Practical Design of Information Interface

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Abstract

This paper deals with design examples for information interface that is defined as human user-information interactions through an information device. In the first part of the paper, we briefly review the model for the interface, and then give a design procedure based on a multiple regression (MR) model. In the second part of the paper, we explain two practical design examples. The first example deals with designing an interface for a computer generated motion picture by using an impressive quality measurement (semantic cost criterion). The second one deals with computer generated 3D city-map perception problem by using an object search time measurement (human cost criterion). Results for two design examples show the quality of interface is improved by adjusting system control parameters.

Key words: User interface, Information interface, Multiple regression model, Semantic differential method, Object search problem

1. Introduction

The goal of using an information device is not operating the device but performing certain information interactions with information. From this interaction viewpoint, we introduced the concept of information interface and formulated a design method with the use of a multiple regression (MR) model [Kamata, Maehara, Wakimoto, & Usui, 2003].

In this paper, we explain two practical design examples and show the usefulness of MR based interface design method. The first design example deals with reception of computer generated motion pictures within allowable impressive quality regardless of the display sizes of mobile information devices such as MPs (Mobile Phones) and PDAs (Personal Digital Assistants). In the design experiment, we use semantic differential (SD) method for measuring impressive/aesthetic attitude of users. The second example deals with computer generated 3-dimensional (3D) city-map service through mobile information devices same as the first example. In the second design example, we adopt human cost (HC) criterion and make an object search experiment. Each of these design results shows that the interface, or information perception, is improved under each criterion by adjusting certain system control parameters. From this, we can say that the design method based on MR model is useful for designing information interfaces, or information systems.

2. Design Procedure

2.1 Model of Information System

A diagram shown in Figure 1 represents an information system, and quality measures for information interface. We explain briefly the system parameters in Figure 1.

(1) Information Source. Information source **S** represents a set of N sources, and is denoted by **S**={S_1, S_2,..., S_N}.

(2) Device Characteristics. Information device characteristics is denoted by **D**. This includes various device parameters such as display size which is discussed in the design examples.

(3) Combined Information Source. A combined information (**S**,**D**) represents the characteristics of information that a user receives through the device.

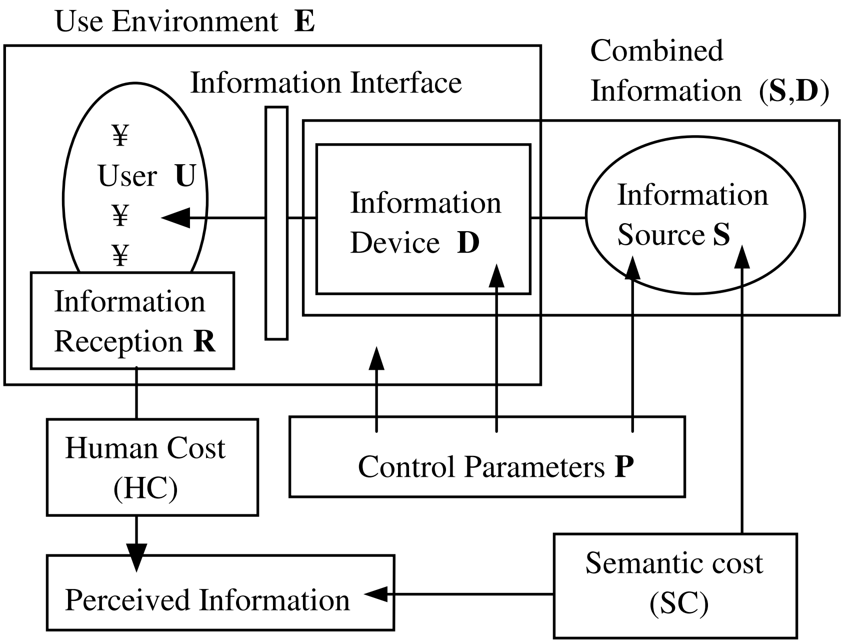

Figure 1. System model for an information interface and quality measures: Human Cost (HC), and Semantic Cost (SC).

(4) User Characteristics. User characteristics **U** consists of physiological, physical, psychological, and cognitive factors for users in a target group.

(5) Use Environment. An information device is used in various situations, and use environment **E** represents environmental factors such as lighting and sound conditions.

(6) Information Reception Characteristics. Reception characteristics **R** represents how information (**S**, **D**) is perceived by a user, and is expressed by use environment **E**, and user characteristics **U.**

(7) Quality Measures for Information Interface. An information interface is defined as the surface between a user and the combined information source. Tow kinds of quality measures are introduced in the companion paper [Kamata, Maehara, Wakimoto, & Usui, 2003]: Human cost (HC) that represents total human information processing load for perceiving information; and Semantic cost (SC) the accuracy of the perceived information by a user.

(8) Control parameters. We can use a set of control parameters **P**=(p_1, p_2,..., p_M) that affects system functions. The parameters will be device parameters, environmental factors, or certain factors that affect directly information source.

2.2 Procedure

We briefly explain the design procedure for the following two examples. The key to designing information interface is building a multiple regression (MR) model for quality measure, **Q**=[w_{nk}], n=1, 2,..., N, and k=1, 2,..., K, with the use of a set of control parameters, **P**=(p_1, p_2,..., p_M), that are specified in advance the design [Kamata, Maehara, Usui, & Wakimoto, 2003].

(1) We measure values for evaluation indicators w_{ij} for various control parameter values of p_m, subjects, and information source **S**. We then generate MR model by statistical analysis [Everitt, & Wykes, 1999]:

$$w_{nk}^{P} = a_{nk}^{0} + a_{nk}^{1} p_1 + \dots + a_{nk}^{M} p_M \qquad \text{for n=1, 2,..., N, and k=1, 2,..., K.}$$

The set of multi-linear expressions above gives the approximated behaviour of quality measure with control parameters **P**=(p_1, p_2,..., p_M).

(2) We set target values for $\mathbf{Q}^{target}$ =[w_{nk}^{target}], n=1, 2,..., N, and k=1, 2,..., K. We then calculate the optimal control parameter values, $p_m^{optimal}$ for m=1,2,..., M, that make the total sum of $(w_{nk}^{target} - w_{nk}^{P})^2$ for all n, k, minimal by the use of an optimisation algorithm (for example, quasi-Newton method).

(3) We finally get optimal control parameter values, $p_m^{optimal}$ for m=1, 2,..., M.

3. Design Example 1

3.1 Procedures

In this design example, we deals with the perception of a computer generated motion picture under an impressive/aesthetic criterion.

(1) Information source **S**={S_1} is a computer generated motion picture that shows interior of a lift with 10 seconds duration.

(2) Device factor **D** is display size. We use information devices with display sizes: Large one is 110x138mm (360x450 pixel), and small one 29x36mm (96x120 pixel). In the experiment, the motion picture is presented on CRT display with a picture size.

(3) User characteristics is specified by people who have normal eyesight.

(4) Use environment is specified by a usual office room with normal illumination.

(5) We use semantic differential (SD) method for measuring perceptual attitude to the motion picture. We adopt 8 semantic bipolar 7-point scales shown in Table 1 for evaluating user's attitude. This evaluation indicator falls in the category of semantic cost (SC).

(6) We use four control parameters, **P**=(p_1, p_2, p_3, p_4), that affect the characteristics of motion picture: p_1: brightness for motion picture, p_2: contrast of motion picture, p_3: vision angle, p_4: moving speed of visual point.

(7) Target of parameter adjustment. We use that two kinds of information devices for this system: One with large display size of 110x138mm (360x450 pixel), and the other small one of 29x36mm (96x120 pixel). Design target is to set parameter values optimal so that each user can perceive information through small display as equal quality as possible with that for the large display case. Information perception is measured with 8 semantic bipolar 7-point scales.

Table 1. Semantic scales.

W_1: narrow - wide	W_5: closed - open
W_2: cold - warm	W_6: clumsy - elegant
W_3: not cozy - cozy	W_7: difficult to see - easy to see
W_4: uncomfortable - comfortable	W_8: fatigued - not fatigued

3.2 Result

(1) MR model. For building MR model, we first made perception experiment with 15 subjects (13 men and 2 women) with the range of 20-40 years old. Table 2 shows regression coefficients for explanatory variables, p_1, p_2, p_3, and p_4.

Table 2. Coefficients for MR mode a_{nk}^{m}.

w_{1k} Measures	a_{1k}^{1} (p_1)	a_{1k}^{2} (p_2)	a_{1k}^{3} (p_3)	a_{1k}^{4} (p_4)	a_{1k}^{0} Constants
w_{11}	-0.02	-0.28	5.18	0.01	-2.14
w_{12}	2.15	-1.27	-1.03	-0.06	0.01
w_{13}	2.26	-0.49	0.35	-0.29	-0.2
w_{14}	2.07	-0.21	0.69	-0.6	0.04
w_{15}	2.03	-0.64	2.7	0.03	-1.54
w_{16}	0.98	-1.44	1.4	-0.52	0.25
w_{17}	1.57	0.52	0.69	-1.01	0.81
w_{18}	2.21	0.34	-0.66	-1.97	2.45

(2) We set target values: $w_{11}^{target} = 0.0$; $w_{12}^{target} = -0.60$; $w_{13}^{target} = 0.20$; $w_{14}^{target} = 0.20$; $w_{15}^{target} = -0.40$; $w_{16}^{target} = 1.40$; $w_{17}^{target} = 0.00$; and $w_{18}^{target} = 0.00$. These target values correspond to the quality values for the case of large display size.
(3) Optimal control parameters are calculated by using quasi-Newton method: $p_1^{optimal} = -0.075$; $p_2^{optimal} = -0.463$; $p_3^{optimal} = 1.075$; and $p_4^{optimal} = 0.789$.
(4) Quality Testing. With the use of optimal control parameters, $p_m^{optimal}$, we made another perception experiment. The subjects were age of 20-30 years old, and were 13 men and 5 women. The subject group was different from the first experiment for MR modeling. Evaluation results were: $w_{11}^{adjust} = -0.78$ (-2.00)*; $w_{12}^{adjust} = -1.28$ (-1.80); $w_{13}^{adjust} = -0.28$ (-1.40)*; $w_{14}^{adjust} = 0.00$ (-1.00)*; $w_{15}^{adjust} = -1.17$ (-1.60); $w_{16}^{adjust} = 1.00$ (0.00)**; $w_{17}^{adjust} = -0.61$; and $w_{18}^{adjust} = -0.72$. The values in the parenthesis stand for values for the initial parameter setting. Where, * stands for statistical significance with $p<0.01$, and ** $p<0.05$.

4. Design Example 2

4.1 Procedures

In the second design example, we discuss interactive object search with 3D computer generated city maps. This system simulates an interactive search of the object (target) in city maps through information devices with large and small display sizes: Display sizes according to MPs, and PDAs.

(1) We use six kinds of computer generated city maps for six different areas. Information source, then, is given by $\mathbf{S}=\{S_1, S_2, S_3, S_4, S_5, S_6\}$.

(2) Device factor **D** is display size. We use two kinds of display sizes: Large one is 120x120mm (500x500 pixel), and small one 36x36mm (120x120 pixel).
(3) User characteristics is specified by people who have normal eyesight.
(4) Use environment is specified by a usual office room with normal illumination.
(5) We use the object search time in second as evaluation indicator W_1 (sec).
(6) We use four control parameters, **P**=(p_1, p_2, p_3, p_4), that affect the characteristics of 3D city map pictures. p_1: brightness, p_2: contrast, p_3: vision angle, p_4: height of visual point.
(7) Target of parameter adjustment. Two kinds of information devices are used for the simulation system: One with large display size of 120x120mm (500x500 pixel), and the small one of 29x36mm (96x120 pixel). Design target is to set parameter values so that each user can perceive information through a small display sized device as equal as possible to that for the large display case. Information perception is measured with the object search time W_1 (sec).

4.2 Result

(1) MR model. We first made object search experiment with 20 subjects (14 men and 6 women) with the range of 20-40 years old. Table 3 shows regression coefficients for explanatory variables, p_1, p_2, p_3, and p_4.

Table 3. Coefficients for MR mode a_{nk}^{m}.

w_{n1} Measures	a_{n1}^{1} (p_1)	a_{n1}^{2} (p_2)	a_{n1}^{3} (p_3)	a_{n1}^{4} (p_4)	a_{1k}^{0} Constants
w_{11}	-176.26	-198.55	-346.43	-94.43	436.84
w_{21}	-428.91	-322.29	-592.27	-219.24	826.46
w_{31}	-16.60	-2.33	-39.93	-19.74	68.84
w_{41}	49.72	18.40	36.01	19.66	-30.06
w_{51}	83.75	90.20	56.22	39.50	-107.28
w_{61}	-92.54	-85.80	-90.93	-31.75	188.17

(2) We set target values that represent quality measures (sec) for object search time in the case of large display size: $w_{11}^{target} = 23.2$; $w_{21}^{target} = 28.5$; $w_{31}^{target} = 24.0$; $w_{41}^{target} = 21.5$; $w_{51}^{target} = 23.4$; and $w_{61}^{target} = 35.5$.
(3) Optimal control parameters are calculated by using quasi-Newton method: $p_1^{optimal} = 0.410$; $p_2^{optimal} = 0.448$; $p_3^{optimal} = 0.552$; and $p_4^{optimal} = 0.678$.
(4) Quality Testing. With the use of optimal control parameters calculated, $p_m^{optimal}$, we made another object search experiment. The subjects were age of 20-40 years old, and were 8 men and 2 women. The group of the subjects was different from the group for the first modeling experiment. Evaluation results (sec) were: $w_{11}^{adjust} = 29.7$ (32.9); $w_{21}^{adjust} = 44.8$ (48.2); $w_{31}^{adjust} = 30.4$ (31.1); $w_{41}^{adjust} = 25.0$ (30.2); $w_{51}^{adjust} = 23.7$ (27.9); and $w_{61}^{adjust} = 34.3$ (37.7). Where, values in the parenthesis gives initial ones as shown in Table 4. The averaged object search time with small display seize was improved: Search times was 35.3 sec, SD=0.796 for the initial parameter setting case, and 32.3 sec, SD=0.481 for the optimal parameter setting calculated by MR model. The difference of these two search times is statistically significant, $p<0.05$.

Table 4. Quality values.

Indicator values	Initial values (sec)	Target values (sec)	Optimised values (sec)	Improvement (sec)
w_{11}	32.9	23.2	29.7	3.2
w_{21}	48.2	28.5	44.8	3.4
w_{31}	31.1	24.0	30.4	0.7
w_{41}	30.2	21.5	25.0	5.2
w_{51}	27.9	23.4	23.7	4.2
w_{61}	37.7	35.5	34.3	3.4

5. Concluding Remarks

We have shown two design examples with the use of MR model proposed in the companion paper [Kamata, Maehara, Wakimoto, & Usui, 2003]. The first example discussed the perception for a computer generated motion picture with the use of 8 semantic bipolar 7-scales. The second example dealt with six kinds of 3D city maps by an object search time measurement. Two systems have been designed to improve the information perception evaluation through the device with small size display. The control parameters were adjusted to improve the evaluation to close to that for large display size. Experimental results have shown the usefulness of the proposed design method.

Acknowledgement

The authors would like to thank Ken-ichi Katoh and Makoto Nakamura for discussion.

References

Everitt, B.S. & Wykes,T. (1999). A Dictionary of Statistics for Psychologists. London: Arnold.

Kamata, K., Maehara, H., Wakimoto, K., & Usui, S. (2003). An Approach to the Design of Information Interface. Proceedings of the 19th Symposium on Human Factors in Telecommunications (HFT2003).