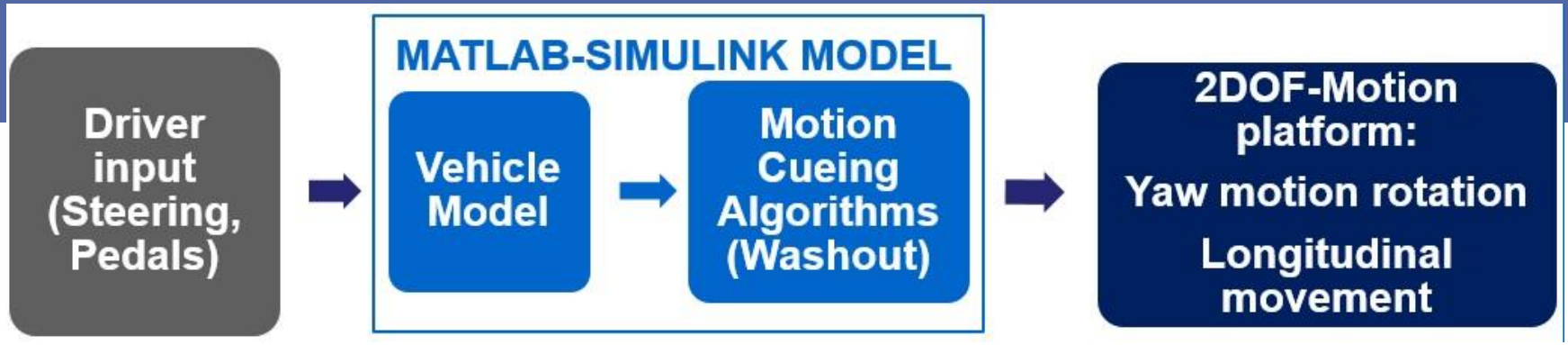
Simulation Model

The vehicle model is implemented in MATLAB-SIMULINK, which calculates the vehicle states in real-time (1000 Hz) using the inputs from the driver cabin.



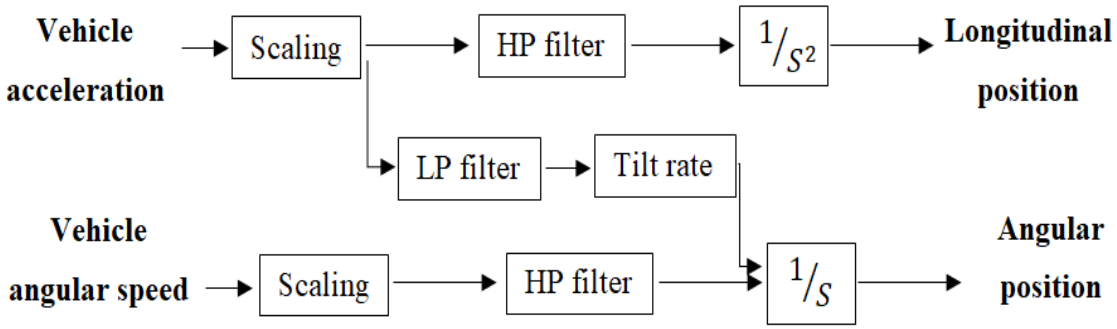
Driver	Engine	Tyre Model:	Force Model:	Trajectory	Motion restitution
	Inputs: Pedals Friction	Inputs: Wheel Torque	Inputs: Forces on tyres rotation angles	Inputs: Acceleration and speed (Earth Fixed)	Inputs: Acceleration, rotation (COG)
Output : Pedals steering	Outputs : Wheel torque	Outputs : Wheel Speed and forces	Outputs : Acceleration and speed (Earth Fixed)	Outputs : Acceleration, rotation and speed (COG)	Outputs : Movement of the platform

Motion Cueing Algorithm



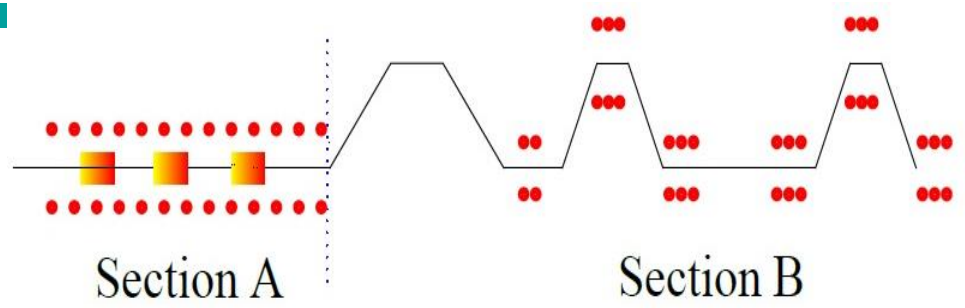
Classical Motion Cueing Algorithm Developed considering :

- Keep the platform within the physical limitations.
- Reproduce accelerations.
- Return the motion platform to zero position for the next movement, under participants perception threshold

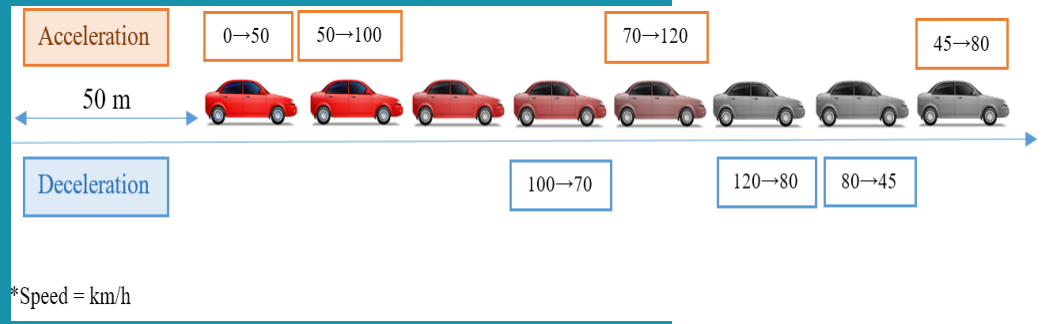


$$\frac{\ddot{x}_s(s)}{a_x(s)} = \frac{s^3}{(s^2 + 2\xi_1\omega_1 + \omega_1^2) * (s + \omega_2)}$$

Experiment Driving Task

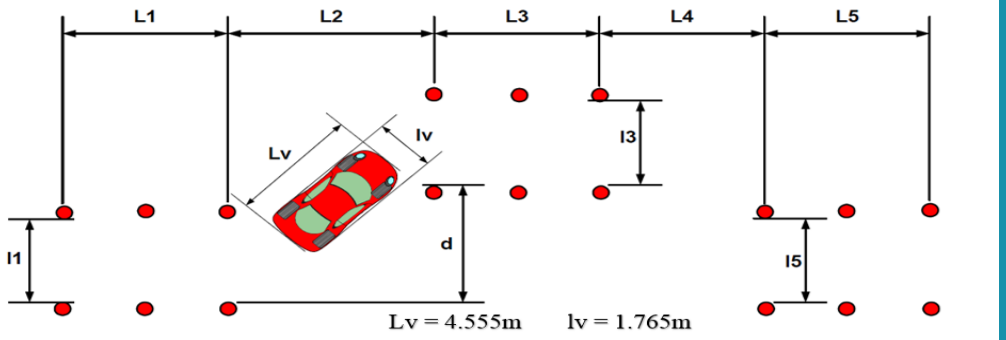


Section A: following the lead vehicle



*Speed = km/h

Section B: Take Over and two Chicane Maneuver



L1	*L2*	*L3*	*L4*	*L5*	*l1 (1.1lv+0.25m)*	*l3 (1.3lv+0.25m)*	*l5 (1.2lv+0.25m)*	*d*
15m	30m	25m	25m	30m	2.2m	3.5m	2.4m	3.5m

Scenarios: Gear Shifting System

Scenario 1:

Manual

Gear Shift

Scenario 2:

Sound assisted

Gear Shift

Scenario 3:

Automatic

Gear Shift

Comparison of subjective and objective driver response

Results: Subjective Assessment

SIMULATION EVALUATION QUESTIONNAIRE

- The participants were satisfied with the motions in the simulator for the automatic session,
- During the movement on the second chicane with higher speed, in the manual and assisted scenario most of the users were undecided

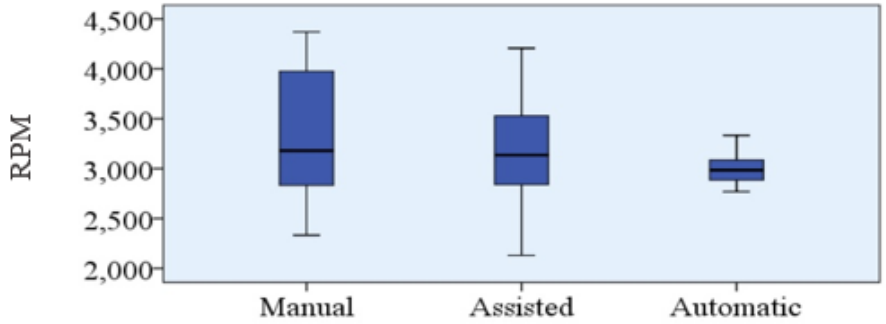
SIMULATOR SICKNESS QUESTIONNAIRE

- All Sessions belongs to no symptom's category regarding the median.
- Considering the mean, the, "Assisted" and "Automatic" Sessions makes negligible symptoms, whereas the "Manual" session illustrates more simulation sickness symptoms

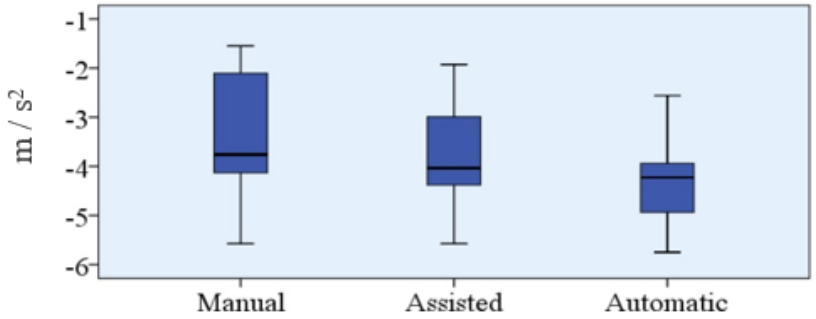
Questionnaire : 5 point Likert scale	Scenarios		
	1	2	3
1. I had a realistic driving experience	4	4	4
2. I drove as I normally would	4	4	4
3. Cabin movements were realistic	4	4	4
4. Cabin movements helped control the car	3	3	4
5. In the overtaking maneuver, the movements of the cabin were realistic	4	4	4
6. The movements of the cabin did not cause me any problem when I had to go back to the straight line after the chicane	4	4	4
7. The movements of the cabin in the first chicane were realistic	4	4	4
8. The movements of the cabin in the second chicane were realistic	3	3	4
9. The movements of the cabin in turning were not exaggerated compared to those of a real car	4	4	4
10. While accelerating, the movements were realistic	4	4	4
11. While braking, the movements were realistic	4	4	4
12. When accelerating and braking immediately, the cabin movements were realistic	4	4	4
13. When braking and accelerating immediately, the cabin movements were realistic	4	4	4
14. The movements were pleasant and not troublesome	4	4	4

Results: Objective Assessment

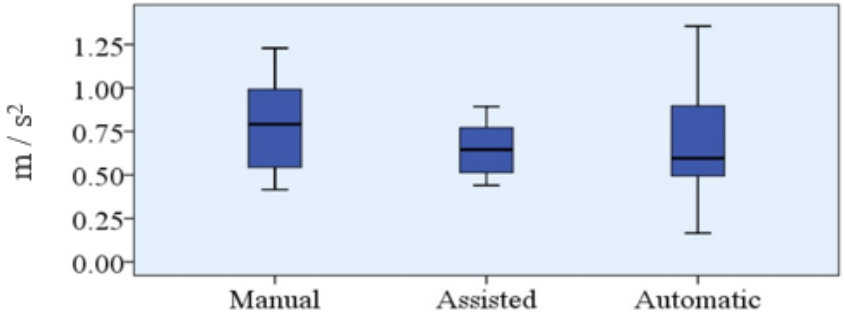
- RPM: No significant difference between the scenarios.
- Maximum longitudinal acceleration was only different during the first braking.
- Maximum lateral acceleration were not significantly different.



Maximum engine RPM in section B



Maximum Longitudinal braking at braking in Section A



Maximum lateral acceleration at chicane in Section B

Conclusions and Future Work

- Motion cueing feedback was favorable by the participants and increased the immersion in the virtual environment.
- The investigation of the motion platform accelerations showed no significant difference in driver control input and output of the vehicle model with different gear shifting scenario.
- In conclusion it can be say that drivers tend to adapt very fast to the driving simulator condition.

Authors

Hocine Imine

Claudio Lantieri

Valeria Vignali

Roland Bremond

Andrea Simone

Navid Ghasemi