Control for Motion Sickness Minimisation in Autonomous Vehicles

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Introduction

Autonomous vehicles (AVs) are expected to become a wide scale deployment for public use in the very near future. **"**Motion sickness**"** plays a key role for the successful introduction of vehicle being full automation. The increase in the susceptibility in motion sickness is due to loss of vehicle control and the ability to anticipate the direction of movement. This project aims to implement a control strategy that could minimise motion sickness in autonomous vehicles.

Motion Sickness

It is marked by symptoms of nausea dizziness, and other physical discomfort. It is resulted from a sensory conflict between inputs from visual, vestibular and somatosensory systems of human body. This conflict then triggers the brain to falsely identify a toxin in the body, with nausea and vomiting a protective response to get rid of it.

"Your eyes tell your brain that you are sitting still, but your vestibular system tells your brain that you are travelling at more than 30 miles an hour."

It is a complex phenomenon and could not be explained with single cause and simply defined mechanisms. Factors involving in motion sickness are: motion environment, non-motion environment, mental activity, drugs, alcohol, age, gender, experiences etc. The main principal cause of motion sickness in road vehicles are closely related to the low frequency,(0.1< f < 0.5 Hz) accelerations. Three main accelerations: fore-and-aft, lateral and yaw acceleration

Motion sickness estimation

(1) British standard 6841 / International standard 2631

The empirical formulation that estimate motion sickness without considering sensory conflicts but the motion environments. This method was developed from experimental researches. It methods calculated predicted illness rating (PIR) as a form to identify motion sickness.

$$PIR(t) = \frac{1}{50}\left(\int_0^T (a_w(t))^2 dt\right)^{\frac{1}{2}}$$

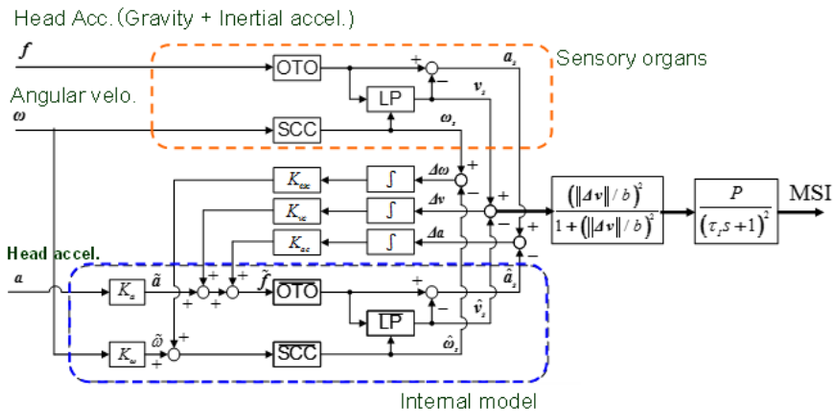
Where PIR is the predicted illness rating

$a_w(t)$ is the weight acceleration

T is the duration time

(2) Sensory conflict model (6 DOF-SVC model)

The 6 DOF subjective vertical conflict model involves vestibular system and considers the inter-vestibular conflict between semicircular canal (SCC) and otolith (OTO). It has been modified to represent motion sickness as when the sensed vertical, v_s (sensed gravity) is at variance with the subjective vertical, $\hat{v}_s$ (expected gravity). MSI is the motion sickness incidence.



Methodology

It is define as optimisation problem such that by developing an objective function as well as defining the required constrains, the optimal solution is generated on which motion sickness is minimised. $\min\{\boldsymbol{Motion\ sickness}\}$

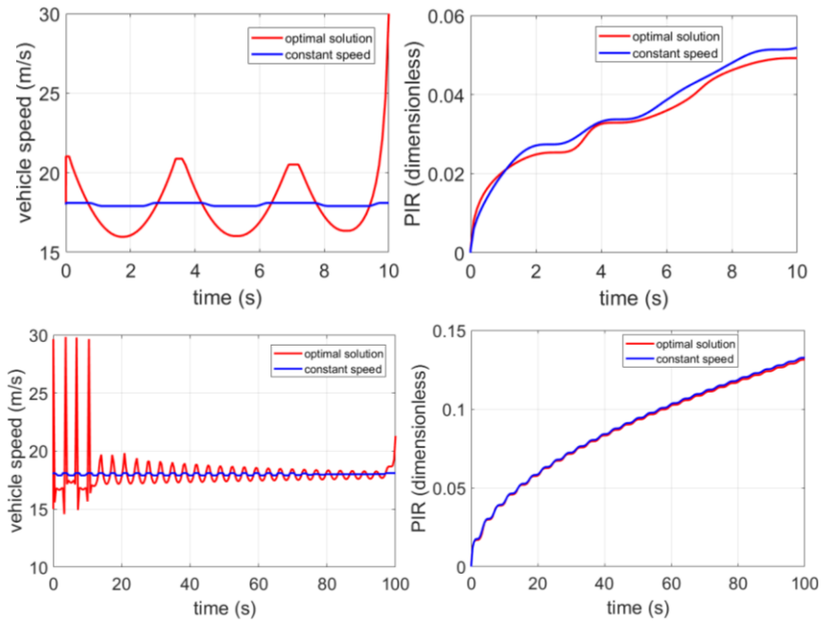
s.t.. vehicle dynamics

path, time, distance bounds

torque, speed, steering limits bounds

Examples

So far, the initial study for developing optimisation algorithm was done on using PIR to represent motion sickness as the cost function. The result gives an average of 6% reduction for short duration journey time (10s) and 0.7% reduction for longer journey time (100s).



Limitations and Future Works

- As shown in example results, PIR values would never decrease over time as it is the integral over time of squared accelerations. Thus present a limitation of such method.
- An optimisation algorithm for 6 DOF-SVC model would be develop to incorporate the sensory dynamics.
- The project would ultimately utilise control theory to implement a control strategy such that the passengers are guaranteed with minimum motion sickness by generating optimum control input to prevent the vehicle entering low frequency lateral motion especially when travelling in winding road and roundabout. More importantly without affecting journey time.