The Effective IVIS Menu and Control Type of an Instrumental Gauge Cluster and Steering Wheel Remote Control with a Menu Traversal

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Abstract. The present study investigated the effective IVIS menu and control type of the instrument gauge cluster and steering wheel remote control. Participants performed menu traversal tasks with a steering wheel remote control and gauge cluster display in a driving video simulation. Two steps of experiment were conducted. The first was focused on the menu type and within-subject factorial design was implemented with two levels of menu types (the spread and overlapped menu type), two levels of control types (the wheel and touch wheel controller) and two levels of menu traversal tasks. Subjective ratings of a preference (using modified Likert-type rating scale) and a menu traversal time and routing error were obtained as performance measures. ANOVA results showed that the menu type, control type and the interaction of the control and task were significantly affected by each of the independent variables. The result implied that the spread menu type and wheel controller were more effective. The second experiment was focused on the control type with the spread menu type and within-subject factorial design was implemented with two levels of control types (the wheel and 4-way directional controller) and two levels of menu traversal tasks. ANOVA results of a performance showed that the control type and task were significantly affected. The result implied that the wheel control type with the spread menu type was more effective IVIS interface alternative on a gauge cluster and steering wheel remote control.

Keywords: IVIS Interface, IVIS Menu Traversal, IVIS Menu Type and Control Type.

1 Introduction

In-Vehicle Information System (IVIS) is increased in the automobile market. This is the one of the main system for the vehicle. This trend is along with the electronic technology development and reflects the driver requirement for information interaction.

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This system (IVIS) makes the increase of the driver information interaction in the vehicle. This means that the driver workload is increased. So, to reduce the driver workload the various approaches to the IVIS interface have accomplished. These have focused on the IVIS menu and control type, location and manipulation efficiency at the center-fascia. These are the effort to provide more safe and effective interface to the driver. [1, 2, 3, 4, 5].

However, IVIS have been changed. From the center-fascia to the gauge cluster, IVIS expands to the whole driver cockpit. This is not only location changes but also information contents transfer. The information that is represented at the center fascia and gauge cluster is not clearly distinguished. However, there is common trend of information categorization in the vehicle market. While the navigation, ventilation and entertainment information are represented IVIS at the center-facia, the convenience system setting, driving information and auxiliary entertainment information are applied IVIS at the gauge cluster. The expansion of IVIS area is required the complex manipulation to the driver. More information is displayed at the gauge cluster that is made by LCD panel as like computer monitor. To control this information the driver may manipulate the steering wheel remote control that is consists of various functions. The previous steering wheel remote control is applied one function to one control. However, more information at gauge cluster is required more complex steering wheel remote control as like 4-way directional, wheel, and touch wheel controller.

These complex manipulations with information display at the gauge cluster and control at the steering wheel makes more workload to the driver also. Especially, as the location of IVIS complex remote control is changed from center console to steering wheel, not only steering control but also menu manipulation are required to the driver.

When there was the change of the display area and input device constraint, other studies that were conducted without the same constraint were not able to apply. [6] Therefore, in this study we focused on the constraint of the gauge cluster display and steering wheel remote control. And we proposed the effective IVIS menu and control alternative through the menu traversal.

2 Methods

Other study on the IVIS interface with the gauge cluster display and steering wheel remote control was focused on the effective menu depth and breath. This study was proposed that the optimum menu structure was 3-depth and 7-breath. [7] And he proposed that the driver preferred entertainment information manipulation contents. This was the auxiliary entertainment information of the other IVIS that was located in center-fascia. And this information was consisted of the music channel selection as like radio, CD, MP3 and outer entertainment device that was kind of i-pod and portable storage device. As the aspect of the system proximity and manipulation convenience, the IVIS that was located in gauge cluster and steering wheel had more advantage.

In this study, we reflected these menu structures and information contents. And to propose the effective menu and control type, we approached to the IVIS menu traversal with the task operation. The task was consisted of two operations. The first was the steering control with the driving video and the second was the menu manipulation. These tasks were applied simultaneously. To conduct this menu traversal experiment, we set up the driving simulator. The driving simulator was consisted of the steering wheel, LCD gauge cluster, driver seat, pedal and driving video projector. The driver who sat down the driver seat saw the front gauge cluster and the driving video and manipulated the steering wheel and remote control. (Fig. 1).

The driver who was the experiment participant controlled the steering wheel with the following direction that was represented by a driving video. And the driver manipulated the remote control mock-up with the gauge cluster menu display. In this experimental environment the driver conducted the menu traversal task and we measured the preference, performance time and error for menu and control type.

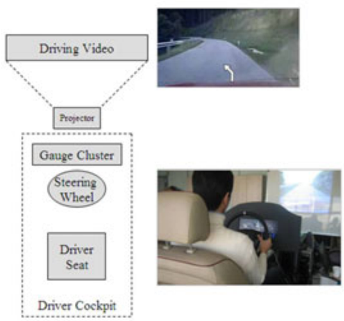

Fig. 1. The experiment environment of the IVIS menu traversal

2.1 Subjects

Two kinds of experiment were conducted. In the first experiment, nineteen Korean male and female drivers (age 40.2 years, driving experiment 13.8 years) participated in this study. In the second experiment, thirteen healthy male and female drivers (age 38.5 years, driving experiment 12.6 years) participated. All the subjects read and signed a consent form before the experiment. They were paid for their participation.

2.2 Apparatus

The gauge cluster that was displayed the IVIS menu was LCD device. And the gauge cluster had two modes. The one was driving mode. And this mode was consisted of the analog representation of the speedometer (left side) and tachometer (right side). These were similar to a commercial vehicle. The other was menu mode. And this mode activated by the wake-up control that was located in the steering wheel remote control. If the menu mode was 'On', the right side representation of the analog type tachometer was changed to the IVIS menu. (In this mode, the tachometer representation type was changed from the analog to the digital.) (Fig. 2).

The menu alternative was encoded by the Flash Program and the main computer displayed this alternative to gauge cluster. The steering remote control was connected by USB channel to the main computer. So, the gauge cluster was the output display

Fig. 2. The driving mode (left) and menu mode (right) of the gauge cluster

device and the steering wheel remote control was the input control device. The performance time and error of the menu traversal was encoded by the Flash Program, also. As the results, this time and traversal error was recorded by the software. The driving video projector was connected by the sub-computer.

2.3 Experimental Design

Two kinds of experiment were conducted. The first experiment was focused on the effective menu type with rotation movement control. The wheel and touch controller that is not applied to a vehicle but applied to an electronic device were used for the control type alternative. These controllers were known to the effective device for manipulating amount of information.

The second experiment was the comparison the rotation movement control to the 4-way directional movement control on the basis of the optimal menu type that was selected by the first experiment. The 4-way directional controller was applied to a vehicle and used to other IVIS study. [1, 2] So, the second experiment was focused on the comparison a new type controller with an existing controller.

2.3.1 Experiment for the Effective Menu Type with Two Controls

To measure a preference, performance time and routing error as dependent variables, we used a within-subject factorial design with two levels of control types, two levels of menu types and two levels of menu traversal tasks as independent variables.

Two levels of control types were a wheel controller and touch wheel controller. Two types of controller had a same movement direction. However, they were different to a movement mechanism. A menu movement was conducted by a clock-wise or a counter clock-wise manipulation. And a menu selection was performed with 'OK' control that was located in the center of a controller. (Fig. 3).

Two levels of menu types were a spread menu and overlapped menu. If a lower depth menu was selected, the spread menu was displayed a lower depth menu with an upper depth menu. On the other hand, the overlapped menu was displayed a just lower depth menu. (An upper depth menu was disappeared.) These menus were used to many electronic devices. A round or circle menu shape was applied for the rotation movement control, also. (Fig. 4).

Fig. 3. A wheel controller (left) and touch wheel controller (right)

Fig. 4. A spread menu type (left) and overlapped menu type (right)

Two levels of menu traversal tasks were a task 1 and task 2. A task 1 was consisted of a driving and convenience device setting. And a task 2 was a menu traversal for music channel setting. (Table 1) So, we made eight alternatives with control types, menu types and tasks. (Table 2)

Table 1. Two types of menu traversal tasks

Task 1	Wake up → Driving Environments → LDWS → OFF → return to first menu
Task 2	Wake up → AV → CD → Track no. 10 → return to first menu → Media → M-Station → Track no. 23

Table 2. An alternative for an IVIS menu traversal experiment

Control Type	Menu Type	Task	Alternative
Wheel	Spread	1	1
		2	2
	Overlapped	1	3
		2	4
Touch Wheel	Spread	1	5
		2	6
	Overlapped	1	7
		2	8

2.3.2 Experiment for the Effective Control Type

To measure a preference, performance time and routing error as dependent variables, we used a within-subject factorial design with two levels of control types and two levels of menu traversal tasks as independent variables. Two levels of control types were a wheel and directional controller. (A wheel controller was more effective in the first experiment.) (Fig. 5).

And a menu type that was selected by the first experiment was used. The task was same to the first experiment, also. So, we made four alternatives with control types and tasks (Table 3).

Fig. 5. A wheel controller (left) and 4-way directional controller (right)

Table 3. An alternative for an IVIS menu traversal

Control Type	Task	Alternative
Wheel	1	1
	2	2
Directional	1	3
	2	4

2.4 Experimental Procedure

A participant conducted a pre-test for a menu traversal and read the menu traversal task flow and memorized. Then, he or she participated in the experiment. Under the steering wheel control task with following direction that was represented by a driving video, the participant performed the menu traversal task. The steering wheel control error was recorded by an operator. If the participant failed to steering control more than two times, the experiment was conducted again. Whenever the participant ends a menu traversal for each alternative, a preference was measured by an operator with Likert-type 100-scale and a performance time and routing error was recorded by the software.

3 Results

3.1 Preference and Performance Analysis of the Effective Menu Type

The ANOVA results for the menu traversal preference showed significant main effects of control type, $F(1, 18) = 12.210$, $p = 0.003$ and menu type $F(1, 18) = 6.617$. The interaction of the control type and task, $F(1, 18) = 4.983$, $p = 0.039$ was significant, also. (Table 4). The result showed that the wheel controller and the spread menu type were more preferred. (Fig. 6).

Table 4. ANOVA results for the preference

Source	DF	SS	MS	F-Value	Pr > F
Control type	1	3971.901	3971.901	12.210	0.003*
Menu type	1	469.007	469.007	6.617	0.019*
Task	1	49.796	49.796	0.179	0.678
Control type × Menu type	1	84.007	84.007	0.590	0.452
Control type × Task	1	703.480	703.480	4.983	0.039*
Menu type × Task	1	123.480	123.480	0.852	0.368
Residual	18	1570.211	87.234		

**: significant at α = 0.05.*

When there is no interaction with independent variables, the result of the mean difference test between the main effect and each level of the independent variable is reliable. However, in this experiment, the interaction of control type and task were significant. This showed that the task was affected by the control type and this interaction was able to have effect on the result of mean difference between the main effect and each level of the independent variable.

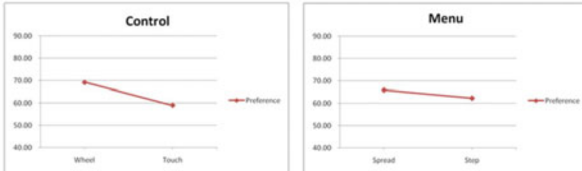

Fig. 6. The means of the control (left) and menu type (right) *(Unit: rating score)*

This interaction showed at Fig. 7. The wheel control kept better preference regardless of the task. However, the preference of the touch wheel control was decreased at the music channel manipulation task.

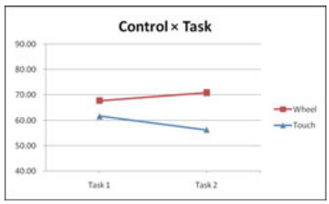

Fig. 7. The means of the interaction *(Unit: rating score)*

Table 5. ANOVA results for the performance time

Source	DF	SS	MS	F-Value	Pr > F
Control type	1	2846.716	2846.716	21.887	0.000*
Menu type	1	10.109	10.109	0.254	0.621
Task	1	35178.906	35178.906	186.277	0.000*
Control type × Menu type	1	122.401	122.401	1.066	0.316
Control type × Task	1	3052.852	3052.852	26.191	0.000*
Menu type × Task	1	91.916	91.916	1.143	0.299
Residual	18	756.601	42.033		

**: significant at α = 0.05.*

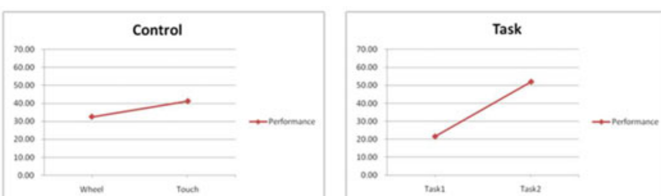

Fig. 8. The means of the control type (left) and task (right) *(Unit: sec.)*

Table 6. The routing error frequency of the controller

Control Type	Wheel Controller	Touch Wheel Controller
Routing Error Frequency	0.65	1.63

The ANOVA results for the menu traversal performance showed significant main effects of control type, F(1, 18) = 21.887, p = 0.000 and task, F(1, 18) = 186.277, p = 0.000. The interaction of the control type and task, F(1, 18) = 26.191, p = 0.000 was significant, as like the preference analysis. (Table 5). The result showed that the performance time and the routing error of the wheel controller was better. (Fig. 8 and Table 6) And the performance time of the task 1 was better, also. (Fig. 8).

As similar to the preference analysis result, there was the interaction of the control type and task. (Fig. 9) In the task 2, the difference between the wheel and the touch wheel controller performance was more. As a result of the preference and performance analysis, the effective IVIS interface alternative was the spread menu and wheel controller.

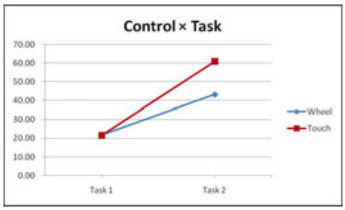

Fig. 9. The means of the interaction with the control type and task *(Unit: sec.)*

3.2 Preference and Performance Analysis of the Effective Control Type

In the second experiment, we compared the wheel controller with the 4-way directional controller. The ANOVA results for the menu traversal preference showed that there was no significant effect. (Table 7)

The ANOVA results for the menu traversal performance showed significant main effects of task, F(1,12) = 71.967, p = 0.000 at $\alpha = 0.05$ and control type, F(1, 12) = 3.929 at $\alpha = 0.1$. The interaction of the control type and task was not significant. (Table 8).

Table 7. ANOVA results for the preference

Source	DF	SS	MS	F-Value	Pr > F
Control	1	12.019	12.019	0.028	0.869
Task	1	0.481	0.481	0.003	0.954
Control × Task	1	300.481	300.481	1.453	0.251
Residual	12	2480.769	206.731		

**: significant at $\alpha = 0.05$.*

Table 8. ANOVA results for the performance time

Source	DF	SS	MS	F-Value	Pr > F
Control	1	122.769	122.769	3.929	0.071**
Task	1	6705.582	6705.582	71.967	0.000*
Control × Task	1	27.623	27.623	0.994	0.338
Residual	12	333.454	27.788		

**: significant at $\alpha = 0.05$.*
***: significant at $\alpha = 0.1$.*

The result showed that the performance time of task 1 and the wheel control was better. However, the routing error frequency was similar. (Fig. 10 and Table 9).

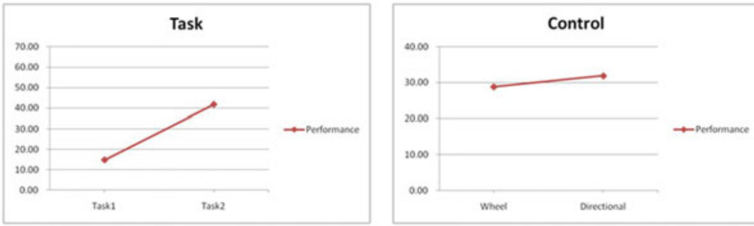

Fig. 10. The means of the task (left) and control type (right) *(Unit: sec.)*

Table 9. The routing error frequency of the controller

Control Type	Wheel Controller	Directional Controller
Routing Error Frequency	0.60	0.65

4 Discussion

This study was intended to propose the effective IVIS interface of the gauge cluster and steering wheel remote control with menu traversal. Present study considered two steps of experiments. In the first experiment, we proposed the effective IVIS menu type with two control types and tasks. Two types of controller had the same movement direction. However, they were different to the movement mechanism. The results of ANOVA showed that the spread menu type was better preference than the overlapped menu type that was a circle type of shape in similar to the controller movement direction. However, the difference of the performance time was not significant. The spread menu type had an advantage on the menu traversal. Because each menu traversal step was represented and confirmed, it was supposed that this menu type was more preferred than the overlapped menu type. To consider the menu traversal in the driving situation, it was supposed that the effective menu type should be provided the confirmation of the menu traversal step to the driver. In two types of controllers, the result of ANOVA showed that the wheel control type was more preferred and had better performance times. To consider the blind control in the driving situation, it was supposed that the wheel control that had the mechanical feedback more advantage than the touch wheel control type that had not the manipulation feedback. This difference was significant in the condition of the task. There was no difference at the task 1 that was simple menu manipulation. However, at the task 2 that was more complex menu manipulation, the wheel controller had more advantage on the preference and performance time. Therefore, it was supposed that the wheel control was more effective controller when the driver manipulated the amount of information.

In the second experiment, we proposed the effective IVIS control type. The result of ANOVA showed that the wheel control type had better performance time than the 4-way directional control type. However, the difference of the preference was not significant. It meant that the wheel controller had better performance and similar preference with the 4-way directional controller that was used to some vehicle. Therefore, it is supposed that the wheel controller was more effective control alternative.

This study proposed that the effective IVIS interface was the spread menu type and wheel control type. However, there were some constraints in this interface. First, present study was focused on the right-hand control. Though a study of a effective location of IVIS menu control that is on a left side or right side of a steering wheel is required, to consider the steering wheel design feature of symmetry, a study of a interaction between left-hand and right-hand control will be required, also. Another constraint was the age. The age of the participant was thirties to fifties. These had less experience to manipulate a touch wheel control that was applied to other electronic devices than twenties. Therefore, a study that was focused on the twenties who is familiar with a touch wheel control will be required.

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