Research on the design factors of H-shaped women's trousers based on eye-tracking technology

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Abstract. In order to accurately study the silhouette of clothing, this paper adopts eye-tracking technology to conduct in-depth analysis on the influencing factors of the silhouette of H-shaped women's trousers, obtain the tracking data of eye movement controlling the silhouette, and finally obtain the pattern-making variables controlling the H-shaped women's trousers through statistical analysis. By eye-tracking experiments, we used image recognition technology to record experimental data, dividing the interest area of H-shaped women's trousers, analyzing the eye movement indicators such as the total fixation duration, visit count in the interest area, and using SPSS software to perform multi-factor of variance and mean value analysis. Finally the key parts that affect the shape of H-type trousers are determined, which has high accuracy and practicality. The research adopts scientific and rigorous methods, which is the basis for the preliminary research of intelligent pattern-making and profile control.

1. Introduction
As the basis of clothing silhouette, clothing silhouette can directly convey the basic characteristics of clothing. At the same time, it is also a way for designers to embody popular elements and design intentions to form a design focus. In recent years, researchers have made corresponding research results on clothing silhouettes. For example, Fu Bailu proposed to detect static pictures in \textit{Building a Smart Women's Dress Profile Size Database Based on Human Body Segmentation}\textsuperscript{[1]}, extract the silhouette size through graph cutting technology to determine the key parts that affect the clothing silhouette, automatically measure and store. Yao Zhuqing uses non-contact three-dimensional scanner technology in \textit{Effects of Separation Lines and Provincial Road Settings on Clothing silhouette}\textsuperscript{[2]}, and uses AutoCAD software to extract cross-sections of clothing control parts, analyzes clothing silhouette parameters change law. It provides the theoretical basis for pattern-making and production practice. Wu Huan took women's trousers as an example in \textit{Classification of Women's trousers Profiles Using Convolutional Neural Network CaffeNet Model}\textsuperscript{[3]}, established a sample database of five women's trousers silhouettes, and automatically extracted women's trousers silhouettes using the convolutional neural network CaffeNet model Shape features, realize the classification of women's trousers silhouettes. Tao Chen proposed a method to quantify and identify clothing silhouettes in \textit{Recognition}
and Quantification of Clothing Silhouettes[4], extract the size data used to judge silhouettes. Therefore, the purpose of this paper is to quickly obtain the data of the control silhouettes parts from the women's trousers through the eye-tracking technology, so as to further study the influencing factors of the H-shaped women's trousers.

With the rapid development of machine vision and digital image recognition technology, eye-tracking technology uses image recognition methods to record the direction of the line of sight or the position of the line of sight accurately in real time, objectively and accurately, and it has been applied and developed in many fields includ clothing industry. For example, Yang Qian in Sportswear Brand Identity Research Based on Eye Tracking Technology[5] through the tracking and identification of different structural forms of brand logos, to find consumers' preferences and cognition of logos. Xu Huijuan solved two problems in Study on the Modeling Features and Image Space of Women's Tops Based on Chanel[6] through eye movement experiments observing the frontal renderings of women's tops: professional and non-professionals' Pay attention to whether there is a difference and if there is no difference, whether there is a difference in the importance of the feature parts. Shen Yuanyang in Recognition of Structural Features of Men's Suit Brands Based on BOSS DOLCEGABBANA, ZEGNA[7] Combining with cognitive psychology theory, taking the clothing structure of men's suit brands as the research objects, conduct questionnaires and eye movement recognition experiments on three brand men's suits, Extract the focus of the experimental brand and the structural identification characteristics of each brand. This thesis mainly adopts eye-tracking experiments. Through the division of interest areas of H-shaped women's trousers, the eye movement indicators of the corresponding interest areas’ total fixation duration and visit count are analyzed, finally, multi-factor of variance and mean value analysis determined the control variables that affect the silhouette of the H-shaped women's trousers.

2. Experimental scheme

2.1. Experimental data collection and division of interest areas

In the experiment, 30 clothing majors were selected to test six H-shaped female trousers. Through the official website of Zara clothing brand, collect six representative pictures of H-shaped women's trousers based on its fit for experimentation as ‘Figure 1’. Participants with normal vision or nearsightedness need to wear the corresponding myopic lenses provided by the instrument. The eye movement data collection and processing adopts the Tobii Pro Glasses 2 eye tracker produced by Tobii, Sweden, which is convenient, automatic data collection, high accuracy and tracking. With the characteristics of stable ability, Tobii ProLab software can record the eye movement data of each tester during the experiment and perform eye movement analysis such as area of interest and heat map. In the division of the interest area, according to the literature [8-10], it can be known that the three important parts that affect the structure of the trousers are waist, hip, and crotch. The patella is necessary for human movement, and it plays an important role in design of trousers. Therefore, in the division of interest area, H-shaped women's trousers are divided into five parts: P (Waist), p2(Hip), p3(Crotch), p4(Thigh) and p5(Calf) as ‘Figure 2’. In terms of data matching, each person’s data record is matched with the reference picture, and the automatic matching function is used to match, then the position, total fixation duration, visit count collected in the record can be projected into the reference picture, Export the heat map corresponding to the record as ‘Figure 3’ through the visualization function to generate the required eye movement index table for subsequent data analysis.
Figure 1. Styles of six H-shaped women's trousers.

Figure 2. Division of interest area of H-shaped women's trousers.

Figure 3. Heat map of H1-shaped women's trousers.

2.2. Selection of eye-tracking indicators
At present, common eye movement indicators include the fixation duration, visit count, average fixation time, ratio of fixation time, pupil diameter, etc. By analyzing the eye movement index data, the subjects' attention to a certain area of interest can be objectively obtained. According to the research purpose of this thesis, the fixation duration and visit count are selected as the research indicators for eye-tracking experiments.

3. Experimental analysis

3.1. Analysis of eye movement data
Through SPSS 23 statistical software combined with eye-tracking technology, the fixation duration and visit count of different area of interest H-shaped women's trousers are obtained, and the multi-factor variance and mean analysis.

3.2. Multi-factor analysis and mean comparison
According to the division of interest areas of H-shaped women's trousers, the fixation duration and visit count of 30 testers were obtained, and the two sets of data were summarized for multi-factor analysis of variance and mean analysis, and conclusions were drawn shown in table1. Table1 shows the results of multi-factor analysis of variance. Through the analysis of the influence of style and area of interest (AOI) on the fixation duration and visit count, it can be seen that the fixation duration of the style F=0.09, P=0.933>0.05, indicating that the style has no significant effect on the fixation duration influences. The fixation duration of AOI, F=10.557, P=<0.05, indicating that the interest area has a significant effect on the fixation duration, indicating that the AOI of the H-shaped women's trousers affects the fixation duration, so this paper can according to different AOI, Extract the factors that affect the silhouette of the H-shaped women's trousers.

Through the mean value analysis of the visit count of style and AOI, it can be seen that the visit count of style F=0.439, P=0.816>0.05, indicating that different styles of H-shaped women's trousers have no
significant effect on the visit count. F=5.466, P=0.004<0.05 indicates that AOI has a significant effect on the visit count, indicating that different AOI of H-shaped women’s trousers will affect the visit count. Therefore, this paper can also extract the design factors affecting the silhouette of H-shaped women’s trousers according to the division of interest.

Table 1. Multi-factor analysis of variance for style and AOI.

| Source     | Sum of Squares | df | Mean Squares | F   | Sig  |
|------------|----------------|----|--------------|-----|------|
| **Fixation Duration/s**                          |
| Style      | 0.102          | 5  | 0.02         | 0.09| 0.993|
| AOI        | 9.582          | 4  | 2.396        | 10.557| 0   |
| **Visit Count**                                  |
| Style      | 3.143          | 5  | 0.629        | 0.439| 0.816|
| AOI        | 31.336         | 4  | 7.834        | 5.466| 0.004|

Table 2. Summary of the mean value of the tester’s eye movement data.

| AOI     | Style | H1  | H2  | H3  | H4  | H5  | H6  | AVG | H1  | H2  | H3  | H4  | H5  | H6  | AVG |
|---------|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Fixation Duration |       |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| P1(Waist)| 1.63  | 2.16| 2.24| 2.18| 2.23| 1.66| 2.02| 5.14| 6.28| 7.12| 6.38| 6.19| 5.33| 6.07|
| P2(Haunch)| 0.88  | 1.19| 1.35| 2.38| 0.79| 1   | 1.27| 5.38| 7.03| 7.45| 8   | 5.93| 6.43| 6.70|
| P3(Crotch) | 3.05  | 2.62| 1.83| 2.89| 2.15| 2.42| 7.1 | 8.67| 6.67| 6.9 | 8.03| 6.72| 7.35|
| P4(Huckle) | 1.12  | 0.96| 1.08| 1.48| 0.65| 0.99| 6.54| 6.33| 5.87| 3.88| 8.5 | 4.78| 5.98|
| P5(Patella) | 1.29  | 0.77| 1.06| 0.86| 0.77| 1.76| 1.09| 4.56| 3.44| 3.46| 4.35| 6.69| 4.29|

A comprehensive study of the above difference shows that style has no significant effect on the fixation duration and visit count, but AOI has significant influence on the fixation duration and visit count. Therefore, the AOI is fully considered in the study of factors affecting the silhouette of H-shaped women's trousers and sort the mean analysis, determine the control area as shown in Table2. The P3 AOI is significantly stronger than the other values in the index values of the fixation duration and visit count. The fixation duration of the five AOI is P3>P1>P2>P5>P4 from long to short, and visit count from large to small is p3>p1>p2>p5>p4, the mean sorting shows that the fixation duration and visit count of the five AOI are inconsistent, and the control area cannot be determined according to a certain index. Therefore, tests of between-subjects effects analysis will be further applied to the fixation duration and visit count on the AOI to determine the significant impact of the fixation duration and visit count on the AOI as shown in Table3. The fixation duration and visit count p<0.05 of the five AOI all have a significant effect, but the five AOIF(fixation duration)<F (visit count).In the tests of between-subjects effects analysis, when the same p<0.05, the larger the F value, the more significant the difference. Therefore, it is feasible to use visit count as an indicator of the control area.

Table 3. Tests of between-subjects effects analysis for five regions of interest.

| Source | Dependent Variable | Sum of Squares | df | Mean Square | F     | Sig |
|--------|--------------------|----------------|----|-------------|-------|-----|
| P1     | Fixation Duration  | 24.402a        | 1  | 24.402      | 290.958| 0   |
|        | Visit Count        | 221.312b       | 1  | 221.312     | 414.515| 0   |
| P2     | Fixation Duration  | 9.601a         | 1  | 9.601       | 28.237| 0.003|
|        | Visit Count        | 269.608b       | 1  | 269.608     | 282.636| 0   |
4. Conclusion.
This paper takes H-shaped women's trousers as the research object, and studies the influencing factors of H-shaped women's trousers. By the eye-tracking experiment, the eye movement indicators of the fixation duration and visit count of the different AOI of H-shaped women's trousers are obtained. Through the analysis of variance and mean value analysis, it is concluded that the different of AOI is significant for the fixation duration and visit count. If the effect is equally significant, through the tests of between-subjects effects analysis, F value of visit count was greater than the F value of fixation duration, so the reference index that affects the control area of H-shaped women's trousers is visit count. The final design factors that affect the silhouette of H-shaped women's trousers are crotch, hip, waist, patella and bottom. The research result has positive significance and application value for promoting the intelligent design and production of clothing.

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