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Product form perceptual image and image representation with emotion design

Hui Li[1], Hailong Lan[2]

Abstract. Perceptive image has great influence on vision, in design process of product, it shall be different according to different environment where product is, and to better realize color selection of user, image manifestation of product modeling based on combination mood of perceptive image in convolutional neural network is proposed in this thesis. Firstly, three-dimensional conception is displayed via NUI window, and interface script of user is designed via Python language, and users are allowed to control web camera and 3D wireless to demonstrate software; then, NUI script operated in Blender can be cross-platform open-sourcing 3D animation suite to conduct design of three dimensional production line, and image manifestation of product modeling can be conducted via convolutional neural network; finally, via case study and design of double-interface display platform, effectiveness of proposed scheme is verified through comparison of same designers to use NUI and traditional method.

Key words. Three-dimensional model, Python script, OpenCV, Interface of natural users, Selection of perceptive image, Convolutional neural network.

1. Introduction

Stage[1] of conception definition is emphasized in design process of product at abroad. For example, basic path of solving scheme is obtained combining abstract working principle via recognizing related problem solving scheme to basic function in Literature[2]. Stage of conception is based on decision-making activity[3], vital to final success of product, and effect[4] of reducing research cycle and cost can be achieved, and it is vital[5] to success of the product. So cost and research cycle can be reduced to conduct change of decision-making in initial period of product research. Furthermore, relatively strong style and image perception[6] are required

[1]School of mechanical engineering, Zhengzhou University, Henan, China, 450000, China
[2]College of art and design, Zhengzhou Institute of Aeronautics Industry Management, Henan, China, 450002, China

by competitive market of product enterprises develop. For example, form of product and image or perceptive combination of perceptive image are defined in Literature[7]. what's more, perceptive image can be basic variation for whether users like product can be decided by themselves, and design of perceptive image plays a highly important role[8] in purchasing decision.

Tool and technology are deciding factors, for they directly influence product design itself[9]. Though Grey Theory[10], Harmony Theory[11] and Neural Network[12] are mostly adopted for selection of perceptive image in former supporting system. Relatively small data basis is established based on opinion of use and designer for these systems so that design precision cannot be guaranteed, meanwhile background factors of product are not fully considered. For this, selection scheme of perceptive image on three-dimensional OpenCV natural user interface based on Python script to improve reasonability for selection of perceptive image.

2. Selection scheme of NUI perceptive image

Natural user interface (NUI) is described as a hidden[13] user interface of complex interaction allowing quick learning. Requirements for NUI are[14]: (1) an integrated software is needed for this interface for conceptual visualization, software rendering or three-dimensional modeling. (2) Interactive simulation of visual background needs to be conducted. (3) An integrated interface shall be used for correspondent distribution of perceptive image and conception. (4) Interface shall be based on object interaction in real life. The strategy used is to guide interaction of software and users via argot, aand virtual camera can be located in three-dimensional software of most users for this interface.

2.1. Scheme description

Three-dimensional virtual background conception is displayed for users by NUI via window argot (on computer screen). Besides, according simulation angle of user head, positions of background and conception can be displayed on the screen via camera(position, rotation and zooming) on position of interface. Camera on the screen is to obtain face position of users and Haar feature of cascade classifier. This algorithm can be realized[15] in OpenCV.

The first step is to obtain head position (x, y) of users to realize positioning of virtual camera on three-dimensional software, as is shown in Fig. 1. Distance z between virtual camera and virtual conception is increasing value of distance z_r between virtual camera and screen, and distance z_c between screen and three-dimensional conception is calculated on basis of head diameter, and medium $H = 156.214$mm is set for this.

OpenCV includes trainer and detector, and pre-trained classifier is used and applied in interesting area on software application, and mobile window is used to conduct facial search on input image. When human face is found, algorithm returns to detected facial position, and (x_h, y_h) is rectangular zenith surrounding face, and width and height are (ω, h).

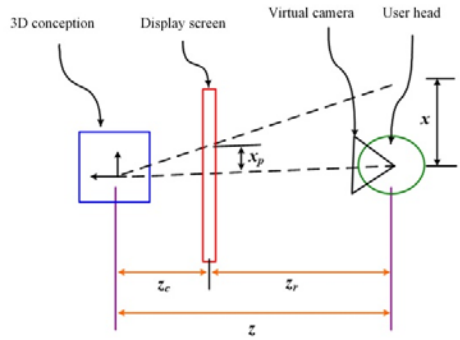

Fig. 1. Conceptual description of the system

Position (x_p, y_p) user head projects on the screen:

$$(x_p, y_p) = \left(\frac{x_h + \omega}{2}, \frac{y_h + h}{2}\right) . \tag{1}$$

Return value of each frame is;

$$P(t) = (x_p, y_p, h) . \tag{2}$$

Position of virtual conception on the screen is via theorem of similar triangles:

$$(x, y) = \left(\frac{x_p (z_c + z_r)}{z_c}, \frac{y_p (z_c + z_r)}{z_c}\right) . \tag{3}$$

Needed variation is position user head to camera based on theorem of similar triangles:

$$z_r = \frac{H \cdot f - h \cdot f}{h} . \tag{4}$$

In the formula, f is focal length of web camera. Vector of virtual camera always points at center of three-dimensional virtual conception. So shooting angle of virtual camera can be calculated via virtual conception and position of virtual camera.

2.2. System overview

Proposed system is shown in Fig. 2, users are allowed to control web camera and 3D wireless to display software script with Python language as user interface if perceptive image is to be changed by 3D virtual conception. OpenCV base is used in this script, and it can be extended with Python script, such as Blender, 3DMAX, Maya, for other 3D software, and image manifestation of product modeling can be conducted via convolutional neural network.

Interface can be extended via Python 3, which can be applied in 3D software. Python is a simple, practical, clear object-oriented programming language. It has many calling interfaces of system and base, so as extension language of application

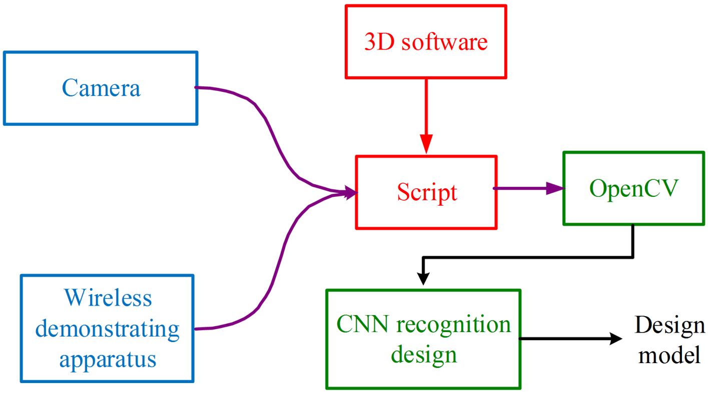

Fig. 2. System overview

program, it has relatively strong universality. Besides, it can operate conveniently in systems such as Unix, Mac and MS-DOS, etc.

NUI script users operates in Blender can be cross-platform open-sourcing 3D animation suite. It totally supports three-dimensional production line design, including modeling, installation, animation and rendering. Besides, individualized API tool of Blender is allowed to use for compiling Python script. It has an embedded Python interpreter to operate script, draw user interface and access function of inner tools. OpenCV used in this script is open-sourcing software base for computer vision and machine learning, offering over 2500 kinds of optimal algorithms to conduct facial detection and cloud recognition of three-dimensional points. Via OpenCV, video streaming of camera is conducted and position coordinate as well as size of head are returned.

3. Convolutional neural network

Convolutional neural network is designed by Specht as a network of probability density estimation. "Winner-take-all Strategy" of multiple probability estimation and learning competition is adopted for core conception of CNN. It is classifier edition that Bayes Strategy combines method of Parzen window, non-parametric estimated probability density function (PDF(s)). Different from traditional radial base function (RBF) network and multi-layer feed-forward network, training process of neural network can be based on statistical principle to handle data. Because CNN is based on PDF estimation rather than iterated function approximation, it has relatively high training speed and good generalization capability.

Classification is conducted according to Bayes Method, and probability category classification of unknown input vector is based on historical data rather than model parameter, such as mean value, standard deviation. Bayes classifier can be prepared as follows:

$$P(C_i|x) = \frac{f(\chi|C_i) * P(C_i)}{f(x)}\,. \tag{5}$$

Where, $P(C_i|x)$ is posterior probability, presenting probability that input x belongs to category i. For any classification problem, posterior probability of category i can be calculated, and input x with maximum $P(C_i|x)$ can be classified into category i. Calculation of $P(C_i|x)$ is based on prior probability $P(C_i)$ obtained from historical data, and class condition probability $f(\chi|C_i)$ can be estimated based on training data of Parzen window. Then non-parametric estimator form based on Gaussian probability-density function is:

$$f(x|C_i) = \frac{1}{(2\pi)^{n/2}} \left[\frac{1}{m} \sum_{j=1}^{m} e^{-\left(\frac{1}{2\sigma^2}\right)\left[\left(x - x_{c_{ij}}\right)^T \left(x - x_{c_{ij}}\right)\right]} \right]. \tag{6}$$

Where, m presents schema number in category C_i, and $x_{c_{ij}}$ is jth schema in category C_i, and σ is smoothness parameter.

CNN is of four-layer structure containing nodes, and it can project input type to scattering category, as is shown in Fig. 3. Structure function description of each layer for CNN is as follows:

Layer 1: input layer and input unit. No calculation process is conducted on input layer, which is to allocate input element to convolutional layer:

Layer 2: Convolutional layer. Node of convolutional layer can be calculated as after receiving training sample from input layer:

$$\exp\left[\frac{(x_T * x) - 1}{\sigma^2}\right]. \tag{7}$$

Where, x_T is training data mode, and x is unknown mode of given category, σ is smoothness factor.

Layer 3: Convergence layer. Convergence value of output value in convolutional layer can be calculated via every node in this layer, and calculation form is:

$$S_L = \sum_{i=1}^{C} exp\left[\frac{(x_T * x) - 1}{\sigma^2}\right]. \tag{8}$$

Where, C is total number of category.

Layer 4: Output layer. Said category of each input mode x can be decided by nodes in output layer based on Bayes Rule, and the form is:

$$\sum_{i=1}^{C} exp\left[\frac{(x_T * x_i) - 1}{\sigma^2}\right] > \sum_{j=1}^{C} exp\left[\frac{(x_T * x_j) - 1}{\sigma^2}\right]. \tag{9}$$

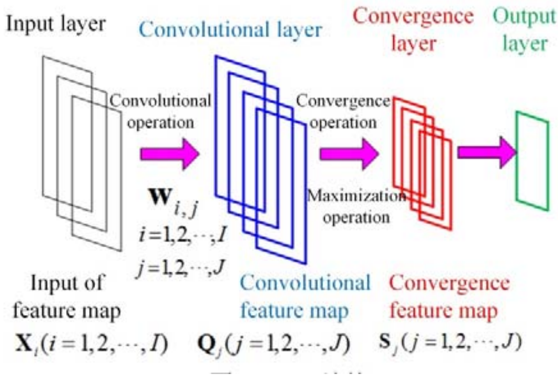

Fig. 3. CNN structure

4. Project design

4.1. Experiment description

In order to verify functions of NUI algorithm mentioned, according to different case studies proposed by two target users and the author's hobby, the author classifies the possible combination of perceptual image for table lamp. Every target used can use NUI and three-dimensional model to preview perceptual image of products. Besides functional verification, the author designs the second target in the process of experiment for conducting correlation identification under the background of perceptual image for related products and perceptual image. The experiment is realized by three different role interfaces for users, but only the "designer" has NUI evaluation function.

Perceptual image selections for conceptual products are made by taking advantages of two different interfaces. "Interface 1" adopts NUI algorithm mentioned, and "interface 2" takes advantages of "traditional tools" to make definitions for three-dimensionally virtual model used by designers and conceptually perceptual image described by users in fuzzy stage, and two interfaces are shown in Table 1. The purpose for identical designer to use NUI and traditional methods to make a comparison is to compare simplicity and interactivity between environment and products. In addiction, use of interface is interpenetrated in the process of test, which is as shown in Fig. 4.

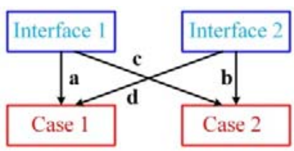

Fig. 4. Test workflow

Table 1. Two Interface NUI Verification instructions

Interface	Description
Interface 1	–Case study -User description -Background of photograph –User interface -Three-dimensional model -Head tracking -Wireless demonstrator
Interface 2	–Case study -User description -Background of photograph –User interface -Three-dimensional model -Pre-selection for perceptual image

Taking advantages of three different role– target user, designer and panel of experts, the author makes a experimental evaluation on the selection process of conceptual image for whether he should use NUI or not.

The experiment conducted by 18 product design engineers (73% of which are professional people and 27% are undergraduates). In addition, the average design experience of the panel is five years (the shortest is two years and the longest is 10 years). The panel of experts is composed of five professors of product design engineering major. The purpose of the experiment is to evaluate user interactive interface in the first example and to make sure influences of perceptual image for conceptual products on perception and background selection. Perceptive objective of perceptual image is stressed in the thesis.

4.2. Natural User Interface

The purpose of this kind of access interface is to realize natural interaction between user and machine and to make relevant optional design scheme for perceptual image. Component software mainly depends on free open source code, which only needs a webcam, a wireless demonstrator and Internet access.

The NUI can conduct metaphorical mapping through windows. The interface allows all elements (environmental and virtual concepts) to be located in relevant face location of users for realizing situation simulation in realistic angles. Usage of the interface can be divided into two stages:

Step 1: (In three-dimension stage) it is conducted according to the following steps:

1-1: Three-dimension conceptual model of products;

1-2: Three-dimension scanning is based on authentic materials and perceptual image and it conducts modeling and rendering under the virtual background.

Step 2: (Conceptual image selection) it makes an evaluation on different three-dimensionally virtual model designs presented by product parts. According to place of user's head, it shows real-time environment and concept. Perceptive image of virtual concept can be changed by using wireless demonstrator. Blender is used for three-dimension modeling of concept, while normal digital camera is used for three-dimension scanning of background.

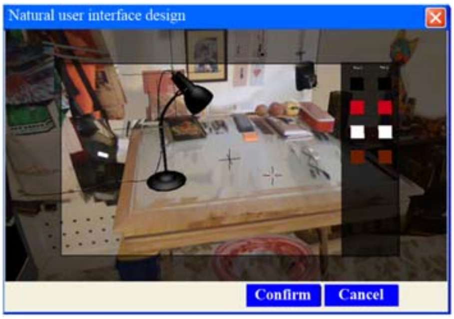

Fig. 5. Screenshot of the application

Evaluations on scanning methods of the following three different backgrounds:

(a) Image projection (reflex mirror ball or box mapping) is easy to be reached and can successfully create a virtual perception to surroundings. Backgrounds of all elements are projected on a basic geometrical shape (sphere or cube), which can be conducted a more sufficiently stable rendering. Therefore, when the user moves, surroundings can indicate a projection.

(b) Photogrammetry allows interaction existence in elements in environment and it correctly shows their geometrical shapes and textures for presenting more depth perception, but calculations of them cost lost of time. There are lots of free online service substitute goods, and permitted uploading photo series return to a three-dimensional model after being processed by server. However, mirror-shaped or lustrous materials can not use the scanning technique. For this reason, it is not suitable for the case proposed.

(c) Mapping camera is allowed to make a better control under the background of three-dimensional model (based on original geometrical shape) with uncomplicated texture, according to practical elements and measure background.

In terms of optional stage for perceptual image, environment and model are displayed in Blender and the following two functions are used in their game modules:

(a) Camera location uses a cascaded Haar and opency target detector to locate the camera, as shown in Section 1.1. If he (she) is behind the screen, movement effect on the user's head is limited. Screen capture of application program can be seen in Fig. 5.

(b) RGB tuple list covers circulatory function of perceptual image and its selected parts of different perceptual images settings. Therefore, when users press the button for next wireless presentation, perceptual image will change to next RGB tuple.

In the experimental equipment shown in Fig. 5, based on user environment having been modeled, table lamp is a conceptual product evaluated by different available perceptual images.

5. Case analysis

5.1. Experiment settings

To evaluate functions of NUI, the author conducts research on two different cases in the process of design. The author sets five perceptual image compositions for table lamp in different conditions and chooses perceptual image conposition which is suitable for specific background defined by users. The table lamp has two sets of different package parts for perceptual image.

In addiction, every case study has different target users with opposite styles: both male target users (situation 1) and female target users (situation 2) are 22-year-old undergraduates. Male target users give priority to cool tone background, and the shape of it usually closes to linear, while female target users use warm perceptual image background, as shown in Fig. 6 in detail.

(a) Cool tone background Warn tone background

Fig. 6. Two different design environments

Every target user participates in making selections on the four perceptual images, as shown in table 2, and they make different compositions and arrange them from other options and select their favorite composition.

Table 2. Experimental color symbols

Situation 1 (male)		Situation 2 (female)	
Code	RGB	Code	RGB
n	0,0,0	n	0,0,0
b	255,255,255	b	255,255,255
a	0,71,255	r	197,0,11
v	92,133,38	c	76,25,0

In addiction, target users submit designs for every case, which covers users' personal data, their favorite perceptual image, films, locations, hobbies, brands and backgrounds of the lamp in photos. Three different kinds of users need to be considered:

(1) Target users are purchasers and users of products and they do not have experience about three-dimensional model. (2) Design team is made up by product design engineers. Every designer is required to determine five compositions of perceptual image in order to make a better description on specific user. (3) Panel of

experts is composed by professors in different fields.

5.2. Results and discussion

In order to analyze interactions between the two interfaces, 18 designers keep records and interact with software. Meanwhile, emotional state or design skill of every designer is uncontrollable without time limit. In terms of interaction with NUI, 100% users are completely able to easily interact with interface; in terms of classic interface interaction, 55% users believe the interface is more decentralized and difficult to operate, as shown in Fig. 7.

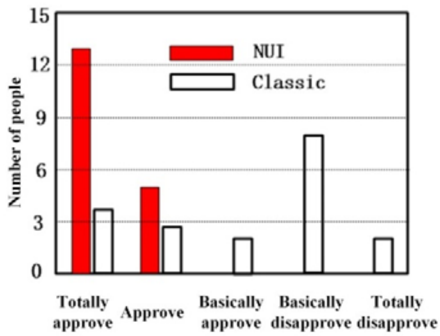

Fig. 7. Comparison of interface interaction

In order to make perceptual image selection easier in decision-making activities, 94% designers believe that NUI is advantaged, but generally speaking, both classic interface and NUI can simplify perceptual image selections, as shown in Fig. 8 in detail.

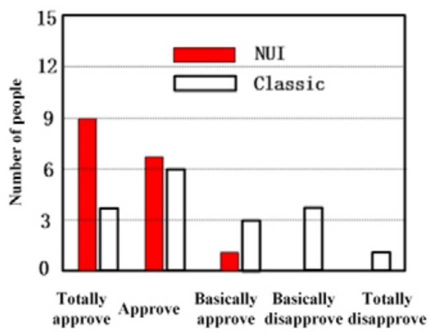

Fig. 8. Color selection is difficult to compare

According to experimental results of Fig. 7 and Fig. 8, compared with perceptual image selection scheme for traditionally classic interface, NUI perceptual image selection scheme adopted in the thesis is approved by evaluation group consisting of three different kinds of users, which reflects the effectiveness of the methods mentioned.

6. Conclusion

The author proposes a kind of three-dimensionally perceptual image selection scheme for OpenCV natural user interface based on Python script and takes advantages of NUI window to display three-dimensionally virtual concept and takes advantages of Python language to make scripts for user interface for allowing users to control webcam and three-dimensional wireless presentation software. The author verifies the effectiveness of scheme proposed.

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