DESIGN AND DEVELOPMENT OF HAPTIC INFORMATION SYSTEM IN AUTOMATED DRIVING VEHICLE TO MITIGATE MOTION SICKNESS

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DECLARATION

I declare that this project entitled "Design and development of haptic information system in the automated driving vehicle to mitigate motion sickness" results from my work except as cited in the references.

Signature : …….

Name : ……..……

Date : …….

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature : …….

Supervisor's Name : Dr Nidzamuddin bin Md Yusof

Date : …….

DEDICATION

This report is dedicated to

my lovely mother (Norzahwati binti Ismail),

all my friends

and

my supervisor for this project (Dr Nidzamuddin bin Md Yusof)

for every possible kind of help and support.

ABSTRACT

An automated driving vehicle is a vehicle capable of driving itself without human interaction by sensing the environment. A driver can do non-driving related tasks such as working, eating, and more. However, drivers' involvement in these tasks will lead to mismatch between sensory organs and cause motion sickness. It led to discomfort and unpleasant feeling when driving an automatic driving vehicle. This project presents the design and development of a haptic information system in the automated driving vehicle to mitigate motion sickness. This project focuses on designing a device that can give earlier information about the direction and prevent misalignment of the driver. The development starts with finding information from the previous study and make a concept design. In this project, three conceptual designs were suggested, and the best design was selected. SolidWorks software has been used for detailed design and documentation of the device. The on-field study will then be conducted, and questionnaires will be given to participants to obtain the data about motion sickness susceptibility, situation awareness, and behavior in the vehicle. It is expected that the device can reduce motion sickness by increasing situational awareness and correcting the posture. The device can help the driver to do the non-driving activities while driving in an automatic driving vehicle.

***Keyword**: automated driving vehicle, motion sickness, situation awareness, gravito-inertial force, haptic*

ABSTRAK

Kenderaan memandu automatik adalah kenderaan yang mampu memandu sendiri tanpa interaksi manusia dengan menganalisis persekitaran. Pemandu boleh melakukan tugas yang berkaitan dengan pemanduan seperti bekerja, makan dan banyak lagi. Namun, penglibatan pemandu dalam tugas ini akan menyebabkan konflik antara organ deria dan boleh menyebabkan mabuk. Ia menimbulkan rasa tidak selesa ketika memandu kenderaan memandu automatik. Projek ini memaparkan reka bentuk dan pembangunan sistem maklumat haptik dalam kenderaan memandu automatik untuk mengurangkan mabuk. Projek ini berfokus kepada mencipta peranti yang memberi maklumat mengenai perubahan arah dan menghalang ketidakseimbangan kedudukan pemandu. Projek dimulakan dengan mencari data dari kajian sebelumnya dan membuat reka bentuk konsep. Dalam projek ini, tiga konsep dicadangkan dan konsep yang terbaik akan dipilih. Perisian SolidWorks telah digunakan untuk reka bentuk terperinci dan dokumentasi. Kemudian kajian lapangan akan dijalankan dan soal selidik akan diberikan kepada peserta untuk mendapatkan data mengenai tahap mabuk, kesedaran situasi dan keadaan diri di dalam kereta. Hasil menjangkakan bahawa alat ini dapat mengurangkan mabuk dengan meningkatkan kesedaran situasi dan memperbaiki postur. Peranti ini dapat membantu pemandu melakukan aktiviti tanpa memandu semasa memandu dalam kenderaan memandu automatik.

***Kata kunci**: kenderaan autonomi, mabuk, kesedaran situasi, daya graviti-inersia, haptik*

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LISTS OF ABBREVIATION

ADAS	-	Advanced driver assistance system
ADS	-	Automatic driving system
CAD	-	Computer Aided Design
CAE	-	Computer Aided Engineering
GIF	-	Gravito-inertial force
LiDAR	-	Sensor light detection and ranging
MSSQ	-	Motion Sickness Susceptibility Questionnaire
MSAQ	-	Motion Sickness Assessment Questionnaire
NHTSA	-	National Highway Traffic Safety Administration
SAE	-	Automotive Engineer’s Society
SPSS	-	Statistical Package for the Social Sciences
VOR	-	Vestibuloocular Reflex

CHAPTER 1

INTRODUCTION

In this chapter, the background of this study is described according to the title and project preview. The problem statement of this project, objectives, and scope are explained clearly.

1.1 Background

Automated driving vehicles or autonomous vehicles are vehicles that can be driven without or with only the driver's remote participation. These vehicles use sensors and navigation systems to avoid obstacles and move at a certain speed without accidents. They can analyze the road's changing conditions to predict future conditions and drive with a low risk of an accident. These vehicles are also called autonomous because they do not require the presence of the driver. Companies like Tesla, Mercedes, Uber, and Google are experimenting with a relatively new concept to develop an automated driving vehicle and be the first to profit from the emerging technology.

The automated driving vehicle can reduce risky and dangerous driver behaviors that can lead to an accident to the unbelted vehicle occupants, speeding, and distraction. Next, the occupants could do more productive or entertaining activities, such as reading, socializing with friends or family, and watching movies to fill their journey time (Sivak and Schoettle, 2015).

However, occupants tend to feel discomfort and experience motion sickness while doing the activity (Diels and Bos, 2017). This experience could lead to symptoms such as dizziness, nausea, sweating, headaches, drowsiness, stomach awareness, and vomiting due

to disturbance of their sense of balance by motion in the vehicle. The occupants might experience motion sickness when their focus is on the activity, and automatically their awareness of the surroundings will decrease. They cannot predict the change of vehicle direction, acceleration, deceleration, and cornering. This can lead to a conflict between the visual system and the vestibular system where the information they feel differs from the information they see (Md Yusof *et al.*, 2017). This is called sensory conflict theory. This is one of the theories on how the motion sicknes is developed.

This study will explore more about the involvement of situation awareness in motion sickness and how they affect each other. The study also looks into methods on how to increase situation awareness when doing non-driving related tasks. A device is developed using a haptic feedback system by sending a piece of information to the driver before changing in direction to increase driver awareness of the surrounding. This device also will be correcting the occupants's position in cornering.

1.2 Problem statement

Automated driving vehicle technology is set to become the most significant evolution in the autonomous industry. It enables the occupant to do a task such as reading, watching movies, working, and more. However, these non-driving related tasks usually require passengers' focus off the road and situation awareness about the surrounding will decrease. This can lead to the conflict in the sensory organ, which is a conflict between vestibular and visual sensors. This conflict occurs when the information from what we see (visual) is different from what we feel (vestibular). The mismatch between this information might give an effect, which is motion sickness when riding in this vehicle. Motion sickness can lead to discomfort and many other symptoms. So, the occupant cannot enjoy the activities while in the vehicle.

1.3 Objectives

This project aims to design and develop a haptic information system in the automated driving vehicle to mitigate motion sickness. The aim is achieved through these objectives:

- To understand the relationship between situation awareness and motion sickness (sensory conflict theory) in a moving vehicle
- To design a haptic device with an active movement that can prevent the misalignment of the occupant's posture
- To analyze the effectiveness of the device on the real-road condition

1.4 Scopes

To ensure that the project is completed as set out in the objectives, which is to design and develop a haptic information system in automated driving vehicle to mitigate motion sickness, the study's scope was therefore proposed to ensure that the project flow is well managed.

- The design will be done in CAD software, including analysis of strength on any critical part.
- The developed device is only for passenger front seat.
- A conventional vehicle will be used to imitate as automated driving vehilce vehicle for real road test.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this process, a comprehensive summary of previous research on a topic is made by reviewing scholarly articles, books, and other sources relevant to a particular research area. The literature review's essential components are a description of publications, a summary of the authors' viewpoint, and discussion and evaluation of the authors' contribution to the topic. The literature review aims to provide a review of writing on specific topics to achieve a unique understanding, specifically for this project. It also helps find proof about the solution based on the previous research and observation of the topic. In this project, all the information and data about automated driving and motion sickness are obtained from the internet, journal, books, and article. All these research papers can be accessed on Google Scholars.

2.1.1 Internet

Internet research is the practice of using Internet information, especially free information on internet-based resources. Internet research can provide quick, immediate, and worldwide access to library research (focusing on library-bound resources) to commercial database research. For example, there are many articles nowadays are uploaded online by the authors on a website. Next, data from a particular issue from a specific country also can be found on the internet. The data is relevant and valid as long as it is from a trusted source such as a government website or professional organization.

2.1.2 Journal, articles, books

Journal articles, research articles, and books are a primary source when writing a literature review. Journal article is a collection of articles that is published regularly throughout the year. Journals present the most recent research, and researchers or experts write journal articles. A research article is a report based on an original study performed by the authors. The research could be an experiment, survey, interview, and observation. It varies on the authors themselves. Books are written by researchers mainly for use by other researchers, educators, students, and more. Books are used for identifying various areas of interest within a more extensive subject; meanwhile, journals and research papers are more focused on a particular topic. These sources can help find information from previous research about the problems, causes, possible solutions, and implementations of motion sickness in an automated driving vehicle

Figure 2.1 show the process in the literature review, benefit, and problem driving self-driving vehicle, which is motion sickness.

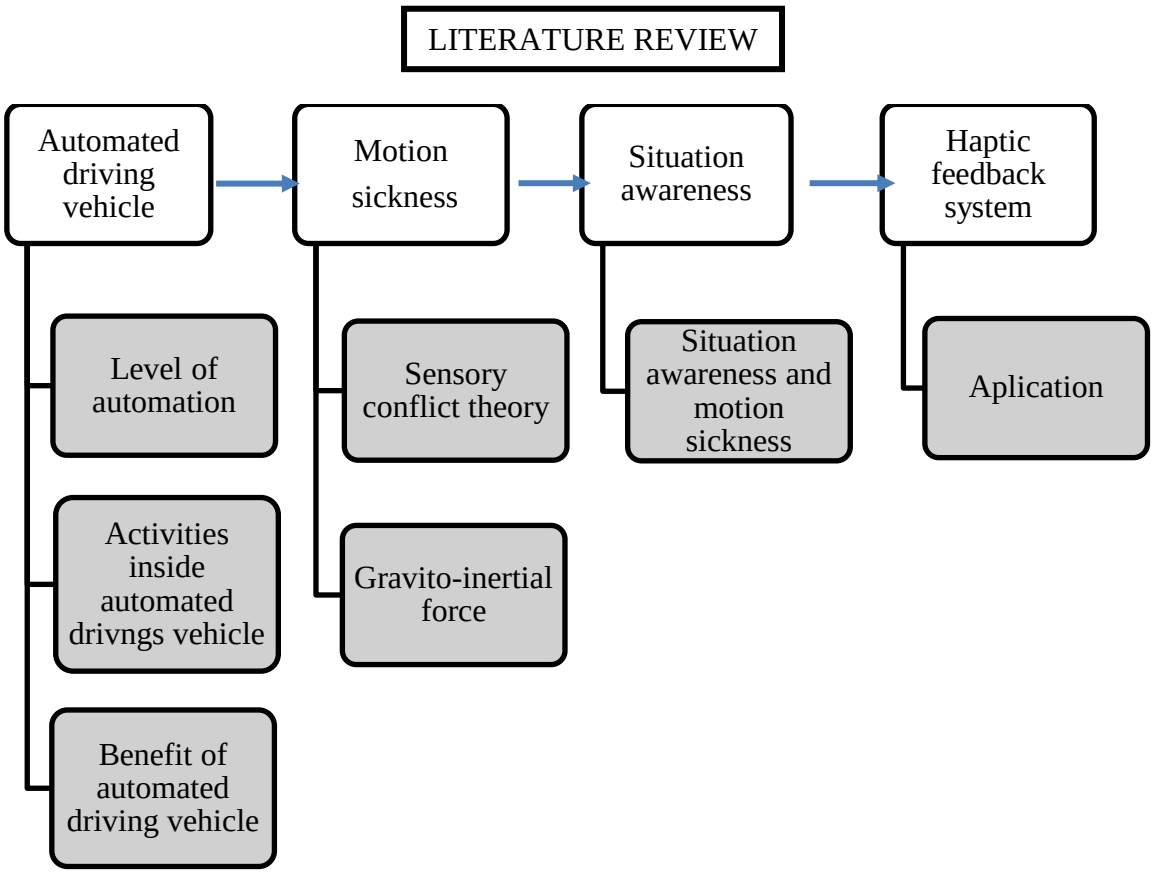

Figure 2.1: Process in the literature review

2.2 Automated driving vehicle

An automated driving vehicle is a vehicle capable of sensing and functioning without human intervention in its environment. A occupants inside the vehicle doesn't need to control the car every time. Therefore, they are likely to occupy themselves with non-driving tasks that require their sight off from looking outside, such as reading, socializing with friends or family, and watching movies to fill their journey time (Sivak and Schoettle, 2015).

2.2.1 Level of automated driving vehicle

According to National Highway Traffic Safety Administration (NHTSA) (2011), they categorize vehicle operations into five levels, ranging from full-manual (level 0), function-specific automation (level 1), integrated automation (level 2), restricted self-driving automation (llevel 3) to full-automated driving (level 4) (Figure 2.2). Meanwhile, the Automotive Engineers' Society (SAE) has adopted the automation level standard J3016. This defines six driving automation stages, ranging from SAE level zero (no automation) to SAE level 5 (full automation vehicle). It serves as the most cited industry benchmark for automated vehicle capabilities (Jennifer, 2019).

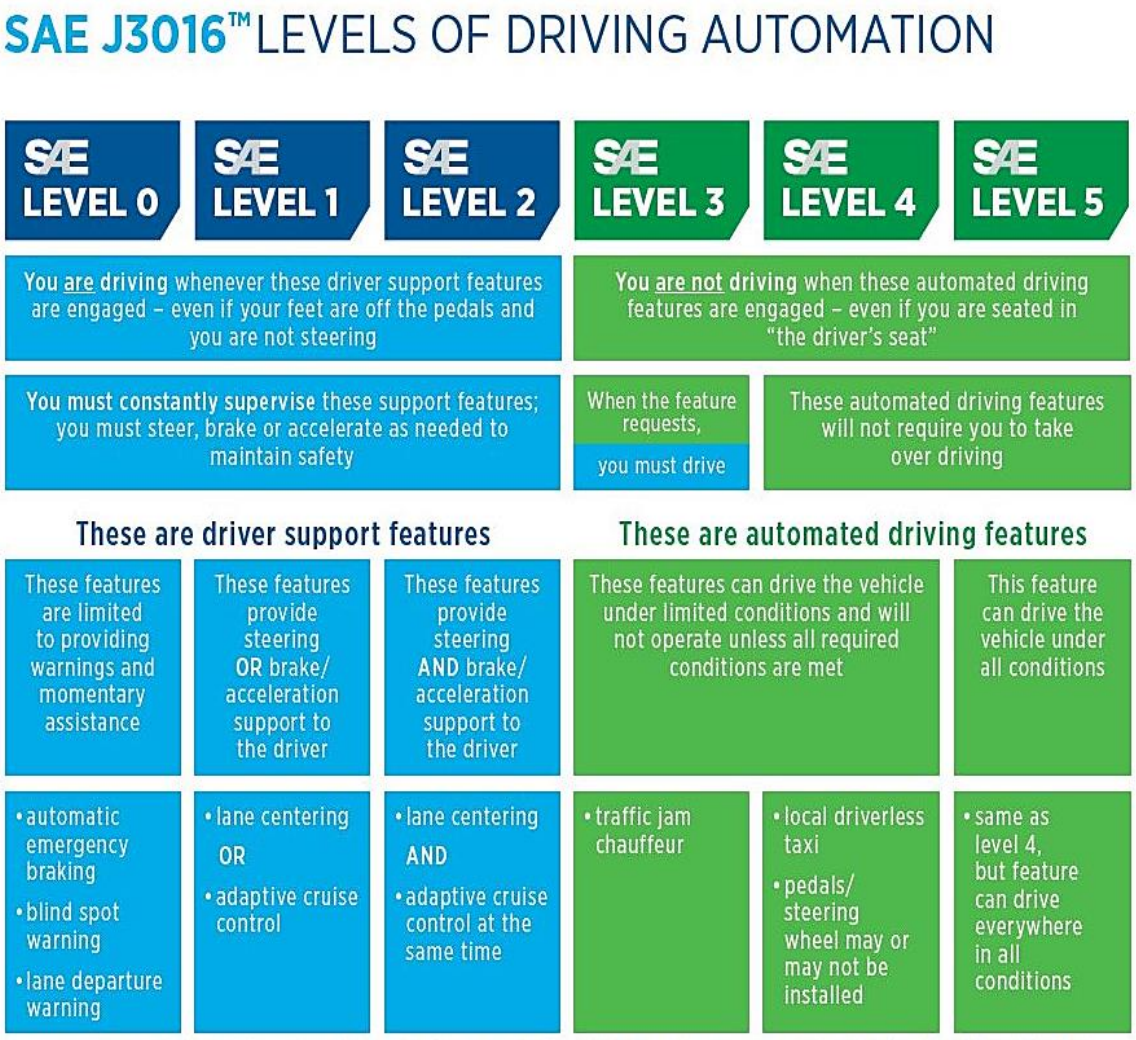

Figure 2.2: Level of automation based on SAE (Source: Jennifer, 2019)

At level 0, the drivers control all the tasks like standard vehicle such as steering, braking, signaling, and more. At level 1, a system will assist the drivers in performing a driving task. It is named the advanced driver assistance system (ADAS). It will help the drivers to accelerate, brake, and steer, but only one task at a time. However, the driver still can handle the car and look at the surrounding for more safety.

Level 2 is slightly improved from level 1, where the ADAS system will simultaneously control the driving task under some situations. This is one of the manufacturer's dream to build a vehicle where it allows the drivers to free from some of their tasks which assist them with steering or acceleration functions. However, it is not safe to disengage all the tasks and let the system do everything, and the driver always needs to prepare to take over the control and monitor the road.

The next level is one step forward to achieve a fully automated vehicle. A new system called automatic driving system (ADS) is used at level 3. The system will do all the works, such as steering, braking, and accelerating under some circumstances with sensor help. The sensor light detection and ranging (LiDAR) will help monitor the exact distance of the environment. Nevertheless, it still necessary for the driver to always prepare to take over the control and leave it to the system when the situation is safe. According to Isabel (2018), most level 3 vehicles are perfectly safe and do not need attention from the drivers as long as the speeds under 37 miles per hour.

All the crucial tasks in driving, such as steering, braking, accelerating, decelerating, and monitoring the vehicle's surroundings, can be done at level 4 and level 5. So, there is no need for human attention to the road. It also can respond to the situations, turn the signal when entering the junction, change lanes, and forth. Before the system takes control of all the tasks, it will inform the driver when the road condition or the surrounding is safe. Then,