Analysis on influencing factors of X-shape dress silhouette based on eye-tracking technology

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Abstract. For a long time, the research of intelligent garment pattern making has become a difficulty in the research of garment science, which involves the summary of the rules of garment pattern making and the accurate control of the shape of garment. In this paper, eye-tracking technology is adopted to analyze the influencing factors of the silhouette of X-shape dress. Multivariate analysis of variance and average of participants' eye-tracking were conducted for different design styles and interest areas of the X-shape dress by using the five interest area’s Fixation Duration, Visit Count and other indicators. According to the research, the influencing factors of X-shape dress silhouette are waist, chest, hem, hip and shoulder. Therefore, it is of great significance to take waist measurement, chest measurement and hem as the main factors affecting the X-shape dress silhouette, and to further study of the relationship between the structure and X-shape dress silhouette, so as to realize intelligent rapid pattern making based on computer technology.

1. Introduction
Silhouette is an important factor in the expression of clothing style and aesthetic feeling. There are five most common silhouettes, A, H, X, T and O, in contemporary women's clothing. The definition of garment silhouette is usually a visual subjective evaluation, lacking the corresponding relationship between subjective evaluation and objective indicator. Many researches have been carried out on the extraction and recognition of silhouette. By analyzing the characteristics of clothing styles, Zhuang Lifeng preprocessed the collected clothing images to a certain extent, and obtained the general outline of the clothing through threshold segmentation, morphological processing and other operations[1]; Zhou Jia used Matlab programming and the improved Canny algorithm to extract the garment outline, and refined it through the skeleton extraction algorithm[2]; An Lixin used Matlab 2010A programming to conduct a comparative study on the extraction algorithm of printed clothing outline. The study showed that the outline error calculation could effectively identify the texture noise data, repair the influence of printing patterns on the clothing outline, and finally obtain smooth clothing silhouette[3]; Fu Bailu used the graph cutting technology to extract the silhouette figure of the dressed woman in the static image, intelligently extracted the size data of the silhouette and built the relevant database. After classifying the
common women's dress, he finally realized the intelligent recognition of the silhouette by using computer technology[4]. Intelligent production of clothing not only helps to shorten the production cycle, but also satisfies people's aesthetic taste and creates more economic benefits for enterprises. While the premise of realizing intelligent rapid pattern making based on computer technology is the control and identification of garment silhouette.

Eye-tracking technology is to record eyes movement on words, images, videos and other visual stimuli, by using eye-tracking devices or eye-tracking systems, so as to obtain real-time and dynamic information, including fixation duration, visit counts, and so on. Compared with traditional methods, the data provided has a finer granularity, which is conducive to cognitive process analysis.

With the popularization of eye-tracking technology, eye-tracking experiment has become one important scientific method on research in various fields. By analyzing eyes-tracking data of different subjects on the effect of costume modeling and comparing with the traditional subjective evaluation, Zhang Yingzi believes that the evaluation method of costume modeling based on eye-tracking experiment is a feasible objective evaluation method[5]; Tang Guanmin used eye-tracking technology to analyze the style of JNBY's women's down jacket by factors such as dividing line, seam binding and dart[6]; by applying eye-tracker to the visual evaluation experiment of clothing fabrics, Zhang Sudao believes that eye-tracking technology can quantify the subjects' emotional and psychological needs, and then establish the color visual evaluation system of clothing fabrics from the perspective of perceptual engineering[7].

The above researches are mainly to establish an objective evaluation system of the style and beauty of the garment by eye-tracking experiments, but few researches are conducted on the influencing factors of the garment silhouette through eye-tracking technology. This paper mainly takes X-shape dress as the research object. By using eye-tracking technology to obtain and analyze the fixation duration, visit count and other data of each AOI, to obtain the main influencing factors of the X-shape dress silhouette, summarizing the main influencing factors of dress silhouette. It is of great significance to further study of the relationship between the structure and X-shape dress silhouette and realize the intelligent rapid pattern making of the X-shape dress based on computer technology.

2. Division of AOI and selection of eye-tracking indexes
The so-called AOI (Areas of interest), it refers to dividing a certain part of the experimental picture as an independent element analysis, according to which the attention degree of the design and characteristic of different parts of the same garment can be compared[6].

2.1. Division of AOI
Dress is typical for women in the traditional sense. Different silhouettes can be realized by changing the size of the parts such as chest measurement, waist measurement, hip measurement and shoulder width. X silhouette is characterized by slightly wider shoulders, fuller breasts, tighter waist, and fuller hips. It is characterized by slightly wider shoulder, fuller chest, tighter waist and fuller hip, combined with the research of domestic and foreign scholars on garment silhouette[8-11], the AOI of X-shape dress is divided into five parts: Shoulder (P1), Chest (P2), Waist (P3), Hip (P4) and Hem (P5) in this paper, as showed in Figure 1.

![Figure 1. Division of AOI](image_url)
2.2. Selection of eye-tracking indicators
In the eye-tracking experiment, a number of data, such as AOI Fixation duration, AOI Fixation Count and AOI Visit Count, are produced. Combined with the purpose of this paper, AOI Fixation duration and Visit Count are mainly selected.

3. Experimental scheme

3.1. Experimental Preparation
Tobii Pro Glasses2, produced by Tobii company of Sweden, is the most portable wearable eye-tracking system in nowadays market. It provides corresponding glasses according to users’ degree of vision, ensuring accurate and realistic eye-tracking data under natural conditions can be obtained to the greatest extent.

30 teachers and students majoring in clothing were randomly invited to test the differences of attention to different styles and AOI of X-shape dresses. In addition to myopia, ensure that participants have no other visual diseases, so as to reduce the experimental errors that may be caused by objective factors. Myope people need to wear the myopia lens matching the eye-tracker.

Pictures are from the official websites of Prada and other clothing brands. In order to reduce interference, they are in uniform colors, irrelevant background elements are also processed by computer software. Pictures are numbered from small to large according to the style of X silhouette: A1, A2, A3, A4 and A5, as showed in Figure 2.

![Figure 2. Pictures of X-line dresses](image)

3.2. Experimental process
Participants entered the experimental site and were fitted with eye-tracker and matching lenses for calibration in turn. When it is complete, participants look at the pre-processed pictures on the computer screen by turns. Pictures were randomly displayed for 8s, and the eye-tracker automatically record the eye-tracking data. Participants should avoid seeing pictures before the experiment, and keep the head still during the experiment to ensure that the distance between the person and the screen does not change significantly, so as to minimize the experimental error. When all participants completed, the data was exported.

3.3. Analysis of experimental data
Through the experimental data and the use of statistical analysis software combined with eye movement tracking technology, Fixation Duration and Visit Count of different styles and different AOI were extracted, and the two indicators were analyzed by multivariate analysis of variance and mean comparison, so as to summarize the main factors influencing the silhouette of X-shape dresses.

3.3.1. Multivariate analysis of variance. Table 1 is the result of multivariate analysis of variance on Fixation Duration and Visit Count of different styles and AOI.
Table 1. Multivariate analysis of variance

| AOI Fixation Duration/s | Source     | Sum of Squares | df | Mean Square | F     | Sig.  |
|-------------------------|------------|----------------|----|-------------|-------|-------|
|                         | Style      | 0.084          | 4  | 0.021       | 0.111 | 0.977 |
|                         | AOI        | 28.308         | 4  | 7.077       | 37.276| 0.000 |

| AOI Visit Count         | Source     | Sum of Squares | df | Mean Square | F     | Sig.  |
|-------------------------|------------|----------------|----|-------------|-------|-------|
|                         | Style      | 0.456          | 4  | 0.114       | 2.418 | 0.091 |
|                         | AOI        | 8.723          | 4  | 2.181       | 46.272| 0.000 |

It could be known from the multivariate analysis of variance of Fixation Duration in the AOI, the main effect of clothing style was not significant, F=0.111, Sig.=0.977>0.05, indicated that style had no effect on Fixation Duration. The main influence of AOI was significant, F=37.276, Sig.=0.000<0.05, indicated that different AOI would affect the corresponding Fixation Duration.

It could be known from the multivariate analysis of variance of Visit Count in the AOI, the main effect of clothing style was not significant, F=2.418, Sig.=0.091>0.05, indicated that style had no effect on Visit Count. The main influence of AOI was significant, F=46.272, Sig.=0.000<0.05, indicated that different AOI would affect the corresponding Visit Count.

Comprehensive analysis shows that style has no influence on Fixation Duration and Visit Count, while AOI has significant influence on Fixation Duration and Visit Count. Therefore, the influencing factors of X silhouette can be extracted according to Fixation Duration and Visit Count in the AOI.

3.3.2. Mean comparison. From the above analysis, it can be seen that the influencing factors of X silhouette can be extracted according to the two indicators: Fixation Duration and Visit Count. In order to determine which one is taken as the reference, and finally obtain the influencing factors of silhouette, the analysis software will be used to compare the mean value of fixation time and visit times. Table 2 and Figure 3 are the mean comparison data table of Fixation Duration and Visit Count of the five AOI of 30 groups of sample data and the corresponding bar charts.

| AOI Fixation Duration/s | Style | A1   | A2   | A3   | A4   | A5   | AVG  |
|-------------------------|-------|------|------|------|------|------|------|
| P1 (Shoulder)           | 0.700 | 0.658| 0.449| 0.638| 0.308| 0.551|
| P2 (Chest)              | 1.906 | 1.537| 2.187| 1.782| 0.992| 1.681|
| P3 (Waist)              | 3.447 | 3.359| 2.494| 3.464| 4.363| 3.425|
| P4 (Hip)                | 0.380 | 0.464| 0.764| 0.393| 0.879| 0.576|
| P5 (Hem)                | 1.248 | 1.382| 0.895| 1.097| 0.796| 1.084|

| AOI Visit Count         | A1   | A2   | A3   | A4   | A5   | AVG  |
|-------------------------|------|------|------|------|------|------|
| P1 (Shoulder)           | 0.60 | 0.37 | 0.53 | 0.43 | 0.30 | 0.447|
| P2 (Chest)              | 1.63 | 1.13 | 1.97 | 1.10 | 0.90 | 1.347|
| P3 (Waist)              | 2.00 | 2.10 | 2.40 | 2.07 | 2.33 | 2.180|
| P4 (Hip)                | 0.63 | 0.70 | 1.07 | 0.47 | 0.97 | 0.767|
| P5 (Hem)                | 1.33 | 1.27 | 1.30 | 1.33 | 1.20 | 1.287|
Figure 3. Mean comparison of Fixation Duration and Visit Count

It can be intuitively seen that: (1) Taking Fixation Duration as the standard, the Fixation Duration of the five AOI from long to short is: P3>P2>P5>P4>P1;(2) Based on the Visit Count, the Visit Count of the five AOI from most to least is: P3>P2>P5>P4>P1. Therefore, the influencing factors of the silhouette of X-shape dress in order of size are waist, chest, hem, hip and shoulder.

4. Conclusion
This paper takes X-line dress as the research object and analyzes the influencing factors of the silhouette of X-shape dress. Firstly, 30 groups of data of Fixation Duration and Visit Count in five AOI of different X-shape dresses were obtained through eye-tracking experiment. Through statistical analysis software, the multivariate analysis of variance and mean comparison of the data were carried out. The study found that different AOI have different attention, Waist>Chest>Hem>Hip>Shoulder. The attention of the waist is significantly higher than that of other parts, followed by the chest and the hem. In real life, X-shape dress length is over hip line, in comparison, the importance of the hip is weakened in the transition of the waist to the hem. Considering pattern making method and ease allowance control, the waist measurement, chest measurement and hem are taken as the main influencing factors of X-shape dress silhouette finally. This is of great significance to further study of the relationship between the structure and X-shape dress silhouette, so as to realize intelligent rapid pattern making based on computer technology.

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