A Fundamental Study on Car Sickness Using Data Science

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Abstract

Car sickness often occurs with dizziness and discomfort accompanied by vomiting and headaches lasting several days in severely affected person. Car sickness has been studied from various standpoints on countermeasures and onset mechanisms, but a general measure has not been established yet. In this study, all dataset of the motion that occurs in the car and the head of the person sitting and/or driving in the car are collected based on data science. By validating the data, the characteristics of person who has experience of car sickness are tested. This study proposes a new measure aiming at development of motion sickness countermeasures that do not depend on car performance and find that the quick rotational motion of the head generated in the car could be considered as one of the factors that cause car sickness.

Keywords: Data-Science, Car sickness, QoL, Statistical Analysis.

1. Introduction

Automobiles contribute to our society not only as private cars, but also as public transportation modes, such as buses and trucks that offer convenience and economical travel methods. Auto sickness is known is a disadvantage that occurs when using automobiles. Car sickness often manifests as dizziness and discomfort, which can be accompanied by vomiting and headaches lasting several days in severely affected individuals. Car sickness has been studied from various viewpoints on countermeasures and onset mechanisms, but a general coping method has not been established. This research endeavor employs a data science perspective to draw metrics on motion sickness that occurs in persons riding in the vehicle. By validating the data, the characteristics of people who experience car sickness are extracted. This study aims to provide insights for proposing motion sickness countermeasures that do not stem from vehicle performance.

2. Related research

With regard to car sickness (motion sickness), a plethora of studies are still being conducted to find countermeasures and preventive measures. According to a study by Schmidt et al. [1], car sickness is a symptom experienced by approximately 2 out of 3 person, and has the following characteristics.

- Those who are completely deaf do not get car sickness. Interestingly, patients with inner ear disorders can also develop visual motion while not physically moving.

- Blind people get car sickness, and sighted people get car sickness even with their eyes closed.
- When you read a book or look at a PC screen in a moving car, it is likely to cause car sickness.
- It is reduced when looking at an open car window, such looking at the road ahead. Car sickness is more likely when sitting backwards in a car.
- It is more likely to occur in the back seat of a car and less likely to be a driver. 46.3% in the rear seat, 36.7% in the front seat, and 17.2% in the driver.
- 62.1% of people experience motion sickness as seasickness when traveling by ships.
- 54.5% of people who are afflicted by this condition develop it even if they are looking outside the auto.
- More than 70% of passengers develop symptoms within 25 minutes after alighting the car.

For car sickness characteristics, research on the onset mechanism [2] and research on a judgment method based on eye movement [3] have been conducted. Furthermore, in recent years, research [4] aimed at countermeasures for "visual sickness" accompanying the development of VR technology has been promoted, but no clear countermeasures against motion sickness have been proposed. In considering car sickness, research [5] focused on the driving state of a vehicle has been conducted, but it is considered necessary to pay attention to the movement of the passenger that is afflicted by car sickness. Accordingly, in this study, we focus on riding posture and vehicle movement, and verify the characteristics of car sickness from the difference between passenger's motion and motion of the vehicle.

3. Objective of this research

The purpose of this study is to propose a riding posture or driving route that is less likely to cause car sickness. To achieve this goal, an experiment was performed and the moving data of a car and passenger's head were collected as time series data of under conditions of acceleration. The method is to develop a comparative study using these data and find common characteristics to of a person who get car sickness. While several factors have been reported to cause motion sickness, such as car odors and vision, this study focuses on car sickness caused by vehicle movement.

4. Proposed method

4.1. *Experiment*

An acceleration sensor (Witmotion BET901CL-E) is attached to the hat of a passenger in order to acquire data on the movement of the head while the car is in motion. The sensor specifications are shown in Table 1.

Table 1. Specification of Accelerometer.

Manufacturer	Witmotion
Model	BET901CL-E
Communication method	Bluetooth
Baud rate	115200
Output frequency	0.1～200Hz
Acceleration range	±16g
Angular velocity range	±2000 °/s

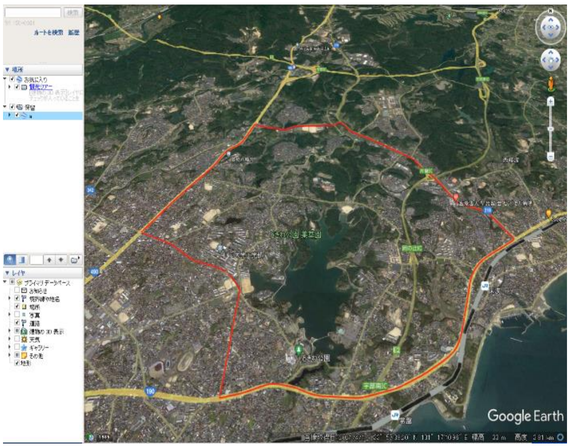

Figure 1

Similarly, the same sensor is fixed on the floor of the vehicle. In addition, a GPS data logger (Digspaice iii) is attached to the vehicle to record the operation information of the vehicle. For the operation route of the experiment, we used an open road near NIT-Ube.

Table 2. List of Average Values of Acceleration and Rotational Speed Generated at the Passenger's Head Obtained.

No.	Ride Time (m)	Symptom	ax(m/s^2)	ay(m/s^2)	az(m/s^2)	a(x,y,z)(m/s^2)	wx(deg/s)	wy(deg/s)	wz(deg/s)
No.3	24.6	-	-0.095	-0.189	0.054	0.003	-4.503	-4.561	-3.096
No.6	30.0	-	-0.006	0.160	-0.042	-0.003	7.731	8.093	7.788
No.11	28.0	Mild	0.070	0.152	-0.056	-0.002	10.755	7.623	9.585
No.19	25.7	-	0.007	0.215	-0.049	-0.003	4.150	4.032	4.851
No.20	28.7	-	-0.039	0.197	-0.031	-0.002	4.167	3.960	3.720
No.21	27.1	-	0.134	0.649	-0.412	-0.006	5.492	4.205	3.854
No.22	29.2	-	0.031	0.184	-0.064	0.001	5.151	4.936	6.254
No.23	28.1	Severe	0.133	0.157	-0.056	-0.001	8.476	8.337	15.637
No.24	27.4	-	0.062	0.320	-0.110	-0.002	6.410	6.059	5.215
Mean	27.6	-	0.033	0.205	-0.085	-0.002	5.314	4.743	5.979

Figure 1 shows an example of an operating route. Since this research aims to prevent car sickness independent on the performance of the vehicle, the official car of NIT-Ube was mainly used because a general car used for the experiment is considered sufficient. The instructor drives the test vehicle, and the subject sits in the back seat. Subjects were 25 male and female students aged 17 to 23 at NIT-UBE.

4.2. *Experimental result*

Figure 2 shows the time-series data of acceleration of the vehicle and the passenger's head movement obtained by the experiment. As shown in Figure 2, it can be seen that the passenger's head and the vehicle floor recorded different movement patterns. Only two cases, No. 11 (19-year-old female) who developed mild dizziness, and No. 23 (23-year-old male) developed car sickness during the test.

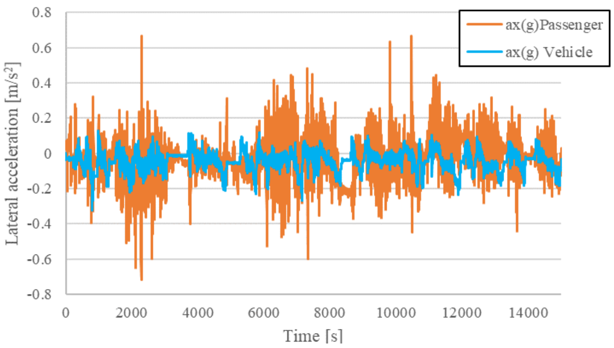

Figure 2. Time Series Results for Lateral Acceleration on Passenger and Vehicle.

5. Analysis and discussion

Table 2 shows the acceleration and rotation speed in the XYZ direction obtained from the ride experiment. Table 2 summarizes the data for ride durations of 20 to 30 minutes. It is difficult to find the tendency leading to car sickness from the movement of the vehicle and the passenger's head. According to the study by Okuyama et al. [3], considering that motion sickness-like symptoms occur even with visual information that does not involve movement, the difference of motion of the car and passenger’s movement should be considered. Here, let the motion of the vehicle be (V), and the motion of the passenger's head be (H). By taking the difference, the index (I) considering the difference between the movement predicted by the passengers from visual information and the actual movement can be calculated as follows.

$$(I) = (H) - (V) \qquad (1)$$

Table 3 shows the difference from the average value of index (I) for each direction of rotation. From Table 3, it is conceivable that in the experiments that caused motion sickness, the rotational speed of the passenger's head tended to be faster in one direction than the average. Next, the quantification of motion sickness symptoms is performed in order to perform correlation analysis. For quantification, the 5-level evaluation items established by NASA were classified into 6-level numerical values by adding 0 to completely asymptomatic. Table 4 shows the results of correlation analysis performed based on classification. From Table 4, a high correlation coefficient of 0.934 was obtained for the difference in rotational speed around the Z axis. This means that the occupant rotates his/her head in the horizontal direction quickly with respect to the yaw generated in the vehicle.

Table 3. The Difference of the Average Rotational Speed of the Passenger's Head and Symptoms.

No.	Symptom	wx(deg/s)	wy(deg/s)	wz(deg/s)
No.3	-	-0.81	-0.18	-2.88
No.6	-	2.42	3.35	1.81
No.11	Mild	5.44	2.88	3.61
No.19	-	-1.16	-0.71	-1.13
No.20	-	-1.15	-0.78	-2.26
No.21	-	0.18	-0.54	-2.12
No.22	-	-0.16	0.19	0.28
No.23	Severe	3.16	3.59	9.66
No.24	-	1.10	1.32	-0.76

Table 4. Correlation between the differences from the average value of the evaluation index related to rotation speed and symptoms.

	Symptom	wx(deg/s)	wy(deg/s)	wz(deg/s)
Symptom	1.000			
wx(deg/s)	0.633	1.000		
wy(deg/s)	0.667	0.887	1.000	
wz(deg/s)	0.934	0.744	0.838	1.000

This seems to support the analysis results of other studies that motion sickness is caused by the discrepancy between sensory motion and actual motion.

6. Conclusion

To shed light on the issue of riding posture that does not lead to motion sickness, an experiment to identify the motion during riding that is common to people who suffer from car sickness was conducted. Based on the findings, it suggested that the quick rotational motion of the head generated in the vehicle is one factor that causes car sickness. On the other hand, for the purpose of identifying the characteristics of movements that cause car sickness from the data science perspective, experimental data on subjects that suffer from car sickness requires further study. Thus more longitudinal data is required for future experiments. In addition, analyzing the motion elements that cause car sickness should be conducted by utilizing frequency estimation using FFT.

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