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Clothing Style Recognition and Design by Using Feature Representation and Collaboration Learning

Yinghui Fan, Guangdong Baiyun University, China*

ABSTRACT

In order to recognize the clothing style, this paper establishes a standard clothing style library. The images of clothing style are provided and annotated by fashion design experts. The clothing style image is represented as a set of line segments that is obtained by detecting the lines and corners consisting of the edge feature points in the image. Then, the authors extract the features of the line segment set and use the extracted features to establish clothing style matching rules to make the system automatically produce the matching and recognizing criteria for the clothing style images. When inputting an image of a person wearing clothes, they first find the position of the person through skin color detection and then locate the clothing. The clothing region is segmented by seed growth algorithm. The features of the segmentation are compared with clothing style matching rules to determine the style. The experimental results show that the recognition rate of clothing style can reach more than 92% for the standard clothing images and more than 91% for real clothing images.

KEYWORDS

Clothing Style Recognition, Collaboration Learning, Feature Representation, Image Segmentation

1. INTRODUCTION

With the rapid development of computer technology, the combination of computer-aided design technology (Barenghi 2019) and computer-aided production technology have been widely used in the clothing industry and greatly improved the efficiency of clothing design and production (Maldini 2019). However, the computer-aided clothing design and production mainly focus on the provision of a design platform and the storage of design result or the control of a production process (Jhanji 2018). It cannot make a more intuitive definition and evaluation of the clothing design scheme. As a platform for information transmission, it is not enough for the clothing industry which emphasizes the combination of production and marketing.

The design and production of clothing is a lasting and eternal industry (Tangchaiburana 2017). With the increasing of economic and consumption requirements, the clothing industry has rapidly developed. Consumers pay more attention to their personal preferences and the diversity of style matching when they choose clothes. In order to cater to the interests of consumers, a large number of unique and novel clothes are introduced into the market by relevant enterprises or designers. The style of clothing is developing towards diversity and personalization, and will undoubtedly become the main trend of the future development of the clothing industry. However, the complicated clothing styles and the rapid update speed make the clothing style judgment be a great burden for consumers,

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*Corresponding Author

designers and related enterprises. Clothing industry is a special, popular, and highly professional industry. There is a common understanding in the style and various details of clothing, but it also has a strict evaluation standard. From the perspective of both designer and consumer, the interaction between the general understanding and professional standard is very important. Designers need to get the general knowledge of users in order to launch products and cater to the public. For consumers, designer's understanding of professional standards will help them to choose more fashionable clothes. Nowadays, non-professional consumers' understanding of clothing style is mainly through the experience from their partners or themselves. They have few opportunities to contact and understand professional standards. It has become an emerging issue to provide a platform for mutual transformation of professional standards and public cognition (Wang 2019).

Image is the main form of clothing information. For either design drawings or photos, the clothing information is transmitted through images, and various styles of clothing are intuitively reflected. From the perspective of computer, images are easy to collect, store, and transmit. Thus, image becomes the best object for clothing style research. From the professional view, all kinds of clothing styles have their relatively steady shape (Zhong 2017). If we can collect a certain number of professional and representative information of clothing styles, we can get the standards to identify different clothing styles through image feature extraction technology. The ordinary clothing image is analyzed by using image feature extraction technology (Wei 2020) to determine whether the clothing matches one of the standard styles. Then, the computer can automatically determine the clothing style to implement the conversion between intuitive cognition and professional standards. This paper first extracts the features of sample clothing images which are provided by experts. Then, the extracted features of clothing images are used to construct training set which is used to learn a classifier which can predict the style of future clothing. The main contributions are summarized as follows:

Ø A personalized clothing style recommendation system is proposed.
Ø A feature extraction framework is proposed for clothing image.
Ø The proposed personalized clothing style recommendation system is evaluated on real clothing images.

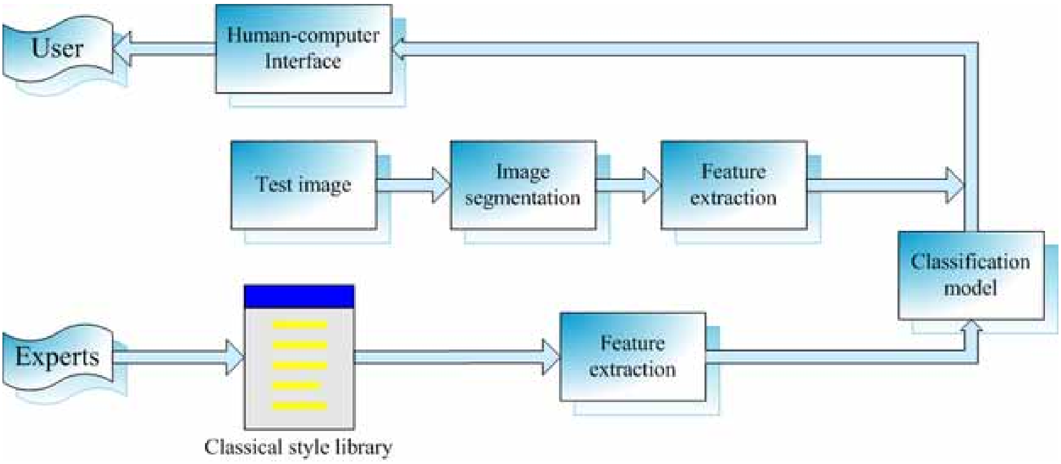
The rest part of this paper is organized as follows: the structure of personalized clothing style recommendation system is summarized in Section 2; the feature extraction for clothing image is provided in Section 3; the experiments and simulations are reported in Section 4; and the last section is the Conclusions.

2. PERSONALIZED CLOTHING STYLE RECOMMENDATION SYSTEM

The personalized clothing style system (Zhu 2018; Yu 2019) is a personalized clothing style recommendation and interaction system, which provides recommendation of the clothing styles to the ordinary customers and helps them to make decisions. It will accept the user's evaluation of the recommendation results and interact with the user. Thus, the system can obtain different users' personalized cognition or aesthetics to different styles of clothing, and make more reasonable and personalized decisions of clothing styles. The recommendation can be close to user's individual needs.

In the personalized clothing style recommendation system, first the experts in the field of clothing provide some typical clothing style samples. The samples include the typical sample image, various details of the style information and the style intensity. Through the feature extraction, the system can obtain the details of criterion for each clothing style and establish a classical rule library of the clothing styles (Karademir 2017). In the process of interaction between the system and users, the system will generate preference model for each user by combining the rule library and user's feedback information. The system will gradually learn the user's personalized cognition and aesthetic of clothing style. An illustration of the architecture of the personalized clothing style system is shown in Figure 1.

Figure 1. The architecture of automatic clothing style recognition



In Figure 1, the experts generate a classical style library according their professional knowledge and experience and a classification model is learnt by using the features of classical style library; for a test image, it is processed through image segmentation and feature extraction and the associated features are input into classification model to determine its style; the user obtains the style through a human-computer interface.

The functions of the modules in the personalized clothing system are summarized as follows:

- Ø The style samples cover most of the typical style sample images, various details of style information, and the style intensity.
- Ø The classical rule library is obtained by mining the details of the clothing style, which is used as the basic standard to make decision.
- Ø The preference model library retains all user's preference models for clothing styles, which is initialized by classical rule library and gradually approaches the personalized preference.
- Ø The style library retains all the fashion data in the system.
- Ø The interactive interface provides human-computer interaction to recommend fashion style to users and receive the feedback from users.
- Ø The rule mining module analyzes the style samples to mine the typical style rules from them.
- Ø The feature extraction module analyzes the input image to obtain the relevant style features for the typical rule library construction.
- Ø The decision-making module utilizes the preference style library to find the suitable clothing styles and give the users recommended advices.

Although the basic purpose of the personalized clothing style system is to make the auxiliary decision-making be close to individual style aesthetic through interaction, the computer itself does not have any relevant prior knowledge. It requires a widely accepted fashion appearance, style definition, performance style, and style intensity standard to ensure the authority of the decision from the system.

The experts in the field of clothing design provide the representative table of clothing style shape, style definition, style expression, style intensity as the clothing style samples for the personalized clothing style system. By using the clothing styles and definitions in the images from these style examples, the computer can obtain some standards for judging style information. The standards can also be used as the basis for the details of the clothing.

3. FEATURE EXTRACTION FOR THE CLOTHING STYLE IMAGE

The conventional method to store the clothing style is to manually input clothing style information of the image into the database. In order to ensure the professionalism and rationality of the clothing style library, it is necessary to define each type of clothing by professional standards, which is a time-consumed process. One way to solve this issue is to resort to the automatically extracting clothing features by using computer vision technology (Cheng 2020; Liu 2019; Zhang 2021), which requires a typical and professional standard as the basis for computer. As the main foundation and basis of personalized clothing style system, it is necessary to summarize the matching standard for computer to recognize the details of clothing through extracting useful features form the clothing style sample images.

On the other hand, the personalized clothing style system is a decision-making recommendation system (Liu 2017; Sun 2018). It should collect enough clothing styles, so that the users can obtain comprehensive style recommendation information. Moreover, the core function of the system is to obtain users' feedback information through interaction between the system and users, thus, it can update the clothing style library in time. In order to ensure the timeliness of the decision-making recommendation, new clothing styles are continuously input into the system to supplement the clothing styles in the library. Thus, the system can retain the state-of-the-art clothing styles in the library which is close to the popular trend. In the real applications, it is impossible for the relevant experts to give a professional definition of each clothing style due to massive data. The system must automatically obtain the relevant details of the clothing in the example image through the analysis of the example image.

The personalized clothing style system adopts the images of people wearing clothing as the system input. According to the typical rule library, the collar depth, collar height, collar type, waistline, start stop line, symmetry, length, decoration, sleeve length, and sleeve type are used as the features to depict the clothing style. The feature extraction module in the system is to utilize computer image processing technology to extract the relevant features for the further decision-making. An illustration of the feature extraction module is shown in Figure 2.

Figure 2. The flowchart of feature extraction for clothing image

In Figure 2, the feature extraction for clothing image contains four steps, including preprocessing, edge detection, line and corner detection and feature element extraction. The feature extraction module mainly processes the clothing images which contains the people wearing clothes. The image is termed as instance image. The instance image contains only one person wearing clothes, which can be extracted features directly. However, the image in real application maybe contains more than one person wearing clothes, background, and other complex components. If we extract features from these images directly, the extracted features may contain massive background information which may induce that the system cannot provide accurate recommendation. Therefore, we must locate the clothing area in the image before feature extraction. This process is termed as image segmentation.

The essence of image segmentation is to connect some similar pixels to form the final segmentation region. The image segmentation (Zhang 2020; Luo 2018; Ji 2018; Xi 2020) must consider both the similarity of pixels and the spatial adjacency. The segmentation region must satisfy the following requirements.

Ø For a certain feature, the pixels in the same segmentation region must has similarity, while the pixels in different segmentation regions behaves obviously dissimilarity.
Ø The segmentation region is connectivity and there exist paths to connect any pair of points in the segmentation region.
Ø The edge of segmentation region must be clear and easy to be located.

The seed region growing (SRG) (Huang 2018; Feng 2018) is an image segmentation algorithm whose aim is to merge pixels of small regions with similar characteristics to form a large region. First, we find a growth seed as the starting point of the segmentation region in the image. The growth seed is a small region in the image. Then, the surrounding regions with the same or similar characteristics are merged into the region, which contains growth seed according to growth and similarity rules. The seed region growing repeats the above two steps until it reaches growth termination condition or no more pixels can be merged.

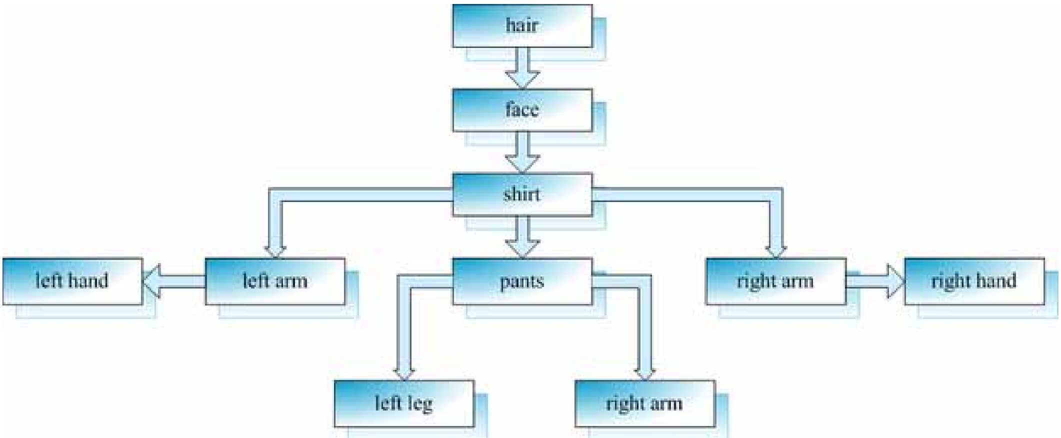
The seed region growth is more expensive than some naïve methods, but it can directly and simultaneously utilize several characteristic of the image to determine the final edge of the segment. Compared with previous naïve method, it has shown superior performance in real scene segmentation which cannot get enough prior knowledge.

In the image segmentation of the people wearing clothes, the color, shape, texture of the clothes is uncertainty, the background is difference, and the contrast between clothing and background is obvious. Thus, the seed region growing is suitable for clothing image segmentation. In order to ensure the clothing segmentation can accurately obtain the region of the clothes in the image, the seed region growing needs to solve the seed pixels selection and similarity criterion.

The purpose of seed pixels selection is to select the appropriate growth starting point which is represented as the location of seed pixels and the gray value of initial point. The selection of seed pixels often depends on the characteristics of specific problems. If there is no prior knowledge of a specific problem, each pixel can be calculated with the help of the growth criteria. If pixels can be clustered, the pixels close to the clustering center can be regarded as seed pixels.

Due to the complex background and the different characteristics of clothing, such as color, style and material, the method of calculating cluster center of gravity obviously cannot guarantee the accuracy of segmentation. In order to pursue the accuracy, the commonly used method selects seeds manually. However, the manual selection will increase the workload. In some images, adopting a single rectangular region below the face as seed region cannot satisfy the requirement of accuracy. Another way to locate the seed region is to adopt a tree to depict the relation between the parts of human and clothes, which is shown in Figure 3.

Figure 3. The tree structure of components of clothes



In Figure 3, the position of shirt can be determined by finding the adjacent node, such as face, left arm, right arm, and pants. The face, left arm, and right arm have obvious characteristic of the skin color. With the help of the spatial relationship between skin color and clothing region, it can help us to locate clothing region and determine the seed pixels.

Another key point in seed region growing is the choice of the similarity criterion. In general, a value representing the range of similar gray levels is used as a criterion to determine whether the pixels are similar or not. Most of the region similarity criterions use the local properties of the image, such as material and texture. The similarity criterion can be formulated according to different principles. Different growth threshold will affect the process of region growth and the final segmentation result. If the gray range is too large, the image may be misclassified earlier. Otherwise, the phenomenon of under segmentation will appear.

The maximum inter class variance method is a classical non parametric and unsupervised adaptive threshold method, which uses histogram. Ideally, there is an obvious valley between the two peaks representing the object and background on the histogram, which may be the optimal threshold. However, in some real images, the valley is very flat and wide, and is seriously disturbed by noise, or the height difference between two peaks is large. In order to solve this issue, the maximum inter class variance is proposed to automatically select the threshold. It has thoroughly considered the information of the pixels in the neighborhood and can better determine the optimal segmentation.

Let the gray value range from 1 to l , $G = \{1,\ldots,l\}$. The n_i represents the number of pixels with gray value i and n represents the total of the pixels. Then, the following equation holds.

$$n = \sum_{i \in G} n_i \tag{1}$$

The probability of the pixel with gray value i is represented as follows:

$$p_i = \frac{n_i}{n} \tag{2}$$

By choosing a gray value t in G ($t \le l$) as the threshold, it splits the images as two gray level sets, $G_1 = \{1, \ldots, t\}$ and $G_2 = \{t+1, \ldots, l\}$ which are denoted as R_1 and R_2, respectively. The probability of pixel is from R_1 or R_2 is represented as follows:

$$\omega_i = p_i\left(R_i\right) = \sum_{j \in R_i} p_j \quad \left(i = 1, 2\right) \tag{3}$$

The mean and variance of the gray values in R_i is represented as follows:

$$\mu_i = \sum_{j \in R_i} j p_j = \frac{\sum_{j \in R_i} j n_j}{\sum_{j \in R_i} n_j} \quad \left(i = 1, 2\right) \tag{4}$$

$$\sigma_i^2 = \sum_{j \in R_i} \left(j - \mu_i\right)^2 p_j = \frac{\sum_{j \in R_i} \left(j - \mu_i\right)^2 n_j}{\sum_{j \in R_i} n_j} \quad \left(i = 1, 2\right) \tag{5}$$

The overall mean and variance of the gray values μ_t and σ_t^2 are represented as follows:

$$\mu_t = \sum_{j \in G} j p_j \tag{6}$$

$$\sigma_i^2 = \sum_{j \in G} \left(j - \mu_t\right)^2 p_j \tag{7}$$

The within-class variance and between-class variance σ_w^2 and σ_b^2 are represented as follows:

$$\sigma_w^2 = \omega_1 \sigma_1^2 + \omega_2 \sigma_2^2 \tag{8}$$

$$\sigma_b^2 = \sigma_t^2 - \sigma_w^2 \tag{9}$$

The threshold T traverse the all gray values until $\frac{\sigma_b^2}{\sigma_w^2}$ reaches the maximum, which is rewritten as follows:

$$T = \max \frac{\sigma_b^2\left(T\right)}{\sigma_w^2\left(T\right)} \tag{10}$$

When treating the daily photos that contain clothes, people, objects, landscapes, the brightness of different areas may vary greatly. The similarity criterion cannot satisfy the requirements of all parts in the image. When the clothes areas only occupy a small proportion in the image, it is more appropriate to take the similarity criterion as a function value that changes slowly with the position in the image. The mean value and standard deviation of several areas around the seed point represented as follows:

$$\mu = \frac{1}{n}\sum_{(k,l)\in R} f\left(k,l\right) \tag{11}$$

$$\sigma^2 = \frac{1}{n}\sum_{k,l\in R}\left|f\left(k,l\right) - \mu\right|^2 \tag{12}$$

Then, the threshold of seed growing is updates as follows:

$$T_u = \left(1 - \frac{\sigma}{\mu}\right)T \tag{13}$$

When the image contains high quality of colors, the variance is high and the threshold of seed growing should be shrunk to avoid mistakenly growing. On the contrary, the threshold should be enlarged. However, it must calculate the threshold of the neighborhood for each seed pixel, which will cost too much time and cannot meet the requirements of the real application. In order to improve the efficiency of the algorithm, the image is divided into several small regions. Then, the threshold of seed growing is calculated on each sub region. When the seed enters into a sub region, it use the threshold of this region. Thus, the threshold can be controlled in a certain range to reduce the consumption.

By using seed growing algorithm, we can obtain the segmentation regions which are associated with the number of candidate seeds. The segmentation regions are independent each other and have similar colors. The candidate regions with similar colors are merged together to determine the location of the clothes.

The system can obtain the candidate clothes objects by using image segmentation for the images which contain people wearing clothes regions. However, the system still needs style samples to determine the clothing style of the candidate objects.

The style samples provided by experts in the field of clothing are used to construct a classical clothing style library which is an oracle for clothing style recognition. In order to make the sample images and example images are comparable, the system adopts the feature extraction to obtain the useful information. The images are quantified as vector data which is convenient for further analysis. Image quantization (Pérez-Delgado 2019) is an interdisciplinary subject that integrates computer vision, computer graphics, computer image processing and artificial intelligence. The core is to convert the edges between the nodes in the skeleton graph as short vectors. The short vectors are merged as long vector. The image quantification includes edge detection, contour tracing, edge feature point determination and feature point quantization.

The sample images are mainly described as shape feature and the spatial relationship feature. This paper adopts edge detection to analyze the edge of the clothes. The process of image quantization is converted as edge detection.

The edge refers to the areas whose brightness changes significantly. The gray profile of edge can be regarded as a step which is from a small gray value in the buffer area to another gray value with large gray difference. As the boundary between the object and the background, the edge can greatly reduce the information to be processed while retain the shape information of the image object. The edge concentrates most of the information of the image. The determination and extraction of the image edge is very important for the recognition and understanding of the whole image scene, and it is also an important feature of image segmentation. The edge detection mainly refers to the measurement, detection, location of the gray changes in the image. The gray changes can be reflected by the distribution of associated gradient. The distribution of gradient is used to construct edge detection operator. This paper adopts Canny operator to detect edge of the clothes in the image.

The Canny operator (Tong 2018) is a multi-stage optimal operator with filtering, enhancement and detection. First, the Canny operator convolutes the image with Gaussian smoothing filter to make the image be differentiable at the edge. Then, the Canny operator extracts the points with significant changes by computing the gradient amplitude of the image. The amplitude and direction of the gradient is computed by using first-order partial derivative. For the edge, the first derivative has an upward step or the second derivative has zero crossing at the boundary. Compared with other edge detection operators, the most important feature of the Canny operator is that it will go through a non maximum suppression process. Finally, Canny operator adopts two closed values to complete the edge connection. The Canny operator finds the local maximum of image gradient by non maximum suppression, and detects strong edge and weak edge by double closed value method in the algorithm. The detection results of the two closed values are connected into contour edge as the result of edge detection. Therefore, it is not susceptible to noises and achieves a good balance between the sensitivity to noise and excellent edge detection effect.

The procedure to detect edge feature points by Canny operator is summarized as follows:
the image is smoothed by convolution of Gaussian filter to make the image be differentiable in the edge region. The Gaussian smoothing function is written as follows:

$$H\left(x,y\right)=e^{-\frac{a^2+b^2}{2\sigma^2}} \tag{14}$$

The image convolution is rewritten as follows:

$$G\left(x,y\right)=f\left(x,y\right)\times H\left(x,y\right) \tag{15}$$

computing the amplitude and direction of the gradient by using first-order partial derivative. The first-order differential convolution template is rewritten as follows:

$$\begin{gathered} H_1=\begin{pmatrix} -1 & -1 \\ 1 & 1 \end{pmatrix} \\ H_2=\begin{pmatrix} 1 & -1 \\ 1 & -1 \end{pmatrix} \end{gathered} \tag{16}$$

The first-order difference is written as follows:

$$\begin{aligned} \Psi_1\left(m,n\right)=f\left(m,n\right)\times H_1\left(m,n\right) \\ \Psi_2\left(m,n\right)=f\left(m,n\right)\times H_2\left(m,n\right) \end{aligned} \tag{17}$$

The amplitude of the gradient is written as follows:

$$\left|\Psi\left(m,n\right)\right| = \sqrt{\Psi_1^2\left(m,n\right) + \Psi_2^2\left(m,n\right)} \tag{18}$$

The direction of the gradient is written as follows:

$$\theta = \arctan\frac{\Psi_2\left(m,n\right)}{\Psi_1\left(m,n\right)} \tag{19}$$

Step 3: non maximum suppression for the amplitude of the gradient.
Step 4: using double thresholds to detect the edges and connect edges together.
Step 5: tracking the contour and extracting feature points.

The aim of clothing image quantization is to extract the size and shape of the clothes. The lines of clothing itself are composed of straight-line segments or approximate straight-line segments. Even, a small number of curve parts can be divided into several continuous straight-line segments. Therefore, this paper first detects the line segments of the set of image feature points, and uses the set of line segments to complete the subsequent sample image standard extraction and the extraction of style details in the example image. The Hough transform is adopted to detect line segments in this paper.

After obtaining the collection of line segments which represents the details of clothing, we need to convert the information of the collection of line segments as the details of clothing by using professional clothing style criterion. The personalized clothing style system provides a large number of style samples by experts in the field of clothing which are used to accurately determine the style characteristics of each part of the clothing for the example image. The system analyzes the sample image and the corresponding data in the style sample to define the matching rules. The matching rules are used to determine the attribute of the clothing in the example image.

The sample clothing mainly contains the collar depth, collar height, collar type, waistline, start stop line, symmetry, length, decoration, sleeve length and sleeve type. The sample image is matched with sample clothing images in the classical style library by using the above features.

4. EXPERIMENTS AND SIMULATIONS

In this section, we will verify the performance of proposed clothing style recognition method. We collect 3,387 clothing images, include short sleeve T-shirt, long sleeve T-shirt, jacket, blouse, breeches, short sleeve dress, and trousers. The details are reported in Table 1.

Table 1. The information of the clothing style images

Style	Total number	Training samples	Test samples
Short sleeve T-shirt	426	340	86
Long sleeve T-shirt	418	334	84
Jacket	512	409	103
Blouse	578	462	116
Breeches	613	490	123
Short sleeve dress	398	318	80
Trousers	442	353	89
Total	3,387	2,706	681

In Table 1, the first column in the total number of images from a clothing style, the second column and third column represent the number of training samples and test samples, respectively. In each clothing style, 80% samples are randomly selected as training set while 20% samples are randomly selected as test set.

The extracted features of the training samples are used as the input to train a classifier, such as support vector machine (SVM) (Zhu 2016; Zhu 2017a; Zhu 2017b), k nearest neighbors (kNN) (Kramer 2013), Gaussian processing (GP) (Belda 2018) or decision tree (Ke 2017). Then, the extracted features of test sample are input into trained classification model and the classification model returns the clothing style of the test sample. The experimental results are reported in terms of the recognition rate of clothing style in Table 2.

Table 2. The recognition rate of clothing style

Style	SVM (%)	kNN (%)	GP (%)	Decision tree (%)
Short sleeve T-shirt	96.7±1.8	93.5±1.5	95.8±1.6	94.6±1.7
Long sleeve T-shirt	97.2±2.7	93.8±2.6	96.3±2.2	95.1±2.4
Jacket	90.3±1.9	88.7±2.0	89.1±1.8	89.3±2.1
Blouse	92.4±2.2	90.5±2.4	91.7±2.1	90.9±2.3
Breeches	94.3±3.2	91.8±3.4	92.4±2.8	93.2±2.9
Short sleeve dress	95.6±2.1	93.7±2.3	94.3±2.0	94.5±1.9
Trousers	100±0	97.8±0.7	98.2±0.6	97.6±0.8
Overall accuracy	94.9±2.1	92.6±2.7	93.7±2.3	93.3±2.2

In order to reduce the randomness in the process of splitting the training set and test set, the experiment is repeated 20 trails. In Table 2, the recognition rate is reported in the form of mean±std. From the result in Table 2, it can be found that the overall recognition accuracy reaches 94.9%, 92.6%, 93.7%, and 93.3% by using SVM, kNN, GP, and decision tree, respectively. The recognition accuracy of trousers is higher than other style and reaches 100%, 97.8%, 98.2%, and 97.6% for SVM, kNN, GP and decision tree, respectively. The reason is that difference between trousers and other styles is obvious. For instance, the shape and length of trousers have obvious difference from others.

Furthermore, we verify the trained classification model on real clothing images which are first extract the region containing clothes by using image segmentation method. The extracted regions are denoted by the experts in the field of clothing design. The associated labels are used as the ground truth of real clothing styles. The details of clothing in real images are reported in Table 3.

Table 3. The information of the real clothes

Style	number	Style	number
Short sleeve T-shirt	162	Breeches	214
Long sleeve T-shirt	153	Short sleeve dress	109
Jacket	155	Trousers	120
Blouse	136	Total	1049

In Table 4, the total is the number of all style clothes. The associated recognition rate is reported in Table 4.

Table 4. The recognition rate of clothing style for real clothes

Style	SVM (%)	kNN (%)	GP (%)	Decision tree (%)
Short sleeve T-shirt	93.4	91.2	92.9	92.4
Long sleeve T-shirt	94.8	92.4	92.5	92.7
Jacket	89.3	86.9	87.3	88.6
Blouse	91.2	89.6	89.8	89.7
Breeches	93.7	90.3	91.7	92.2
Short sleeve dress	94.2	92.4	93.1	92.6
Trousers	98.6	95.6	96.2	95.8
Overall accuracy	93.4	91.0	91.7	91.8

For real clothing images, the recognition rate achieves 93.4%, 91%, 91.7% and 91.8% for SVM, kNN, GP and decision tree, respectively. The recognition rate of trousers is still superior to that of other styles and achieves 98.6%, 95.6%, 96.2%, and 95.8% for SVM, kNN, GP and decision tree, respectively. Compared with the images only containing clothes, the performance reduces 1.5%, 1.6%, 2%, and 1.5% for SVM, kNN, GP, and decision tree, respectively. The reason is that the real clothing images must be preprocessed by image segmentation to determine the local of clothes.

5. CONCLUSIONS

In order to implement automatic clothing style recognition, this paper establish an intelligent system which first collects the image from an camera, second locates the position of the clothes in the image by using image segmentation and seed growth algorithm, third divides the clothes into several parts and extracts the features of each part, lastly uses the features of clothing images from an expert library to learn a classifier. The features of future clothing image are input into the classifier and the style is determined by the output of the classifier. The clothing style of the images in the library are annotated by the expert in the field of fashion design. The proposed clothing style recognition system is evaluated by standard clothing images and real clothing images. The results show that the proposed clothing recognition system can recognize more 92% clothing style in standard images and more than 91% clothing style in real images. In the future work, we will focus on improve the recognition rate of clothing style by considering other machine learning models, such as deep neural network.

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Yinghui Fan received his M.S. degree from the Bunka Fashion Graduate University, Japan in 2015. Currently, she is a lecturer in the Guangdong Baiyun University, Guangdong, P.R. China. She has authored more than 15 published papers. Her interests include wireless sensor network, costume design, and virtual simulation application.