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Towards the Prediction of Aesthetic Requirements for Women's Apparel Product

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***Abstract*—**The prediction of aesthetics of apparel is helpful for the development of a new type of apparel. This study is to build the quantitative relationship between the aesthetics and its design parameters. In particular, women's pants have been preliminarily studied. This aforementioned relationship has been carried out by statistical analysis. The contributions of this study include the development of a more personalized apparel design mechanism and the provision of some empirical knowledge for the development of other products in the aspect of aesthetics.

***Keywords*—**Aesthetics, crease line, cropped straight leg pants, knee width.

I. Introduction

APPAREL design has undergone a huge change with the increase of requirements from wearers [1]. Generally, there are three types of requirements for apparel design; function, comfort and aesthetics [2]. The requirement of apparel has been promoted from the simple functions (e.g. covering the body and keeping warm) to more design led parameters and requirements. Aesthetics is now highly considered by wearers [3]. Existing studies have already investigated the relationships between apparel design requirements and apparel design parameters. For example, De Klerk and Lubbe proposed a conceptual model for the role of aesthetics in apparel product, where aesthetics was associated with color and texture of apparel [4]. Rahman studied the visual inputs (such as color) and the aesthetics of apparel [5]. The above literature focused within the aspects of color, material and apparel design requirements. Besides color and material, structure is one of the important apparel design parameters [6] and the relationships between structure of apparel and apparel design requirements are essential to be clarified in apparel design. However, only a few studies have explored the structure of apparel. For example, Travis et al. found that a good silhouette influences the aesthetics of a suit for men [7]. De Klerk and Lubbe pointed out that proportion of apparel (in the aspect of the structure of apparel) affects aesthetics [4]. These studies show the limitations in finding the relationship between the structure of apparel and apparel design requirements (function, aesthetics, and comfort), including (1) the description for illustrating the degree of aesthetics of apparel is absent and (2) silhouette is a generic design parameter, and it should be decomposed into descriptive parameters for conducting an apparel design. Nevertheless, these studies have laid the foundation for developing apparel structure related models, such as quantitative models between structure and the requirements of apparel.

Women's cropped straight leg pants are considered as the starting point in building a model between apparel structure and apparel design requirements due to its simple structure and popularity among wearers [8]-[10]. In this paper, only aesthetic requirement of apparel is studied. Two objectives are explored in modeling the relationship between aesthetics and the structure of cropped straight leg pants. Objective 1 is to find the key parameters in determining the structure of cropped straight leg pants for women. Objective 2 is to establish a mapping from the structure of cropped straight leg pants and their aesthetics.

The rest of the paper is organized as follows: Section II is the methodology for modeling the relationships between aesthetics and the structure of cropped straight leg pants for women. 9Section III is the results and discussion. Section IV is a conclusion with some further works.

II. Methodology

Pattern Design Parameter Determination

Parameters, such as length, waist, hip, crotch depth, knee width and the location of crease line, are required to draft a pants' pattern [11]. Among these parameters, knee width and the location of crease line show more significant impacts to the structure of pants when the body size has been determined. For example, Hulme presented that knee width influences the fitness of the pants from crotch to the bottom [12]. Zhu et al. built a model mapping from the location of crease line to the structure of pants. The change of the location of crease line causes the significant change of the pants' structure [13]. Song and Ashdown pointed out that the position of crease line at the back pattern of pants influences the fitness of the pants from waist to the bottom [14]. Thus, in this paper, knee width and the location of crease line were found as the major parameters in determining the structure of cropped straight leg pants for women.

Data Collection

(1) Establishment of the Test Bed

The test bed establishment includes the determination of material and pattern of the cropped straight leg pants of women; procedural of manufacturing for pants; equipment and location for data collection.

Pattern of cropped straight leg pants for women: Fig. 1 is a refereed pattern of the cropped straight leg pants for women

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[15]. In Fig. 1, L is short for length of pants, W is short for waist circumference, H is short for hip circumference, KW is short for knee width and "a" represents the location of crease line. Standard size system of GB/T1335.1-1997 was employed in this study, and 160/68A was set as the standard size [16]. In this study, the standard sizes of cropped straight leg pants are in Table I.

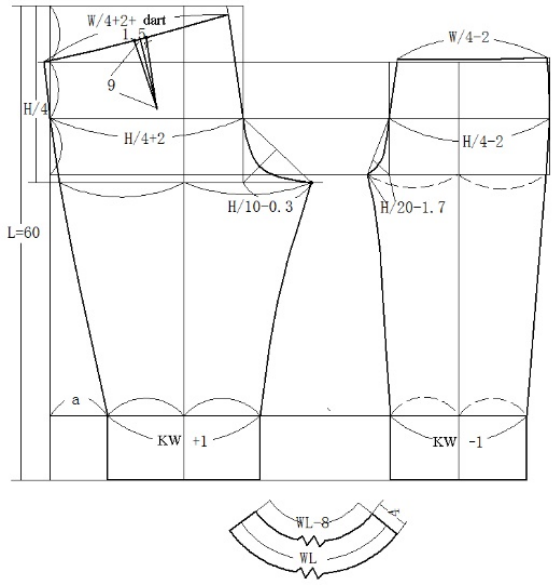

Fig. 1 The pattern of cropped straight leg pants for women

TABLE I
THE SIZE OF CROPPED STRAIGHT LEG PANTS

Item	Size (cm)
Length of pants (L)	60
Waist circumference (W)	80
Hip circumference (H)	88
Knee width (KW)	18
a	6.85

In order to investigate the impact of different KW (one of the major parameters in determining the structure of pants) on aesthetics of pants, KW with 17, 18 and 19 cm were applied in the pants' design in this study. Another major parameter "a" (position of crease line) with five different levels (1 cm difference between two levels) were also applied. Other parameters, such as L, W, and H were constant in this study. Thus, in total, with three different KW, and five different "a", there were 15 different sizes of cropped straight leg pants (Table II).

Material of cropped straight leg pants for women: The material of the pants was 3% Lycra and 97% cotton. A concealed zipper was also used.

Manufacture of cropped straight leg pants for women: All pants were made by the same experimenter with the same iron (GC1021, Philips) and sewing machine (NV980K, Brother).

Equipment and location for image capture: Canon 550, 18-55 mm lens, and tripod were used for capturing images of pants worn on participants in a static status. The images were captured indoor during the day.

TABLE II
SIZES FOR 15 PAIRS OF CROPPED STRAIGHT LEG PANTS FOR WOMEN

Item	L (cm)	W (cm)	H (cm)	KW (cm)	a (cm)
A1	60	80	88	17	3.85
A2	60	80	88	17	4.85
A3	60	80	88	17	5.85
A4	60	80	88	17	6.85
A5	60	80	88	17	7.85
B1	60	80	88	18	3.35
B2	60	80	88	18	4.35
B3	60	80	88	18	5.35
B4	60	80	88	18	6.35
B5	60	80	88	18	7.35
C1	60	80	88	19	2.25
C2	60	80	88	19	3.25
C3	60	80	88	19	4.45
C4	60	80	88	19	5.25
C5	60	80	88	19	6.25

(2) Acquisition of Data

The data were acquired in following steps: 1) 15 pairs of pants were worn by participants in a static status. The participants are in Chinese standard size of 160/68A; the criteria for recruiting audience includes that they must be Chinese residents and they have experience related to fashion design, such as enrolling in a fashion design program, runway models, and fashion designer. 2) The experimenter took photos for each pants worn by participants when they are in the static status (an example of photos in Fig. 2). In the study, 5 people were recruited as participants and 11 people were recruited as audience. It is noted that the number of participants and audience meet requirement of human factorial experiment that 5 to 12 participants are a sensible baseline range [18].

Fig. 2 One of the photos with a participant in a static status

Photos taken by the experimenter were further processed through image analysis. In this study, image analysis is used to analyze the characteristics of wrinkles on pants, as the wrinkle is the main factor to determine the sense of aesthetics [19]. The procedural of the image analysis includes: 1) converting image from RGB mode (photo taken with camera) into grey-level mode, 2) filtering the noise from grey image, 3) drawing the line chart with grey-level intensity and distance along wrinkles'

profile in terms of filtered image, 4) analyzing the line chart from 3), and obtaining location of peak and valley, distances between peak and valley, grey level, absolute grey- level distance between peak and valley, number of peak, and number of valley of wrinkles [20] (Table III), and 5) calculating the value of wrinkles' characteristics in terms of the values from 4) (Table IV) [19]. Wrinkles' characteristics used in this study include the number of wrinkles, the height of wrinkles, the width of wrinkles, wrinkle surface roughness, and wrinkle sharpness [21]. Equations for calculating these characteristics can be accessed from [20] and [21]. The values of wrinkle characteristics from 15 pairs of pants were collected for this study [17].

Data Analysis

Kendall's coefficient was employed to assess agreement among raters (participants and audience) including agreements on evaluating aesthetics from audience. Cluster analysis [22] was applied on data of aesthetics evaluation, including clustering the ranks from participants, and clustering the wrinkle characteristics. The purpose of the cluster analysis was to find out the overlapping data sets in both clustering of the ranks from participants and clustering of the wrinkles characteristics. These overlapping data sets were further used for building the model between aesthetics and the structure of pants. After analyzing the characteristics of the data (see the results in next section), liner regression was employed for building models in this study.

TABLE III
THE INFORMATION OBTAINED FROM THE LINE CHART

Item (P: peak; V: valley)	P1	V1	P2	V2
Location of P or V	11	13	20	22
Distances between P and V		2	7	2
Grey level	135	70	124	22
Absolute grey-level distance between P and V		65	54	102
Number of P	2			
Number of V	2			

TABLE 4
WRINKLE'S CHARACTERISTICS

Item	Value
Number of wrinkle	2
The height of wrinkle	53.69
The width of wrinkle	3.81
Wrinkle surface roughness	28.11
Wrinkle sharpness	16.14

III. RESULTS AND DISCUSSION

In Table V, all Kendall's coefficients are close to 1, which represents that the audience has been unanimous on evaluating aesthetics of cropped straight leg pants for women. This table shows that the data collected from the audiences are valid for modeling.

15 pairs of pants were clustered into three groups in terms of the audience evaluation and the wrinkle characteristics, respectively. Table VI is the cluster result from audience evaluation, and Table VII is the cluster result in terms of the wrinkle characteristics. Results from group 1, 2 and 3 indicate that the aesthetics of cropped straight leg pants is in good, neutral and bad conditions, respectively. From Tables VI and VII, pants itemed as A1, A2, B1, B2, C1, A3, B3, C2, C3, A4, A5 and C4 are overlapping for both audience evaluation and wrinkle characteristics, and these overlapped pants were then used for modeling the relationship between aesthetics and the structure of cropped straight leg pants for women.

TABLE V
KENDALL'S COEFFICIENT OF AUDIENCES' RANKS ON AESTHETICS OF CROPPED STRAIGHT LEG PANTS FOR WOMEN

Items	Number of audiences	Kendall's coefficient
Front of stretch pants	11	0.681
Back of stretch pants	11	0.763
Side of stretch pants	11	0.741
Overall	11	0.833

TABLE VI
THE RESULT OF CLUSTER ANALYSIS ON AUDIENCES' EVALUATION

Group number	Group 1	Group 2	Group 3
Items of pants	A1, A2, B1, B2, C1	A3, B3, B4, C2, C3	A4, A5, B5, C4, C5

TABLE VII
THE RESULT OF CLUSTER ANALYSIS ON THE WRINKLE' CHARACTERISTICS

Group number	Group 1	Group 2	Group 3
Item of pants	A1, A2, B1, B2, C1	A3, B3, B5, C2, C3, C5	A4, A5, B4, C4

TABLE VIII
AESTHETIC EVALUATION MODEL SUMMARY AND OVERALL FIT STATISTICS

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.882[a]	.778	.728	.543527

a. Predictors: (Constant), a, knee_width

TABLE IX
THE RESULT OF ANOVA FOR AESTHETIC EVALUATION MODEL

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.305	2	4.652	15.748	.001[b]
	Residual	2.659	9	.295		
	Total	11.964	11			

a. Dependent Variable: aesthetic_evaluation
b. Predictors: (Constant), a, knee_width

TABLE X
THE COEFFICIENTS OF AESTHETIC EVALUATION MODEL

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	13.418	4.046		3.316	.009
	knee_width	-.212	.207	-.183	-1.026	.332
	a	-.680	.127	-.954	-5.344	.000

a. Dependent Variable: aesthetic_evaluation

The employment of linear regression was determined in terms of the examination of the characteristics of data. Table VIII is the model summary and overall fit statistics. R is 0.82, which shows a good positive correlation of the model. R2 = 0.778 means that 77.8% of the variation in the dependent variable (aesthetic_evaluation) can be explained by this model with "a" and "knee_width" as the independent variable. Table

IX is the F-test. P-value is 0, which indicates that there is a linear relationship between the variables in the model. Table X is the coefficients of the model. "a" (p-value = 0) is a more significant variable in predicting aesthetics than "knee_width" (p-value = 0.332). The model for predicting aesthetics of cropped straight leg pants for women is:

$$y = 13.418 - 0.212\ x1 - 0.68\ x2$$

where y is the evaluation of aesthetics towards the cropped straight leg pants for women, x1 is the knee width, and x2 is the location of crease line.

IV. Conclusions

In this paper, the model to predict the aesthetics from pattern design parameters was developed. The data applied for the aesthetics were collected through evaluating pants worn by participants when they are in static status and through the image analysis. The linear regression was applied for modeling after analyzing the characteristics of the data. The following conclusions can be drawn from the results: (1) The knee width is less significant in predicting the aesthetics of cropped straight leg pants compared with the location of crease line. It is reasonable. As according to the pattern of pants, it seems the knee width is more robust than the crease line. (2) The developed model is promising in realizing the personalized apparel design, particularly, in satisfying customer's aesthetic requirements. The future work could be the validation of the developed model and the extension of the cropped straight leg pants to be a more complex apparel, such as a jacket, suit and gown, and find out how their structures influence the aesthetics.

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