The Influence of the feedback control of the hexapod platform of the SAAM dynamic driving simulator on neuromuscular dynamics of the drivers

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Context

Multi sensorial cues (visual, auditory, haptic, inertial, vestibular, neuromuscular) [Angelaki 2009] play important roles to represent a proper sensation (objectively) and so a perception (subjectively as cognition) in driving simulators. For a similar situation, the driver has to react in the same way as in reality in terms of 'self motion'. To enable this behavior, the driving simulator must enhance the virtual immersion of the subject in the driving situation.

Aim of the Study

This study addresses the simulator motion sickness as a correlated function of this deviation for the both cues with the perception questionnaires as well as the EMG analysis results for the subjects who joined in those experiments with respect to the motion platform control type such as; open loop controlled (classical motion cueing algorithm) and closed loop controlled (adaptive motion cueing algorithm) hexapod platform.

Motion Sickness

"Motion Sickness Dose Value" is one of the methods used to objectify the subjective motion sickness ratings and has been defined in accordance with ISO 2631-1 1997 [Griffin 1990]). In this work, an illness rating method, derived from motion sickness dose value, has been utilized. Eq. 1 gives the mathematical expression of the Motion Sickness Dose Value (MSDV).

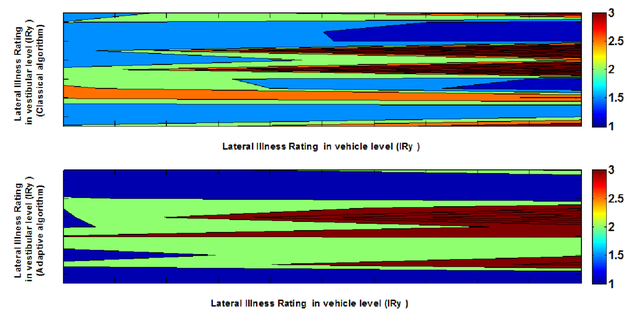
$$MSDV = \left[\int_0^t a_{wf}^2(t).\,dt\right]^{0.5} \ [m/s^{1.5}] \qquad (1)$$

MSDV: Motion sickness dose value (ISO 2631-1 1997 [$m/s^{1.5}$]
a_{wf}: frequency weighted acceleration, [m/s^2]
t : exposure time (in seconds)
The equation above with an analogy can be expanded for roll, longitudinal and lateral acceleration to assess the motion sickness dose value sourcing from the roll, longitudinal and lateral dynamics within the driving simulators.

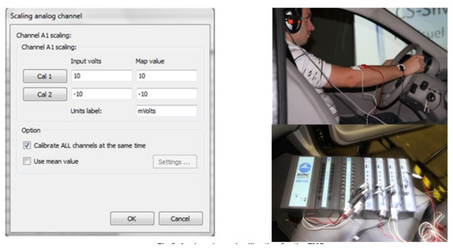
- Illness Rating (IR) deduced from MSDV is the following function:

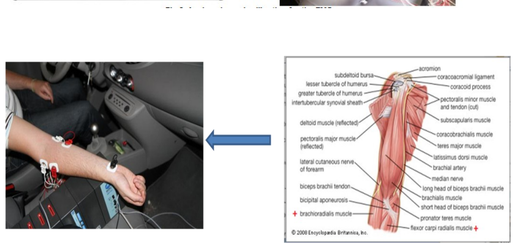
$$IR = \frac{1}{50}.MSDV$$

- RGB contour comparison of vestibular to vehicle level lateral illness ratings for the fourteen participants

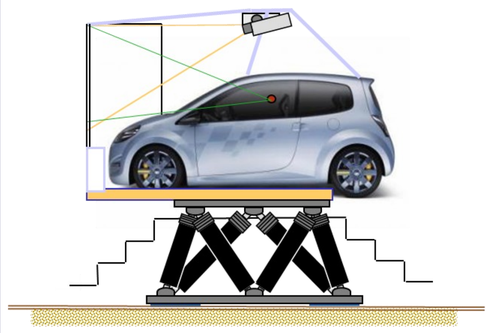


According to the yielded results of IR in [$m/s^{1.5}$]
IR = 0: I felt good -> ***(blue)***
IR = 1: I felt a mild illness -> ***(blue)***
IR = 2: felt very bad -> ***(green-yellow)***
IR ≥ 3: I felt absolutely terrible -> ***(red)***





EMG RMS Power Analysis for arm muscles

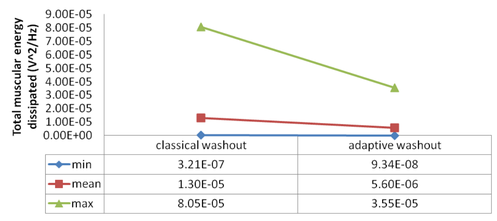


A 6 DOF motion platform

- Subjects' cumulative EMG Total Power Analysis with respect to feedback controlled platform dynamics

$$Accumulated\ total\ power = \int_0^{Epoch} \frac{V^2}{f}\, dEpoch$$

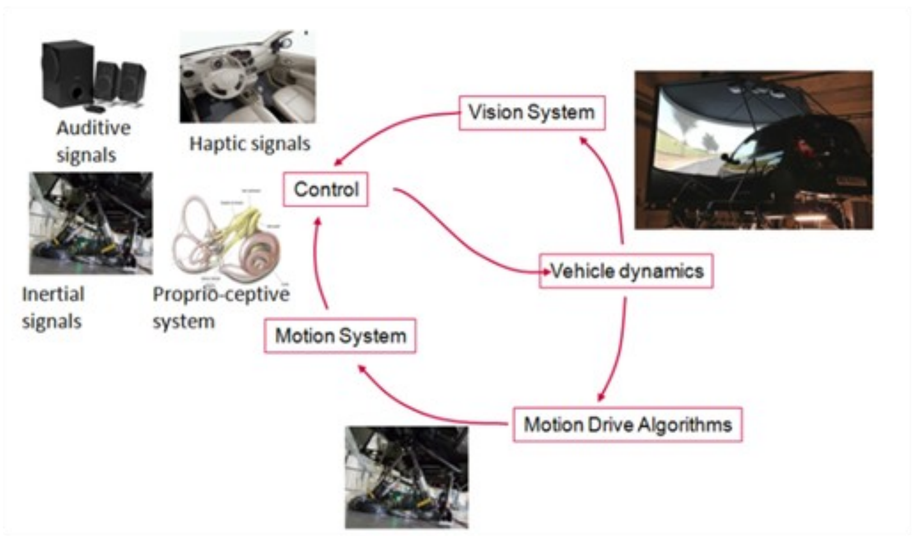
V: electric potential in volts
Epoch: sample
f: frequency in Hz.



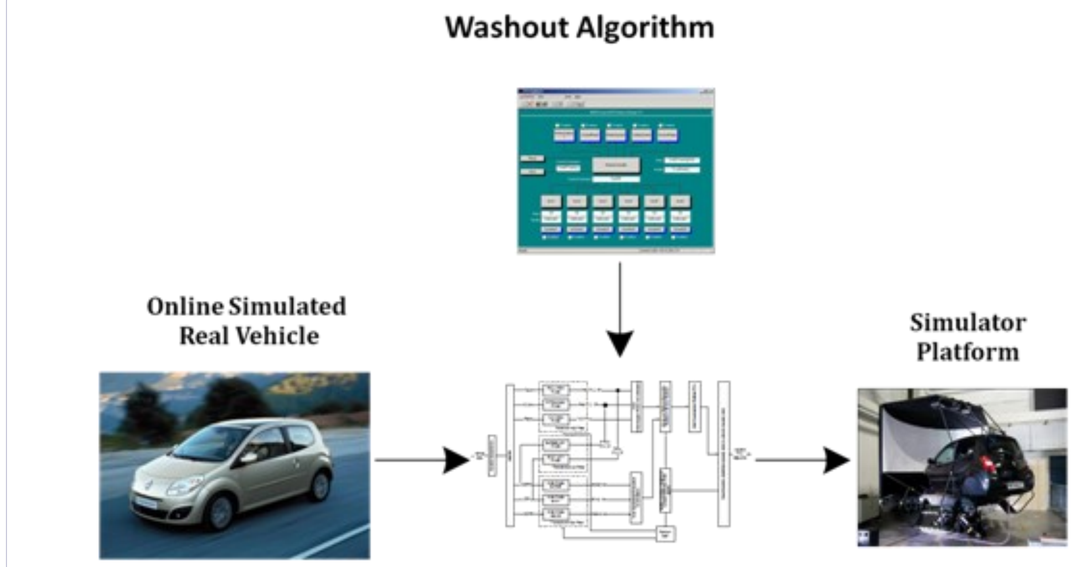
	classical washout	adaptive washout
min	3.21E-07	9.34E-08
mean	1.30E-05	5.60E-06
max	8.05E-05	3.55E-05

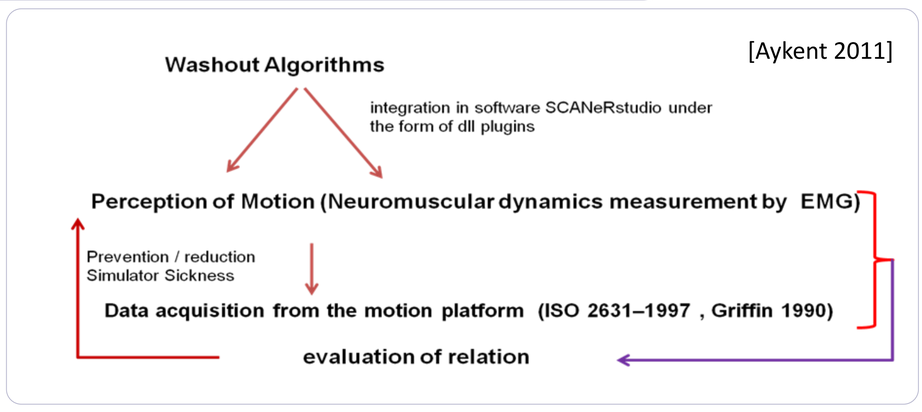
Approach to Reduce Simulator Sickness [Aykent 2011]

- Structure of the dynamic simulator [Aykent 2011]

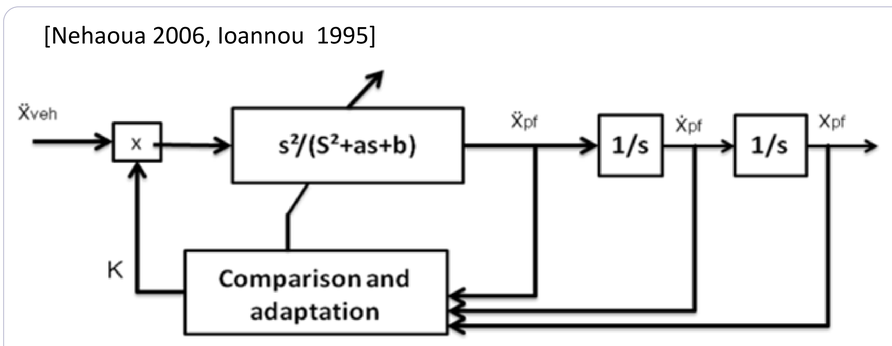


- Control of the motion platform to reduce the simulator sickness [Aykent 2011]

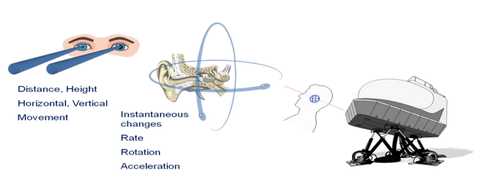


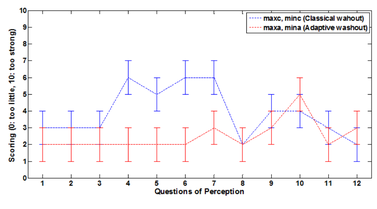


[Aykent 2011]



- Subjective Evaluation





- Questionnaire on the perception due to psychophysics

	Expression of the question	Rating
Q1	Were you prone to vomit?	(0: too little → 10: too strong)
Q2	Did you feel nausea?	(0: too little → 10: too strong)
Q3	Did you have a cold sweat?	(0: too little → 10: too strong)
Q4	Did you feel dizziness?	(0: too little → 10: too strong)
Q5	Did you feel eyestrain?	(0: too little → 10: too strong)
Q6	Did you have eyes trouble?	(0: too little → 10: too strong)
Q7	Did you have a headache?	(0: too little → 10: too strong)
Q8	Did you feel mental pressure?	(0: too little → 10: too strong)
Q9	Did you fear?	(0: too little → 10: too strong)
Q10	Were you bored?	(0: too little → 10: too strong)
Q11	Were you tired?	(0: too little → 10: too strong)
Q12	Did you feel anxiety (uneasiness)?	(0: too little → 10: too strong)