南京航空航天大学

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机电学院

（第1分册）

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机电学院

051～052系

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1	高光磊 陈炳发	硕士生 教授	051	基于FBO和GPU的动态CEM算法及实现	世界科技研究与发展	2008. 30(4)
2	陈安全 孙菁	讲师 讲师	051	Extension-Evaluation Method Product Form Design Using	2008 Proceedings of the 5th International Conference on Innovation & Management	2008. 12
3	陈安全 孙菁	讲师 讲师	051	Study On Development Tendency of Product Design Representation	2008 IEEE 9th International Conference on Computer-Aided Industrial Design & Conceptual Design	2008. 11
4	李政民卿 朱如鹏	博士生 教 授	051	基于包络法的正交面齿轮齿廓尖化研究	中国机械工程	2008, 19(09)
5	李政民卿 朱 如 鹏	博士生 教 授	051	正交面齿轮齿廓的几何设计和根切研究	华南理工大学学报（自然科学版）	2008, 36(02)
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基于FBO和GPU的动态CEM算法及实现*

高光磊 陈炳发
（南京航空航天大学机电学院，南京 210016）

摘 要：改进了OPENGL中动态立方体环境映射的实现方法，新方法利用FBO使环境图像直接渲染到立方体纹理，利用GPU编程语言GLSL进行逐像素纹理和光照计算，与传统方法相比，该方法提高了帧率和图象质量。最后给出了该方法实现过程。

关键词：OPENGL；FBO；动态；立方体环境映射；CubeMap；GPU

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A Method of Dynamic CEM Based on FBO & GPU*

GAO Guanglei CHEN Bingfa
（Nanjing University of Aeronautics and Astronautics，Nanjing 210016）

Abstract：A new method of OPENGL CEM is introduced，which renders into CubeMap texture directly using FBO，and computer per pixel texture coordinate and lighting using GPU programming language GLSL. Compared with tradition，this method increases display speed and achieves good image quality. The realization of this method is given.

Key words：OPENGL；FBO；dynamic；CEM；CubeMap；GPU

1 引言

当今游戏大量使用动态环境映射技术，以加强真实感显示。通常采用的动态环境映射技术是动态CEM（Cube Environment Mapping，立方体环境映射）技术，可以实时地生成水、金属、玻璃等物体的反射和折射效果。因此，动态CEM技术具有很强的应用和研究价值。

动态CEM包括两个过程：实时生成CubeMap和用CubeMap绘制物体。生成CubeMap需要六次渲染纹理操作。文献[1]中提出OPENGL渲染到纹理的方法是调用glCopyTexImage2D()或glCopyTexSubImage2D()函数。但窗口的大小限制了纹理的使用大小，并且纹理的大小必须是2的幂。为解决这个限制，文献[2]提出PBuffers渲染到纹理的标准方法。Pbuffers允许离屏渲染，并独立于帧缓存。但和前者有个相同的缺陷：需要从Pbuffers到纹理的复制过程，如图1所示。为解决这个问题，文献[3]提出了WGL_ARB_render_texture扩展，它允许PBuffers直接绑定纹理，避免了复制过程。然而该方法并没流行。首先，PBuffers需要独立GL上下文，操作烦琐，上下文切换操作耗费资源；其次，PBuffers拥有独立的颜色缓存、深度缓存、模板缓存，且不能被共享，这就占用了昂贵了存储空间；最后，该扩展是基于Windows系统的。综上因素限制了其使用范围。

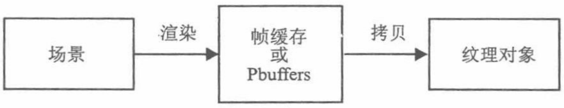

图1 传统的渲染到纹理的方法

Fig.1 Traditional way of rendering to texture

传统使用CubeMap渲染物体的方法是采用固定渲染管道，该方法采用顶点纹理坐标生成和顶点光照计算，并且不能计算折射，所以生成真实感图形的效果有限。

2 动态CEM理论及算法

2.1 使用FBO(framebuffer object)渲染到纹理

FBO[4]是GL_EXT_framebuffer_object扩展多种对象中最主要的对象，它封装了所有的帧缓存相关的状态。每个FBO都被做为逻辑缓存(logical buffers)的标示符。逻辑缓冲可以是颜色缓存、深度缓存或模板缓存。逻辑缓存能够独立创建并绑定到FBOs(framebuffer objects)上。一个FBO可以与一个以上的颜色缓存，一个深度缓存和一个模板缓存绑定。一个逻辑缓存也可以同时与多个FBOS绑定。每个FBO都有一套绑定点用来绑定多个逻辑缓存。当使用FBO时候，就可以使用离屏渲染，并将传统的帧缓冲区自动关闭，将图像直接渲染到逻辑缓存，这样避免了纹理复制过程，降低了计算机开销。如图2所示。

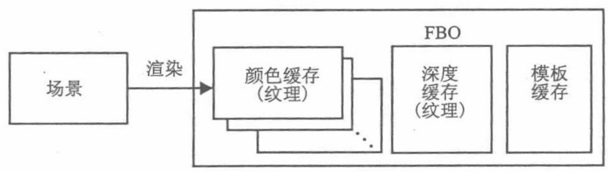

图2 利用FBO直接渲染到纹理

Fig.2 Rendering to texture with FBO

2.2 GPU可编程渲染管道

使用GPU可编程渲染管道大大提高了显卡编程的灵活性，随着显卡性能的逐日提高，可以由显卡绘制出更真实的特效。对于环境贴图来说，如果使用了逐象素(Per-Pixel)计算，将会把效果表现的更加真实。本系统采用GLSL着色语言实现此功能。

2.3 CEM算法

2.3.1 渲染CubeMap

基本原理是用摄象机对周围六个方向按照一定的角度照相，获得六幅图片分别作为CubeMap的六个面如图3示。

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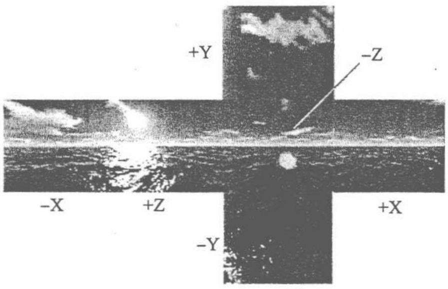
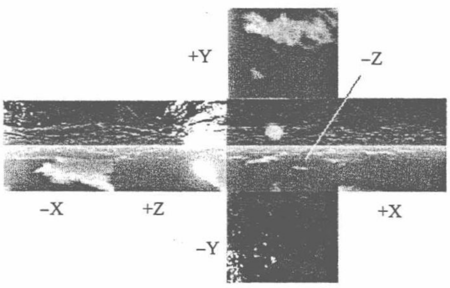
需要进行环境映射的物体可能不断发生位置变化，所以需要首先将场景以及场景中的模型的物体坐标移动到世界坐标的原点，由于六个方向摄象以及 CubeMap 上的二维纹理坐标原点在图片展开之后不全在左下角，所以然后还需要旋转至需要的方向，转换矩阵如下：

$$M_i = R_i \cdot T \tag{1}$$



(a) 周围环境的六幅图片



(b) 最后渲染到CubeMap纹理上的图片

图 3 渲染 CubeMap

Fig. 3 Rendering to CubeMap

2.3.2 计算纹理采样方向

首先求的模型矩阵并将模型的物体顶点坐标和法向坐标转换为世界坐标，然后在世界坐标中计算反射折射向量。摄象机坐标为 e，模型世界转换矩阵为 M_{4x4}，模型法向从物体坐标到世界坐标的变换为 M_{3x3}

$$V_{word} = M_{4x4} V_{obj} \tag{2}$$

$$N_{word} = M_{3x3} N_{obj} \tag{3}$$

摄象机方向单位向量

$$E = normalize(e - N_{obj}) \tag{4}$$

反射单位向量

$$R = 2(N_{word} \cdot E) - E \tag{5}$$

折射单位向量

$$T = [\eta \times N_{word} \cdot E - \sqrt{1 - \eta^2 \times [1 - (N_{word} \cdot E)^2]}] \times N_{word} - \eta \times E \tag{6}$$

2.3.3 计算纹理坐标

立方体纹理图由六个二维分量组成，分别对应立方体的六个面。rx，ry，和 rz 坐标组成了从立方体中心指向待采样纹理像素的方向向量。应该对哪个面采样有绝对值最大的坐标的符号决定的，表 1 中的 sc、tc 和 ma 分别表示对应二维纹理坐标的两个分量和 rx、ry、rz 中的最大值。计算公式(7)、(8)。经计算得到的纹理坐标映射到[0,1]上，以生成坐标(s,t)。然后在立方体纹理图的相应面上，就可以使用相应的纹理坐标实现二维纹理图的采样[1]。

表 1 纹理坐标映射到二维面上

Table 1 Mapping texture coordinates to CubeMap faces

方向	sc	tc	ma
$+rx$	$-rz$	$-ry$	rx
$-rx$	$+rz$	$-ry$	rx
$+ry$	$+rx$	$+rz$	ry
$-ry$	$+rx$	$-rz$	ry
$+rz$	$+rx$	$-ry$	rz
$-rz$	$-rx$	$-ry$	rz

$$s = (\frac{sc}{|ma|} + 1) \times \frac{1}{2} \tag{7}$$

$$t = (\frac{tc}{|ma|} + 1) \times \frac{1}{2} \tag{8}$$

3 实现过程

3.1 预处理

3.1.1 创建 CubeMap 纹理存储空间

步骤 1 生成纹理 CubeMap 对象标识；

步骤 2 绑定当前 CubeMap 纹理；

步骤 3 设置 CubeMap 纹理；

3.1.2 为 FBO 设置标识

```
glGenFramebuffersEXT(1,&fb);
```

3.1.3 创建深度缓存

步骤 1 为渲染缓冲对象指定标识；

步骤 2 绑定当前渲染缓冲；

步骤 3 分配深度缓存空间；

```
glGenRenderbuffersEXT(1,&depth);
glBindRenderbufferEXT(
GL_RENDERBUFFER_EXT,depth);
glRenderbufferStorageEXT(
GL_RENDERBUFFER_EXT,
GL_DEPTH_COMPONENT16,
SIZE,SIZE);
```

3.2 实时渲染 CubeMap

在每帧图象执行前，都需执行以下代码，从而实时更新 CubeMap。

(1)设置视口和投影矩阵

(2)绑定当前 FBO，并连接深度缓存

```
glBindFramebufferEXT(
GL_FRAMEBUFFER_EXT,fb);
glFramebufferRenderbufferEXT(
GL_FRAMEBUFFER_EXT,
GL_DEPTH_ATTACHMENT_EXT,
GL_RENDERBUFFER_EXT,depth);
```

(3)对 CubeMap 的六个面进行渲染

```
FOR(i=0;i<6;i++){
步骤 1 将 FBO 连接点指向 CubeMap 第 i 个面;
glFramebufferTexture2DEXT(
GL_FRAMEBUFFER_EXT,
```

GL_COLOR_ATTACHMENT0_EXT,
GL_TEXTURE_CUBE_MAP_POSITIVE_X + i,
tex,0);

步骤 2 清除 FBO 该连接点对应的帧缓存;

步骤 3 模型视点矩阵转换;

步骤 4 绘制环境场景;}

(4)禁用 FBO,将图象输出到正常缓存

glBindFramebufferEXT(
GL_FRAMEBUFFER_EXT,0);

(5)恢复到正常视口和投影矩阵

3.3 渲染模型

渲染模型采用 GPU 可编程渲染管道,包括两个管道,顶点处理器和片段处理器。顶点处理器在本系统中实现顶点坐标变换,计算摄象机向量和顶点光源向量,以及反射向量和折射向量;片段处理器进行纹理采样和计算光照强度。实现过程如下:

(1)顶点着色

步骤 1 计算模型世界矩阵;

步骤 2 求在视点坐标中顶点的位置,法向方向向量,摄象机方向向量;

步骤 3 计算反射和折射向量;

步骤 4 计算光照参数;

(2)片段着色

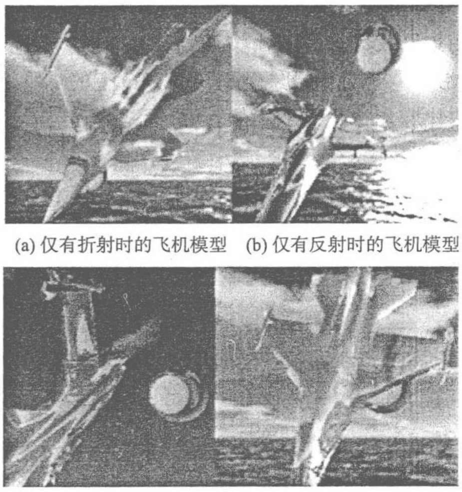
步骤 1 计算求反射和折射方向的采样值;

步骤 2 计算光照;

步骤 3 返回总的颜色值。

3.4 实验结果

本程序运行的平台是操作系统 Windows XP,显卡蓝宝石 X600,显存 128M,CPU INTEL P4 3.0GHZ,内存 512M 编译环境 VC6.0,图形接口 OPENGL 着色语言 GLSL,效果如图 4 所示,周围环境为海面蓝天,绕飞机旋转的是带有纹理的球体。其中(a)是开启折射时的效果,(b)是开启反射时的效果,(c)是开启反射和折射时的效果,(d)是开启反射、折射和光照时的效果。达到如图 4 的图象质量,如采用本文介绍的方法运行,FPS 平均为 310,而采用用 glCopyTexImage2D()和 glCopyTexSubImage2D()函数进行动态 CEM 时 FPS 平均为 210,显然本文介绍的方法比后者绘制速度更快。由于本程序采用了 GLSL 进行逐象素光照和纹理坐标计算,与 OPENGL 固定渲染管道的逐顶点光照和纹理坐标计算相比,大大提高了图象质量。



(a) 仅有折射时的飞机模型 (b) 仅有反射时的飞机模型

(c) 反射和折射共同作用时的飞机模型 (d) 反射、折射和光照共同作用时的飞机模型

图 4 境映射效果

Fig.4 The effect of CEM

4 结论

动态 CEM 技术是真实感图形显示研究的重要的内容,由于立方体环境映射需要多遍渲染,则动态 CEM 的图象更新速率是不得不重视的问题。本文采用 FBO 来加快 CubeMap 的更新速度,以及 GPU 编程语言 GLSL 提高图象质量。实验证明,如果需要环境影射的物体的顶点数量越少,本文介绍的方法优势越明显。由于本系统中的折射仅仅计算模型面向视点的单层面的折射,结果并不完全真实,未来的研究方向应该就模型前后两层面上的折射进行加速显示研究。

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作者简介

高光磊(GAO Guanglei,1983,7-),男,南京航空航天大学机电学院硕士研究生,研究方向计算机图形学;E-mail:37435704. qq. com。

陈炳发(CHEN Bingfa,1963,3-),男,硕士,教授,硕士生导师,研究方向为计算机图形及应用,计算机辅助工业设计,图象处理,计算机视觉,数据库应用等。

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Extension-Evaluation Method Product Form Design Using

Chen Anquan[1] Sun Jing[2]
1 Department of Design Engineering , Nanjing University of Aeronautics and Astronautics, Nanjing, P.R. China, 210016
2 School of Art, Southeast University, Nanjing, P.R. China, 210000
(E-mail: cz-sj@sohu.com, sunjing915@hotmail.com)

Abstract The product development process involves a series of distinct processes, including market research and planning, conceptual design, mechanism design, engineering analysis, prototype assembly and testing, molding, pilot trials. This paper aims to extend the superiority evaluation method to deal with the product form decision process. Based on extension set theory, it will conduct evaluation from the angle of feasibility and optimum by selecting a few solutions obtained by employing matter-element extension methodology. To evaluate in such a quantified way a scheme's superiority or inferiority by using dependent function will be discussed.
Key words Product design, Feature base, Superiority evaluation

1 Introduction

The product development process involves a series of distinct processes, including market research and planning, conceptual design, mechanism design, engineering analysis, prototype assembly and testing, molding, pilot trials, etc. Within today's highly competitive marketplace characterized by short product life cycles, reducing the lead time of each of the product development stages is a key consideration for many enterprises. Now, advances in technology have enabled the use of computers in performing the CAD/CAM/CAE/PLM tasks in the product development process, which not only address the physical aspects of a product's design, but also the psychological aspects of a product, including the emotional response of an individual to the proposed product design.

The Kansei engineering method has been proposed, which brings a consumer's psychological feelings towards a product into the product development process by regarding the consumer-oriented "emotional design" as a specific engineering objective. There are several methods for computer-aided industrial design and image evaluation based upon fuzzy set theory, gray theory, back-propagation neural networks, genetic algorithms, and the analytic hierarchy theory. Although these methods can be used to design a product which will satisfy a given image evaluation, or can predict the evaluation of a constructed shape, they are unable to best match the designer's image requirements. And new mathematical concepts lead to new schemes. Applying the extension engineering method, we can construct the new relationship between the feature parameters and impression words.

At very beginning of the year 1983, a Chinese researcher, Prof. Cai Wen, published his creative paper "The Extension Set and non-compatible Problems" and later a book named 'Analysis of Matter Element', which studies rules and methods of solving contradiction problems by employing formalized tool, i.e. qualitative analysis and quantitative analysis. The theory pillar of extenics is matter-element theory and extension set theory, and its logical cell is matter-element. Applying extension methodology, a problem can be solved by using qualitative means based on the extensibility of matter-element or quantitative means based on extension set theory and dependent function. [1]

In this paper, the superiority evaluation method will be proposed to deal with the product form decision process –evaluating from the angle of feasibility and optimum and selecting a few from among the many solutions obtained by employing matter-element extension methodology, whose basis is the extension set theory .To evaluate in a quantified way a scheme's superiority or inferiority by using dependent function will be discussed.

2 Superiority Evaluation Method

2.1 The concrete steps o f superiority evaluation method

(1) Determine judging conditions

Inferiority and superiority are related with standards; therefore, before an object is evaluated some evaluation criteria must be determined. Some may favor an object; some other criteria may not. So it is necessary to reflect its degree of advantage or disadvantage of a certain criteria and its likely impact when evaluating an object. This requires the formulation of make evaluation standards in accordance with the requirements of technology, economics and society based on needs of practical problems; to define the set of judging conditions M= {M_1, M_2, ..., M_i }, where M_i = (c_i, V_i) is a characteristic-element, and V_i is a quantified measure domain (i = 1, 2, ..., n).

(2) Determine weight coefficient

Every judging condition of M has its weight in evaluating an object N_j (j = 1, 2, ... , m). Weight coefficient is used to express the Λ importance of each judging condition. Index Λ is used to denote a condition that must be satisfied; other conditions are given different weight coefficients, which are real numbers from [0, 1], according to their importance. Weight coefficients are denoted by

$$\alpha = (\alpha_1, \alpha_2, ..., \alpha_n) \qquad \text{Where, if } \alpha_{i0} = \Lambda, \text{ then } \sum_{\substack{k=1 \\ k \neq i_0}}^{n} \alpha_k = 1$$

Weight coefficients play very important roles in superiority evaluation. Different weight coefficients will lead to different results. Usually decide weight coefficients are decided at will, this influences the authenticity and reliability of the evaluation of the solution. In order to make weight coefficients as far reasonable as possible, the analytic hierarchy process may be used to determine. Relative order of importance is among judging conditions.

(3) Initial evaluation

Having decided weight coefficients of evaluation conditions, firstly we eliminate those objects that do not meet the relative conditions. Then, we take following steps for qualifying objects (let N_1, N2, N_m be conditions that must be satisfied).

(4) Construct dependent function arid calculate degrees of qualification

Suppose the set of evaluation conditions is M = { M_1, M_2, M_n }, M_i = (c_i, V_i) (i= 1,2,..., n). and weight coefficients are decided as

$$\alpha = (\alpha_1, \alpha_2, ..., \alpha_n)$$

Construct dependent functions with regard to V_1, V_2,..., Vn:

If V_i is denoted by an interval X_{0i} ,let

$$K_i(x) = \frac{\rho(x, X_{0i})}{|X_{0i}|}, (i = 1,2,...,n)$$

And denote the value of dependent function of N_j about evaluation condition M_i by K_i (N_j). Then, degree of qualification of each N_1, N_2,..., N_m about evaluation condition M_i is

K_i= (K_i,(N_1),K_i,(N_2), ..., K_i,(N_m)) (i -- 1,2, ..., n)

(5) Normalize degree of qualification

$$k_{ij} = \begin{cases} \dfrac{K_i(N_j)}{\max\limits_{x \in X_0} K_i(x)}, K_i(N_j) > 0 (i = 1,2,...n; j = 1,2,...,m) \\ \dfrac{K_i(N_j)}{\max\limits_{x \notin X_0} |K_i(x)|}, K_i(N_j) < 0 \end{cases}$$

Then normalized degree of qualification of each N_1, N_2,..., N_m about judging condition M_i is

$$k_i = (k_{i1}, k_{i2}, ..., k_{im})(i = 1,2,...,n)$$

(6) Calculate degree of superiority

Normalized degree of qualification of N_j about every judging condition M_1, M_2,..., M_n is $K(N_j) = (k_{1j}, k_{2j}, ... k_{nj})^{\Gamma}, (j = 1,2,......m)$,Then, the degree of superiority of object N_j is $C(N_j) = \alpha K(N_j) == \sum_{i=1}^{n} \alpha_i k_{ij} (j = 1,2,...,m)$ .Comparing degrees of superiority of object N_j:

If $C(N_0) = \max\limits_{j \in (1,2,...,m)} |C(N_j)|$,then, N_0 is the best.

2.2 Advantages of superiority evaluation method

In the process of solving problems, certain conditions must be satisfied some conditions; before other conditions are considered. When an object is evaluated, the aspects of advantage and disadvantage aspects must be taken into account simultaneously, then a comprehensive evaluation undertakes to find a suitable screening methods. In addition, dynamic nature, latent advantages and disadvantages are often taken into account.

With above superiority evaluation method is advanced; it has the following three functions:

(1) To describe conditions that must be satisfied by Λ

(2) Since values of dependent function can be positive and negative, degree of superiority can reflect degrees of advantages and disadvantages of an object.

(3) Since extension set can describe changeabi l ity, advantages and disadvantages of an object can be judged from a changing angle after the introduction of parameter t (time parameter).

3 Constructing the Relationship Between the Feature Parameters and Impression Words Based on the Superiority Evaluation Method

In this paper, we select the representative samples of mobile telephone cases in market for experiments and study. A feature-based method [2] is first used to find out the basic feature components of the mobile telephone case and to construct a CAD model. Then, defining the reasonable variation of each feature parameter based on the analyzed principles of shape generation and feature elements from the representative samples, and, furthermore, various new shapes would be generated from the morphological chart, construct image evaluation for ten samples using SD method [3]. Finally, to construct the relationship between the feature parameters and impression words by applying the extension engineering method.

Suppose image linguistic of mobile telephone can be described as Economical—Luxurious, Stream-lined—Straight-lined, Formal —Casual, Modern—Classic, with these characteristic, a product can be defined as R=(N, c, v)=(the optimized product , image words , measure)

Table 1 Experimental Image Values for Ten Basic Samples

	Economical-Luxurious	Stream-lined-Straight-lined	Formal-Casual	Modern-Classic
Sample 1	3.35	2.6	2.33	3.45
Sample 2	4.13	3.45	3.83	3.35
Sample 3	3.5	4.13	4.48	3.68
Sample 4	4.18	3.45	4.6	2.98
Sample 5	3.23	3.25	4.48	3.7
Sample 6	4.58	3.65	4.08	3.38
Sample 7	3.95	3.43	4.43	3.5
Sample 8	4.05	3.85	4.65	3.28
Sample 9	4	4.03	4.38	3.25
Sample 10	2.9	3.6	4	2.63

3.1 Determine judging conditions

Supposing consumer inputs a linguistic measure (c) as that: 3 - 4 - 5 - 3.

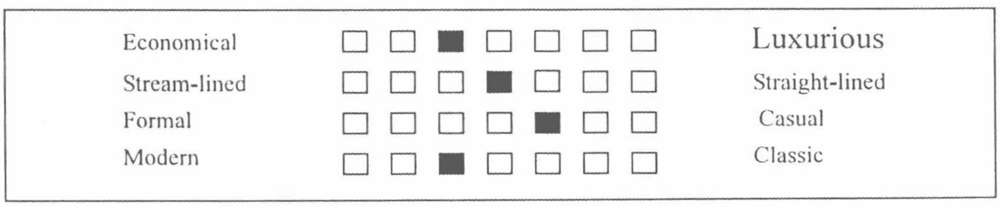

Figure1 Consumer Input Linguistic Measure

3.2 Determine weight coefficient

By using Factor Analysis method, we get a vector of weight coefficients (the contribute degree of image words to a product).

$\alpha = (\alpha_1, \alpha_2, ..., \alpha_n)$=(0.3873,0.3043,0.2211,0.7863)

3.3 Construct dependent function and calculate degrees of qualification, normalize degree of qualification

The value of input linguistic measure is suggested to ± 0.5 front and back, which construct a fuzzy distance to perform optimal searching for possible alternative combinations in the product. But the fuzzy distance must satisfied $M = \frac{a+b}{2}$, b>a, linguistic measure is denoted as M, the value of linguistic measure ± 0.5 is denoted as a, b. Respectively construct the linguistic dependent function $K(x)=\begin{cases}\frac{2(x-a)}{b-a}, x \le \frac{a+b}{2}\\ \frac{2(b-x)}{b-a}, x \ge \frac{a+b}{2}\end{cases}$, (the average linguistic value of a sample is denoted as x), and calculate the normalize degrees of qualification of sample 1 as (0.3, -1.8, -4.34,0.1)

3.4 Calculate degree of superiority

The degree of superiority of sample 1 is $(0.3873, 0.3043, 0.2211, 0.7863)\begin{bmatrix}0.3\\-1.8\\-4.34\\0.1\end{bmatrix} = -1.3126$

The rest may be deduced by analogy, then the degree of superiority of other samples are listed as

Table 2 The Degree of Superiority of Other Samples

Sample (A)	The degree of superiority
1	-1.3126
2	-0.5789
3	-0.0665
4	0.2416
5	-0.2663
6	-0.7423
7	-0.4421
8	0.1992
9	0.2387
10	0.3539

Comparing degree of superiority, we have

$$C(A_{10}) > C(A_4) > C(A_9) > C(A_8) > C(A_3) > C(A_5) > C(A_7) > C(A_2) > C(A_6) > C(A_1)$$

So, A_{10} is the best scheme.

As a result, we construct the relationship between the feature parameters and impression words, then combined with SolidWorks or ProE, we can get form parameters according to consumer linguistic needs.

4 Conclusions

At the conceptual design stage, designers often tend to be restricted by general stereotypes and by their previous design experiences. Therefore, developing a design method which is capable of generating a large number of diverse ideas, and which can then identify the most appropriate design solution, is of crucial importance. Consequently, this study has introduced a method using an extension engineering method to evaluate design candidates automatically. This method provides a PC-based, or even web-based, system for product form design and image evaluation prediction. With the aid of this system, a product form and its image can be designed by inputting a set of form parameter variables, or by inputting a set of target image values. Although this study has taken the form design of a mobile telephone as a case study, it is noted that the proposed method is suitable for the design and development of other products.

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Study on Development Tendency of Product Design Rendering

Chen anquan[1], Sun Jing[2]
[1]*Nanjing University of Aeronautics and Astronautics, Nanjing, P. R. China*
Chen70204264@hotmail.com
[2] *Southeast University, Nanjing, P. R. China*
Sunjing915@hotmail.com

Abstract

The goal of the product design rendering is to express design concepts and creative ideas through the reasonable recurrence of product shape, color and material quality as well as the description of product function, usability and etc. The designs are often represented by the real or hand-pained object, or being aided by computer or the above all. However, with the development of information technology and changing of people's social cognition, traditional design rendering is inevitably undergoing a profound transformation. Although the general tendency is the vision extension in multi-dimensional space, the design rendering has practically evolved into two completely different methods: (1) an independent and complex communication employed by a designer during conceptual development; (2) a mutual communication with multiple perspectives employed during discussion on proposed project. In this article the authors tried to systematically discuss these two methods from both conceptual and technical perspectives, and summarized some experiences obtained during the design practice.

Keywords: product design rendering; independent and complex communication; interactive communication

1. Introduction

Product design needs to draw plenty of graphic plans with the necessary word illustration to convey the design concept no matter it is in the stage of the concept generation or the deepening of the function and structure. This process is called the product design rendering. It is not design any more if without the design rendering. [1]

Designer's performance has two goals: (1) to record design originality, deepen design details, and coordinate structural relation; (2) to demonstrate design and communicate with other people. There are two different representation targets: designer himself and the design related personnel. The different audiences mean the difference not only in the cognition but also for the performance goal. Therefore, the representation ways varied.

2. Cognition behavior of the design performance's chart

The chart and the illustration used in the design performance are made and arranged purposely by the designer, which is to satisfy the audience's cognition. Cognition is the people's explanation (idea or faith) for certain event and the intermediary between emotion and behavior's response. As for the product form design the product cognition is the process for the audience to learn about the product and the many complicated psychological activities such as attention, discernment, understanding and thinking occurring during the process[2] .

For the designer himself his cognition to his own design is a positive and initiative behavior. No matter he is drawing or reviewing after finishing the designer is capable to understand clearly the implied idea and the content which is hard to be expressed in his design such as the motif and the humane emotion. He even understands clearly the insufficiency existed in his design proposal. The purpose of the performance is not for the appreciation and being complacent for the achievement but to provide the ways to think more deeply and improve the design. During the process of the product form design many factors have to be considered. Thus, if the designer paid too much attention to the aesthetic or the understandable ability of other people the designer's own idea and creativity will definitely be limited and stray away from the main requirement of the design.

From the reviewer's perspective his cognition to the design is relatively passive. But it is also mixed with some initiative behaviors, which are related to his personal experience and emotion. First he has to pay attention to the entire design, review the design details and understand clearly the purpose of the design and other kinds of suitability. His expectation to the design is to being complete, clear, beautiful and organized. He gradually understands and learns about the design, but due to the complexity of the actual cognition behavior,

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