Letter from the Special Issue Editors

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Special Issue on Enhancing Motion Comfort on Passenger and Commercial Autonomous Vehicles for Securing Their Acceptance

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Automated driving is one of the major technological developments in the automotive industry, which influences future mobility and improves quality of life. Based on research surveys, there are suggestions that Level 3 and 4 autonomous vehicles (AVs) will be widely deployed in the short term and that, by 2040, AVs will likely constitute approximately 50% of vehicle sales and 40% of all vehicle travel. At the same time, important challenges still need to be overcome to prevent the disuse of AV technology and to ensure AVs become part of our daily life. Consumers consider the ability to engage in other activities during the ride to be one of the key reasons for adoption of AVs. However, engagement in non-driving activities will contribute to occupants' motion sickness (MS). According to a survey performed across several countries, 25% of adults riding in fully self-driving vehicles would be expected to often, usually, or always experience some level of MS. This special issue emphasizes motion comfort as a key factor when considering the impact of AVs.

MS and motion comfort are affected by multiple factors. The level of motion comfort, including the likelihood of MS, depends on the motion perception of the occupants, which includes the sensory conflicts between the visual, the somatosensory, and the vestibular systems. These are strongly affected by the vehicle motion (e.g., direction, amplitude, frequency, and duration of the vibrations experienced by the occupant), the occupant's situational behaviors (e.g., drug or alcohol use, mental activity, and cognitive load), and dispositional susceptibility (e.g., experience, posture, age, gender, and ethnicity). However, existing models fail to accurately predict motion comfort, especially in automated driving where more factors will affect it. At the same time, because of the multitude of factors affecting motion comfort, solutions concerning both vehicle dynamics and human factor aspects should be considered.

To address these questions, the special issue editors have invited authors from different sectors across academia and industry. The articles investigate fundamental questions regarding the factors affecting motion comfort and potential solutions toward the mitigation of MS and the enhancement of comfort.

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In the first article, Cyriel Diels et al. highlight principal research questions and the need for common protocols for the assessment of MS in automated vehicles. So far, the assessment of MS is conducted mainly using the International Standard ISO 2631-1 (1997), which assesses the likelihood of MS as a function of vertical motion input only. However, in the context of automated vehicles, where the horizontal accelerations have proven to affect more MS and where the engagement in non-driving-related activities in AVs will be the norm, the current standard is of limited use. At the same time, modulating factors that affect the MS levels (such as vision, anticipation, passenger orientation, and reclination angles) are not considered, while consistent protocols to assess MS are absent. Hence, the authors propose the identification and development of appropriate vibration measurements and MS assessment and evaluation methods.

In the second article, Adrian Brietzke et al. point out the importance of investigating the frequency of MS and its correlation with the occupant's dispositional susceptibility to extrapolate their effects for future mobility systems. By using three surveys conducted from 2015 to 2020, gender and age showed a strong influence on the frequency of MS. Moreover, the authors used a logistic order regression model to assess the MS frequency for different user personas. According to the results, the risk of MS occurring during an automated journey is reduced based on the current user demands.

In addition to human factor aspects related to MS, the special issue investigates solutions to enhance motion comfort and mitigate MS in future mobility. Although vehicle dynamics factors play an important role in the likelihood of MS, there is not extensive literature on the subject. Few works have recently investigated the motion planning for mitigating MS. In this vein, Muhammad Rehan Siddiqi et al. develop ergonomic paths using transition curves such as three-point B-splines and Non-Uniform Rational B-Splines (NURBS). Then, the various paths are assessed with regard to passenger MS and vehicle handling behavior. According to the analysis, the use of three-point NURBS is suggested.

To achieve better motion comfort, Nathan D. Spike et al. investigate the optimization of the maneuver length for obstacle avoidance across the range of friction surfaces (packed snow, gravel, and pavement). Also, a process for determining a calibration table for maneuver length for a specific velocity is outlined. In the optimization configuration, the authors consider the vehicle controllability and passenger's comfort through appropriate constraints, while the MS has been performed in simulation and refined with hardware results from an automated test vehicle.

Even if motion planning is considered to be one of the main countermeasures to enhance motion comfort in AVs, the excessive reduction of speed to minimize MS can have a negative impact on user satisfaction due to longer journey times. Hence, acceptance and subjective comfort will decrease. Therefore, additional approaches to mitigating MS should also be considered without affecting journey time. Along these lines, this special issue includes two papers prompting novel seat designs that could enhance motion comfort in future AVs.

In the first of these articles, Xiangjun Xia et al. propose a disturbance observer-based event-triggered $H\infty$ controller for a semi-active seat suspension equipped by an advanced electromagnetic damper system. The performance of the proposed controller is also validated with experiments. According to the results, the proposed controller not only can save the communication resources of data transmission in $H\infty$ controllers but also can work as a filter to increase motion comfort.

Finally, Georgios Papaioannou et al. propose a novel active seat suspension (ActiveK) that operates according to a passive isolator with negative stiffness elements (K-Seat). The passive isolator has proven to enhance comfort but has difficulties in design, which can be overcome with ActiveK-Seat. The ActiveK-Seat is benchmarked against multiple seat models and is proven superior not only with regard to ride comfort but also for its ability to mitigate MS while the vehicle is driving on a real road path.

The special issue editors believe that this special issue on "Enhancing Motion Comfort on Passenger and Commercial Autonomous Vehicles for Securing their Acceptance" provides great insights regarding motion comfort and suggests novel solutions for its enhancement. Hence, it should be of great interest for both academic and industry communities working on automated driving technologies and human factors in AVs.

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