Adaptive Display Strategy using Analytic Hierarchy Process

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Abstract—**A strategy using a model based on Analytic Hierarchy Process on controlling display of mobile information device is proposed in this paper. An evaluation system installing the proposal was produced and validation test was conducted. The result showed the system was operated as had been anticipated from the proposed model, thus the validity of the proposed model was confirmed.**

Keywordst; Analytic hierarchy process; design strategy; optimized user interface; Display

I. INTRODUCTION

This paper deals with a strategy for controlling display of mobile information device. As for the display of mobile information device that are actually carried by users, users can simply adjust its luminescence in order to enhance the easiness to see the display depending on the brightness of the incident light [1, 2]. Therefore following inconvenience occurs depending on circumstances. That is; (1) Deterioration of gradation such as poor contrast of colors or excessive black color due to emphasized black level etc., (2) Deterioration of color reproduction under artificial luminescence that has specific spectroscopic characteristics, (3) Deterioration of sight recognition due to farsightedness, myopia, and color blindness of users.

Therefore, a class analysis method model that deals with display control strategy and that takes both an effect from circumstances and sight characteristics of users into account will be proposed in this paper. Also, an experiment using the evaluation system based on the proposed model was conducted. Its effectiveness was confirmed and the result will be reported in this paper.

II. PROPOSED MODEL

A. Outline of proposed model

Fig. 1 shows the circumstances around the display device. As can be seen from the figure, the anticipated display performance at design stage is drastically deteriorated depending on the characteristic of incident light on the display surface from circumstance and also depending on the characteristic of the user who watches it.

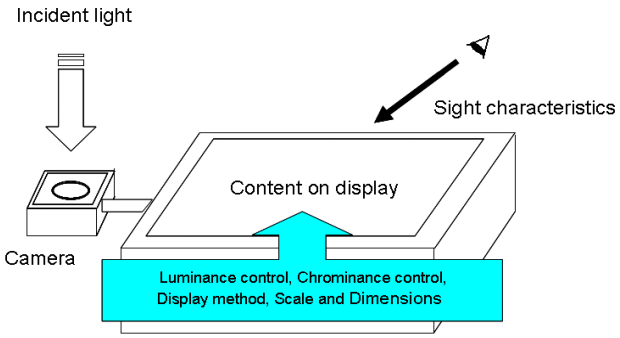

Figure 1. Display device and its circumstances

Therefore, we propose a model of display strategy shown in Fig. 2 that is based on Analytic Hierarchy Process (AHP) and that takes account of the measured incident light from circumstances and the user characteristics [3].

The goal of the present model is to obtain the strategy for adaptive display control. For this purpose, four evaluation criteria are decided; (a) luminance, (b) chrominance, (c) content on display, and (d) sight characteristics of users. Also, four alternatives, luminance control, chrominance control, display method, and scale of dimensions were chosen in order to achieve the goal.

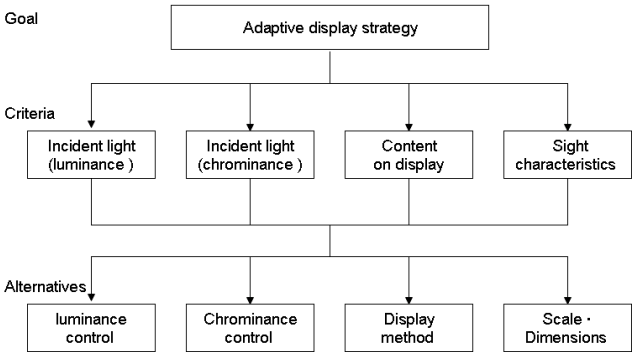

Figure 2. Adaptive strategic display model using AHP

B. Calculation example of the proposed model

Calculation was conducted in the cases of strong incident light from circumstance, an old person with farsightedness, and a person with color blindness.

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First, the weight of four criteria is calculated resulting in weight values shown in the Table 1. The consistency index (CI) value in this case is 0.051, satisfying the necessary and sufficient conditions.

Next, the weight of alternatives is calculated, taking strong incident light from circumstances as an example. Table 2 shows the calculated result of weight concerning luminance of incident light.

The CI value in this case is 0.051, satisfying the necessary and sufficient condition. Same calculation was conducted in order to obtain weight of incident light chrominance, content of display, and characteristic of user's sight.

From above calculation of the weight, the evaluation value of alternatives in the case of strong incident light from circumstances can be obtained as follows.

$$\begin{bmatrix} \text{Luminance} \\ \text{Chrominance} \\ \text{Display} \\ \text{Dimensions} \end{bmatrix} = \begin{bmatrix} 0.508 & 0.223 & 0.487 & 0.488 \\ 0.075 & 0.487 & 0.096 & 0.208 \\ 0.265 & 0.162 & 0.209 & 0,208 \\ 0.151 & 0.127 & 0.209 & 0.096 \end{bmatrix} \cdot \begin{bmatrix} 0.263 \\ 0.099 \\ 0.116 \\ 0.523 \end{bmatrix} = \begin{bmatrix} 0.467 \\ 0.188 \\ 0.219 \\ 0.127 \end{bmatrix} \quad (1)$$

Same calculation was conducted and its resulted is shown in Table 3 in the cases of strong incident light from circumstances, an old person with farsightedness, and a person with color blindness. It can be seen from this table that most important control is luminance control for strong incident light, dimension control for an old person with farsightedness, and chrominance control for a person with color blindness respectively. As is described, the display strategy for each case can be obtained.

TABLE I. WEIGHT OF FOUR CRITERIA

	Luminance	Chrominance	Content	Characteristics	Weight
Luminance	1	3	3	1/3	0.263
Chrominance	1/3	1	1	1/5	0.099
Content	1/3	1	1	1/3	0.116
Characteristics	3	5	3	1	0.523

TABLE II. CALCULATED EXAMPLE OF AN ALTERNATIVE IN THE CASE OF INCIDENT LIGHT FROM CIRCUMSTANCE

	Luminance	Chrominance	Display	Dimensions	Weight
Luminance control	1	5	3	3	0.508
Chrominance control	1/5	1	1/3	1/3	0.075
Display method	1/3	3	1	3	0.265
Dimensions	1/3	3	1/3	1	0.151

TABLE III. COMPARISON OF THREE CALCULATED EXAMPLES

	Incident light	Color	Farsightedness
Luminance	0.467	0.234	0.164
Chrominance	0.188	0.482	0.071
Display method	0.219	0.200	0.274
Dimensions	0.127	0.085	0.493

III. EVALUATION SYSTEM

A. *Outline of evaluation system*

The evaluation system was realized with a small resource system with embedded Linux API, considering the usage in mobile information device, and taking account of embedded MPU and extensive characteristics

According to the fundamental specifications listed in Fig. 3, the display can show QVGA full color view with a touch-panel structure, and has a camera with 300,000 pixels that is enough to measure incident light.

Figure 3. Fundamental specifications of the evaluation system

B. *Experiment of the evaluation system*

The evaluation system was used under two different incident light conditions; one is interior condition with luminance of 500lx (equivalent luminance of about 150cd/m2), and the other is entrance condition with luminance of 2000lx (equivalent luminance of about 600cd/m2). As a result, it was confirmed that both gradation characteristic and maximum luminance are automatically controlled by an image pick-up from the camera. It was also confirmed that the displayed character size becomes larger and the display is converted from negative to positive making the view easier to see if the user input characteristic information of farsightedness.

IV. CONCLUSIONS

A strategy using a model based on AHP on controlling display of mobile information device is proposed in this paper.

The goal of the present model is to obtain an adaptive display control. For this purpose, four evaluation criteria, luminance and chrominance of incident light obtained by a camera, content on display, and sight characteristics of users are chosen. Also, four alternatives, luminance control, chrominance control, display method, and scale of dimensions were chosen in order to achieve the goal.

Calculation was conducted for each example of strong incident light, an old person with farsightedness, and a person with color blindness. It was shown that there are effective alternatives for each example.

Finally, an evaluation system installing the proposal was produced and validation test was conducted. The result showed the system was operated as had been anticipated from the proposed model, thus the validity of the proposed model was confirmed.

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