CHAPTER 6
MOTION SICKNESS EFFECT USING LATERAL CONTROL

Sarah 'Atifah Saruchi, Mohd Hatta Mohammed Ariff,
Mohd Azizi Abdul Rahman, Nurbaiti Wahid, and Nurhaffizah Hassan

6.1 INTRODUCTION

While driving on curvy roads, the direction of head tilt movement with respect to the direction of lateral acceleration has a strong influence on the susceptibility to motion sickness (MS) (Konno et al., 2010; Wada et al., 2012). The passengers have a higher severity level of MS than the drivers because the passengers tend to tilt their heads in the same direction with the lateral acceleration when the vehicle turned into a corner. In contrast, under the same situation, the drivers normally tilt their head to the opposite of the lateral acceleration direction. It has been proven that a correlation existed between the head tilt movement and lateral acceleration. The head tilt is measured by observing the response of head roll angle. The degree of head roll angle has an effect on the level of MS. Based on the relationship between head roll angle, lateral acceleration and MS level, it is understood that MS will increase if the head roll angle towards lateral acceleration is large and decreases, vice-versa.

Based on the vehicle dynamics perspective, MS occurs in a low frequency of vertical oscillation, fore-and-aft oscillation and lateral oscillation environments (Donohew & Griffin, 2009; Joseph & Griffin, 2007).

On the other hand, pure roll oscillation is not provocative towards MS. Vertical oscillation causes MS particularly in sea, while the fore-and-aft and lateral oscillations are responsible for MS in road transport (Donohew & Griffin, 2004). Turner and Griffin (1999) stated that the factor of MS is the low frequency of lateral oscillation which is caused by the steering. The frequency is between 0.1 Hz until 0.5 Hz. The same author proved the existence of a correlation between lateral acceleration and MS level. The lateral acceleration which resulted from the driver's turning method is the main root cause of MS. Therefore, it can be concluded that a bigger lateral acceleration will lead to a higher level of MS.

Combining these two factors of MS occurrence in terms of occupant's and vehicle dynamic perspectives, it can be concluded that the wheel's turning, lateral acceleration, head tilt movement and MS level are correlated to each other. The excessive wheel's turning will produce a higher lateral acceleration which will then cause a larger head roll angle towards the lateral acceleration direction. In this situation, the MS level will be increased. Thus, it is understandable that the main origin of MS is the inappropriate driver's turning skills when dealing with curves.

In conventional vehicle, the driver can enhance their driving skills through practices and experiences. However, for autonomous vehicles, the application of a MS mitigation system is necessary to avoid the excessive turns, hence, prevent the production of a high lateral acceleration.

Despite the path tracking control system integration with a computationally demanding system, this study is concerned with finding a simpler way to improve the vehicle lateral system. The main origin of the lateral motion is from the steering movement (Utbult, 2017). Thus, this study proposed a control system that combines the wheel angle generated from the path tracking controller with an additional corrective wheel angle. Basically, the additional wheel corrector design is the same with the configuration of the well-known active front steering (AFS) control system, whereby a corrective angle is computed based on the selected controlled variables.

Based on the correlation between occupant's head roll angle and vehicle lateral acceleration, the main contribution of this study is the proposal of head roll angle as the controlled variable that leads to an additional corrective wheel angle into the vehicle system. The objective of the corrective angle is to improve the lateral control system by reducing the lateral acceleration of the vehicle. In traditional vehicle dynamics, lateral acceleration, especially during cornering poses a challenge to maintaining passenger comfort and safety. High lateral acceleration forces can cause discomfort, reduce vehicle stability, and increase the likelihood of MS.

As mentioned earlier, drivers experienced less MS because they tend to tilt their head against the lateral acceleration direction. Thus, the driver's head roll angle response is regarded as a reference to the passenger's head roll angle and treated as the desired response. In addition, the passenger's head roll angle response is considered as the actual controlled response. In the control structure design, there is a non-negligible problem arises that need to be solved. The concern is in the indefinite values or amount of the driver's and passenger's head roll angles towards and against the lateral acceleration direction during cornering. An autonomous vehicle does not involve a driver; therefore, the prediction or estimation of the driver's head roll angle is compulsory. Moreover, it is also crucial to predict the passenger's head roll angle since it is impractical and inappropriate to attach the motion sensors on the passenger's heads throughout travelling.

As mentioned earlier, it is evidenced that the occupant's head roll angle is correlated with the vehicle lateral acceleration during curve driving. Thus, the estimation of the head roll angle can be realised by establishing a model that represents the correlation. The model will then be used as the head roll angle predictor based on the lateral acceleration information. The model can be derived by using a predictive modelling technique. Machine learning (ML) is capable to develop prediction model regardless of the data complexity, the presence of complicated nonlinear interactions and a large amount of data (Bzdok et al., 2018).