Selection of the Human Factors Design Variables of In-Vehicle Navigation System

(자동차 항법장치의 HMI 설계변수 선정에 관한 연구)

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ABSTRACT

Navigation system is regarded as the interface border line between the Intelligent Transportation Systems (ITS) and the driver as the prospective information provider of the ATIS (Advanced Traveler Information System). Following theory, if the navigation system appropriately designed and utilized, that can maximize the transport efficiency, contribute to improvements of the environments and road safety. To accomplish these kinds of objectives of the navigation system use, human factors plays an important roles specially focused on the driver's safety, performance and system usability. Because the effectiveness of the system depends on the acceptance of the system, and the extent to which the system conforms to driver physical and cognitive limitations and capabilities. Therefore, the ergonomic design variables must be seriously selected and reflected in early design step for more effective and appreciate product design. As the first step of this aim, this study selected and categorized the human factors design variables of the navigation system.

1. BACKGROUND OF THE RESEARCH

In these days, the functions of the navigation system is tends to be closed to the multimedia system in a vehicle also, that will be the information terminal of all available information sources. However, the clear difference between two systems is obvious. Navigation system is used on the road, namely dynamic environments and the multimedia system usually in the static environments. Therefore, the many research results about the multimedia system cannot be applied directly for the navigation system, also if possible, HMI assessment and guidelines should be verified through the real road experiment. This paper suggested the ergonomic design variables of the navigation system that could be used for the basic items of the HMI design guidelines of the navigation system.

2. DIFFICULTIES IN SELECTING THE HMI DESIGN VARIABLE

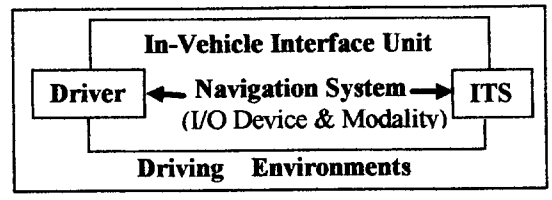
Past research has established that the human factors guidelines following traditional formats for presenting information are not useful and are often ignored by designers [6]. Because, what the human factors engineer can actually offer to the designer is by no means a complete set of design specifications. Therefore, a set of boundary conditions and operational ranges within which the designer can be assured that physical, perceptual and cognitive abilities and limitations of drivers will be accommodated systematically [3].

In America, designers of advanced automotive displays have criticized may existing human factors reference materials for being too wordy, too general, and too hard to understand, and have requested guidance that is concise, specific and clear. Campbell suggested the three critical issues associated with the development of human factors design guidelines for ATIS, (1) Lack of Human Factors Design Criteria, (2) Developing Selection Criteria for Data Sources Used to Produce Guidelines, (3) Variability in the User Population of Human Factors Design Guidelines [2]. Most of hardware designers and engineers do not know what is the human factors and why designers have to consider the human factors considerations to design the product. Moreover, it is hardly find the design team that include a human factors engineer. They were only wanted to know how they should conducted the usability test of their developed system.

3. SELECTION OF THE HMI DESIGN VARIABLE

3.1 First Selection of the HMI Design Variables

HMI design variables selection procedure conducted with 3 steps of filtering session. Because it includes too wide areas to making guidelines for all kinds of components of the navigation system. The first step conducted by the extensive literature reviews, detailed product analysis, and the navigation HMI conceptual model analysis [7]. Also, the manufacturing and research experts were participated through all study step.



<Figure 1 > Conceptual HMI Model of Navigation Using the Navigation System

To consider the human-vehicle-road system in a real driving situation, HMI model between driver and overall ITS can be defined conceptually like Figure 1. It deals with a three-dimensional space at the HMI point of view : driving environment X driver characteristics X navigation system (Input / Output Device & Modality) x ITS [3]. Through these kinds of study, 11 sub-categories and 73 basic design variables were selected without any filtering from three dimensions. Table 1 shows the first selected design variables.

3.2 Second Selected HMI Design Variables of Navigation System

Not to disregard the important HMI design variables, firstly selected variables were collected without any screening study. Therefore, in the second step of determining the HMI design variables of the navigation system, similar variables were integrated ,for example, *error detection* and *error recovery function* was integrated to the *error handling*. Also, the *easy to find, easy to understand*, and *information density & mass* integrated to the *easy to access*. And then, experts opinions and choices were influenced to diminish or add the effective variables [7].

Each variable also examined that could be adapted for designing the experimental parameters. For example, the driving environment dimension variables are very difficult to designing the experiment. Because, those evaluation data could only acquire through the traffic data from the real road investigation. Also, because of the ITS is not yet completely installed, and the physical environment variables are difficult to estimate. Moreover, the social environment variables are qualitative variables those are dealt in the traffic engineering areas. Table 2 shows the selected variables through these kinds of filtering procedures.

3.3 Third Selected HMI Design Variables of Navigation System

In this step, based on the secondly selected variables, omitted the abstract variables for example, *easy to access, user-defined control*. Also, using the Cronbach's alpha value, the internal reliability of each selected variables was investigated. Namely, it examined the each variable whether it is suitable for its category. Because well categorized data gives a more convenient and effective chance to developing the description of each variable and using by the navigation developer. Generally, when the Cronbach's alpha value is over 0.5, that variable is regarded has the high reliability [5]. Table 3 shows the thirdly selected variables for the navigation HMI design. In this table, despite the below 0.5 values of the several variables in the interface category, they were not ignored because they are the most crucial human factors issues for the navigation system and are not suitable changing their category. However, the *Mapping method with the map and the vehicle position* is neglected because already most of navigation system adapted the vehicle position always center of the digital map. These days, dimension of the digital map, information supply timing etc. are the hot issues for the HMI of the navigation system.

4. RESULT & FUTURE STUDY

Already, the first version of the NAVI-HEGS (Navigation HMI Evaluation & Guideline System) was constructed. And these guidelines database also included as the part of this system. However, the descriptions of each variable is not verified by experiment, therefore the database is designed upgradable by the user. Also, most of the guidelines that are designed through the literature study of the other countries are not suitable for the Korean drivers and traffic situations, through this year, the real road test and the simulation study will be conducted for constructing the HMI standardization of the navigation system. Constructing the HMI standardization of the navigation system based on these variables. This can be use for experimental variables, evaluation and design variables for the navigation system. Also, in considering the trend that the user interface standards have become the object of increasingly intense activities [6], this research get a more importance than any other kinds of hardware development. Also, despite the time and cost demanding works, the guidelines should be identify the its reappearance and reliability through the reliable test.

<Table 1> First Selected HMI Design Variables of Navigation System

Category	Sub Category	HMI Design Variables
Driver (End User)	Demographics	Age Education level Gender Hearing ability Occupation Personality Visual ability
	Physical & Psychological State	Fatigue level Mental workload Physical condition Psychological condition Stress level
	Driver Support Function	Error detection Error recovery function HELP function
	Experience Level	Experience with multimedia Experience with the navigation system Experience with another in-vehicle information system

Navigation System	Input Device Mode	Consistency Easy to access Easy to learn (specially for novice) Easy to operate Efficiency Minimal workload Mode (device pattern) Required workload Safety System operation complexity
	Information	Accuracy Compatibility Consistency Display layout Easy to find Easy to understand Information density & mass (Economy) Length of delay Mapping method with map and vehicle position Minimal workload Mode (output device) Priority Response time User demand control availability User information requirement Presentation Rate
	Interface	Bookmark function Brightness Color Command type Font Friendliness with modality Graphic dimension Position Illumination level Menu Selection type Navigation support Size Standardization level with other products Typography User defined control
Driving Environment	Driving Situation	Congestion level Residential location Regular travel time
	ITS Environment	Current ITS availability Linkage with the ITS sub-system
	Physical Environment	Climate Humidity Illumination level Noise Level Physical vehicle state Temperature
	Social Environment	Current transportation system Social acceptability Transportation law

< Table 2> Second Selected HMI Design Variables of Navigation

Category	Sub Category	HMI Design Variables
Driver (End User)	Demographics	Age Gender Hearing ability Visual ability
	Experience Level	Experience with multimedia Experience with another in-vehicle information system
Navigation System	Input Device Mode	Consistency Easy to learn (specially for novice) Easy to operate
	Driver Support Function	Bookmark function Error handling HELP function
	Information	Accuracy Compatibility Display layout Easy to access Length of delay Mapping method with the map and the vehicle position User Information Requirement
	Interface	Brightness (Hue, Illumination) Color Command type Graphic dimension Friendliness with modality Map graphic dimension Menu selection type Size Standardization level with other products Typography user-defined control

<Table 3> Third Selected HMI Design Variables of the Navigation System

Category	Sub Category	Cronbach's Alpha without own attribute
Demographics	Age	0.2452
	Gender	0.5241
	Hearing ability	0.4830
Experience Level	Experience with multimedia	0.9399
	Experience with another in-vehicle information system	0.9698
Input Device Mode	Consistency	0.4111
	Easy to operate	0.7261
Driver Support Function	Bookmark function	0.7637
	Error handling	0.9353
	HELP function	0.7762

Information	Accuracy	0.7743
	Compatibility	0.7842
	Display layout	0.7391
	Length of delay	0.6421
	Mapping method with map and vehicle position	0.6841
	User information requirement design	0.7221
Interface	Brightness (Hue, Illumination)	0.4780
	Color	0.3669
	Command type	0.3846
	Friendliness with modality	0.2628
	Graphic dimension	0.2958
	Menu selection type	0.3405
	Standardization level with other product	0.7504
	Typography	0.6865

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