Developing Character Input Methods for Driver Information Systems

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Abstract. This study proposes a framework for developing an input method to enter characters into a driver information system (DIS). The framework consists of two phases. The first phase is a conceptual design phase that helps to create and design conceptual input methods and to conduct formative evaluation. The second phase is a detail design phase that helps to design detailed interfaces and interaction, and to select the most usable character input method. A case study is conducted to verify the effectiveness of the developed methodology and to find appropriate input methods for knob control. As a result, character input methods appropriate for knob control were developed, which were proved to work more effectively than an existing method.

Keywords: Character input method, DIS, Development framework, Usability.

1 Introduction

Cars have changed from pure transportation devices to mobile living space. As a result of the convergence of consumer electronic devices with a car, driver information systems (DISs) in cars provide services such as not only air condition control, but navigation assistance, wireless internet service, entertainment, office work, and so on. Drivers often need to input characters (i.e., alphabet, Korean characters, numerals, symbols, etc.) for using input services [1] [2]. Unlike other consumer electronic products, usability considering safety is one of the most important issues to design character input methods or devices for a DIS [3] [4] [5].

Numerous previous studies have been conducted to design efficient and safe input methods for navigation assistance, and almost all of them used a touch screen as an input device [2]. However, they have been focusing mainly on design guidelines for usable and safe input methods, and usability testing for comparing design alternatives. It is difficult to find a systematic framework for developing character input methods appropriate to the driver and input devices as well. In addition, there are only a few studies about the knob control that has been recently introduced as an input device in a car.

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The primary purpose of this study is to propose a framework for developing a character input method for a DIS. In addition, a character input method appropriate for knob control has been developed. Specific objectives of this study are as follows: (1) Constructing a framework for developing character input methods for a DIS; (2) Verifying the framework with a case study of developing character input methods using knob control; (3) Developing a usable character input method appropriate for the Korean characters through the case study

2 Framework for Developing Character Input Methods

The framework, proposed in this study, for developing character input methods for a DIS is composed of two phases. As shown in Fig. 1, the design steps of each phase were specified, and the design techniques needed at each step were provided.

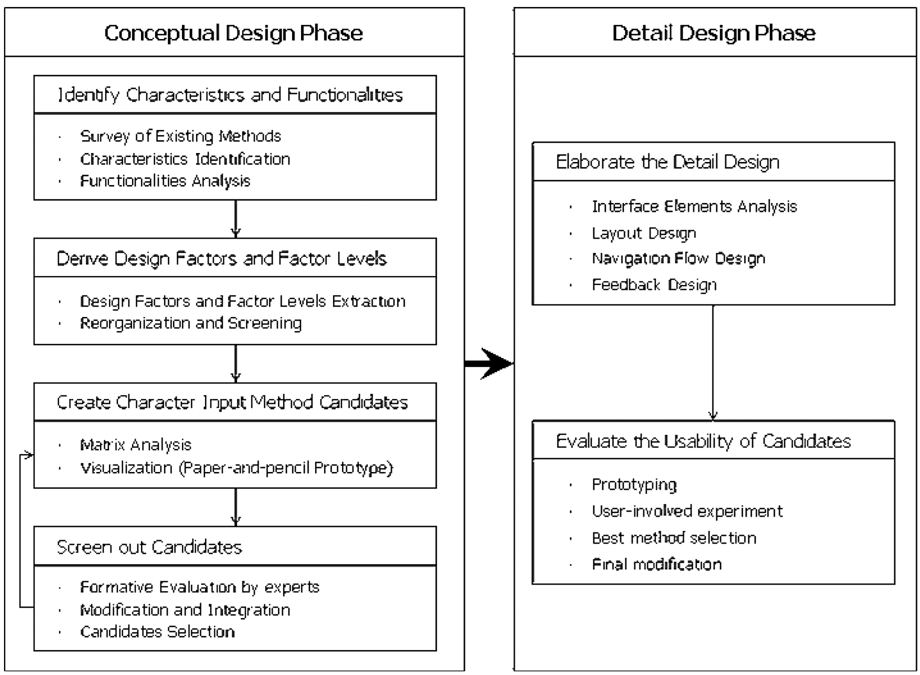

Fig. 1. Proposed Framework for Developing Character Input Methods for a DIS

2.1 Conceptual Design Phase

The first phase is conceptual design in which input methods are created and formative evaluation is conducted. The conceptual design phase consists of four steps.

The first step is to identify functionalities and characteristics of character input methods. Existing character input methods, used in PDAs, mobile phones, navigation assistance products, etc., are surveyed. The functionalities provided in various character input methods are investigated and classified according to the user's goals or tasks. Second, the characteristics of the character input methods are identified considering software/hardware aspects and usage context. Here, several constraints are applied to specify the characteristics such as display size, controller, target user, etc.

The second step is to derive design factors and factor levels. The meaning of the design factors and the factor levels are similar to those in the experimental design. Design factors are important features for designing character input methods and factor levels are values or specific conditions that a factor can have. For example, when a controller is a design factor, knob control, touch screen, and keypad can be the factor levels. Design factors are obtained from important characteristics identified in the previous step. For each design factor, design types of existing character input methods are listed and they become the levels of the factor.

The third step is to create design candidates of the character input methods. In this step, a design candidate can be created by taking one of the factor levels from each factor and combining them together. However, creating design candidates using all possible combinations is too costly and time-consuming. To reduce the number of combinations, it is necessary to reorganize and screen out design factors and factor levels by the importance level. Conceptual designs of each combination are then visualized. Paper-and-pencil prototypes are good methods for this purpose. Critical interface features and operating mechanisms are specified next.

The forth step is to screen out design candidates. The design candidates are presented to the experts and a pluralistic walkthrough is conducted. Each candidate is evaluated using the criteria such as compatibility, learnability, effectiveness, efficiency, and so on. In addition, pros and cons of each candidate are analyzed. When it is possible to create a more usable design by modifying or integrating the design candidates, visualization and evaluation are iterated from the third step. Finally, the number of candidates is reduced based on the evaluation results.

2.2 Detail Design Phase

The second phase is detail design in which interfaces and interaction are specified and the most usable character input method is selected (i.e., summative evaluation). The detail design phase consists of two steps.

The first step is to elaborate the detail design. The interface elements of each candidate are analyzed to determine the size, position, color, and shape. Next, a screen layout is designed by considering the design constraints.. Control functions to move cursors or select some interface element are allocated to each control mode (i.e. button push, rotating of the jog dial, etc.). Finally, navigation flows and feedback for a user input are designed.

The second step is to evaluate the usability of design candidates and to select the most usable method. Prototypes are implemented on the basis of interface/interaction designs of the previous step. A user-involved experiment is then conducted to evaluate the usability of the prototypes. Both quantitative measures and qualitative measure are collected together. Based on the experimental results, the most usable method is selected. Finally, the most usable method is modified by resolving any problems found in the evaluation experiment.

3 Case Study: Input Method for Knob Control and Korean Characters

A case study is conducted to verify the effectiveness of the developed framework and to design a usable character input method appropriate for knob control and the Korean characters. The pre-determined assumption about the knob control is that it has 7 degrees of freedom (i.e. 4-way joystick, 2-way rotary, and push).

To survey existing character input methods, 28 papers (i.e. journal, proceedings, and technical report), 67 patents, and 23 products were surveyed and 100 different types of character input methods were collected. The functionalities used in character input methods are presented in Table 1. There were three design constraints. The screen size was fixed at 800px*480px and a knob control was used as an input device.

Table 1. Functional requirements of character input methods

Function	Category (# of characters)
Input	▪ Korean Alphabet – [Consonant: Single(14), Twin(5), Compound(9); Vowels: Single(10), Compound(11)]
	▪ Alphabet – Big(26), Small(26)
	▪ Figures – 0~9(10)
	▪ Special Character
	▪ Space
Modification/ Delete	▪ Previous Phoneme ▪ Previous Syllable ▪ Between Words
Finish/ Cancel	▪ Finish or Cancel of a Character Input

Design factors for developing character input methods was made by considering interface, control, interaction, and Korean characters aspects. Eight design factors were extracted and the levels of each factor were listed by classifying design types of existing methods (see Table 2.).

However, creating design candidates using all possible combinations was too costly and time-consuming. Critical factors and factor levels were selected based on the importance, and a matrix analysis was conducted using the four factors that were expressed in bold in Table 2. Design candidates were created by taking one of the factor levels from each factor and combining them together. As a result of the matrix analysis, 100 conceptual designs were created. Fig. 2 shows some of the conceptual designs.

Table 2. Design factors and factor levels

Category	Design Factors	Factor levels
Interface (Display)	**Layout**	Keyboard type, **Matrix type, Circular type, Matrix + Circular**, None
	Mode change	**Yes** or No
Control	Controller	Touch screen/Pad, Numeric Keypad, 4 Arrow+ 'OK', Joystick+Push, Jog dial+Push, Glove, Mouse, Track point, Roller, **Joystick+Jog dial+Push**
Interaction	**Interaction method**	Two-step selection, Direct selection, Multi-press, Chording, Character recognition, Pattern recognition
	Support	Character unit, Word unit, None
Korean Alphabet	Layout of Cons. & Vowel	Left-Right, Top-Bottom, Main+Pop-up, Inner+Outer
	Consonant	**Type C1(Chun-ji-in), Type C2, Type C3, All**
	Vowel	**Type V1(Chun-ji-in), Type V2, All**

Bold: Critical factors and factor levels

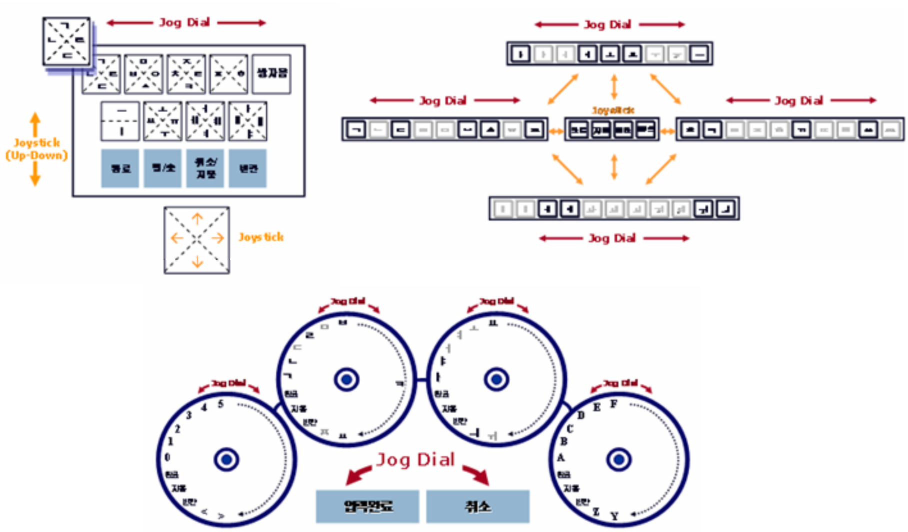

Fig. 2. Examples of Conceptual Design

Pluralistic walkthroughs were conducted by three usability experts. Efficiency, compatibility, simplicity, learnability, and memorability were used as the evaluation criteria and the weights of the criteria were estimated by using the analytic hierarchy process technique. As a result, three design candidates, i.e., single circle type, twin circle type, and two step type, were selected (See Fig. 3).

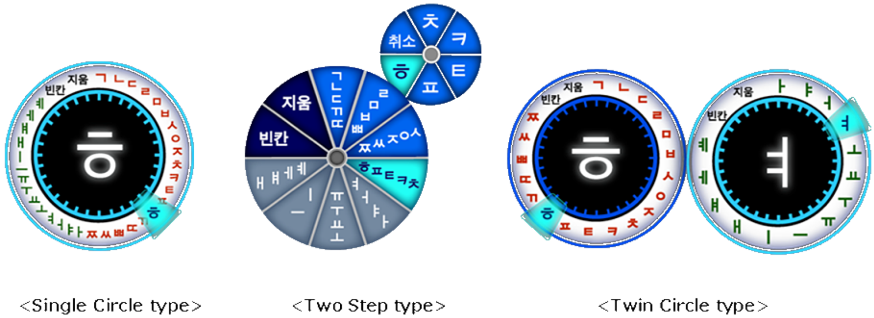

Fig. 3. Selected Design Candidates

As a result of analyzing interface elements, 19 characters for consonants, 14 characters for vowels and soft buttons for changing the input mode (Korean, English, Numerals/Symbols) were included in the interface features to be implemented. In addition, spaces for a text entry box and an address list were allocated when designing the screen layout. As shown in Fig. 4, navigation flows and feedback for function selections were designed by paper-and-pencil drawing.

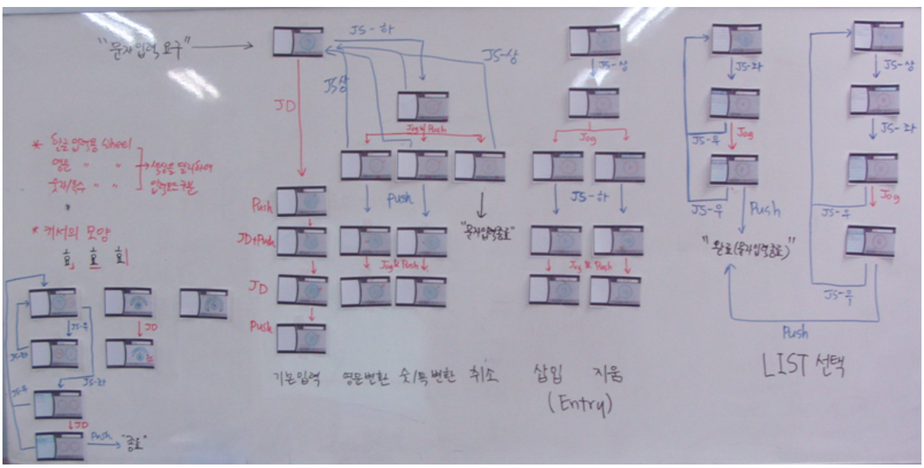

Fig. 4. Navigation Flows & Feedback Design

Each design candidate was prototyped using the MS visual studio .net and an HP multimedia keyboard. A traditional input type was also prototyped to compare with the new designs. Using the prototypes, a user-involved experiment was conducted. Ten subjects participated in the experiment. Their age ranged from 30's, 40's, and

50's because the target population for the DIS was restricted to these ages. The subjects performed text input tasks. They evaluated each design candidate based on six criteria (i.e. ease of use, ease of search, ease of learning, ease of adaptation, ease of recall, overall satisfaction) and the task completion time for each task was recorded. In addition, they were asked to provide ranking of the candidates, pros/cons, and improvement ideas, if any. As a result, the single circle type was found to be the most usable design in terms of both the objective (i.e., task completion time) and the subjective (i.e., usability score and overall satisfaction) measures. However, the best design was redesigned based on the suggestions made by the subjects during the experiment. Major suggestions were that characters and spaces were too small to find easily and it was difficult to distinguish the consonant part from the vowel part clearly. Thus, the single circle type was modified by combining the circles as shown in Fig. 5.

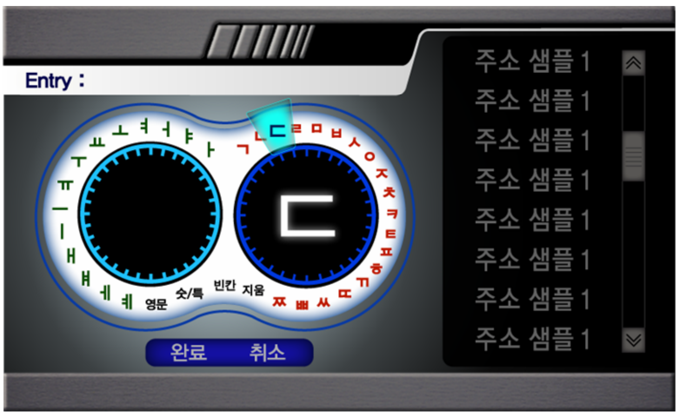

Fig. 5. Modified Design of the Single Circle Type

4 Conclusion

The framework proposed in this study helps to develop character input methods for a DIS easily and systematically. Most design work depends on the designer's creative ideas in the traditional development process. However, in this study, using a bottom-up approach for extracting design factors and a matrix approach for creating conceptual designs, a variety of design ideas could be created easily and systematically. Through a case study using the framework developed, this study designed a usable character input method appropriate for the knob control, which was proved to work more effectively than an existing method.

Design factors and factor levels extracted in this study are applicable to developing other input methods using different control devices in a DIS. It is also expected that the framework can be applied to developing character input methods for mobile phones, PDA, and so on.

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