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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Short Summary

Multi sensorial cues (visual, auditory, haptic, inertial, vestibular, neuromuscular) [Ang2] 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. The subject has to perceive the motion of his own body in the virtual scene of the virtual car as he will have in a real car. For that reason, restituting the inertial cues on driving simulators is essential to acquire a more proper functioning [Kol15]. Simulation sickness has been one of the main research topics for the driving simulators. It has been assessed between dynamic and static simulators [Cur5], [Wat24]). For a braking maneuver; [Sie22] stated that if the motion platform is activated, the bias in reaching increased levels of decelerations was reduced strongly comparing to inactivated platform case. However, there have been a few publications of vehicle-vestibular cue conflict based illness rating approach and its correlation with the neuromuscular dynamics for that kind of research. In order to reduce the simulator sickness, the difference between the accelerations through the visual and the vestibular cues have to be minimized (cost function minimization via model reference adaptive control, in this paper). Because of that fact, this paper 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. Due to the restricted workspace, it is not possible to represent the vehicle dynamics continuously with scale 1 to 1 on the motion platform [Moo17]. Nevertheless, the most desired aim is to minimize the deviation of the sensed accelerations between the represented dynamics as realistic as possible depending on the driving task. This research work has been performed under the dynamic operations of the SAAM driving simulator as an open-loop and a closed-loop controlled tracking of the hexapod platform of the SAAM dynamic driving simulator. The dynamic simulators are being used since the mid 1960s (Stewart platform) [Ste23] firstly for the flight simulators, then the use has spread to the automotive applications. The dynamic driving simulator SAAM (Simulateur Automobile Arts et Métiers) involves a 6 DOF (degree of freedom) motion system. It acts around a RENAULT Twingo 2 cabin with the original control instruments (gas, brake pedals, steering wheel). The visual system is realized by an approximate 150° cylindrical view. Within the cabin, the employment of extensive measuring techniques (XSens motion tracker, and Biopac EMG (electromyography) device [Acq1]) are equipped, which have been already used with numerous attempts such as sinus steer test, NATO chicane, etc.

The visual accelerations of translations (longitudinal X, lateral Y and vertical Z axes) as well as the visual accelerations of roll and pitch, which correspond to the vehicle dynamics, have been taken into account for the control. Then the platform positions, velocities and accelerations have been controlled and fed back to the vehicle level, in order to minimize the conflict between the vehicle and the platform levels. The research question about this paper explains a comparative study between an open and a closed loop controlled platform in order to determine the spent power by the muscles to maintain the vehicle pursuing among the pylons with real time controls of the platform at a longitudinal velocity of 60 km/h.

This research has indicated that the vehicle to vestibular level's representation is near to 1:1 with an adaptive controlled platform. And also; the peak values for dizziness, eye strain, eyes trouble and headache for the classical strategy have coincided greater values which mean a higher level of sickness. Accumulated EMG total power analysis denotes that; the minimum, mean and the maximum cumulative EMG RMS (root mean square) total powers have been reduced from the proposed classical washout to our adaptive control drastically. Having a closed loop feedback control of the platform has decreased the IR level with respect to the open loop controlled platform. Pearson's *r* depicts that having a classical algorithm (open loop control) causes more discrepancy (sensorial conflict) in multisensory interaction (vestibular-vehicle) compared to the adaptive control. When evaluating the association of the EMG total power with psychophysics, a Pearson's *r* differences which are more

than 0.1 are the *significant* characteristics; vomit, nausea, cold sweat, eye strain, mental pressure, having tired. Only for the eye strain, the classical algorithm is agreeable. Because it has coincided the bigger oscillations with respect to the adaptive strategy. Because of the decreasing discrepancy in multisensory cues for the closed loop control; the orientation related (vomit, nausea) and emotions related (cold sweat, mental pressure, tired) sicknesses are more agreeable whereas the eye strain has been worse in the case of adaptive control which might be exerted by having a less conflict in multisensory, so that the participants could have been more related with the visual environment. As prospective, we will report and publish different coupling and decoupling variations with different types of degrees of the freedom (7 and 8 DOF) and their effects on the drivers' as well as the passengers' behaviors.

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