AN EXPERIMENT ON DRIVERS' ADAPTABILITY TO OTHER-HAND TRAFFIC USING A DRIVING SIMULATOR

Koji Makanae, Prof.,
Miyagi University;
koji@makanae-lab.jp   http://www.myu.ac.jp/~makanae

Maki Ujiie,
ARRK Corporation

ABSTRACT: Traffic orientation is of two types—left-hand traffic (LHT) and right-hand traffic (RHT). With the increasing cross-border movement of people and the development of worldwide motor vehicle traffic network, the difference in traffic orientation becomes a barrier in the international traffic environment. The objective of this study is to clarify drivers' adaptability to other-hand traffic (right-hand traffic for Japanese drivers) by conducting an experiment with a driving simulator, which can easily switch the traffic orientation. According to the results of the experiment, most of the subjects recorded route mistake in the experiment and feel uncomfortable in the other-hand traffic orientation, and half the subjects recorded route mistakes in the experiment.

KEYWORDS: Right- and Left-hand traffic, Driver's Adoptability, driving simulator, worldwide traffic network

1. INTRODUCTION

Vehicles travel on the left or right side of the road. The Convention on Road Traffic agreed upon in Geneva in 1949 stipulates that each contracting state should adopt an uniform travel system but has not defined any standard international vehicular travel system. At present, 75 countries and regions adopt the left-hand traffic system (LHT) and 164 the right-hand traffic system (RHT). Several countries have changed the system, mostly from LHT to RHT. As a result, RHT is now prevalent.

Drivers learn to drive under a particular traffic system adopted in their country. As more people move across the national border in recent years, opportunities have been increasing of driving under a different traffic system. The construction of big civil engineering structures such as strait-crossing bridges and tunnels has created global road networks. Then, safely connecting networks incorporating different traffic systems is a present issue. The means for removing the barriers created by the difference of traffic system include globally standardizing the traffic system and enforcing drives operating a vehicle across the border to learn driving for adaptation to a different traffic system. In either way, drivers need to adapt themselves to varying traffic systems temporarily or permanently. Against the above background, the authors developed a driving simulator (DS) applicable to varying traffic systems. In this study, driver's adaptability to different traffic systems is evaluated by having domestic drivers who have accustomed themselves to LHT drive under RHT using the DS.

2. SIGNIFICANCE OF TESTS USING A DRIVING SIMULATOR

Studies of driver behavior frequently require testing under special environments or conditions. Tests using actual vehicles under actual conditions involve risks for drivers or surrounding environments in numerous cases. Applying a driving simulator (DS) to these tests enables the reproduction of a certain point in time under the same environment for numerous subjects because it ensures the safety of subjects and because it can reproduce the test environment and control test conditions. These benefits are the reasons why DS have been used for various tests and training such as the tests of driving burden and the assessment of road design. In order to evaluate how scared the driver is, Matsui et al. (2002) verified the relationship between the distance between vehicles and driver's scare in tests using a DS. Tests for evaluating the fatigue of drivers who travel long hours were conducted by Nishida et al.(2003) and others. Thus, DS have been employed as a useful tool for conducting tests that would be difficult under an actual environment because of the need to ensure the safety of subjects.

DS involve high-speed dynamic image processing with the aid of computer graphics that work in cooperation with the operation of the steering wheel. DS therefore used to be developed based on costly graphics-oriented work stations. In recent years, however, DS systems can be built based on personal computers owing to the advancement of image processing capability of personal computers (ex. FORUM8 UC-Win/Road). In the meantime, DS systems have been developed for practical application that are equipped with a motion controller capable of representing not only changes in image and sound but also changes in sense of equilibrium due to acceleration or centrifugal force (Onuki et.al., 2006).

3. DEVELOPMENT OF A TRAFFIC SYSTEM DRIVING SIMULATOR

3.1 Composition of the Driving Simulator

The driving simulator (DS) discussed in this study is intended for a comparative study of driver adaptability at the time of switchover to a different traffic system. The requirements specified in DS development are the capabilities of switchover to a different traffic system, specification of road structures on an ordinary road or expressway according to the switchover, and control of the timing of emergence of other vehicles. Providing high-resolution pictures is, however, not so important. In this study, therefore, a personal computer-based dedicated DS is developed and tests are conducted.

FIG.1 shows the composition of the DS developed in this study. The DS is composed of a personal computer (with Microsoft WindowsXP), driving control system (Microsoft Sidewinder Feedback Wheel) and liquid crystal display projector. The driving control system is connected to the personal computer via a USB port.

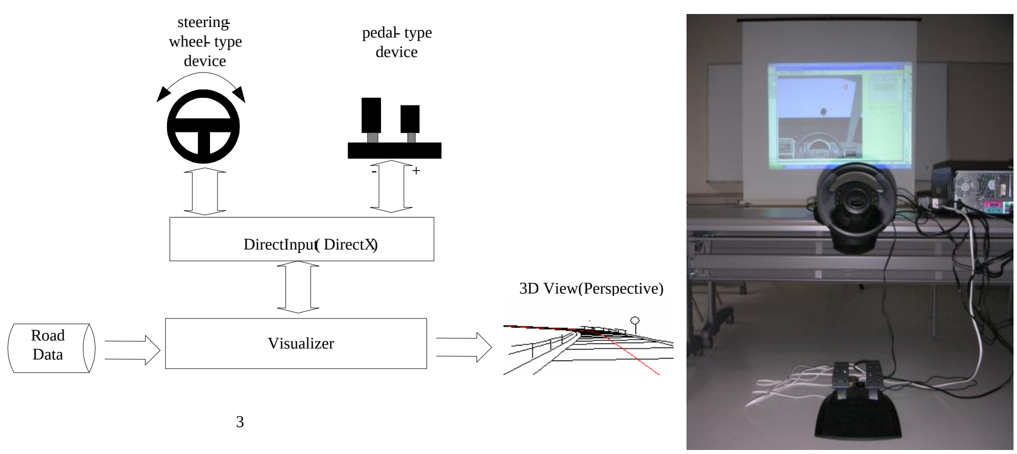


FIG. 1: The composition of the DS

Languages used for developing the DS are C# as a basis, OpenGL for drawing and DirectX9.0 for acquiring operation data from the driving system. Course data can be expressed by XML and DOM (Document Object Model) is used for data input and output.

3.2 Acquisition of driving data and drawing of the vehicle

The data on the operation of the driving system is acquired using DirectInput. Data on the angle of rotation of the steering wheel and the degree of acceleration or braking is obtained as integers between 0 and 1000. The data is converted to the angle of rotation of the steering wheel and acceleration or deceleration to calculate the position of the vehicle and generate an image. A DS user interface is shown in FIG.2. As the initial settings for the DS, whether or not the position of the steering wheel is changed, whether or not dynamic images of other vehicles exist and whether or not the degree of control is displayed are specified, and drawing is carried out accordingly.

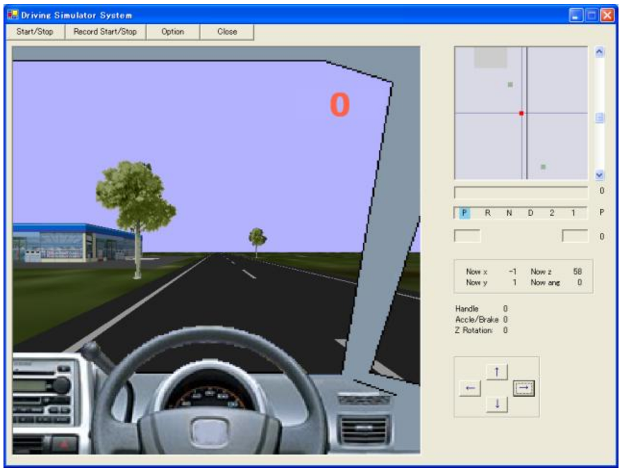


FIG. 2: The DS user interface

3.3 Acquisition of driving data and drawing of the vehicle

Objects of drawing are the road, accessories to the road, surrounding facilities and oncoming vehicles.

(1) Road

The road object is constructed based on the data on the road alignment composed of straight lines, circular curves and clothoids; and the road cross section. Based on the object, such objects as crossings, T intersections and interchanges are also prepared as parts and drawn according to their positions.

(2) Accessories to road

As accessories to the road, traffic signals, road signs and vegetation are specified. Traffic signals are designed to be controllable according to time. The drawing function is specified so that the positions of traffic signal supports may be changed whenever the traffic system is switched. Multiple types of road signs are generated including regulatory, warning and guide signs. The supports are also re-positioned when the traffic system is switched as traffic light supports. Trees can be arranged as vegetation, which is represented by billboards using two textures.

(3) Surrounding facilities

Multiple types of structures can be arranged along the road. Texture mapping is possible for some structures.

(4) Oncoming vehicles

Oncoming vehicles are represented by texture mapping. They are designed to emerge in relation to the position of the test vehicle.

3.4 Output of travel data

Vehicular travel data is recorded using XML. The current position (coordinates), angle of rotation of the steering wheel and the degree of acceleration or braking are recorded and output every 0.5 second.

3.5 Construction of an analysis system

An analysis system is built to analyze the travel data recorded by the DS. Graphs and plan views can be drawn for the speed, time and tracks based on the travel data of a single or multiple subjects.

3.6 Construction of an analysis system

A course editor is generated to facilitate the arrangement of road objects, accessories and surrounding facilities on the experimental course (FIG. 3). Data is described using XML.

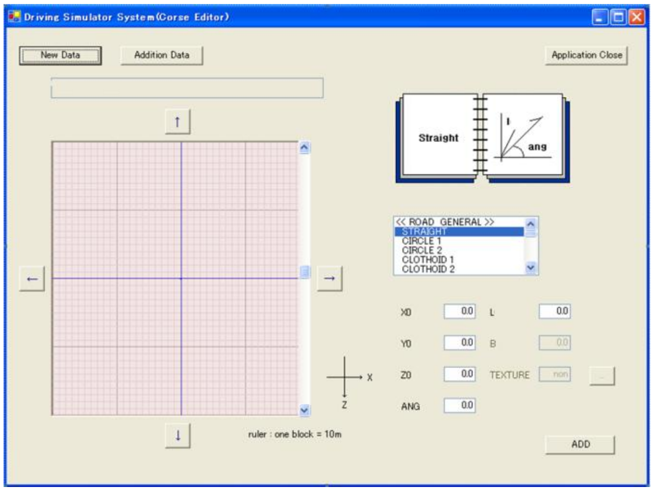


FIG. 3: The course editor

4. ADAPTABILITY EVALUATION TESTS

4.1 Test method

Tests were conducted for 13 subjects with a driver's license for an ordinary motor vehicle who had never driven overseas. Ten males and three females of an average age of 22.1 participated in the tests. Test courses were prepared for LHT and RHT. The course was composed mainly of an ordinary road, expressway and interchanges. The round-trip course had right- and left-turning curves, merging zones and entries into parking space, which are the key points when comparing the travel under different traffic systems. Subjects practiced driving for several minutes to get themselves accustomed to the driving system and travelled under the LHT and then RHT systems. Data such as the travel speed and tracks was recorded. Questionnaires were distributed to subjects to report the points where they felt scared. FIG.4 shows the model course map and the points where travel records were compared under LHT and RHT systems.

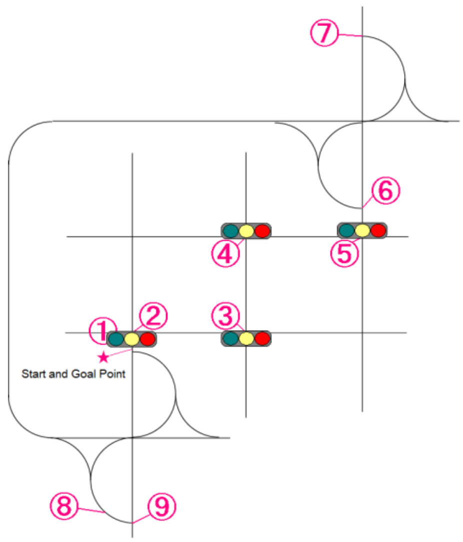
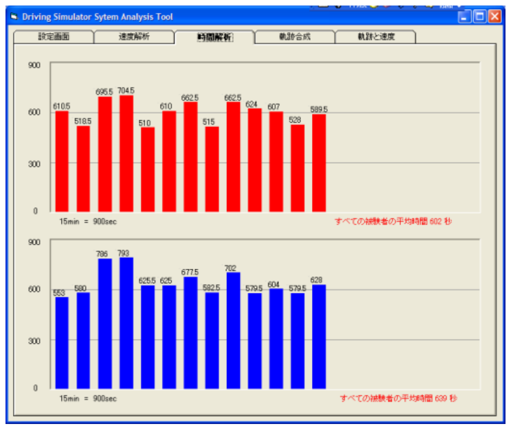


FIG. 4: The model course map

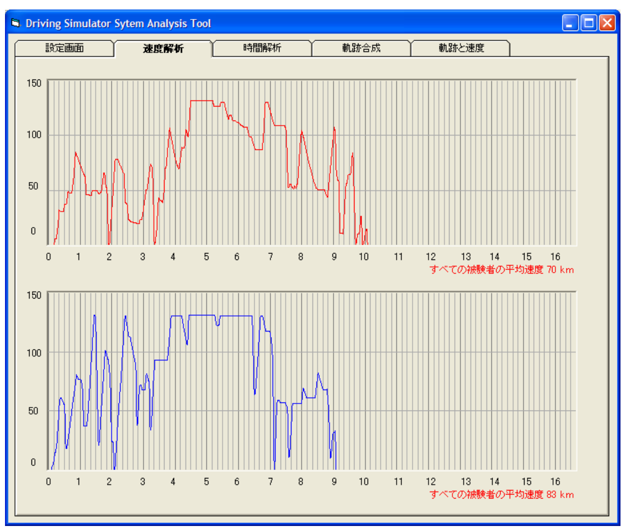
4.2 Test results and discussions

FIG. 5 gives graphs showing the time that the subjects required to complete the round-trip. The subjects required an average of 602 seconds, or approximately ten minutes, to go around the course under LHT and an average of 639 seconds, or approximately 10 minutes and 30 seconds, under RHT, 30 seconds more than under LHT. Actually, however, less time was required under RHT than under LHT because the course is longer under RHT by as long as 900 m owing to the location of the entrances to interchanges and travelling the distance at a speed of 50 km/hr, the speed limit specified for ordinary roads, took nearly one minute. FIG. 6 shows changes in speed for subject A. Subjects travelled at a speed of 71 km/hr under LHT and 75 km/hr under RHT. In response to the questionnaire distributed after the test, subjects reported that they got accustomed to simulation under RHT because they first travelled on the left side of the road. The time they spent for practice before the test may have influenced the result.



Upper (red): LHT, Lower (Blue): RHT

FIG. 5: The time to complete the round-trip



Upper (red): LHT, Lower (Blue): RHT

FIG. 6: Changes in speed for subject A

Table 1 gives the number of cases where the subjects explicitly deviated from the lane as indicated by the tracks. Table 2 shows the points where the subjects felt scared based on the results of the questionnaire survey. The number of cases of lane deviation under RHT was three to four at intersections (1) and (4). Subjects passed intersection (i), the first intersection to pass under RHT, while they were not yet accustomed to travelling on the right side of the road. They therefore may have taken the wrong travel lane (FIG. 7). The cases of lane deviation increased at the passage of intersection (4) because it was designed that oncoming vehicles would emerge at the intersection. Subjects probably took the wrong lane while being distracted by the oncoming vehicles. Actually, a vehicle running on the right lane crashed into another. The subject focused attention on one side and may have been careless about the right-hand traffic. Intersections scored high in the questionnaire survey as a point where the subjects felt particularly scared.

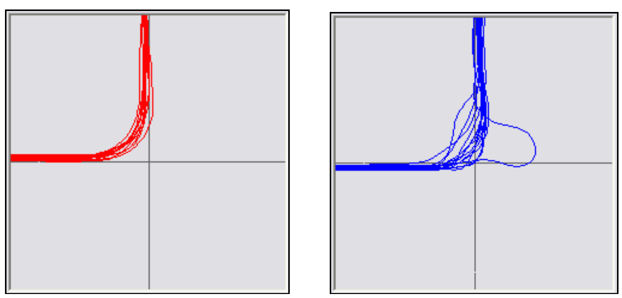
Table 1: The number of cases where the subjects deviated from the lane

No.	Point	LHT		RHT	
		Correct	Mistake	Correct	Mistake
1	Parking access	11	2	13	0
2	Intersection(1)	13	0	9	**4**
3	Intersection(2)	13	0	12	1
4	Intersection(3)	13	0	13	0
5	Intersection(4)	13	0	10	**3**
6	Entrance of IC(1)	12	1	7	**6**
7	Entrance of IC(2)	—	—	12	1
8	Rampway	11	2	12	1
9	Exit of IC	13	0	12	1

Table 2: The scared points from the questionnaire survey

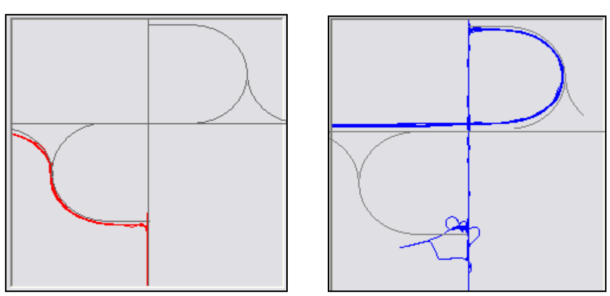
	Point	Average	Mode
Street	Parking access	3.6	5
	Straight way	4.8	5
	Inside turn(Right)	2.9	4
	Outside turn(Left)	1.8	2
Expressway	From ramp way to expressway	2.9	4
	Straight way	4.2	4
	From expressway to rampway	3.5	2

※ 1<< scared -- not scared>> 5



(a) LHT (b) RHT

FIG.7 : The trajectories at the intersection(1)



(a) LHT (b) RHT

FIG. 8: The trajectories at the entrance of ramp way

Six subjects out of 14 entered the expressway without noticing the different way of installing the entrance at the interchange (FIG.8). Under a different traffic system, the merging movements of vehicles on an expressway are reversed. Subjects may have taken the same path as under LHT. Numerous subjects pointed out in response to the post-testing questionnaire that particular attention should be paid.

The conclusion is that improper driving frequently occurs at intersections (during left-turning movements in particular) and at entrances at the interchange when LHT is switched to RHT. These points are therefore considered risk points. Improper driving is ascribable to distractions by other phenomena in such cases where a traffic system was switched to another or other vehicles emerged after the passage of an intersection.

5. CLOSING REMARK

In this study, the adaptability to RHT of local drivers accustomed to LHT was evaluated, using a dedicated driving simulator in order to evaluate the adaptability of drivers to varying traffic systems. Numerous subjects actually drove improperly under unfamiliar RHT traffic system, running off the road or committing other errors. The post-testing questionnaire survey revealed that many subjects felt scared under RHT. It was also shown that numerous driver errors occurred when turning at the intersection or entering the interchange and that the emergence of other vehicles including those coming toward the subject caused errors.

In this study, analysis was made based on the behavior of a test vehicle reproduced using a driving simulator and the results of a questionnaire survey. In the future, driver anxiety or sense of fear needs to be evaluated based on more objective parameters through physiological measurement in such terms as the pulse rate and blood pressure. Increasing the duration of testing is also necessary to determine the driving experience required for adapting to a different traffic system. In this study, driving under LHT was simply compared with driving under RHT and a personal-computer-based simple driving simulation system was developed and applied. In order to increase test accuracy, it is necessary to conduct tests to evaluate driver adaptability using a driving simulator with motion control capability that generates a greater sense of reality.

In addition to evaluating driver behavior in testing, studies on social systems are also important. As described in Section 1, the development of global road networks and the growth of international exchanges are likely to make the difference in traffic system a barrier in transportation. The two traffic systems established separately in different countries in the 19th century through the beginning of the 20th century remain, dividing the world. Whether the switchover of traffic systems and different road networks is possible or not under the present mature transportation environment is a big research issue in the future. Large-scale social experiments may be required. We should energetically make efforts to tackle these issues in the future.

6. References

Forum8 (2009). “UC-Win/Road”, http://www.forum8.com .

Matsui,Y., Kim, J, Hayakawa,S., Suzuki,T., Okuma,S., Tsuchida,N.(2002). “Evaluation of Fearfulness of Driver Using Three-Dimensional Driving Simulator”, Proceedings of the Human Interface Sympsium 2002, Sapporo, Japan, Sep. 1-3, 2002, 131-132. (in Japanese)

Nishida, Y., Shirai, Y., Otsubo, T.(2003). “Development of a driving simulator program for evaluation of long-time drive tiredness.”, Proc. of Traffic Engineering Meeting(JSTE), Vol.23, 97-100. (in Japanese)

M. Onuki, Y. Suda, Y. Takahashi, H. Komine and K. Matsushita, Study on Improving Angular Acceleration Feel of the Driving Simulator and its Effects on Drivers’ Behaviors, International Journal of ITS Research, Vol. 4, No. 1, (2006), 47-52.