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Study of Occlusion Technique for Making the Static Evaluation Method of Visual Distraction

1. Summary

This test used 4 types of navigation systems and was taken by 10 subjects.

The test results are as follows.

- As iteration of interaction with glances and operations of the navigation system during driving the subject vehicle increases, uneasiness feeling of the subjects and lateral deviation of the subject vehicle increase.
This result shows necessity of upper limit of number of interaction.
- Total Glance Time (TGT) that causes visual distraction of the driver had high correlation with uneasiness feeling of the subjects and lateral deviation of the subject vehicle.
The upper limit of TGT estimated from the uneasiness feeling and the lateral deviation was 8 seconds.
- Total Task Time (TTT) and Total Shutter Open Time (TSOT) based on Occlusion Technique were evaluated as an index that should be used on a test bench instead of using actually equipped vehicle. TSOT had stronger correlation with TGT than TTT.
- The TSOT shutter pattern which has 1.5 seconds open time and 1.0 second close time had highest correlation.
TSOT that is equivalent to 8 seconds TGT was 7.1 seconds.
- TSOT around 7 seconds using Occlusion Technique can be a good criteria to evaluate and extract the interactions with visual equipment that require long time continuous attention or too many iteration of glances and operations.

2. Policy of this study

- 1) Obtain upper limit of TGT that does not interfere normal driving from uneasiness feeling of the subjects and lateral deviation of the subject vehicles during the test drive.
- 2) Obtain the best test bench based evaluation method that indicates highest correlation with TGT. (TTT or TOST)
- 3) Estimate the upper limit of selected index from the upper limit of TGT.

3. The experimental method

3.1 Experimental conditions

3.1.1 Subjects for the experiment

10 males from 25 years old to 51 years old

3.1.2 Vehicles and navigation systems used



Picture 1: BMW 525i (Rotation Type)



Picture 2: Toyota Crown (Touch Panel Type)



Picture 3: Nissan Cedric (Joy-stick Type)



Picture 4: Toyota Mark II (After Market : Remote Control Type)

3.1.3 Operations for experiment

- Map scale change (2 times operation)
- Display of near by facilities
- Destination setup (3 to 7 characters input)
- Destination setup (10 digits telephone number input)
- Map continuous scroll
- Selection of text information from VICS* (8 times operation)
- Selection of text information from VICS (12 times operation)
- Page skip of text information (8 times operation)
- Page skip of text information (12 times operation)

*VICS : Vehicle Information and Communication System

3.1.4 Test course for total glance time

- 1) Urban road (2 lane for each side, regulation speed 60km/h)
- 2) Urban road (1 lane for each side, regulation speed 60km/h)
- 3) Joban Expressway (3lane for each side, regulation speed 100km/h)
- 4) Shuto Expressway (2 lane for each side, regulation speed 80km/h)

3.2 Measured items

3.2.1 Measurement of Human visual behavior and lateral control quality while driving on the test course

*Subjects were indicated to operate as safe as possible, and operations were carried out as soon as possible to look forward.

1) Movement of eyes measured with a camera

- Single glance time
- Glance times
- Total glance time



Picture 5 :Measuring Total Glance Time

- 2) Lateral control quality of the subjects (Deviation from the lane markings was measured by a camera)



Picture 6: Lateral deviation measurement camera

Reference data was obtained by measuring lateral deviation without navigation control. (Mean value of 40 seconds)

(cm)	Touch Panel	Joy-stick	Remote Control	Rotation
2 Lane Urban Road	298	293	283	276
1 Lane Urban Road	407	385		
Joban Expressway	576	591	491	486
Syuto Expressway	574	382		

Table 1: Lateral Deviation Reference Data

- 3) Measurement of uneasy or dangerous feeling
 1=very easy, 2=easy, 3=rather easy, 4=neutral, 5=rather dangerous, 6=dangerous, 7=very dangerous

3.2.2 Measurement of Total Task Time (TTT) on test bench

*Subjects were instructed to operate two ways.

- A. To operate as fast as possible
- B. To operate as if operate while driving

3.2.3 Measurement by the occlusion technique on test bench

- Goggle with liquid crystal shutter was used to control open time and close time
- Color when shutter closed was white
- Response time of shutter were less than 10msec (Both open to close / close to open)
- Transparency of shutter was 73% when opened / 12% when closed



Shutter Open



Shutter Close

Picture 7: Transparency of Goggle

- Open / Close pattern of shutter

- Open 1.0sec / Close 0.5sec
- Open 1.0sec / Close 1.0sec
- Open 1.5sec / Close 0.5sec
- Open 1.5sec / Close 1.0sec
- Open 1.5sec / Close 3.0sec

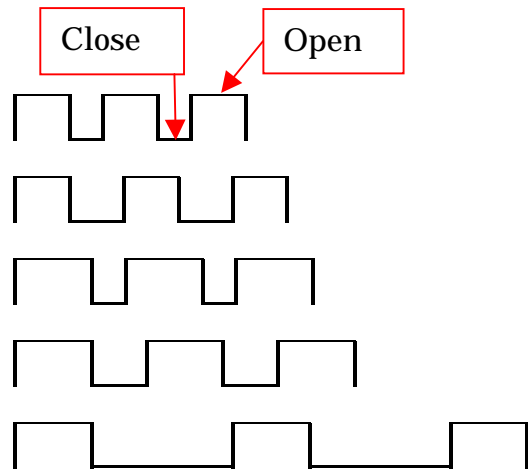
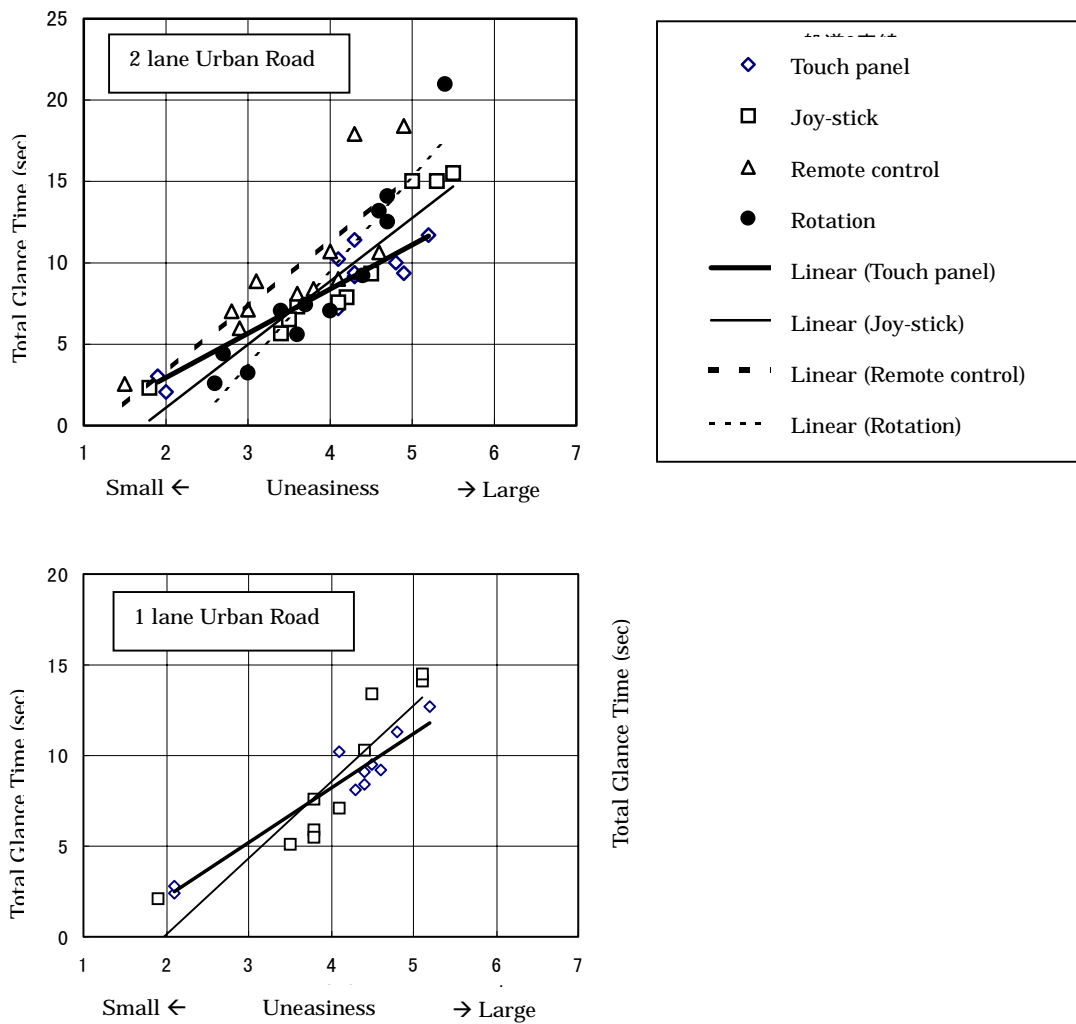


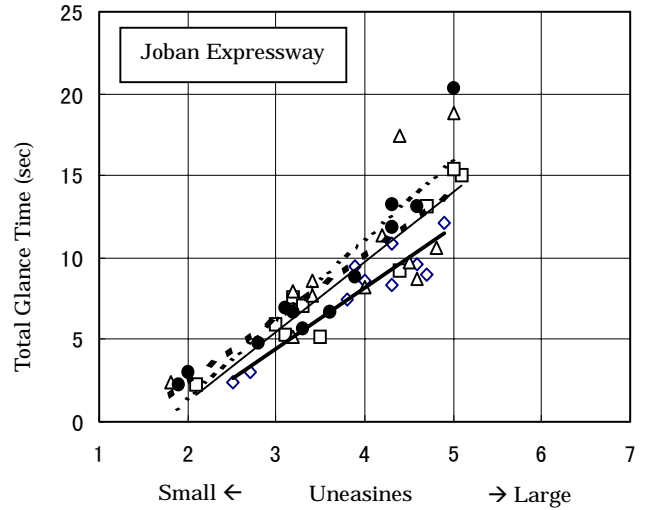
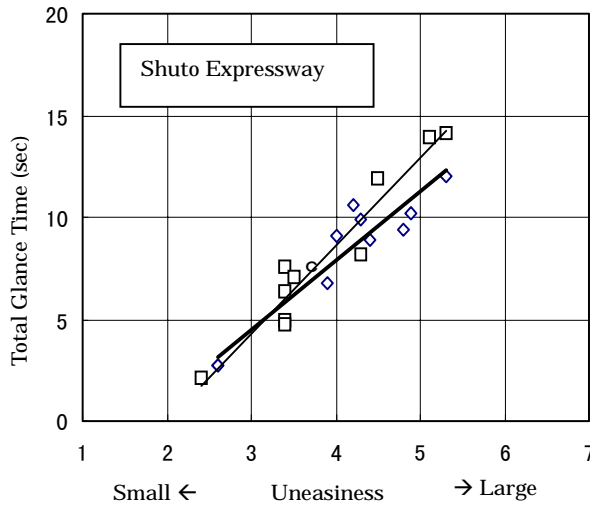
Figure 1: Shutter pattern for occlusion method

4. Experimental Result

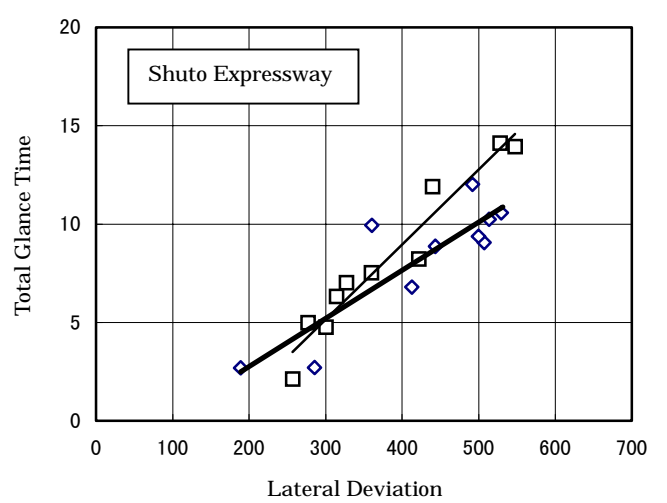
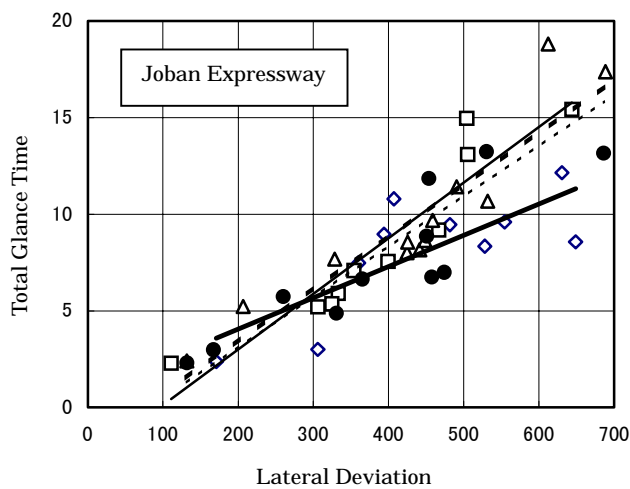
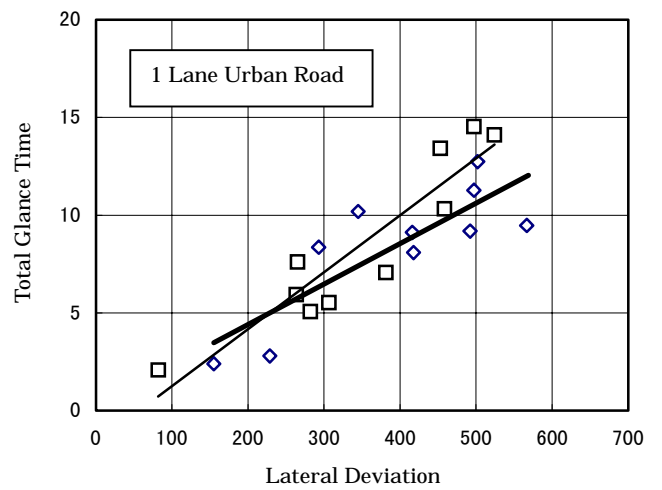
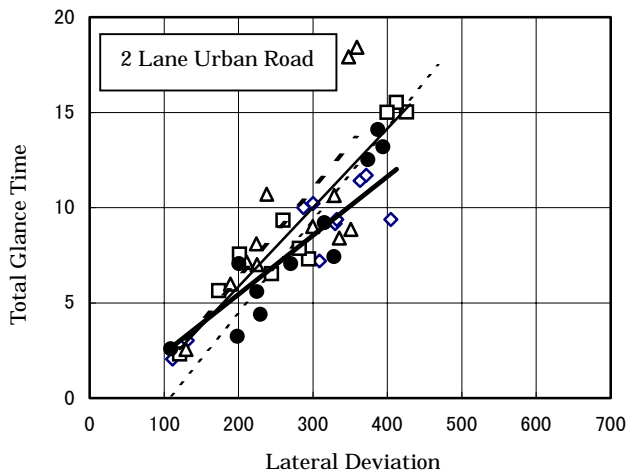
4.1 Upper limit of Total Glance Time while vehicle is in motion

Graph 1: Relation between TGT and Uneasiness





Graph 2: Relation between TGT and Lateral Deviation



a) Upper limit of TGT that does not cause uneasiness feeling to the subjects

These figures are obtained from “Graph 1”.
(uneasiness = 4)

	2-lane urban	1-lane urban	Joban expressway	Syuto expressway
Touch pane	8.4	8.2	8.2	7.9
Joy-stick	8.9	8.6	9.7	8.7
Remote control	11.4		10.2	
Rotate	9.5		11.1	

Table 2 : Upper Limit of TGT regarding Uneasiness

b) Upper limit of TGT that does not affect lateral control

These figures are obtained from “Graph 2” referring “Table 2”.

	2-lane urban	1-lane urban	Joban expressway	Syuto expressway
Touch pane	8.5	8.7	10.2	11.9
Joy-stick	9.7	9.6	14.3	8.3
Remote control	10.2		12.3	
Rotate	8.2		10.6	

Table 3: Upper lint of TGT regarding Lateral Deviation

c) Upper limit of TGT that does not cause uneasiness feeling to the subjects AND that does not affect lateral control

(The minimum value of Table 2 and Table3 of each boxes)

	2-lane urban	1-lane urban	Joban expressway	Syuto expressway
Touch pane	8.4	8.2	8.2	MIN →7.9
Joy-stick	8.9	8.6	9.7	8.3
Remote control	10.2		10.2	
Rotate	8.2		10.6	

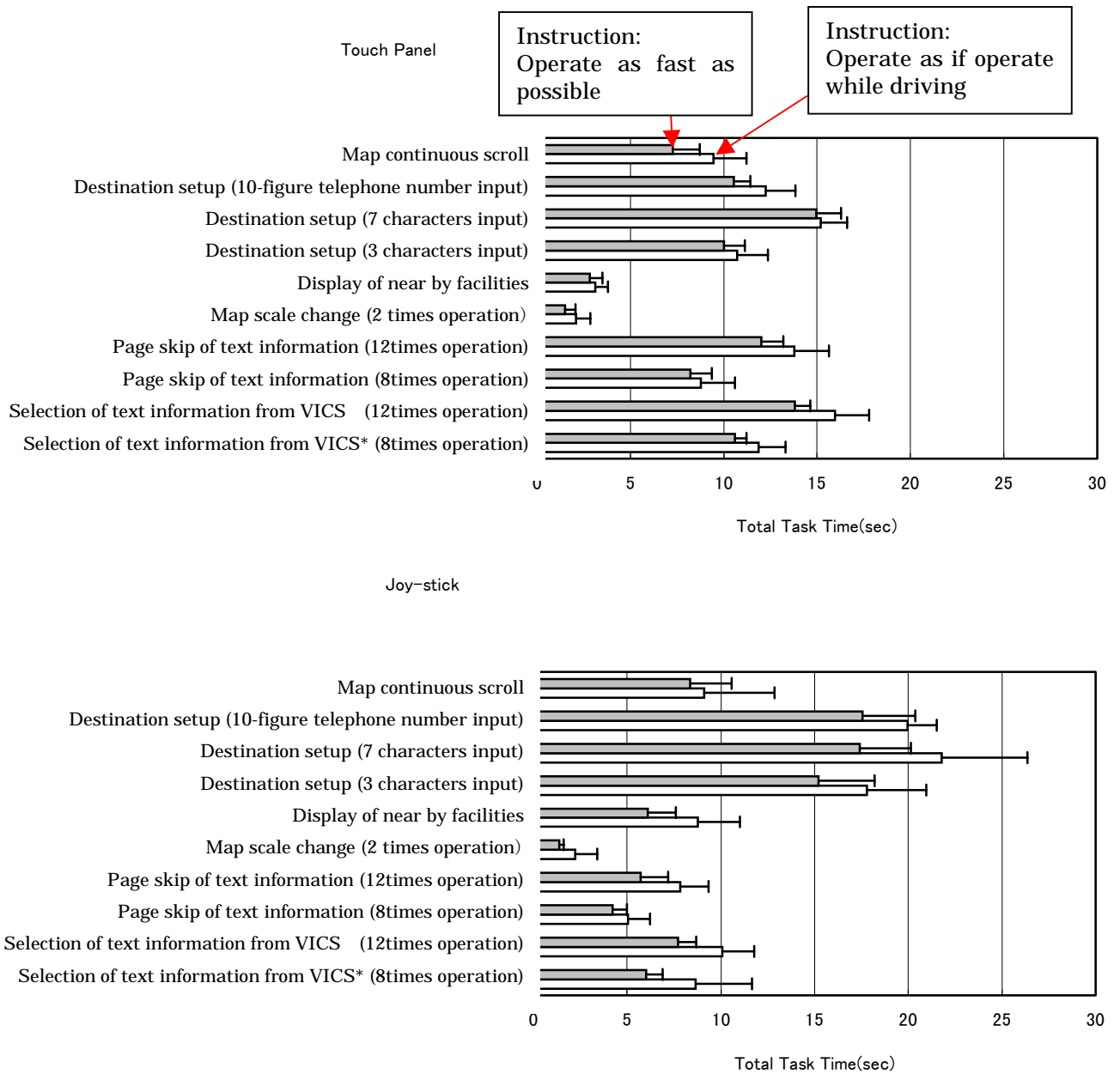
Table 4: Minimum TGT

(Result)

- Visual distraction while vehicle is in motion is directly evaluated by Total Glance Time
- Total Glance Time should be less than 8 seconds.
- It is difficult to evaluate visual distraction by Single Glance Time only, because t subjects feel more dangerous as Total Glance Time increases.

4.2 TTT

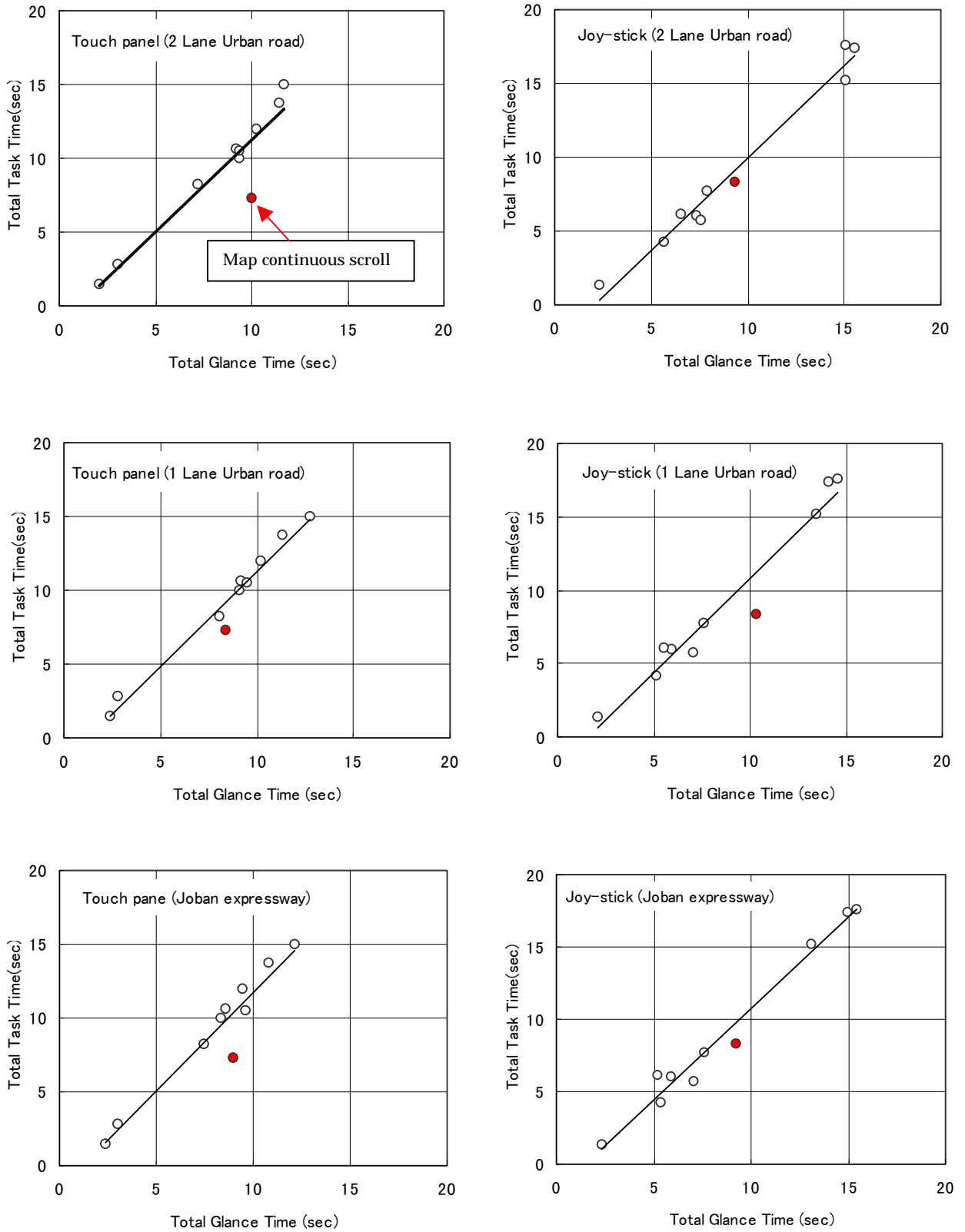
Graph 3: Instruction effect to TTT

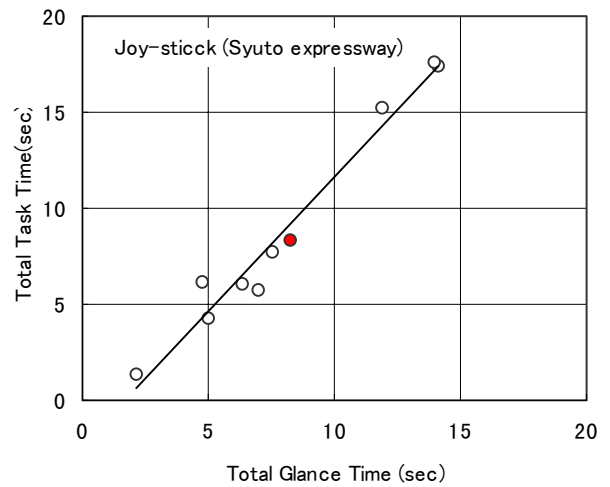
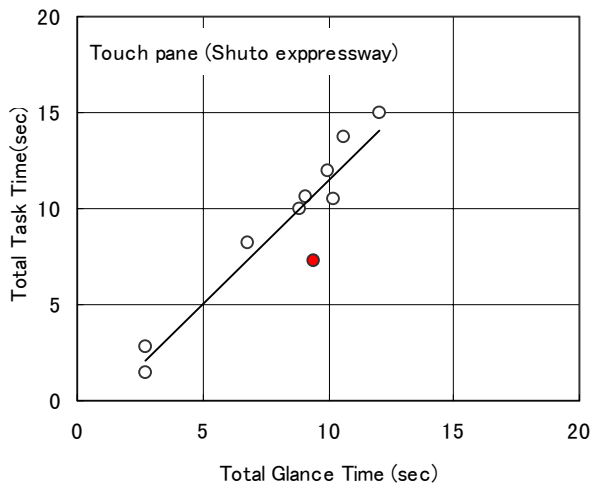


(mean of 4 kinds of road)

TTT was affected by instruction.

Graph 4: Correlation between TTT and TGT





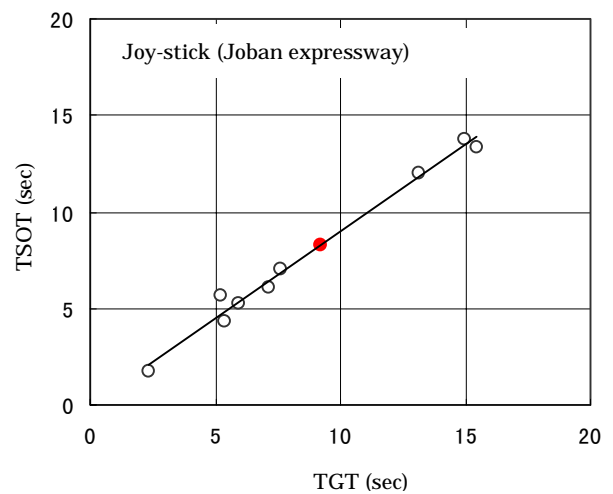
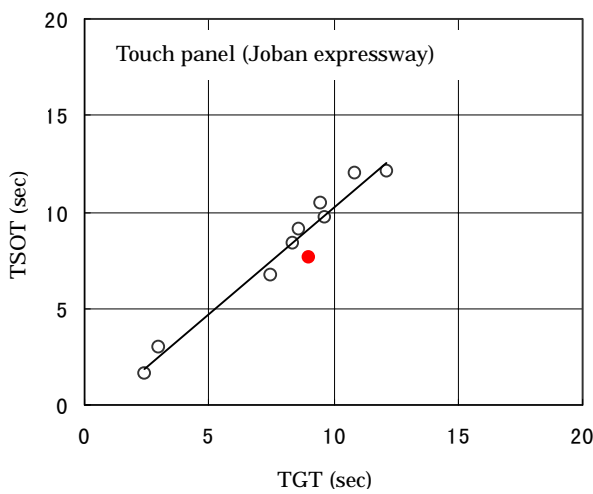
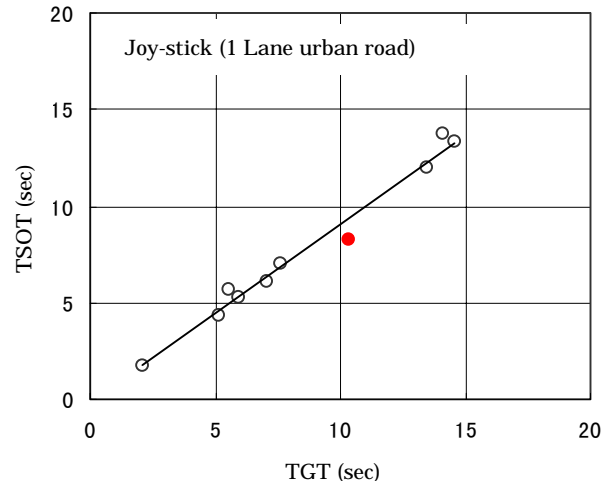
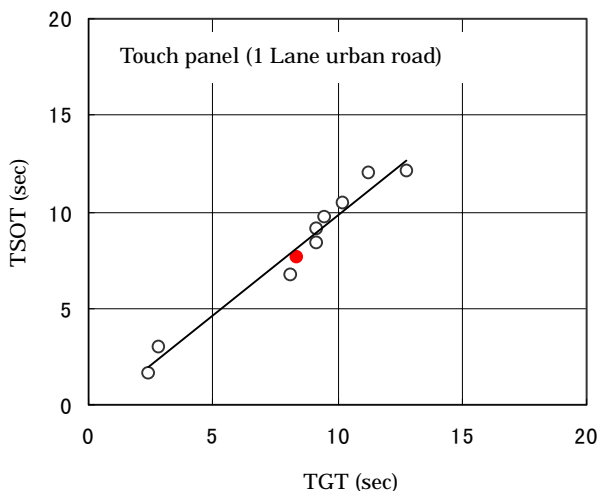
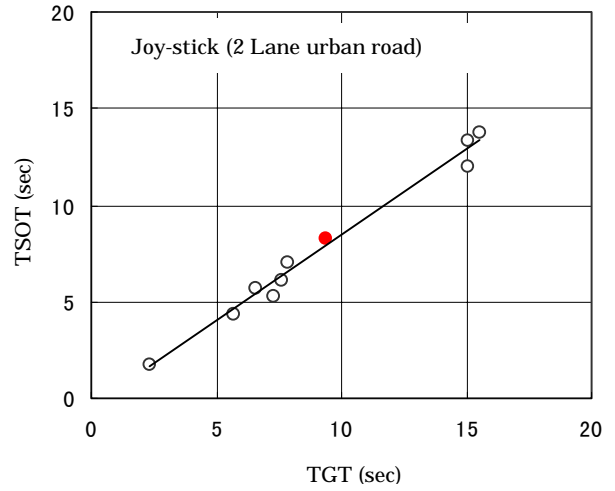
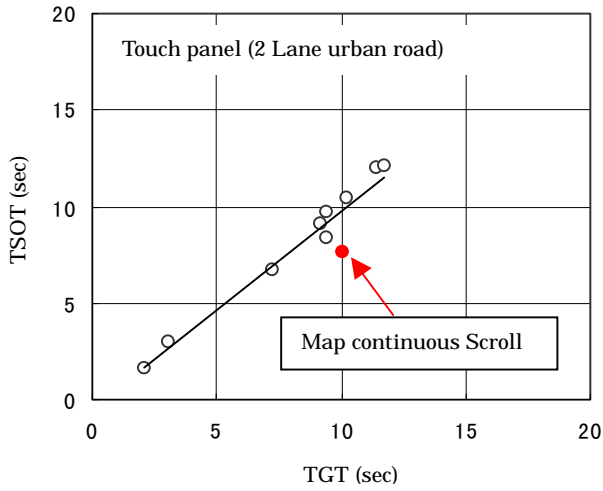
(Mean of 10 subjects)

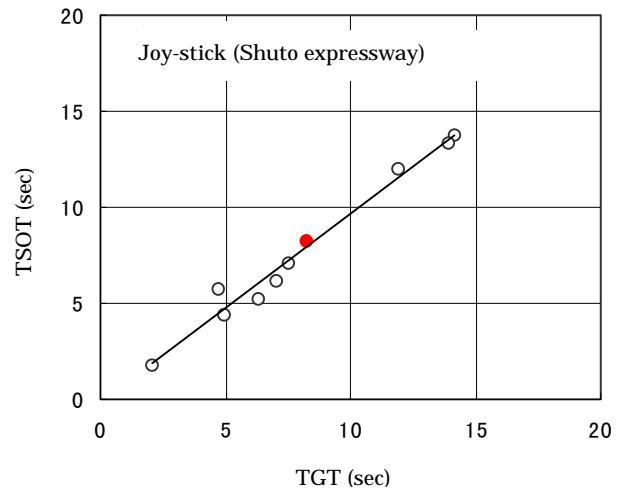
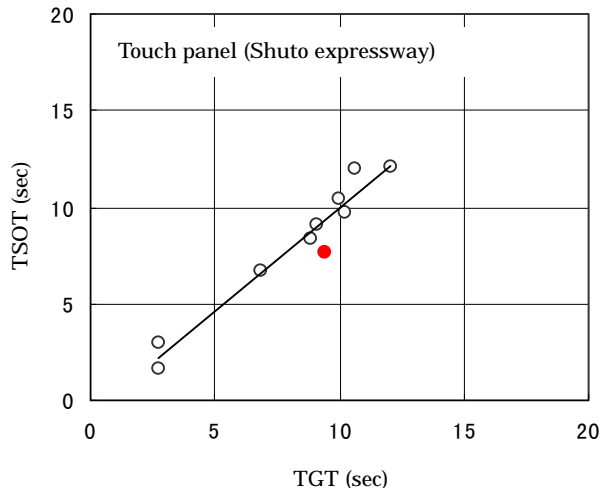
(Result)

- TTT was affected by instruction
- TTT shall be less than 8sec, because it is equivalent to 8sec in Total Glance Time
- TTT had fairly close correlation between Total Glance Time
- TTT could not evaluate the visual distraction which cause involuntary continues gaze such as map continuous scroll (indicated by red mark in above glaphs).

4.3 Occlusion

Graph 5: Correlation between TSOT and TGT
 (Open / Close pattern: Open=1.5sec / Close=1.0sec)





(Mean of 10 subjects)

(Result)

- TSOT had very high correlation between Total Glance Time
- TSOT could evaluate all visual distraction including map continuous scroll.

Effect of shutter pattern in occlusion method
(select the most suitable shutter pattern)

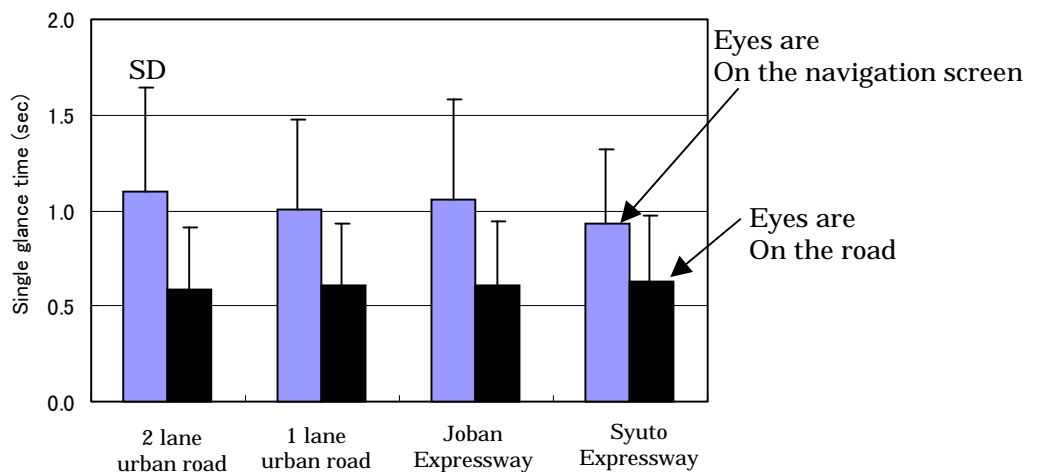
	TTT/TGT	TSOT/TGT				
		Close 0.5 Open 1.0	Close 1.0 Open 1.0	Close 0.5 Open 1.5	Close 1.0 Open 1.5	Close 3.0 Open 1.5
Touch panel	0.833	0.858	0.845	0.847	0.857	
Joy-stick	0.857	0.867	0.891	0.885	0.888	
Remote control	0.883	0.887	0.868	0.900	0.889	0.862
Rotation	0.928	0.890	0.932	0.926	0.939	0.924
Average	0.8760	0.8755	0.8840	0.8895	0.8933	0.8930

Shows higher correlation than TTT/TGT

Table 5: Correlation between TSOT shutter pattern and TGT

(Result)

- TSOT had higher correlation than TTT with TGT.
- Shutter pattern in Occlusion technique shall be open=1.5sec / close =1.0sec, because it has most close correlation between Total Glance Time
- This pattern is similar to the actual visual behavior (average + 1SD)
(The selected shutter open time was almost equal to watching time on the navigation screen and close time was almost equal to watching time on the road in actual driving. But note that occlusion method does not simulate actual visual behavior while driving.)



Graph 6: Mean of Single Glance Time on the Actual Visual Behavior while driving

Conclusions

- As iteration of interaction with glances and operations of the navigation system during driving the subject vehicle increases, uneasiness feeling of the subjects and lateral deviation of the subject vehicle increase.
This result shows necessity of upper limit of number of interaction.
- Total Glance Time (TGT) that causes visual distraction of the driver had high correlation with uneasiness feeling of the subjects and lateral deviation of the subject vehicle.
The upper limit of TGT estimated from the uneasiness feeling and the lateral deviation was 8 seconds.
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