Space Hierarchical Design of Mobile User Interface Based on Eye Movement Experiment

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Abstract. In this paper, the idea of UI space hierarchy of mobile terminal was put forward and the UI space was divided into four levels. Taking iPhone5 as an example, RGB, angle, opacity, size and other regional shadow parameter values were set first of all and then representative sample combination was selected by orthogonal experimental design, subjects need to perceptual image evaluate the sample pictures through the eye movement experiment and the eye movement experimental data was analyzed by the method of orthogonal analysis. The results proved the existence of UI space hierarchy, and the best UI space shadow hierarchy combination regimen was summed up. The results have theoretical and practical value to the study of UI interface design.

Introduction

With the development of network technology, the mobile terminal interface design needs to reflect the elements of fashion trend, meet the characteristics of human culture and have affinity. The mobile terminal interface should not only have high picture quality, but also need more personalized recognition and operational process[1].

Interface design is a complex project which has different subjects to participate in and the criterion for testing an interface is the feeling and experience of the end user[2]. Similar studies at home and abroad were often limited to subjective feeling before, which were lack of objective evaluation, rarely referring to the study of UI space hierarchy of mobile terminal. Based on the eye movement experiment method of cognitive psychology, this paper studied the UI space hierarchy of mobile terminal and selected representative sample combination combined with orthogonal experiment method. The data was comprehensively analyzed from subjective and objective aspects, which makes up for the lack of objective data analysis in such studies and makes the conclusion more objective and reliable. The research can provide reference for mobile terminal interaction design.

The idea and element of UI space hierarchy of mobile terminal

The idea of UI space hierarchy of mobile terminal

Since the electronic screens of mobile terminal are completely complanation, which is not 3d as in the reality. This study aims to put the characteristics of real paper into electronic screens and present the information content in the virtual paper which has the upper and lower hierarchy relationship with another paper (information content). The projection was used to simulate the spatial traits of the paper[3], which is shown in Fig. 1.

Fig. 1 Shade expression of cards

The elements of UI space hierarchy of mobile terminal

As shown in Fig. 2, this study chose iPhone5 with IOS mobile operating system to research the user interface.

Fig. 2 Example of APP interface

(1) The size and resolution of iphone5

iPhone5 interface dimension：640×1136, 72ppi is usually used in both website UI and mobile terminal UI.

(2) Basic element of interface

640 x 1136 was chosen for the size design of which the element sizes are as follows: The size of status bar was 40 pixels, the size of navigation bar was 88 pixels, the size of main menu bar was 98 pixels and the size of content area was 910 pixels. The color was white, so the RBG values were R: 255, G: 255, B: 255.

(3) Shadow hierarchy design

We can get the shadow value of each area by setting the parameters (RGB values, angles, opacity, and size) in Photoshop software. In order to avoid the influence of color on the shadow hierarchical design, color was uniformly set as black, so the RGB values were R: 0, G: 0, B: 0. Angle was divided into -90° and 90°. The numerical range of opacity was from 20% to 70%. The numerical range of size was from 10 pixels to 60 pixels.

UI space hierarchical design experiment of mobile terminal

This study selected representative samples from many compositions by the orthogonal experiment. Photoshop was used to make the sample image pictures, subjects need to perceptual image evaluate the sample pictures through the eye movement experiment and the eye movement experimental data was analyzed by mathematical analysis to discover the influence factors and the best scheme for UI space hierarchical design of mobile terminal.

Orthogonal experimental design of UI space hierarchy

Orthogonal experimental design is a design method to study multiple factor and level. It selects partial typical sample combinations from comprehensive experiment according the orthogonality, of which the combinations are usually representative and scientific[4].

Analyzing the designing elements of UI space hierarchy of mobile terminal, factors and levels table for orthogonal array design is established, in which there are nine factors, three rows with four levels and six rows with two levels. As shown in table 1, in order to simplify the name of factors, the shadow position between status bar and navigation bar was called position 1, the shadow position between navigation bar and main menu bar was called position 2, and the shadow position between main menu bar and content area was called position 3.

Table 1 Factors and levels for L16 ($4^3×2^6$) orthogonal array design

level	factor	Position1 opacity （%）	Position2 opacity （%）	Position3 opacity （%）	Position1 size （pixels）	Position2 size （pixels）	Position3 size （pixels）	Position1 angle （°）	Position2 angle （°）	Position3 angle （°）
	mark	A	B	C	D	E	F	G	H	I
1		A1(20)	B1(40)	C1(60)	D1(10)	E1(30)	F1(50)	G1(-90)	H1(-90)	I1(-90)
2		A2(25)	B2(45)	C2(65)	D2(20)	E2(40)	F2(60)	G2(90)	H2(90)	I2(90)
3		A3(30)	B3(50)	C3(70)						
4		A4(35)	B4(55)	C4(75)						

465

Eye movement experiment

Equipment and programming

(1) Equipment

Canada SR company of Eyelink1000 desktop eye tracking system production was used in this experiment. Eye tracking technology was used to test interface hierarchy layout and evaluate the designing schemes of UI space hierarchy.

(2) Programming

The EB programming of EyeLink1000 is a kind of modular and visual programming. While programming we get the basic frame by dragging the controls to the panel and connect them according to their experiment logical sequence by arrows[5].

Subjects

There are 55 subjects in the experiment, of which are 25 males and 30 females. The subjects are the college students or graduates majored in interaction or visual design. The eyesight of all subjects (naked or in glasses) was required to reach 1.0 and above vision.

Method

16 kinds of UI space hierarchy design combining scheme got from orthogonal experiment were made into sample image pictures by Photoshop. Guides for the typical tasks which subjects need to complete in the experiment are as follows: The first step is to observe which area of the picture is most obvious according to the first feeling and observe in turn; The second step is to observe the transition of three positions of shadow; The third step, if the subjects think they can't find fixation point or the fixation point is not obvious in the first two steps, they can press the space key to pass.

Data extraction

On rare cases in the process of the experiment, the related data of eye movement indicators will appear to be lack of records. 50 valid subject samples were obtained after examining the data records of all subjects' eye movement indicators and deleting some invalid samples which have much default value and vision loss.

Experimental data analysis

Eye movement experiment data analysis

The experimental data consists of two parts: fixation duration and fixation count. By classifying and average processing the output of excel report, the total fixation time data of 50 subjects for different hierarchical area of 16 pieces of image pictures was obtained.

Orthogonal experiment data analysis

The average of total fixation duration (K) in the same level was calculated by orthogonal analysis and is shown in table 2.

Table 2 The results of orthogonal experiment data analysis(s)

Factor / Number	1 A	2 B	3 C	4 D	5 E	6 F	7 G	8 H	9 I	Results Total fixation duration
1	1	1	1	1	1	1	1	1	1	42.85
2	1	2	2	1	1	2	2	2	2	63.88
3	1	3	3	2	2	1	1	2	2	65.96
4	1	4	4	2	2	2	2	1	1	72.31
5	2	1	2	2	2	1	2	1	1	56.42
6	2	2	1	2	2	2	1	2	2	50.23
7	2	3	4	1	1	1	2	2	2	66.62
8	2	4	3	1	1	2	1	1	1	60.54
9	3	1	3	1	2	1	2	1	2	59.08
10	3	2	4	1	2	2	1	2	1	52.5
11	3	3	1	2	1	1	2	2	1	43
12	3	4	2	2	1	2	1	1	2	50.58
13	4	1	4	2	1	1	1	1	2	70.46
14	4	2	3	2	1	2	2	2	1	54.15
15	4	3	2	1	2	1	1	2	1	67.46
16	4	4	1	1	2	2	2	1	2	74.58
K1	61.25	57.2	52.67	60.94	56.51	58.98	57.57	60.85	56.15	
K2	58.45	55.19	59.59	57.89	62.32	59.85	61.26	57.98	62.67	
K3	51.29	60.76	59.93							
K4	66.66	64.5	65.47							
Range	15.37	9.31	12.8	3.05	5.81	0.87	3.69	2.87	6.52	
Optimal case	A4	B4	C4	D1	E2	F2	G2	H1	I2	

By calculating the average (K) of total fixation time in the same level, we can get the maximum average of total fixation time of the same level, so this level of factor is the optimal level. For example, the maximum average of total fixation time of the factor A is K4, therefore A4 is the optimal level for the opacity of position 1.

To sum up, the best combination schemes of UI space shadow hierarchy is: Position 1 with the 35% opacity, 10 pixels size and 90°, Position 2 with the 55% opacity, 40 pixels size and -90° and Position 3 with the 75% opacity, 60 pixels size and 90°. The effect of the best combination schemes is shown in Fig. 3.
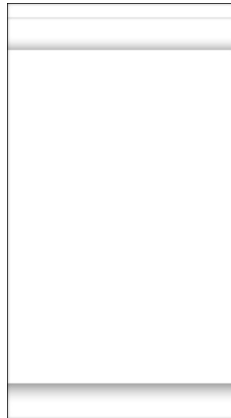
Fig. 3 The best combination scheme for UI space shadow hierarchy

Conclusion

The former interface design usually adjusts parameters only by designer's experience and feeling of which the interaction design can't meet the feeling and experience of the end user. However, The UI of mobile terminal is a direct dialogue between product and user. The design grasping the user will greatly improve the user experience of product. This research is a constant process to design satisfying visual effects for the end user, and produces interaction relationship with interface design by researching user experience.

This study researched the UI space hierarchy of mobile terminal by eye tracking experiment, orthogonal experiment and so on. And this paper got the best scheme for UI space hierarchy and discussed the factors influencing the UI space hierarchy. Several conclusions are presented as follows:

(1) This study proved the idea of UI space hierarchy through the experiment and quantified and implemented the UI space hierarchy.

(2) This study summarized the best combination scheme of UI space shadow hierarchy, and its design parameters are as follows: Position 1 with the 35% opacity, 10 pixels size and 90°, Position 2 with the 55% opacity, 40 pixels size and -90° and Position 3 with the 75% opacity, 60 pixels size and 90°. which has a guideline value for UI design.

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