Intelligent Clothing Interaction Design and Evaluation System Based on DCGAN Image Generation Module and Kansei Engineering

Lu Chen¹2, Qi Fang¹2 and Yu Chen¹2*

¹Clothing Institute, Shanghai University of Engineering Science, Shanghai, 201620, China

Abstract. The deep convolutional generative adversarial network (DCGAN) model can be applied to personalized fashion design. Determining the best design from fashion sketches that is of interest to customers is an important research field. In this study, we propose a rapid evaluation method based on Kansei engineering to evaluate personalized fashion images generated by DCGAN. The degree of customer interest in the generated fashion images is determined by tracking the eye movements and facial expressions of customers. Images with a high number of fixations are added to the training data for iterative training; this aims to improving customer satisfaction. The method was verified in an interaction design of personalized black dresses. After several iterations, the customers’ satisfaction rating of the generated images by DCGAN improved. This method can be applied to other styles of fashion design.

1. Introduction

At present, research on the image generation model is closely related to the fashion image generation technology. The image generation technology can be generally divided into two categories: generative parametric approaches and adversarial approaches[1]. Various studies have shown that adversarial approaches have clear advantages in image generation, especially the generative adversarial network (GAN). The generation of deep convolutional GAN (DCGAN) algorithm[2] is a milestone in the development of the GAN model, which determines a stable training structure to facilitate engineering implementation.

In recent years, research on GANs has increased, and related research has made some progress. For example, Phillip et al.[3] used the conditional GAN algorithm as an image conversion solution that effectively implements the conversion of linear drawings to rendered images. Jun-Yan Zhu et al.[4] also carried out a research on image style migration through the CycleGAN algorithm. Yoo D et al.[1] set a converter in the generative model to generate an image of a person wearing clothes. Makkapati V et al.[5] put forward related theories on the symmetry of generated fashion images. Although the aforementioned research has made contributions to the application of deep learning in fashion design, these studies have not considered users’ personalized needs. Therefore, generated fashion images should be evaluated and selected from the perspective of customers, and explorations should be made in terms of improving customer satisfaction.

Currently, in addition to traditional methods, Kansei engineering has also been widely used[6]. For example, eye tracking[7] can reflect customers’ attraction on a certain product. The longer the fixation...
time, the more interested the customer is in the design\cite{8}. In addition, facial expressions are the most important, natural, and direct channels for people to express emotions\cite{9}.

This study creatively applies deep learning algorithms to automatically generate fashion designs and Kansei engineering for the evaluation of customers’ preferences, achieving a fusion of Kansei engineering and fashion design. This paper is organized as follows: In Section 2, the framework of the system proposed in this study is presented. In Section 3, the experimental procedure and results are presented to show the effectiveness of our method. In Sections 4 and 5, a discussion and future outlook are given, respectively.

2. Framework of interactive design system
Figure 1 presents a schematic of the proposed interactive design system.

![Figure 1. Proposed system.](image)

The dashed box represents the DCGAN network that automatically generates design modules. Outside the dashed box, the customer quickly selects the evaluation module. The specific steps are described as follows:

2.1. Initialization training
We selected a certain number of fashion images from the browsing records of customers on shopping websites or related web pages. After the data augmentation, the images were used to train the DCGAN network as real training data.

2.2. Selection
After the training of the DCGAN network was completed, we used the DCGAN module to generate the fashion design images. When the fashion designs were automatically and continuously played in the form of a slideshow, the user showed her response to the related designs and screened out the clothing designs that are positively attracted.

2.3. Replacement
The fashion design images that the customer selected through the interactive evaluation module were used as new training data to replace part of the original training data after passing through the data augmentation module, and the design images not selected were discarded.

2.4. Iterative training
After the training data were updated, DCGAN underwent an iterative training. After the training was completed, a new generation of DCGAN generated new design images again. The customer’s preferred images were selected by the interactive evaluation module while viewing slides. Then, the selected images replaced some of the training date again for iterative training.

3. Experiment
This study used little black dress images as a training data set. The specific processes of the experiment are presented as follows:

3.1. Procedure

3.1.1. Construction of the DCGAN model to generate little black dresses
DCGAN already has a ready-made code in Tensorflow:carpedm20/DCGAN-tensorflow; we used this code directly. We found a few lines of code to read data, as shown in Figure 2. Then, we created a new anime folder in the data folder, placed little black dress images into this folder, and specified the dataset anime at runtime. The training environment is win10+cuda9.2+Tensorflow.

![Figure 2. Data-read code.](image)

3.1.2. Generate personalized little black dress designs
We selected two female college students, aged 23 and 25 years old, as the experimental subjects, and named them S1 and S2 hereinafter, respectively. For each customer, we obtained 20 little black dress images from their recent online browsing records and added the images to the training data. Then, we let them choose their top 20 favorite little black dresses to be added into the training data. The last 60 little black dress images, which were randomly selected from the database, were added to the training data. The 100 little black dresses were augmented to 1,000 images and normalized to a $28 \times 28 \times 1$ size. Figure 3 presents the selection of the initialization training data set.

![Figure 3. Initialized training data source distribution.](image)

In this manner, each of the two customer has their own training data set. Accordingly, we named two groups of modules, i.e., DCGAN-S1 and DCGAN-S2, as shown in Figure 4. The training environment is win10 + cuda9.2 + Tensorflow.

![Figure 4. Modules of each customer.](image)
After the training, we randomly selected 25 images through the DCGAN network, removed five pictures with inferior pictures, and made the remaining 20 pictures into continuous slides. The Tobii eye tracker was used to collect the eye tracking data of customer S1, whereas the FaceReader software (launched by VicarVision and Noldus Information Technology) was used to measure and analyze the facial expressions of customer S2. Before the experiment, the customers were informed that for the research study, expression video materials need to be collected; they were ensured of data confidentiality. We recorded the number of designs that the customers tended to positively select (i.e., customers’ favorite designs) in each round, as shown in Figures 5 and 6. The selected design images replaced some of the training images.

3.2. Results
Table 1 presents the number of images selected by each experimental subject through the interactive evaluation module in the first four rounds. The table shows that after three rounds of iterative training of the DCGAN, the proportion of selected generated images increased.

|       | S1     | Pos | S2     | Pos |
|-------|--------|-----|--------|-----|
| Round 0 | 3/20   | 15% | 2/20   | 10% |
| Round 1 | 5/20   | 25% | 3/20   | 15% |
| Round 2 | 6/20   | 30% | 3/20   | 15% |
| Round 3 | 4/20   | 20% | 5/20   | 25% |

4. Discussion and summary
This study proposes an intelligent clothing interaction design and evaluation system based on the DCGAN image generation module and Kansei engineering, which creatively allows customers to participate in the design process. We performed experiments to verify the effectiveness of the method. From the results shown in Table 1, after three rounds of iterative training, the number of small black dress designs selected by customer S1 increased from 15% to 20%, whereas that selected by customer S2 increased from 10% to 25%. However, due to the limitation of equipment and technology, only four rounds of experiments were performed in the present study; only two customers participated; and no large-scale experiments were implemented. It is expected that with multiple rounds of experiments and higher number of participants, the customers’ satisfaction ratio will increase, and the performance of the entire system will greatly improve.

5. Future outlook
This research creatively applies deep learning algorithms to automatically generate clothing designs, achieving a fusion between Kansei engineering and fashion design. In the future, more experiments should be performed to verify the effectiveness of this system. In addition, the following improvements will be made: the specific effects of eye tracking and facial expression analysis on
customers’ fashion design preferences should further examined; training data should be updated in a timely manner; customers’ selected design images should be used to make real clothing; fashion designers will benefit from this type of system.

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Two students joined in the experiment, S1 Qi FANG, S2 Chongchong LEI

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