A universal design method using 3 Point task analysis and 9 universal design items

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Abstract

In order to examine universal design, I have developed two analytical methodologies based on 3P(point) task analysis: structured task analysis and task matrix analysis. I also extracted nine universal design items, namely (1) adjustment, (2) redundancy, (3) specification and function transparency, (4) feedback and (5) error tolerance, (6) effective acquisition of information, (7) ease of understanding and judgment, (8) comfortable operation, and (9) continuity of information and operation.

Structured task analysis is used to uncover problems in each of the tasks constituting a job for each functionally challenged condition of users, and solutions to the extracted problems are examined in terms of the above-mentioned nine universal design items. Task matrix analysis calls for the production of a table for each task in a job. In each table, nine items form the columns, and the horizontal rows list all disability types. Then, solutions are formulated for each cell formed by the intersecting columns and rows. Using these two analysis methods, I have conducted a verification experiment for the universal design of a public bus. The results of the research have enabled me to propose various solutions from a system-based perspective, instead of coming up with the superficial and isolated solutions which are normally produced when conventional analytical methods are used.

Keyword: universal design, 3P task analysis, structured task analysis, task matrix analysis

1. Introduction

Although various discussions have focused on the universal design philosophy, only the "seven principles" for the implementation of Ronald Mace's universal design[(1)] and guidelines[(2) (3)]are available.

The examination of universal design requires not only an understanding of those basic principles and guidelines but also an identification of user requirements to which the principles and guidelines are applied. In other words, only after the user requirements are identified and understood can the seven principles and guidelines be applied to visualize requirements in design work.

However,

these seven principles and guidelines cannot provide users with good design solutions. So, users like industrial designers, architect and so on cannot understand how to construct universal design using such guidelines.

There are a number of methods for extracting user requirements, including direct observation and interviews. For universal design, however, these methods tend to result in a superficial understanding of user-interface problems, and they are not effective for comprehending structural information nor are they sufficient for eliminating design condition oversights.

The following describes the methods that I designed by modifying the 3P (point) task analysis method for use in universal design examination. A structured task analysis is used to extract user requirements, while a task matrix analysis is applied to examine task scenarios.

2. 3P task analysis

2.1 Conventional task analysis

The key point in task analysis is to describe the flow of tasks and extract the interface-related problems in each task. This analytical method originated from the work analysis conducted by F.W. Taylor and L.G. Gilbreth, and a variety of methods were developed in the 1950s.[1] Since most interface problems in those days were related to physical characteristics, sequential task analysis methods were commonly used to extract device-related problems.[2]

When the application of electronic technology spread in products produced after 1980, task analysis for the examination of cognitive aspects was proposed and used.[3]

In addition to sequential task analysis, hierarchical task analysis (HTA)[4] was also adopted. In this method, tasks are broken down into subtasks, which are then arranged in hierarchical layers. The resulting hierarchical chart was used as a base in extracting problems. Another common method used was cognitive task analysis. This analysis method was an extension of the then-conventional task analysis method, and was designed to obtain information of the structure of a target as well as users' thinking patterns and knowledge which could affect task performing results.[5]

There are many other types of task analysis methods, but sequential task analysis has been used most commonly. HTA is also based on the sequential task analysis method.

2.2 What is 3P task analysis?[6]

As mentioned previously, conventional sequential task analysis is used to examine the input/output sections of devices. In this method, the cognitive level is included as an examination item perfunctorily, and it rarely serves the purpose of evaluating the users' information processing level.

The reasons for examining the users' information processing level are to eliminate evaluation item oversights and to incorporate users' viewpoints in the evaluation. This is because users receive external information as input and follow the information processing procedures of understanding, judging and operating.

The users' information processing level was thus divided into the following three stages for problem extraction: acquisition of information -> understanding and judgment -> operation. In the previous methods, analysis ended when problems were extracted. To link analysis results to the formulation of a product concept, I added a column on the right side of the table for writing the requirements to resolve the problems extracted from each task. This column is further divided into two sections: one section is for items that can be resolved immediately in a practical manner and the other is for items which cannot be solved at the present time due to cost and technical factors but which are expected to be solved in the near future. Solution ideas described in this column are reusable in the future. Then, there is a seventh cue for designing solutions (Fig. 1).

Norman[7] focused on seven stages of user activities in task execution. However, application of his concept to task analysis requires a great deal of descriptive work. In addition, since the purpose is to extract problems, I concluded that dividing user activities in three stages would not cause much difference as far as problem extraction is concerned. In the "acquisition of information" step, users obtain information, and this step is equivalent to the "sensory" and "perceptual" levels in humans' information processing flow. The key point in this step is ease of information acquisition.

The "understanding and judgment" step is a stage for recognizing perceived information — that is, a level in which information is understood and a judgment is made. In the "operation" step, the user's intention is conveyed to the machine. This means that the judgment of information is converted to an instruction to be given to a machine by means of humans' effective devices (hands, legs, etc.).

The following shows the most frequent evaluation items in the task analyses I conducted for 30 electronic products. In other words, using these items allow easy discovery of problems.

Acquisition of information:
(1) poor layout (position), (2) difficulty of seeing,
(3) no emphasis, (4) lack of information,
(5) mapping

Understanding and judgment:
(1) indecipherable, (2) no affordance,
(3) confusing, easy to mistake, (4) no feedback,
(5) procedural problems, (6) inconsistency,
(7) problems in mental model

Operation:
(1) incongruity with humans' physical characteristics

(three important items: posture, fitness and torque (force necessary for operation)),

(2) cumbersomeness

2.3 3P task analysis method

The following describes the 3P task analysis procedures.

(1) Consider a typical scenario for the use of the product being surveyed.

(2) Determine a general flow of tasks in the selected scenario.

(3) In each task or subtask, extract problems in each of the users' steps — "information acquisition," "understanding and judgment" and "operation" — by referring to the cues.

(4) Design the requirements for resolving the extracted problems by referring to the seven cues. In the rightmost column, write memos or draw illustrations to indicate whether the requirements can be solved at the present or in the future.

3. Universal design items

3.1. Nine universal design items

I collected information on products and facilities which were considered to feature "universal design" and classified their design points into the following five items [8]: (1) adjustment, (2) redundancy, (3) specification and function transparency, (4) feedback and (5) error tolerance. And, the three items, (6) acquisition of information, (7) understanding and judgment, and (8) operation, were selected from 3P task analysis items, while (9) continuity of information or operation was an item extracted from actual universal-design-related problems.

These nine universal design items are cues to find universal-design-related problems and solutions to universal designs. A universal design can be realized by examining these nine items.

The following describes the nine items in detail.

(1) Adjustment: a machine can adjust itself to diverse users (including the population with disabilities)

Example: a chair with a continuous height adjustment range a chair with several height adjustment steps

(2) Redundancy: there are a number of alternatives in the interface input and output.

Example: Data can be read from HD, FD, MO or CD.

An ATM which accepts either card or bankbook

(3) Specification and function transparency: an interface's methods of enhancing its clearness

Example: An indicator that uses size and color intensity to show sound level

A window on a water pot that shows the amount of the content (water surface level)

(4) Feedback: a reaction of a machine to user input

Example: A button that provides light and sound as feedback

A button that provides sound as feedback

(5) Error tolerance: reactions of a machine to mistakes made by users.

Example: An automatic gate machine in which a ticket can be inserted in either direction An ATM that makes an announcement when a user makes a mistake

(6) Acquisition of information

Using cues and recognizable differences as media, we examine not only the visual aspect but also the auditory and tactile aspects to practice a multi-modal inspection. For example, cues for sight-impaired individuals can be provided by protrusions on individual operation points and controls (slide switches, rotary switches) which allow them to feel the amount of operation.

a. Visual aspect: Easy to see (large characters with high contrast. Avoid a layout required

b. Auditory aspect: Easy to hear, appropriate sound volume

c. Tactile aspect: Cues can be recognized by touch

d. Physical aspect: Easy operating posture

e. Environmental aspect: Optimum light intensity, glare-free display, air conditioning, etc.

(7) Understanding and judgment of information (The following describes general methods of making information easy to understand.)

a. Information is displayed sequentially, and only one task is shown on a display at a time.

b. Graphic symbols such as icons are used as cues.

c. Use of metaphor and analogy to reduce the memorization burden.

d. Selection based on recognition (use of menu) instead of replay (memorization of rules).

(8) Operation

a. Easy operating posture: No need to take an awkward posture for operation.

b. Fitness: Controls such as tools are fit for operation.

• Surface: Anti-slip feature

c. Operation force: Controls can be operated with minimal force.

d. Operating method

• Controls can be operated with one action, instead of requiring two different actions or delicate adjustment.
• Controls can be opetated by one hand.
• Controls employ familiar operating methods.

e. Environmental aspect:

Optimum light intensity, Optimum space, glare-free display, air conditioning, etc.

(9) Continuity of information and operation

The flow of information and operation must not be interrupted. In other words, the step of "acquisition of information" -> "understanding and judgment" -> "operation" must be continuous and flowing. Usually, effort is focused on resolving easy-to-notice universal-design-related problems in the subtask level, and an approach to solve problems in view of task scenarios is not taken when extracting problems. Therefore, this item was selected for use in task matrix analysis. Here is an example: in train stations where elevators are installed for people on wheelchairs, there are often staircases with several steps which make it difficult for wheelchair users to access the elevators.

3.2. Compared with the seven principles

The nine universal design items are compared with the seven principles. The relation between them is as follows.

(1) principle one: equitable use -----(2) redundancy

(2) principle two: flexibility in use------(1) adjustment

(3) principle three: simple and intuitive ----(3) Specification and function transparency

(4) principle four: perceptible information ------(6) acquisition of information, (7) Understanding and judgment of information

(5) principle five: tolerance for error-----(5) error tolerance

(6) principle six: low physical effort------(8) operation

(7) principle seven: size and space for approach and use------(8) operation ,(9) Continuity of information and operation

The (1)--(5) items of the nine design items focus on mainly providing industrial designers and so on with concrete solutions. The (6)--(9) items of the nine design items focus on humans' information processing stages — "acquirement of information" -> "understanding and judgment" -> "operation" — and on "continuity of information". And so, universal-design-related problems in each task in a scenario are extracted and solved from the viewpoint of information processing.

4. Structured task analysis and task matrix analysis based on 3P task analysis

4.1. Structured task analysis

The first step taken in structured task analysis is similar to that in 3P task analysis. A typical scenario is selected, and target users are determined since user types are important for universal design. Target users may be wheelchair users, elderly persons, and sight-impaired or hearing-impaired individuals. The rest of the population can be considered together with the physically challenged during the examination of universal design.

Since a job can be divided into tasks, it is necessary to focus on tasks. For the modification of an existing system, tasks are examined from the viewpoint of universal design in order to extract problems. For the development of a new system, problems are extracted in predicted tasks. Consideration of the previously mentioned items — (1) adjustment, (2) redundancy, (3) specification and function transparency, (4) feedback, (5) error tolerance, (6) acquisition of information, (7) understanding and judgment, (8) operation and (9) continuity of information or operation — will be useful in finding cues for problem extraction.

We start by writing extracted problems next to the tasks, as shown in Fig. 2. Then, we write solutions for the enumerated problems. When the solutions are expected to generate no problem, the analysis ends here. If there are problems, solutions must be added. As such, necessary solutions (requirements) are extracted from the viewpoint of universal design.

4.2. Task matrix analysis

Task matrix analysis is fundamentally the same as structured task analysis. In task matrix analysis, however, for each task, functionally challenged conditions (old age, sight impairment, hearing impairment, wheelchair use, etc.) are formed in matrixes together with the universal design attainment items and the items related to information processing stages, then solutions for achieving universal design are indicated for each of the functionally challenged conditions in each task based on the items in the matrixes. The previously mentioned five items — (1) adjustment, (2) redundancy, (3) specification and function transparency, (4) feedback and (5) error tolerance — are used as the universal design attainment items. Items related to information processing include (6) acquisition of information, (7) understanding and judgment, (8) operation, and (9) continuity of information or operation. These items((6)-(9)) focus on humans' information processing stages — "acquisition of information" -> "understanding and judgment" -> "operation" — and on "continuity of information," and universal-design-related problems in each task in a scenario are extracted and solved from the viewpoint of information processing.
The nine items are arranged vertically in the matrix, as shown in Fig. 3. Using these items, solutions can be deduced.

4.3.Features of structured task analysis and task matrix analysis

One notable feature of structured task analysis is that minimal design oversights result since the examination is conducted on the task level. In the conventional brainstorming method, topics are extracted haphazardly; therefore, chances are high that some things are overlooked and structural problems are neglected. Structured task analysis can be used for both hardware and software.

In structured task analysis, examination is conducted for each functionally challenged condition. Task matrix analysis, on the other hand, lets us grasp all applicable functionally challenged conditions at the same time; thus, it is suitable for examining universal design with a macro view.

Structured task analysis and task matrix analysis have fundamentally same structure as they are based on 3P task analysis. Structured task analysis is recommended when procedures of tasks are focused on. On the other hand, task matrix analysis is recommended when each functionally challenged condition are focused on

5.Constructing structured universal design concept based on requirements and designing

A structured universal design concept is constructed based on universal design requirements.
Universal design requirements are extracted using structured task analysis or task matrix analysis.
Universal design requirements are grouped into a few upper items which are grouped into a top universal design concept item. These requirements are weighted by AHP(Analytic Hierarchy Process) or subjective assessment. High weighted requirements are given priority in constructing an universal design.

Condense universal design ideas at the very bottom of the universal design concept system view as design proposals on a par with the top universal design concept items. Each universal design items are visualized as universal design ideas (solutions), or using words if visual representation proves difficult. Bring together all universal design ideas that were visually represented and use them to form an universal design proposal (Fig 4).

6. Verification experiment with a public bus

For universal design application, I examined a public bus operating in a city with a population of 400,000.

6.1 Implementation of structured task analysis

I examined the general tasks to be performed in a series of processes — starting with boarding the bus and ending with disembarking — conducted by elderly persons, sight-impaired persons, hearing-impaired persons and people in wheelchairs, and extracted anticipated problems (Fig. 4). The problems extracted for each task corresponded with the predictions, unlike the haphazardly extracted problems of a focus group. Furthermore, when solutions were not complete, this analysis method made it possible to structurally extract solutions to resolve the problems.

6.2 Task matrix analysis

Using task matrix analysis, I was able to view all measures for each functionally challenged condition in each of the tasks, such as entering the bus, receiving a numbered ticket, and moving inside the bus. The use of the four items — (1) acquisition of information, (2) understanding and judgment, (3) operation and (4) continuity of information or operation — allowed me to check the environmental aspect that tends to be overlooked (Fig. 5). For instance, the analysis results pointed out the lack of light (when a bus card is used) at the entrance of the bus at night.

6.3 Concept and design plan.

Based on the requirements obtained in my structured task analysis and task matrix analysis, I created a structured universal design concept. A main concept is "Taking a bus comfortably" and subconcepts are "efficiency", "no fatigue" and "relieving"(Fig. 6). And a visual image of the universal design (Fig. 7,8,9) is created based on a structured universal design concept.

7. Conclusion

The use of structured task analysis and task matrix analysis allowed me to extract universal-design-related problems in the bus. As verified in my experiment, the two analytical methods offer the following features.

(1) Structured task analysis enables thorough and detailed extraction of problems. Problems can be extracted effectively when the cues used in 3P task analysis for problem extraction and the nine universal design items are used, as compared to the use of an analytical approach relying on intuition.

(2) Task matrix analysis makes it possible to understand problems from a macro viewpoint, and provides information on system flaws based on a structural approach.

(3) Designs created in consideration of the functionally challenged conditions generally offer improvements for the rest of the population, but this does not hold true in all cases. For people with no physical limitations, it is necessary to use 3P task analysis to grasp general problems. Conversely speaking, when there is not enough time, 3P task analysis can be used to understand problems areas, and those problem areas can be studied in depth using structured task analysis and task matrix analysis.

(4) While the previous methods focused on resolving each of the discovered problems, the methods proposed in this paper allow structural problems and other problems to be understood in terms of overall system operations.

Acknowledgments

I thank Ryota Mori for assistance with drawing figures of bus.

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Scene:					
t a s k	Pick up problems in "information acquisition –understanding/ judgement—operation" process.			Solution (requirement)	
	Information acquisition (1)emphasis (2)simplicity (3)consistency	Understanding & judgement (1)term (2)feedback (3)mapping (4)cue (5)consistency (6)system structure	Operation (1)posture (2)fit (3)torque	Solution in a practical manner	Soluti-on in the near future

fig.1. 3 P(point) task analysis

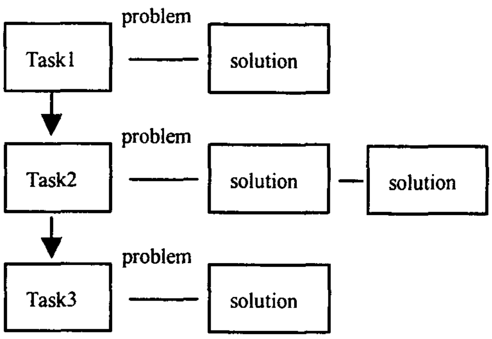

fig.2. structured task analysis

task	Old age	Sight impairment	Hearing impairment	Wheelchair use
adjustment				
redundancy				
Specification and function transparency				
feedback				
Error tolerance				
Acquirement of information				
Understanding and judgement				
operation				
Continuity of information or operation				

fig.3. task matrix analysis

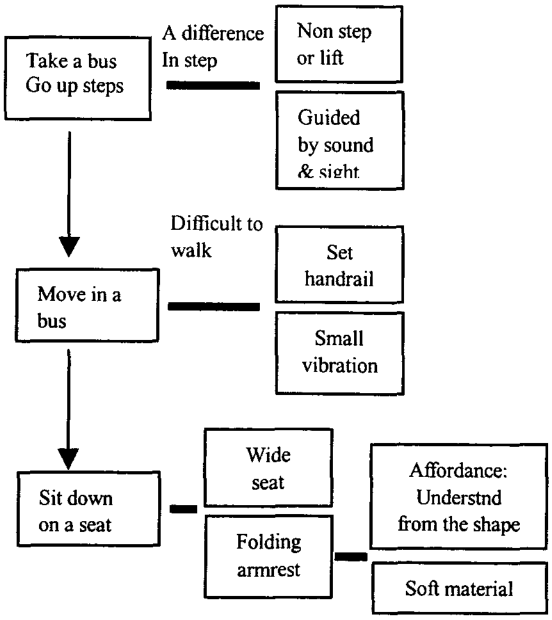

fig.4. example(bus) of structured task analysis

task	Old age	Sight impairment	Hearing impairment	Wheelchair use
adjustment	Set handrail	Set handrail	Set handrail	Set handrail
redundancy				
Specification and function transparency	Indicate steps	Guided by sound	Indicate steps	Indicate steps
feedback				
Error tolerance	Guided by sound and sight	Guided by sound	Indicate error	Guided by sound and sight

operation	Non step	Non step	Non step	Non step
Continuity of information or operation	Same level between bus step and bus stop base	Same level between bus step and bus stop base	Same level between bus step and bus stop base	Same level between bus step and bus stop base

fig.5. example(bus) of task matrix analysis

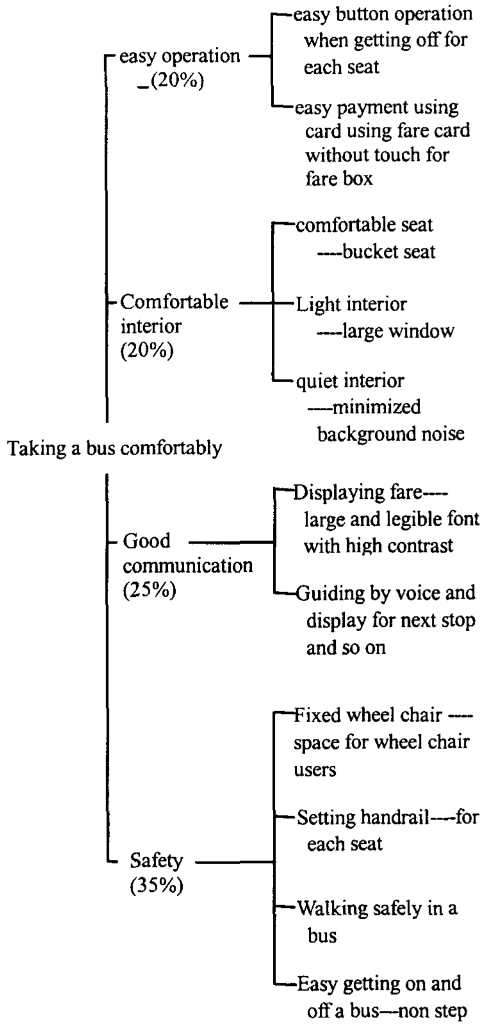

fig.6. universal design concept

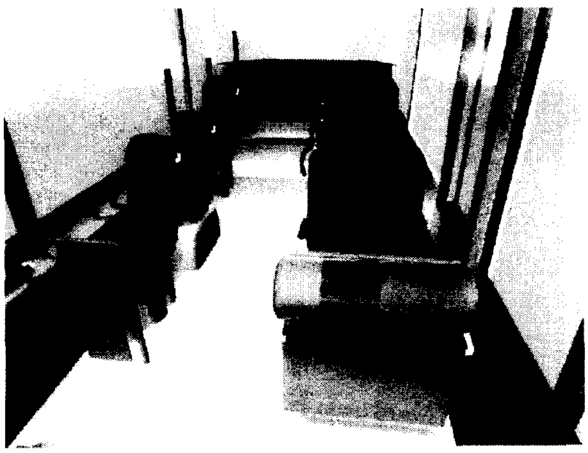

fig.7 The interior of a bus(1)

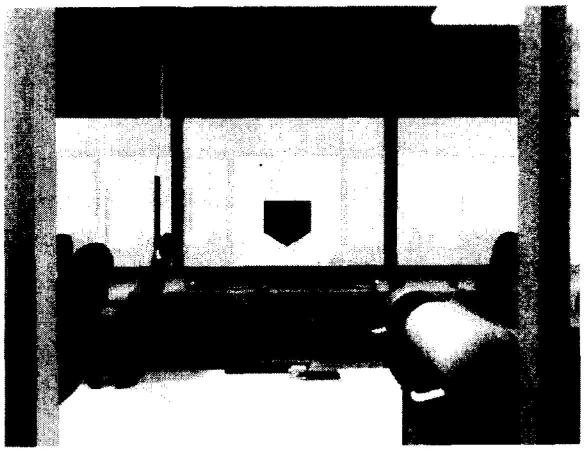

fig.8 The interior of a bus(2)

fig.9 The interior of a bus(3)