SUGISAKA MASANORI

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Research Article

An Empirical Research Using Data Science Analysis of Kinetosis

Satoshi Ikeda[1], Tsutomu Ito[2], Matsuno Seigo[2], Makoto Sakamoto[1], Takao Ito[3]
[1]*Faculty of Engineering, University of Miyazaki, 1-1 Gakuen Kibanadai-Nishi, Miyazaki, 889-2192, Japan*
[2]*Department of Business and Administration, Ube National College of Technology, 2-14-1 Tokiwadai, Ube, Yamaguchi, 755-0096, Japan*
[3]*Graduate School of advanced Science and Engineering, Hiroshima University, 1-4-1 Kagamiyama, Higashi-Hiroshima, 739-8527, Japan*

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ABSTRACT

Car sickness often causes dizziness and discomfort that lasts for several days, accompanied by vomiting and headaches. Countermeasures and symptoms have been studied from various perspectives, but there are no comprehensive and unique countermeasures. In this study, data on motion sickness were taken from a random sample of drivers and passengers in a car. This study proposed a new measure to prevent motion sickness that does not depend on the performance of the car, and clarified that the rapid rotational movement of the head that occurs in the car is considered to be one of the causes of kinetosis.

1. Introduction

Vehicles have contributed to humanity as a means of public transportation such as private cars, buses, and trucks. Car sickness occurs when using a vehicle. It manifests itself as dizziness and discomfort while traveling in a moving vehicle, and some people may experience nausea and headaches that last for several days. Countermeasures and onset mechanisms have been studied from various perspectives, but no effective countermeasure has yet been established. This research developed a new method by using data science analysis to derive indicators related to motion sickness in people traveling by vehicle. The main purpose of this research is to propose a new method to prevent motion sickness that is not caused by vehicle performance.

2. Related research

With regard to Kinetosis, a plethora of studies have been conducted to identify remedies and preventive measures to combat motion sickness. According to a study by Schmidt et al. [1], Kinetosis is a symptom experienced by approximately 2 out of 3 persons, and has the following characteristics.

- Those who are completely deaf do not experience car sickness. Interestingly, patients with Meniere's disease, also referred to as inner ear disorders, can also develop visual motion while not physically moving.
- Blind people get Kinetosis, and sighted people get Kinetosis even with their eyes closed.
- Reading a book or looking at a PC screen in a moving car is likely to cause car sickness.
- Kinetosis 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.
- Kinetosis is more likely to occur in the back seat of a car and less likely to be experienced by a driver. (Specifically, by 46.3% in the rear seat, 36.7% in the front seat, and 17.2% in the driver.)
- 54.5% of people who are afflicted by Kinetosis develop it even if they are looking outside the auto.
- More than 70% of passengers develop symptoms of Kinetosis within 25 minutes after alighting the car.

Corresponding author E-mail: saka2000@cc.miyazaki-u.ac.jp.

- 62.1% of people experience Kinetosis as seasickness when traveling by ships.

To identify the conditions under which Kinetosis occurs, research on the onset mechanism [2] and research on a judgment method based on eye movement [3] have been investigated. What's more, in recent years, studies [4] focusing on identifying countermeasures for "visual sickness" accompanying the development of VR technology have been promoted, but no clear countermeasures against auto sickness have been proposed. In considering Kinetosis, research [5] 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 based on the difference between passenger's motion and motion of the vehicle.

3. Objective of this research

The main purpose of this research is to propose riding positions and driving routes that will prevent car sickness. An experiment was conducted to collect time-series data on the movement of the heads of cars and passengers under acceleration conditions. The proposed method uses these data to find common characteristics of people who experience movement syndrome. There are various factors that cause motion sickness, such as the smell and sight of a car, but this research focused on motion sickness caused by moving vehicles and developed a new method.

4. Proposed method

4.1. *Experiment*

An acceleration sensor (Witmotion BET901CL-E) was attached to the cranium of each passenger to collect data on the movement of the head while the car is in motion. The sensor specifications are shown in Table 1.

In a similar vein, the same sensor was fixed on the floor of the vehicle. In addition, a GPS data logger (Digspaiceiii) was 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.

Fig. 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 used, although a general car used for the experiment would be considered sufficient. The instructor drives the test vehicle, and the subject sits in the back seat. The randomly selected subjects comprised of 25 male and female students aged 17 to 23 at NIT-UBE.

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

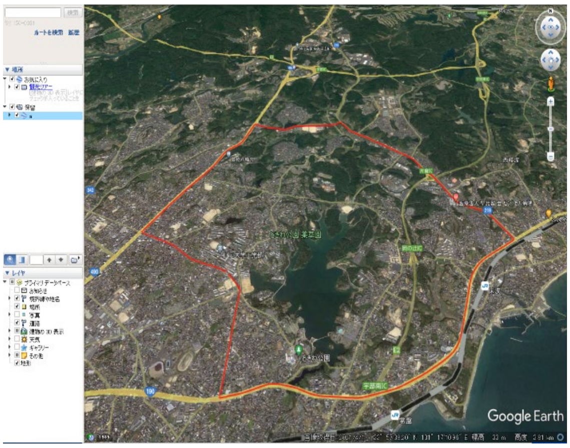

Fig. 1 Experiment Route around NIT-Ube Depicted on Google Earth

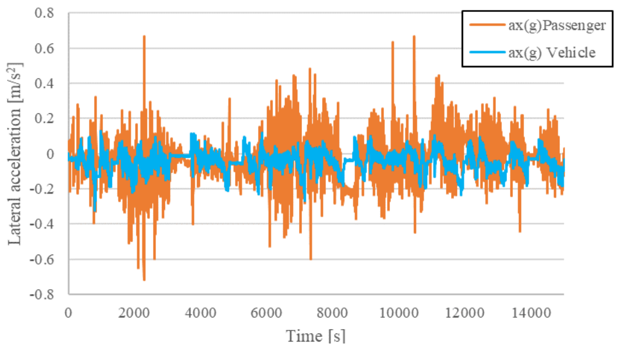

Fig. 2 Time Series Results for Lateral Acceleration on Passenger and Vehicle

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

4.2. *Experimental result*

Fig. 2 shows the time-series data of acceleration of the vehicle and the passenger's head movement obtained by the experiment. As shown in Fig. 2, it is evident 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.

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 ascertain the occurrence of 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 taken into consideration. Here, let the motion of the vehicle be (V), and the motion of the passenger's head be (H). To calculate the index (I), 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 to compute the inter-correlations among the focal constructs. For quantification, the 5-level evaluation items established by NASA were classified into 6-level numerical values by adding 0 to completely asymptomatic. The results shown in Table 4 based on classification reveal a high correlation coefficient of 0.934 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

Seemingly, these findings are congruent with the results reported in other studies that motion sickness is caused by the discrepancy between sensory motion and actual motion.

6. Conclusion

In order to clarify the riding posture that does not cause kinetosis, we conducted an experiment to identify the movements while riding that are common to people who suffer from this condition. The results revealed that the rapid rotational movement of the head that occurs inside a vehicle is one of the factors that causes kinetosis. On the other hand, in order to identify the characteristics of movements that cause kinetosis from a data science perspective, we need experimental data on subjects who experience car sickness. Therefore, in the future, additional data will need to be collected from experiments. Analysis of the motion factors that cause car sickness requires frequency estimation using FFT, which has been found to be useful in increasing knowledge of kinetosis.

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Authors Introduction

Dr. Satoshi Ikeda

He received PhD degree from Hiroshima University. He is an associate professor in the Faculty of Engineering, University of Miyazaki. His research interest includes graph theory, probabilistic algorithm, fractal geometry and measure theory.

Dr. Tsutomu Ito

He is an Associate Professor of the Department of Business Administration at National Institute of Technology, Ube College, Japan. His current research interests include internet of things (IoT), mechanical engineering, artificial intelligence (AI), automata theory, quantitative analysis of Japanese Keiretsu. Dr. Ito earned his doctor degree of Engineering from Hiroshima University, Japan in 2018

Dr. Seigo Matsuno

He is Professor of the Department of Business Administration at National Institute of Technology, Ube College, Japan. He received his Ph.D. degree in Economics from Kyushu University, Japan in 2004. His current research interests are in the areas of IT management and strategy, information systems outsourcing, and interfirm relationship management.

Dr. Makoto Sakamoto

He received the Ph.D. degree in computer science and systems engineering from Yamaguchi University. He is presently Professor in the Faculty of Engineering, University of Miyazaki. He is a theoretical computer scientist, and his current main research interests are automata theory, languages, and computation. He is also interested in digital geometry, digital image processing, computer vision, computer graphics, virtual reality, augmented reality, entertainment computing, complex systems and so on.

Dr. Takao Ito

He is Professor of Management of Technology (MOT) in Graduate School of Engineering at Hiroshima University. His current research interests include automata theory, artificial intelligence, and systems control, quantitative analysis of interfirm relationships using graph theory, and engineering approach of organizational structures using complex systems theory.