A Logical Design Method for User Interface Using GUI Design Patterns

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Abstract. This paper presents a discussion of method for user interface design using graphical user interface (GUI) design patterns. GUI design patterns are defined as "general operation and expression of embedded system products". Purpose of this study is to develop a user interface design efficient. GUI design patterns were extracted in embedded system products. Then, interviews were conducted with students and researchers in which the practical applicability of the extracted GUI design patterns. This process allowed the number of GUI design patterns to be narrowed down to 81 patterns. 81 patterns were analyzed using the cluster analysis, between them and classifies these objects into different 7 groups. The GUI design patterns, which were composed of 7 groups, divided into 4 layers. Finally, Design method using GUI design patterns was discussed. This proposed method is based on the Human Design Technology (HDT). HDT is a logical product development and UCD method easily accessible to anyone.

Keywords: User Interface, Design Pattern, Human Design Technology.

1   Introduction

User Centered Design (UCD) is a type of user interface design and a process in which the needs, wants, and limitations of users of a product are given extensive attention at each stage of the design process. UCD is defined as "a user interface design process that focuses on usability goals, user characteristics, environment, tasks, and workflow in the design of an interface; it is an iterative process, where design and evaluation steps are built in from the first stage of projects, through implementation" [1]. Since UCD method has been recognized as a powerful tool, large enterprises have been introducing UCD method and facilities. But, it is hard to introduce present UCD methods to middle/small enterprises because introducing UCD method is rather expensive. Thus, we have studied a design method to introduce UCD into middle/small enterprises.

In this paper, we suggest a method of screen design with the GUI design patterns. The design patterns were developed by Christopher Alexander, in collaboration, as a method to allow anyone to design and build at any scale [2]. They based on the idea that users know more about the buildings they need than any architect could, idea that has been exported to the design of websites [3]. The GUI design patterns are defined as "general operation and expression of embedded system products". So, the GUI design patterns are noticeably different from software design patterns, which are focused on the source code and software structures. Designers tend to utilize GUI design methods based on individually accumulated knowledge and experience. Designers are offered patterns that help them to design usable interfaces using proposed GUI design method. This method is based on the Human Design Technology (HDT) [4]. HDT is a logical product development and UCD method easily accessible to anyone. So, this method makes it possible to introduce UCD into middle/small enterprises.

2   Design Process Based on Human Design Technology

2.1   Human Design Technology (HDT)

The Human Design Technology (HDT) is a design method for product design. It is defined as "Method to integrate ergonomics, industrial design, marketing research, cognitive science, usability engineering, and statistics, to review process of product development to rely on intuition in the past by aspect of quantification as much as possible, and to support product making with charm of man priority that examines" [5]. The HDT process has 5 phases that assist the product development. The HDT design process is as follows.

1. Gather user requirements

User requirements are extracted to product problems. Extract problems using group interviews, observation and task analysis.

2. Grasp current circumstances

Investigate how users perceive a target product in the market using correspondence analysis.

3. Formulate structured concepts

Constructing structured concepts based on user requirements and other types of information. Since the main specifications must be determined at this stage, structured concept should be structured for logical continuity among their various items, thereby avoiding any omissions. The weighting of the different concept items is particularly important as a measure to ensure logical continuity among them. This is also significant for revealing the items that are important. Once the items are weighted, those that should take precedence may be determined automatically when certain design items must be traded off against one another.

4. Design (synthesis)

Visualize a product based on the structured concepts. HDT requires that the design be based on the seventy predetermined design items.

5. Evaluate the design

The design idea is evaluated by user test. A protocol analysis, questionnaires were made on 5 people.

Figure 1 depicts the clusters in HDT's design process. HDT is a design method for product design. So, HDT needed to customize for GUI design. When product was designed in HDT process, designer visualized using the 70 design items. Proposed GUI design method is visualized using 2 items instead of the 70 design items as follows.

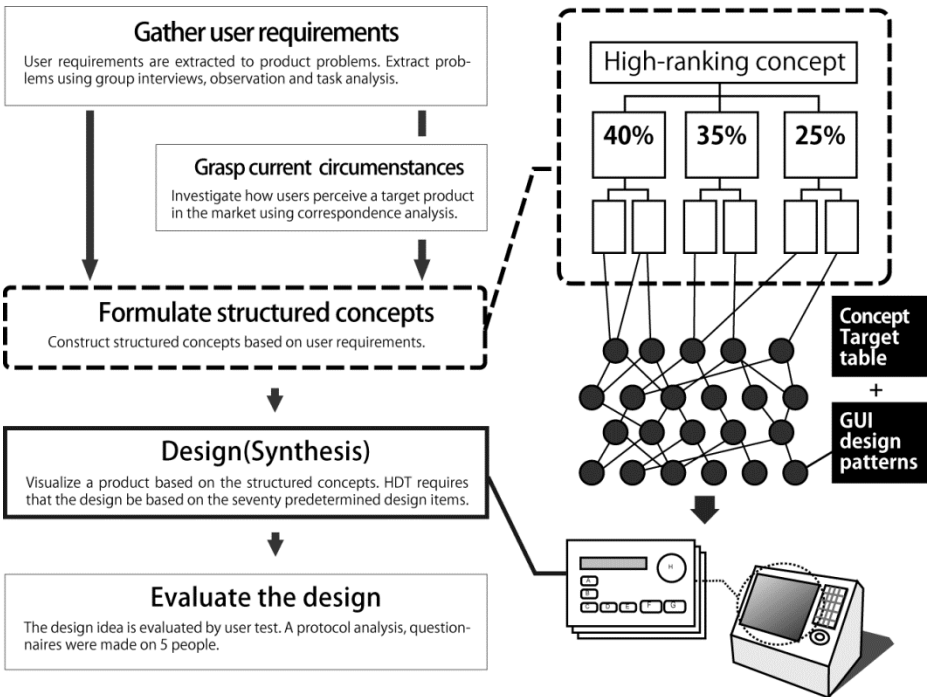- Concept target table
- GUI design patterns

Fig. 1. Design process of Human Design Technology (HDT)

2.2   Concept Target Table

Table 1 shows the concept target table, which is one of the system's specifications. For the modeling of user interface, we must consider the target user and system's spec. GUI design required information to system specs and user. The concept target table could define target system and users clearly. The contents of target system and target users are included as follows.

- System: Function, Device, Space, Hours, and Implementation
- System's element: User decided 3-4 elements among the 18 elements.
- User Interface
- Task
- Attribute: Age, Sex, Occupation, and Earn
- User level: Experience, Education level, Similarity experience, Life style
- User's mental model: Functional model, Structural model

Table 1. Concept target table

Clear targeted system	System	Function		Exclusive	
		Device		Touch pad	
		Space		Bank, Public space	
		Hours		9:00-17:00	
		Implementation		・Staff use when system is broken ・Receptionist guides user if user don't Operate	
	System's element	Safety	Convenience	Modern	Functional
		Security	Efficiency	Surprise	Legible
		Confidence	Economical	Entertainment	Aesthetic
		Reliability	Tolerance	Achievement	
		Usability	Conservative	Emotional	
	UI	User need not get new knowledge of operation			
	Task	Withdrawals, Remittance, Contributed, Money received			
Clear targeted user	Attribute	Age	18 – 65		
		Sex	Man, Woman		
		Occupation	General		
		Earn	General		
	User level	Experience	User has been able to use the ATM some time		
		Education level	User is able to read the Japanese text		
		Similarity Experience	User has been able to use the station ticket reservation system some time		
		Life style	Various		
	Mental model	Functional model		Model to understand How-to-use it	
		Structural model		Model to understand How-it-works	

2.3   GUI Design Patterns

To develop a user interface design efficient, the GUI design patterns were extracted. Generally, designers use guidelines to good solutions in order to ensure to their systems. These guidelines are offered as general sentences that have to be determined in each case. General sentences have various meaning. Thus, this diversity is also introduced complexity in the process of GUI design. On the other hand, the GUI design patterns are offered as concrete examples that have to be determined in each case.

The GUI design patterns are defined as "general operation and expression embedded system products" [6]. Each GUI design pattern is composed of summary, utility and examples (Fig. 2). For instance, the GUI design pattern "Various expressions" was as follow.

－ Summary: Information design is changed by situation.
－ Utility: icon, List, preview, etc.

This study used the following process to identify and select GUI design patterns that are applied to practical design situations.

First, we extracted GUI design patterns in embedded system products.

Then, selecting useful device "touch panel" for further examination further narrowed these GUI design patterns.

Finally, interviews were conducted with students and researchers in which the practical applicability of the extracted GUI design patterns to artifact GUI design were discussed. This process allowed the number of GUI design patterns to be narrowed down to 81 patterns.

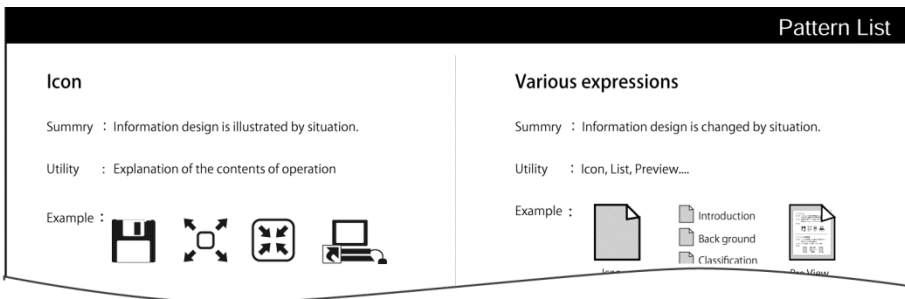Table 2 shows 81 patterns, which were selected as samples for classification by aforementioned process.

Fig. 2. Example of GUI design patterns

Table 2. GUI design patterns list

Display zoon out/in	Rearrangements of items	Move items using tab key
Undo	Item editing	Drop-down menu
Cloze items	Menu bar	Tree structure
Structural input	Adjust text size	Guidance of input area
Direct operation	Continuous filtering	Aggregation structure
Default indicate	All select by one click	Drag
Gray display	Searching	Procedural operation
Right down enter	Keyword sorting	Hub structure
Metaphor selection	Shortcut key	Gradual addition
Free input	One click enter	Visible and Un visible
Tool menu	Scroll bar	Auto complete
Round button	Re-layout	Guidance
Setting	All process display	Tab button
Double click	Cancel along the way	Enter after selection
Resize	List operation	Top navigation
Icon	Hierarchical information	Waiting time indicate
Various icons	Rectangle	Emphasis
Consistency color	Information of top class	Model display
Color information	One display	Modal dialog
Picture information	Simple line	Two windows
Current position	Center information	Three windows
Footer information	Flexible screen	End of task
Common header	Dual display	Tab
Complement of change	Stripe background	Base display
Pop Up	Emphasis of selection	1/0
Stand in	Proximity	Ruled line
Top with impact	Look flow	Check selection

3   Classifications of GUI Design Patterns

3.1   Analysis Using the Cluster Analysis

To clarify the GUI design patterns, they were analyzed using the cluster analysis, which is a method that defines the similarity of select objects from the distance between them and classifies these objects into different groups. We analyzed relationship between GUI design patterns and the user interface (UI) design items. The UI design items are prepared expert designer's know-how by precedence research [7]. Problem of how to select GUI design patterns can be fixed using the UI design items. Table 3 shows the UI design items.

Table 3. UI design items

Flexibility	Simplicity	Minimization of physical load
Customization for different user levels	Ease of information retrieval	Sense of operation
User protection	At a glance interface	Efficiency of operation
Accessibility	Mapping	Emphasis
Application to different cultures	Identification	Affordance
Provision of user enjoyment	Consistency	Metaphor
Provision of sense of accomplishment	Mental model	System Structure
The user's leadership	Clue	Feedback
Reliability	Term/Message	Help
Presentation of various information	Minimization of users' memory load	

We found 7 groups as a result of the cluster analysis. The results are as follows.

1. "Output" group's pattern

Gray display, Complement of change, color information, Footer information, All process display, Current position, 1/(), Guidance of input area, Hierarchical information

2. "Operation" group's pattern

Right down enter, Undo, Incremental search, Searching, Item editing, Shortcut key, Setting, Default indicate, Cancel along the way, Continuous filtering, Top navigation, Adjust text size,

3. "GUI parts" group's pattern

Scroll bar, Tab button, Close items, Switch, Slider, Drop-down menu, Menu bar, Metaphor selection, Drum menu

4. "Screen Layout" group's pattern

One display, Dual display, Model display, Modal dialog, center information

5. "Design Guideline" group's pattern

Consistency color, Proximity, Rectangle, Alignment, Common header, Blank effect, Top with impact, Icon, Picture information, Round button, Stripe background, Emphasis of selection, Unified color's bar, Emphasized label, Simple line, Various icons

6. "UI Guideline" group's pattern

Look flow, Support of users' memory load, Gradual addition, one click enter, Aggregation structure

7. "Operation's Structure" group's pattern

Right down enter, Undo, Incremental search, Searching, Item editing, Shortcut key, Default indicate, Setting, Cancel along the way, Continuous filtering, Top navigation, Adjust text size, Tool menu

The GUI design patterns, which are composed of 7 groups, can be divided into 4 layers (Fig. 2). GUI design patterns are connected between them by a hierarchical structure, so designers can resolve complex design solutions as simple.
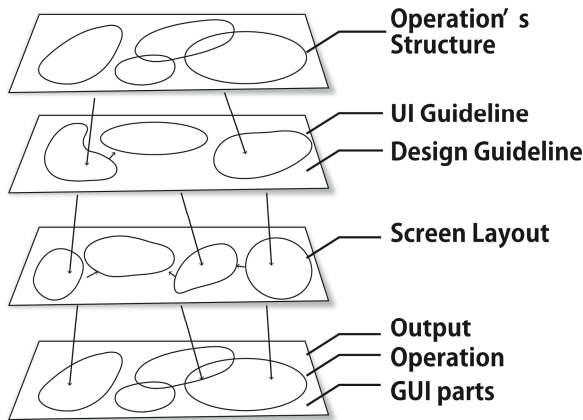

Fig. 3. The GUI design patterns can be divided into 4 layers

3.2 Applying GUI Design Patterns to Design Process

This chapter outlines design method using GUI design patterns. GUI design patterns were characterized the relationship between the structured design concept and the concept target table. The concept item that is a part of the structural design concept and the target device that is a part of the concept target table select these GUI design patterns. The procedure to apply GUI design patterns on presented method is as follows.

1. Constructing the structured concept: The structured concept is constructed based on user requirements. Relation to make hierarchy grouped concept items. After that, weight is put to each item and total weight of the items becomes 100. The priority of each item was described as the weight in this process.

2. Making the concept target table: The concept target table is able to define target systems and target users clearly. All items are related to the design structure concept.
3. Select GUI design patterns (Operation's structure): Operation's structure patterns are selected to the concept target table and concept item's weight. Pattern that is related to the concept item is assigned at least one.
4. Select GUI design patterns (UI guideline, Design guideline): As shown in Figure 3, second layer consists of 2 groups: UI guideline and Design guideline. These groups are related to concept item's weight and target user that is a part of the concept target table.
5. Select GUI design patterns (Screen Layout): GUI design patterns are selected to the concept target table and second layer patterns.
6. Select GUI design patterns (Output, Operation, GUI parts): As shown in Figure 3, second layer consists of 3 groups: Output, Operation and GUI parts. GUI design patterns are related to the concept target table and third layer patterns.
7. Visualize user interface based on the GUI design patterns.

4   Conclusions

In this paper, a method of screen design with the GUI design patterns is discussed. The design process for GUI design was described based on HDT and the GUI design patterns. We extracted GUI design patterns in embedded system products. Selecting useful device "touch panel" for further examination further narrowed these patterns. Then, interviews were conducted with students and researchers in which the practical applicability of the extracted GUI design patterns to artifact GUI design were discussed. This process allowed the number of GUI design patterns to be narrowed down to 81 patterns. 81 patterns were analyzed using the cluster analysis, between them and classifies these objects into different 7 groups. The GUI design patterns, which were composed of 7 groups, divided into 4 layers.

Logical design approach is needed for middle/small enterprises. As the usual traditional design method depends on designer's intuition or skill, it takes a lot of time to achieve design. But, beginner designers don't know GUI design items systematically. When they started GUI design, they tried to collect suitable GUI design items taking a lot of time. When they know the structure of the systematizing GUI design patterns, they collect suitable GUI design items quickly. In addition, design representation could be described quite clearly. The methodology used in GUI design pattern can be as follows.

1. GUI design representation could be described quite clearly.
2. GUI design process could be clearly.
3. Designer's ability is little influence.

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