

Examination of evaluation criteria for individual driver

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KEYWORDS	ABSTRACT
Evaluation criteria comfortable driving individual subjective evaluation	The evaluation criteria for feeling comfortable driving are various by the person. Focusing on the evaluation of driving skills, Okita et al. fixed the constant $Kid = F(EOV, \Delta G)$ from the characteristics and actual running feel of the vehicle with EOv as the energy of the overshoot and ΔG as the acceleration change width causing this overshoot, the driving skill is judged based on the constant Kid . Yamakado et al. are verifying the formulation of a successful trajectory of vehicle train driving of expert driver as good driving. Although these are required from quantified indices, but they are not corresponding to the variation of individual subjective evaluations. If it can establish a method that can be adjusted to individual evaluation criteria, it is thought that driving assistance system can be brought closer to driver's preference. Therefore, the driving that the individual driver feels comfortable is assumed good subjective evaluation driving. And, we consider the selected good subjective evaluation from the plural driving and the quantitative characteristics of the operation.

1.0 INTRODUCTION

In recent years researchers are constantly studying automatic driving and driving support in order to prevent accidents and reduce the burden on drivers.

Omoda et al. [1] says that it is important to analyze the driving method of the expert driver and apply it to the support method.

Yamakado et al. also analyze the driving methods of expert drivers. They [2] assumes that the expert driver will operate well, and verifies the formulation of a vehicle trajectory that is good from the viewpoint of correction based on the clothoid curve and analytical thinking on the premise that acceleration / deceleration is not performed.

Furthermore, Togane et al. [3] developed a driving skill improvement support system based on the driving of an expert driver.

Okita et al. [4] calculate the characteristics of the vehicle, the constant from the actual driving feeling, Kid from the energy of the overshoot from the stationary stable position and the acceleration change width that caused this overshoot, and calculate the traveling amount based on it judged. They have developed a system that helps improve driving skills by communicating the results to drivers.

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As described above, evaluations of driving smoothness and skill have been studied from various points of view so far, and driving support is provided based thereon.

Any can be calculated and evaluated from vehicle information, and they are quantitative, but they are not based on individual subjectivity.

As a problem of the current driving support device, Takahashi mentions that [5] there is only one type of driving support characteristic for operation characteristics of various driver characteristics. They think that the function of achieving good driving support by individually adjusting to the operation characteristics of the driver is considered to be one of the important viewpoints in the future. Furthermore, they state that "adaptive response to the driver's operation characteristics" is to adapt to the driver's vehicle behavior expectation.

Hiraoka et al. [6] implemented the collision avoidance support system on a driving simulator and conducted a subject experiment. As a result, they confirmed the opinion that "the system is interfering with driving" and stated that it is necessary to consider a collision avoidance support system that determines the support torque according to each person.

Kobayashi et al. and Koga et al. are studying on the individuality of driving operation. Kobayashi et al. [7] analyzed the driving operation with the objective of quantifying the individuality in the driving operation in order to promote the improvement of the driving skill. Koga et al. [8] as an alternative to a driver for vehicle testing of automobiles, it aims to realize an automatic driving system for vehicle testing that can mimic human driving characteristics found in novice and expert drivers. The driving characteristics were examined according to the driver's skill level. As a result, they found that the difference in the characteristics appeared in the smoothness and followability of steering, and achieved automatic control that reflected the driving characteristics of beginners and experts. However, none of them is associated with the driver's subjective evaluation, and the driver does not necessarily feel uncomfortable.

In this study, we aim to provide driving support in accordance with driving that is subjectively evaluated by individual drivers in the future, and to reduce driver discomfort. Therefore, the purpose of this study is to clarify the definition method of driving that subjective evaluation of each driver is good. The authors investigated the relationship between driver's subjective evaluation and driving operation, and examined the driving that the subjective evaluation is good and the items that become the factor.

2.0 DRIVING EVALUATED SUBJECTIVELY AS GOOD

The purpose of this research is to examine factors of driving subjectively evaluated as good. As a part of this paper, we will examine behavior at the intersection left turn. The schematic diagram of the running environment used in this research is shown in Figure 1, and the parameters and their meanings in Figure 1 are shown in Table 1. It is assumed that there are no other traffic participants.

When turning left such a course, the driver thinks the speed at the time of left turning and the course picking target from the road linearity. Decelerate from the initial speed v_0 toward the target at the deceleration start point x_1 and decelerate to the target speed v_1 when entering the intersection. Since the vehicle passes through the path of the target, the steering is started from the steering start point x_2 and the steering is smoothly performed until the steering end point y_1 . As it moves from the left turn to the straight line, it accelerates from the point y_2 where acceleration is judged and accelerated.

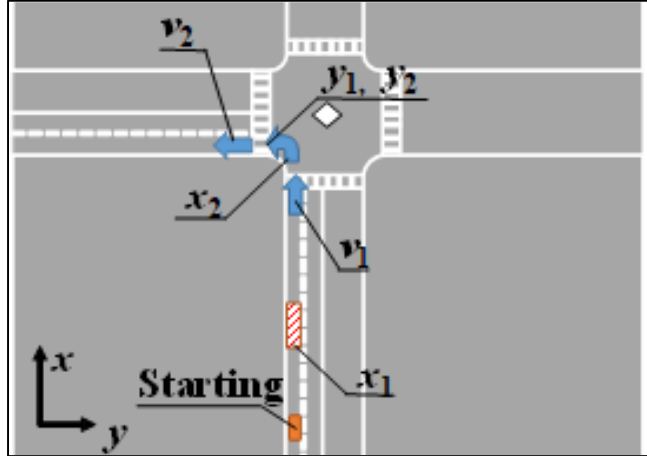


Figure 1: Driving environment

Table 1 Parameters and meaning

Parameters	meaning
x_1	Break start point
x_2	Steering start point
y_1	Steering end point
y_2	Re-acceleration point
v_0	Initial velocity
v_1	Intersection entry speed
v_2	Intersection escape speed

In these behaviors, it is considered that the driver will set action targets to set for each item from previous experiences, and then act accordingly. Misalignment may occur as a result of taking action. I made a hypothesis that this shift amount is related to the judgment of good and bad driving.

In this study, we measure driving behavior of each driver and consider factors of driving with good subjective evaluation.

3.0 OUTLINE OF EXPERIMENT

In this research, we carry out the experiment using the driving simulator (DS). The outline of the experimental apparatus is a three-sided DS as shown in Figure 2, which is equipped with a small liquid crystal monitor in front of the driver. The experimental apparatus consists of three personal computers as shown in Figure 3. PC 1 is a control computer and calculates the dynamics of the car. The PC 2 is a computer for projecting a screen, and displays the running scenery on the screen based on the calculation result of the PC 1. The PC 3 is an information presentation computer, and presents speed information on a small liquid crystal monitor.

The driving environment is an intersection where a straight road of two lanes on one side intersects as in Figure2. This intersection has a crosswalk. The straight road is over 150 m and has a sufficient length.

In this paper, in order to narrow down the factors, the cars traveling in this driving environment are the only vehicles the driver drives, and there are no disturbances such as pedestrians and bicycles.

The participant are six men in their twenties who are usually driving.



Figure 2: Outline of experiment equipment

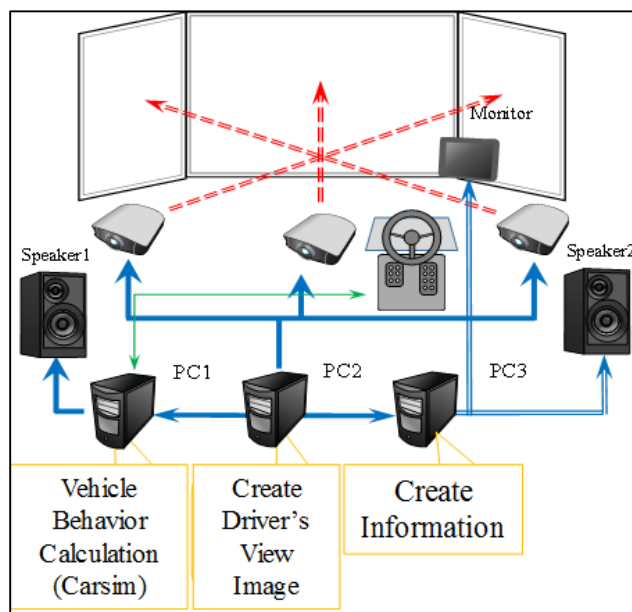


Figure 3: Structure of experimental apparatus

DRIVING CONDITIONS

The driver starts from the driving lane of the straight road before turning and accelerates to the instructed speed v_0 . After traveling a sufficient distance, he/she decelerates towards left turn. He/She enters the intersection and makes a left turn and enter the driving lane. After turning the intersection, it accelerates again. These actions and timing were left to the driver's judgment.

EXPERIMENTAL METHOD

In order to get used to traveling in DS, after practice a few times and then do five times with traveling condition of $v_0 = 20$ [km / h]. When the 5th trial is over, ask the driver to rank in the order in which five driving operations are good. Next, change to $v_0 = 40$ [km / h] and do the same experiment. The schematic diagram of the flow of experiment is shown in Figure 4.

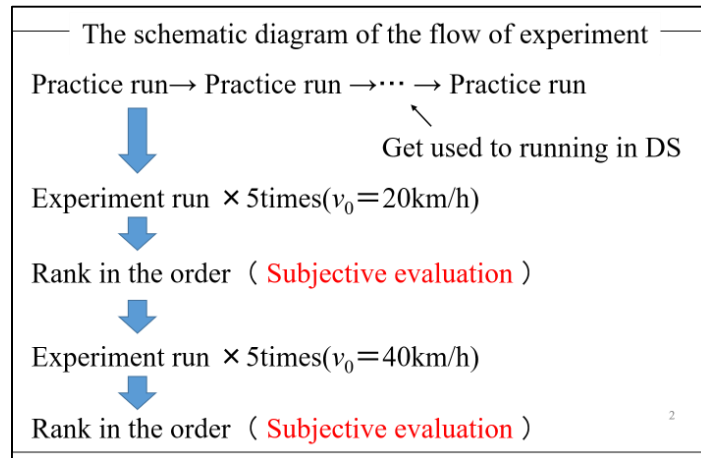


Figure 4: The schematic diagram of the flow of experiment

EVALUATION ITEM

As a parameter to examine factors of good subjective evaluation, we evaluate the steering angle at turning, the steering angular velocity at turning, the accelerator pedal stroke amount and the brake pedal stroke amount under each speed condition.

After the fifth trial, a questionnaire survey was conducted for the driver, and five driving operations were rearranged in descending order of evaluation. In this study, the driving with the best subjective evaluation by the driver is 1, and the driving with the worst subjective evaluation is 5.

4. EXPERIMENTAL RESULTS

Figure 5, Figure 6, and Figure 7 show the results of sorting by ranking which is the subjective evaluation of the drivers of subjects participant A, B and C at $v_0 = 40$ [km / h]. Table 2 shows the relationship between graph color and subjective evaluation. The horizontal axis represents the moving distance from the origin and the vertical axis represents the steering angle. Figure 8, Figure 9, and Figure 10 show the relationship between the moving distances of the participant A, B, and D from the origin and the steering angular velocity at $v_0 = 40$ [km / h].

From Figure 5, it can be seen that participant A tends to have a better subjective evaluation when the maximum value of the steering angle is smaller. Purple with the worst subjective evaluation has the smallest maximum value of the steering angle, but from Figure 8 it can be seen that the steering angular velocity is unstable. In other words, it is not smooth steering.

In contrast, the participant C tends to judge that the subjective evaluation is better if the maximum value of the steering angle is larger.

There is no particular tendency in the maximum value of the steering angle of the participant B, but the subjective evaluation tends to be better when the steering angular velocity is smaller. On the other hand, the participant D has no tendency in the steering angular velocity.

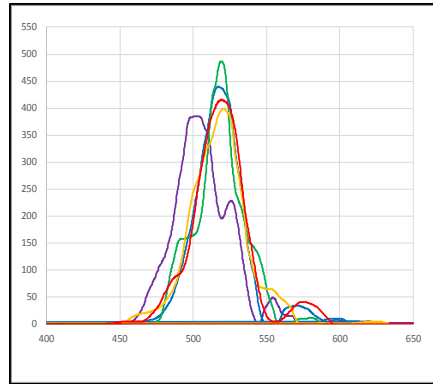


Figure 5: Participant A at $v_0 = 40$ [km / h]

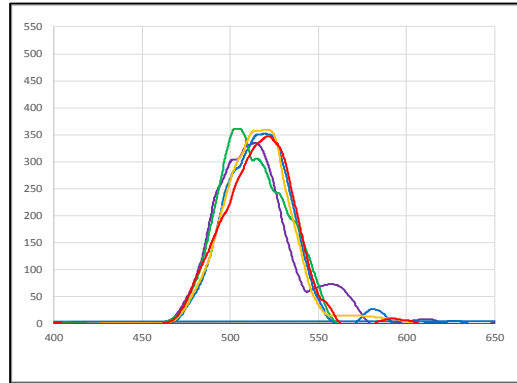


Figure 6: Participant B at $v_0 = 40$ [km / h]

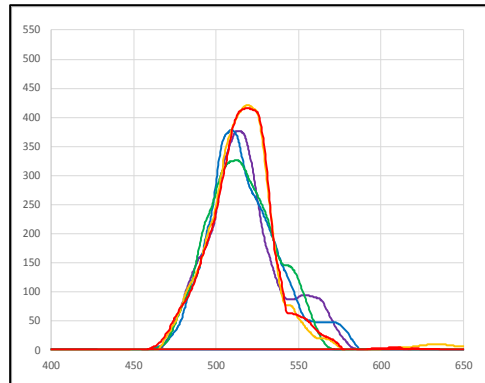


Figure 7: Participant C at $v_0 = 40$ [km / h]

Table 2: Parameters and meaning

Color	Rank in the order (Subjective evaluation)
red	1(good)
orange	2
green	3
blue	4
purple	5(bad)

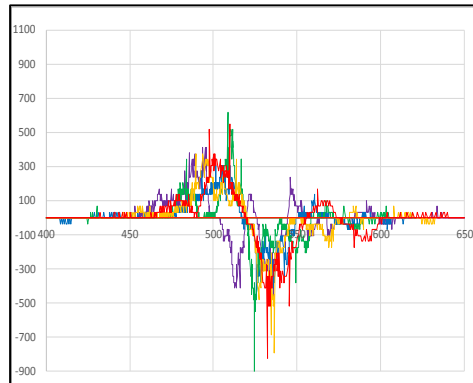


Figure 8: Participant A at $v_0 = 40$ [km / h]

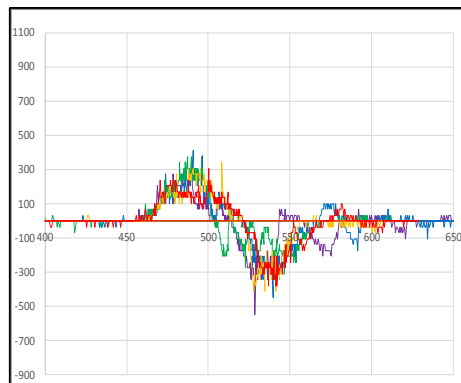


Figure 9: Participant B at $v_0 = 40$ [km / h]

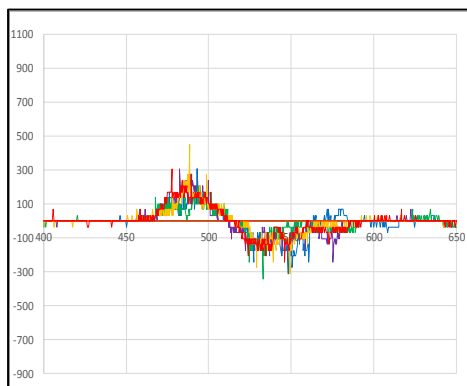


Figure 10: Participant D at $v_0 = 40$ [km / h]

5. CONSIDERATION

Focus on turning, consider the items that most important when each participant subjectively evaluates his / her driving. Participant A considers it good if it can turn with a small steering angle. It is also considered to be one of the evaluation items whether or not smooth steering is being performed.

Participant C considers it good if it turns quickly at a large steering angle.

Participant B considers it to be good if he/she steers slowly.

Participant D does not consider smooth steering as a particularly important evaluation item.

If attention is paid to the steering angle, the participants A and C perform the opposite evaluation for the same driving operation. Moreover, if attention is paid to the speed of steering, the participants B and C perform the opposite evaluation for the same driving operation.

From this result, it is considered that the factor affecting the subjective evaluation is different for each driver. Therefore, in order to perform optimal driving support and automatic driving for each driver, it is necessary to provide different support for each driver, not uniform support. At that time, the driver's subjective evaluation should be considered.

6.0 CONCLUSION

In order to improve the comfort of driving support and automatic driving, it is necessary to clarify the driving feeling subjectively comfortable. In order to reduce discomfort and discomfort of automatic driving and driving support, we considered to perform automatic driving and driving support suitable for each occupant. For that reason, it is necessary to consider items that cause the driver to subjectively evaluate driving. In this research, we investigated the relationship between driver's subjective evaluation and driving maneuver by DS experiments at the intersection left turn.

From the results, it was confirmed that the factors which subjectively evaluate each driver differed for each driver. Also, it was confirmed that there was not one evaluation item for driving operation.

From the above, it was suggested that it is necessary not to support uniform support but to support different drivers for each driver in order to carry out optimum driving support and automatic driving for each driver.

In the future, I will simulate automatic driving by DS and I will confirm that driving feeling comfortable is the same as driving with the best subjective evaluation.

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In this paper, we focused on the items that the driver considered the most important, but we plan to consider paying attention to the second priority item in the future.

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