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A Measuring Method for the Level of Consciousness while Driving Vehicles

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Abstract- Recently, the driver's attention while driving a vehicle has to be taken seriously in a modernized society. Although some studies of attention while driving are being conducted now, the character of human activity is complicated for estimating attention while driving a vehicle. In the present study, the driver's attention was studied by driving performance and meandering of the vehicle. Two sets of drivers were used to compare driving while alert and while drowsy. For driving performance, the degree of steering and the degree of acceleration were measured. For meandering, the shoulder line on the road was detected by a CCD camera to calculate the coordinates of the vehicles. These three values showed the dynamical degree of the driver's attention. The results show that the meandering values and the degree of steering values correlated with the degree of attention of the driver, and these results can be applied to make an alert system for drivers during decreased consciousness or concentration in order to realize a safe society for our modern roadways.

I. INTRODUCTION

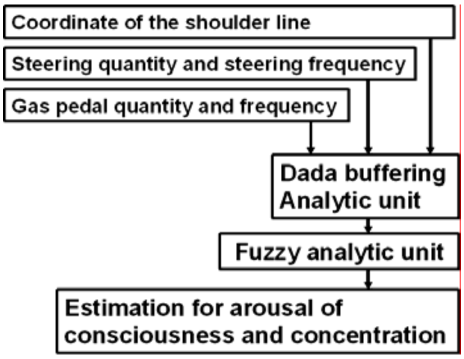
Basically, people are concerned about how their cars perform. They choose cars that car easily be repaired, are low cost maintenance and have low gas emissions. They further modify their cars with features such as satellite navigation systems that include advanced high intelligent safety systems that monitor the condition of the driver and provide warnings of unsafe traffic conditions or obstacles. They do these things all in the hope that their driving is0 pleasurable for them and safe for society and does nor damage the environment more. However, many traffic accidents are caused by dozing off at the wheel, with the most serious accidents happening at high speeds on heavily trafficked roads. The performance features of cars should be developed to improve the performance of drivers. The limitations for driving safely depend on driver performance, vehicle performance, and road conditions. Advanced technology that improves these limitations will contribute to a safer society. To this end, many improvements can be made on the human-machine interface for vehicles [1] Studies on the degree of consciousness of the driver have utilized techniques of capturing eye movements [2, 3]. However, this method is not suitable for studies on driving due to the continual movement of the driver's head. It is more practical to estimate the decrease in the level of consciousness by a decrease in the performance of the driver.

II. ESTIMATION METHOD

There are various indicators to estimate the level of consciousness and concentration while driving vehicles. For example, there is the variation of depression upon the gas pedal, the interval time between eye blinks, the variation of steering angles, the distance maintained between vehicles and the lane line on the road, and the degree of inconsistency in vehicles speed. Such estimates are conventionally accounted for by individual differences of the ability of the driver. So many factors need to be accounted for in these estimations. This study compared four drivers with two different levels of driving abilities, a low ability set and a high ability set, against their meandering when driving. For both sets of drivers, a low level consciousness is induced through the consumption of alcohol, with further comparisons made against two different levels of consciousness, non-inebriated and inebriated. Meandering is measured by the distance between the front of the vehicles and shoulder line of the lane.

III. SYSTEM CONFIGURATION

The study was been done on a simulator for unconcentrated driving because of the danger of drinking and driving. A similar experiment was conducted by in-vehicles on the highway but only for concentrated driving to estimate the deviation between the central coordinates or the vehicles and the shoulder line. The system configuration of this study is shown in Figure 1. The estimation for level of consciousness and concentration when driving a car is applied against (a) the distance values between the central coordinate of the vehicles and the shoulder line, measure. Along a line for both conditions, unseen by the driver, running orthogonal to the shoulder line, (b) steering quantity and frequency, and (c) gas pedal quantity and frequency. (b) and (c) were done on the simulator. The image processing method for measuring the output variables is done through a board attached to the computer.



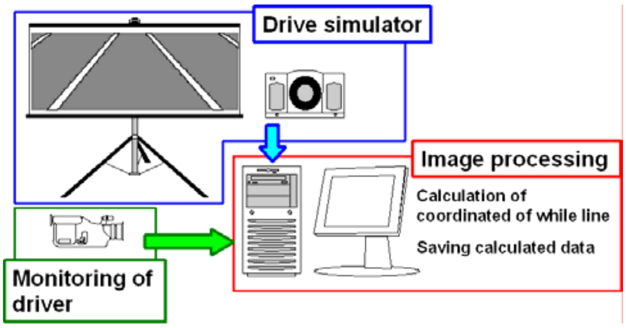


Figure 1. Estimation method

Figure 2. System configuration

Figure 2 shows the simulation system. The image is made by computer graphics technology projected in colour on a screen of 90 inches. Driver participants are sitting down in front of the screen at a distance of 1 m. The simulation driving conditions are during the daytime with no traffic. The shoulder line appeared yellow on grey asphalt, set on an oval track with limited scenery. The steering wheel had a force-feedback feature. Driving speed was kept between 40 km/h and 120 km/h on the simulator. Drivers had to maintain their speed by a foot pedal, and they controled the steering by either one or two hands. Three drivers with high ability participated both in the simulator experiment as in the in-vehicle experiment. Two driver with low ability panticipated only in the simulator experiment. Distances are calculated by image processing from the obtained image data. The driving test course where the radii of the semi-circle turns are both 955 m and the total track circumference is slightly over 10 km. Future work on this research will include a trafficked road as well as measurements of steering angle, depression of the gas pedal or throttle, and distance between vehicles. The experiment for in-vehicles was conducted on a trafficless highway driving daytime. The speed was kept at 100km/h. The participants drove for one hour, then rested for one hour with a total of 6 hours of driving. A CCD camera was mounted on the rearview mirror, to record the driving lane. The data from this camera was recorded on a video deck and supplied to the image processing board mentioned above.

Estimation method

Both the drivers with high ability and the driver with low ability were tested for concentrated and unconcentrated driving as shown in table 1. Concentrated driving is defined as driving without feeling drowsy on being inebriated, where as unconcentrated driving means driving while feeling drowsy or being inebriated but still trying to concentrate. The simulated image data are made by computer graphics and fed into to a high speed image processing board attached to another computer by a bus line.

Table 1. Applied experiment conditions

driver type	condition	simulator	In-vehicle
driver with high ability	concentrated	tested	tested
	drowsy	tested	untested
	inebriated	tested	untested
driver with low ability	concentrated	tested	untested
	drowsy	tested	untested
	inebriated	tested	untested

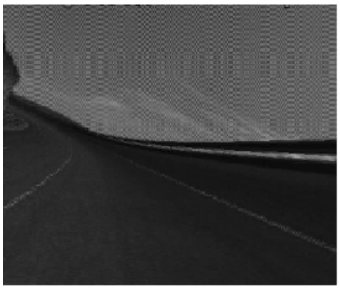


Figure 3. Original data obtained by CCD camera

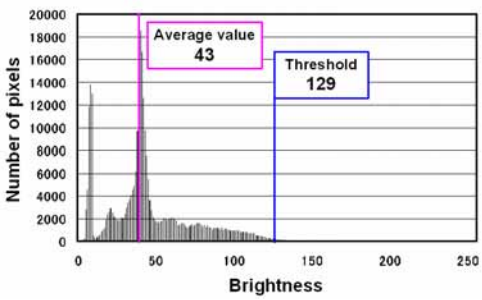


Figure 4. Brightness histogram for the original image data

Estimation of the coordinates of the shoulder line and central vehicles between simulator and in-vehicles. The sane method to estimate the coordinates between the shoulder line and the center of the vehicles is used for borh the simulator and in-vehicles. The image data are sampled at 0.125 µ seconds and stored into a buffer memory. An original image from these data is shown in Figure 3. The frequency distribution of the brightness histogram in Figure 4 is made to get the threshold level of the distance measurements. The peak brightness level is one-third of the threshold brightness, to reach a suitable level for extracting the shoulder line. Data are enhanced to show contrast between the shoulder line and the pavement, as shown in Figure 5. After that, the image data went through binarization to mark the threshold level, as shown in Figure 6.

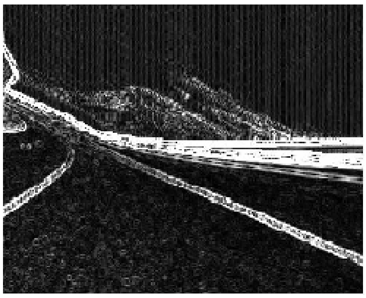


Figure 5. Differential processing

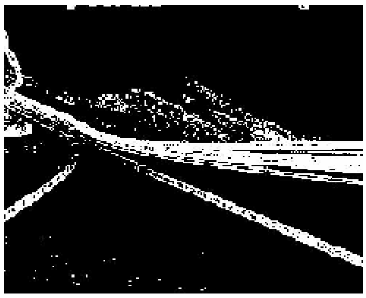


Figure 6. Binarized image data

In order to keep the continuity of the shoulder line on the lane, the data are processed through dilation and then erosion, as shown in Figure 7. The threshold level is calculated every second to obtain image data. To obtain suitable coordinates for measurement distances to the shoulder line are sampled every 1/30 seconds because frames run at 30 frames/second. As shown in Figure 8, the vehicles is located at the centre of the lane. The coordinates are measured two meters ahead of the center of the moving vehicle and the orthogonal direction of the lane. Deviation values are calculated and shown as meandaring values.

Figure 7. Processing dilation and erosion

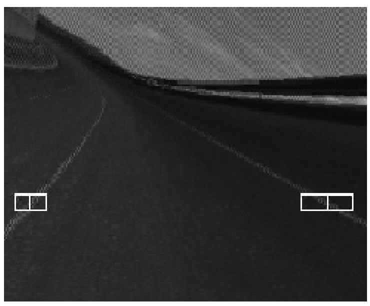


Figure 8. Processed image

Figure 9 shows the quantity of meandering measured from the left shoulder line. The standard deviation for each frame is calculated every 1/30 seconds. Calculations from a 5-second period to a 30-second period, with intervals increasing every 5 seconds, found that a 15-second period is reasonable for data sampling, shown in Figure 10.

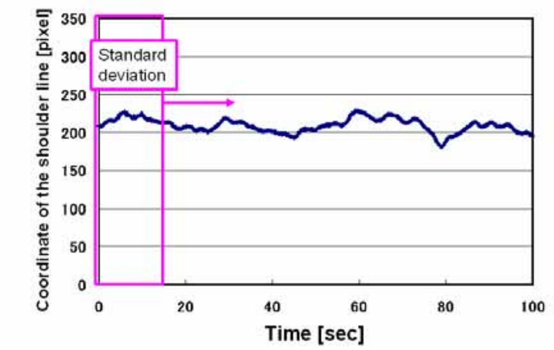


Figure 9. Coordinate of the center point of the shoulder line in a vertical direction on the screen

The resulting values defined the quantity of meandering. The quantity of meandering depended on driving ability as well as the level of consciousness and concentration for driving.

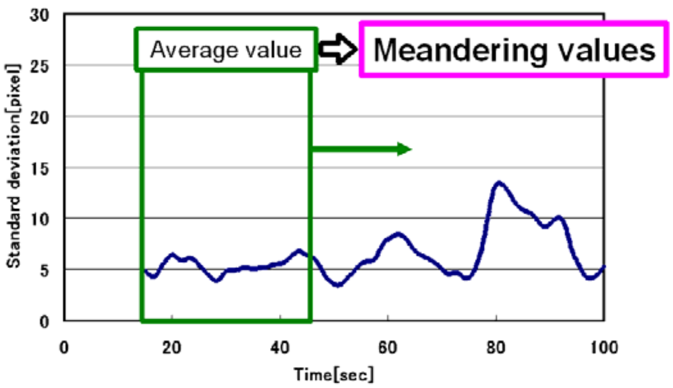


Figure 10. Moving average values for standard deviation calculated every 1/30 sec

IV.RESULTS

The meandering between a high ability driver and a low ability driver appears obviously different in the averages, as shown in Figure 11, where the blue line represents a driver of low ability and the red line represents one with high ability. The high ability set has advanced driving ability and enough practice time, i.e. over 10 hours driving in the simulator. The low ability set has little experience. The average values for the high ability drivers is kept to a smaller deviation, ranging from 5 to 12 pixels, while the low ability drivers have a larger deviation, ranging from 10 to 20 pixels, meaning less stability or control of the vehicles. The difference is noticeable.

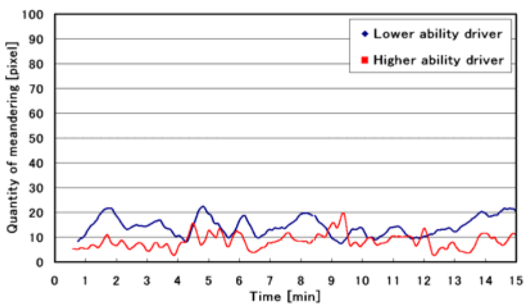


Figure 11. Meandering when concentrated

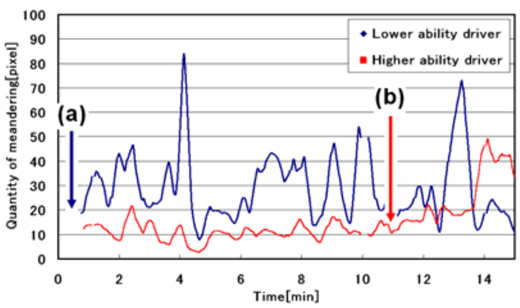


Figure 12. Meandering when drowsy

Figure 12 shows the effects from the deterioration of the level of consciousness on driving when drowsy. The blue line shows a low ability driver and red shows a high ability driver, respectively. Level of drowsiness was self-assessed and reported. The arrow labelled (a) marks the points where the low ability driver became drowsy. The meandering occurs in sharp, erratic increases thereafter. However, the high ability driver also rapidly lost control of the vehicle after point (b) of becoming drowsy.

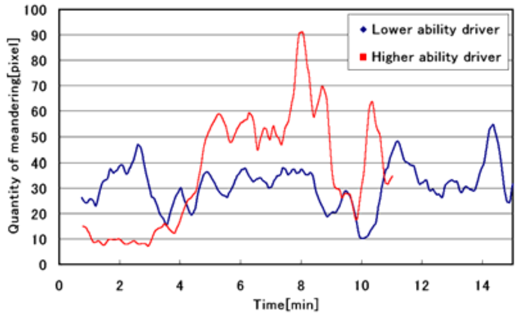


Figure 13. Meandering when inebriated

Figure 13 shows the effects from the deterioration of the level of consciousness on driving when inebriated. The low ability driver, shown in blue, received 1050 ml of an alcoholic drink with a 14% concentration, and the high ability driver received a 700 ml drink with the same concentration. The driving began one hour after consuming the alcohol. Although the alcoholic intake is about one-third less, the high ability driver performed considerably worse and even gave up before twelve minutes passed. The low ability driver appeared less affected. As an effect of being drowsy and inebriared the drivers concentration is reduced and they show dengerous driving. This result can be interpreted as evidence of individual differences. Furthermore, the performance when inebriated was far worse than when simply drowsy. Inebriated drivers seem to be less able to follow the shoulder line than drowsy drivers, and , therefore, are perhaps less safe on the road.

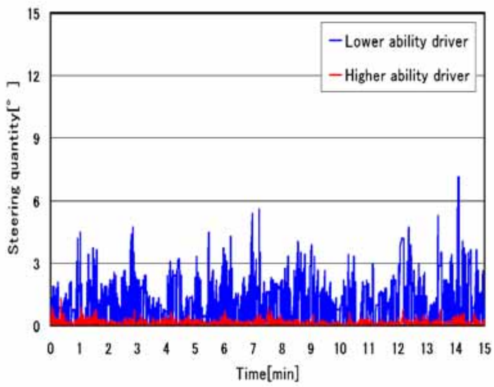


Figure 14. Steering quantity when concentrated

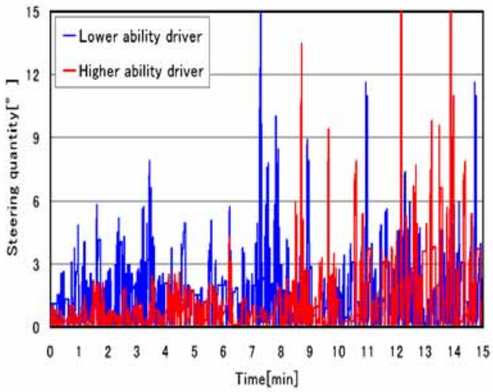


Figure 15. Steering quantity when drowsy

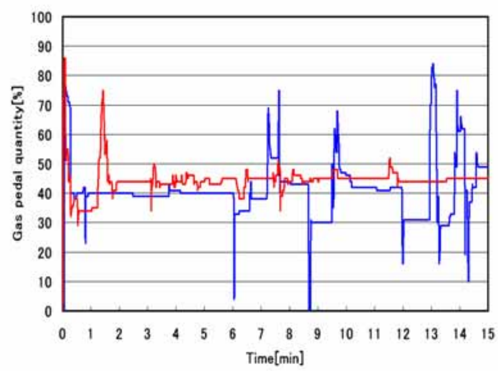


Figure 16. Accelerator quantity when concentrated

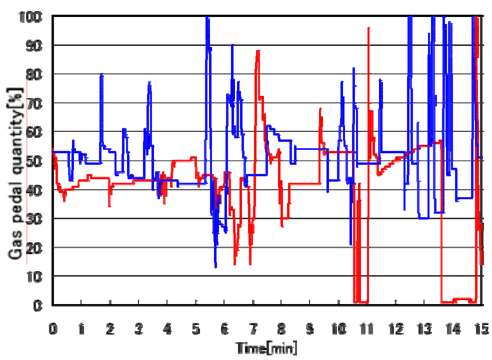


Figure 17. Accelerator quantity when drowsy

Although these data might be different between in-vehicles and the driving simulator for drivers who are drowsy on inebriate, it is very hard to run this experiment on actual equipment and in actual conditions. Further more, it would be preferable to understand how the results from this experiment compare with a similar experiment under non-simulated conditions. Figure 15 and 17 show the effects from the deterioration of the level of consciousness on driving when drowsy. The quality of stearing deteriorates and remaining between the white lines as well as driving smoorthly becomes difficult. Therefore, the amount of correction to maintain safe vehicle operation is increasing. Maintaining a consistent speed through the gas pedal becomes especially difficult. Therefore, the vehicle operation is erratic.

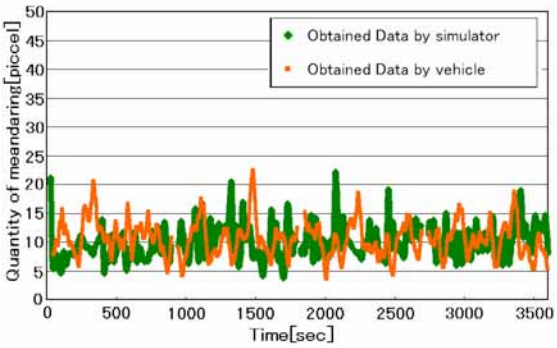


Figure 18. Meandering values on simulator and in-vehicle

Figure 18 shows the comparison for meandering values on the simulator and in-vehicle for high ability driver. Driving is done on the highway with keeping the speed at 100km/h. The values of meandering maintain the same tendency. These results indicate that the data obtained with the simulator are valid.

V. CONCLUSION

Results from this study show that the quantity of meandering depends on the driving ability. Driver with low ability are especially unable to follow along the shoulder line at length with accuracy ever at the stout when their level of concentration could still be expected to be high. It depends on how well drivers have mastered driving techniques. Also, as the level of concentration decreased, the quantity of meandering increased. This relationship appeared strong throughout this study. Particularly when inebriated, the quantity of meandering increased rapidly. The meandering values of simulator and in-vehicles show the same range of deviation. These results suggest that it is possible to estimate the level of consciousness and its effects on driving

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