Fit evaluation for virtual men’s shirt

J Q Yan1 and V E Kuzmichev1

1Ivanovo State Polytechnic University, Department of Garment Design
No.21 Sheremetev Avenue, Ivanovo, 153000, Russian Federation

e-mail: naclplus7@163.com

Abstract. A fit evaluation can be conducted to determine a clothing is good or not in terms of concrete criteria such as the appearance, the comfort, etc. However, the existing criteria are still inadequate in predicting the fit in virtual reality and providing numeric recommendations. This research is aimed to develop the criteria of fit evaluation for men's shirt with regard to body measurements, 2D pattern block, 3D virtual fitting and shirt photos. The databases of consumer's opinions about misfit of men's shirt and real try-on photos were first established based on the online resources. Derived from the well-fitted customized pattern block, the variant pattern blocks with estimated reasons of misfit were generated by gradually change the responsible indexes. The specific criteria for different shirt segments were determined by integrating the fit level, real photos, virtual images, body measurements and pattern block. The developed criteria can be not only used for exactly evaluating the fit of sewed shirt, but also for predicting the fit and providing numeric recommendations.

1. Introduction

The fit is a more important element of clothing to customers [1]. The result of fit evaluation is always conducted to determine a clothing is good or not in terms of concrete criteria such as the appearance, comfort, etc.

The fundamental theory of fit is based on three groups of criteria: first, related to “body - clothing” system (the concordance between the shapes of body and clothing which is influencing on proportions, contour lines, smoothness, balance of clothing segments, etc.); second, related to textile material (grain direction, mechanical properties, etc.); third, related to construction of pattern block (body measurements, ease allowance) [2]. The extended criteria of fit evaluation for different categories of clothing (e.g., men’s shirt as a kind of one-layer clothing) have also been proposed [3]. However, the existing criteria are still inadequate in predicting the fit in virtual reality and providing numeric recommendations concerning body measurements and the pattern blocks.

With the spread of advanced IT technologies such as 3D body scanning, virtual reality, etc., the fit evaluation is possible to be further improved. This research is aimed to develop the comprehensive subjective and objective criteria of fit evaluation for men’s shirt regarding body measurements, 2D pattern block, and 3D virtual fitting with database of consumers’ opinions and misfit photos established and sensory analyses conducted.
2. Methods

2.1. Instruments
3D body scanner VITUS Smart XXL and software Anthroscan were used for acquiring the virtual clones (VC) of male bodies. CLO 3D was used for constructing 2D pattern block (PB) and sewing 3D shirt in virtual reality.

2.2. Initial database of consumers’ opinions
In order to make certain of the existing fit problems existed from the consumers’ perspective, 5,146 pieces of consumers’ opinions towards 81 pieces of men’s shirts from 30 famous menswear brands in Tmall (China) were surveyed. These shirts varied in styles (e.g., body-fit, slim-fit, regular-fit, loose-fit), quality levels (from normal to entry lux).

In general, the diverse consumers’ opinions could be divided to three main categories: positive, neutral and negative. Among the positive and neutral opinions, most consumers tended to compliment the good designs, comfortability, suitable size, etc. While the negative opinions included four primary aspects: improper size or dimension, undesirable properties of textile materials, low quality of products or unsatisfactory services provided. The overall proportions of consumers’ opinions regarding positive, neutral and negative ones are, %:

- positive and neutral feedbacks - 81.9,
- negative feedbacks – 18.1 including size or shape - 10.9, textile materials - 2.8, quality of shirt - 2.4, quality of services - 2.0.

Most of consumers (10.9%) declared the uncomfortableness and the undesired appearances caused by improper size or shape of the shirt, although they chose the shirts of closest dimensions to their own body measurements (BM). Concretely, the opinions related to size or shape were in the following aspects:

a) Shirt style:
   1. The dimension or shape is too small or big overall or locally (especially on the levels of chest, waist);
   2. The length from neck to hemline is too short or long;
   3. The sleeve is too loose or tight;
   b) Clothing fit:
   4. The collar is too tight or loose;
   5. The shoulder seam is too short or long;
   6. The sleeve is too short or long;
   7. The cuff is too tight or loose;
   8. The bodice (chest, belly, hip or back) is too tight;
   9. The shirt is unsmooth with folds or creases after wearing.

The problems of shirt style greatly depended on the personal tastes or habits. While the problem of clothing fit was caused by the inadequacy between the individual morphology and the shirt construction based on RtW system. The database of the fit problem perceived from the consumers’ subjective perspective was established accordingly.

2.3. Initial database of misfit photos
Based on the proposed fit problems, the next database of misfit photos was established to reveal the exterior appearances of the misfit of the men’s shirt. 187 online photos of shirt from eighty brands in the internet photographed in different views were selected.

Each photo was segmented to different segments (front and back bodice, neck and collar, shoulder seam, sleeve) which were compared and analyzed together. A five-level scale (1 – worst, 2 – poor, 3 – medium, 4 – good, 5 - best) was applied for distinguishing the fit state in consideration of the exterior appearance of the shirt segments. Table 1 shows the gradation of misfit in neckline and collar segment.
Table 1. Misfit gradation of neckline and collar.

| Fit level | Neckline and collar | Neckline and collar |
|-----------|---------------------|---------------------|
|           | Too large neckline  | Too small neckline  |
|           | and collar           | and collar           |
| 1         | ![Image](image1)     | ![Image](image2)     |
| 2         | ![Image](image3)     | ![Image](image4)     |
| 3         | ![Image](image5)     | ![Image](image6)     |
| 4         | ![Image](image7)     | ![Image](image8)     |
| 5         | ![Image](image9)     | ![Image](image10)    |

As shown in Table 1, the neckline and collar segment involved a bilateral gradation. When the segment was too large, the gap between body and cloth was observable; when it was too small, the folds around neckline were observable. Similarly, shoulder seam, sleeve and bodice were reflected by two bilateral gradations (too long, short; too down, up), two bilateral gradation (too long, short; too large, small sleeve cup height) and three gradation specific to armhole, chest, hip, respectively. From level 1 to level 5, the exterior appearance of the shirt varied from the worst one with most misfit to the best without misfit.

Therefore, the second database of misfit photos with gradations for different fragments were established. For one thing, it reflected the exterior appearances of the fit problems from the consumers’ opinions. For another, the both databases could be referred as the subjective criteria for evaluating the men’s shirt by subjective perceptions and visualization of misfit.

2.4. Construction of virtual shirts
The virtual shirts from different pattern blocks (PB) were sewed in CLO 3D to acquire the subjective and objective criteria. A male body who possessed the similar front and back chest girths was scanned and selected as the subject for subsequent experiments.

Firstly, the well-fitted customized PB (PB$_F$) in body-fit style was generated with corresponding BM by the previous algorithms [4]. Figure 1 shows the VC of the selected body and the 3D virtual visualization of the customized shirt in CLO 3D.
Figure 1. Selected male body (a) and 3D virtual visualization of the customized shirt (b).

As shown in Figure 1 (b), the customized shirt well fitted the VC with good fit – e.g., overall satisfied exterior appearance and contours, no stress folds around neck, shoulder seams, bodice or sleeves, correctly-positioned horizontal and vertical structural lines. Thus, derived from PB\(_F\), the defective shirt with misfit could be generated.

Secondly, the patterns with different estimated misfit (PB\(_M\)) were constructed by gradually increasing or decreasing the responsible pattern indexes. Figure 2 shows PB\(_F\) and PB\(_M\) of shoulder and sleeve segments.

Figure 2. Fragments of bodice with different shoulder seam angle (a), shoulder seam length (b), sleeve cup height (c) and sleeve length (d) of PB\(_F\) (grey lines) and PB\(_M\) (red and blue lines).

As shown in Figure 2, the variant PB\(_M\) were constructed by stepwise increasing or decreasing the angle and length of shoulder seam, sleeve cup height and sleeve length with interval of 2°, 0.5 cm, 1 cm and 1 cm, respectively. Other PB\(_M\) were also constructed by configurating the neckline length, armhole depth, chest width and hip width, respectively.

VC and its BM, PB\(_F\) and PB\(_M\) were utilized to sew the virtual shirt with the same digital fabric (40s_Streched_Poplin) in CLO 3D.

3. Results and discussion
The both fragments - photos of misfit and VR images - were matched together. The experts were invited to compare and evaluated the similarity of both fragment (by scoring each pair from 0 when the both objects are totally different to 10 when the both objects are the same). As shown in Table 2, five counterparts (P\(_1\) – I\(_{SA0}\), P\(_2\) – I\(_{SA2}\), P\(_3\) – I\(_{SA4}\), P\(_4\) – I\(_{SA6}\), P\(_5\) – I\(_{SA8}\)) were determined with high similarities between real shirts and its VR images in terms of shoulder seam segment.
Table 2. Average scores of similarities between real photos and VR images (when shoulder seam is too up).

| VR image   | P₁ | P₂ | P₃ | P₄ | P₅ |
|------------|----|----|----|----|----|
| Iₛₐ₀       | 0  | 0.25 | 0.25 | 0.5 | 9  |
| Iₛₐ₊₂     | 1  | 2.75 | 5.25 | 7.5 | 2.25 |
| Iₛₐ₊₄     | 4.75 | 6 | 8.25 | 3.75 | 0  |
| Iₛₐ₊₆     | 4.5 | 8.5 | 3.25 | 1.75 | 0.25 |
| Iₛₐ₊₈     | 8  | 7.25 | 3 | 0 | 0  |

where P₁ – P₅ represents the real photos of shirt with fit level from 1 to 5, respectively; I₀ represented the VR images of customized shirt; I₂, I₄, I₆, I₈ represented the VR images of shirt with increased shoulder seam angle from 2 to 8°.

Therefore, the evaluation criteria of shoulder seam fit depending on sloping shoulder lines were proposed with integrating the fit level, photos of real shirts, BM, PB₉, PBₘ and virtual images as Table 3 shows.

Table 3. Fit evaluation of shoulder seam influenced by shoulder line patterns.

| Fit level                                                                 | BM                  | PB₉ and PBₘ          | Real shirt | VR image |
|---------------------------------------------------------------------------|----------------------|----------------------|------------|----------|
| 1 (unsmooth seam with prominent bulge)                                    | ![Image](image1)    | ![Image](image2)    | ![Image](image3) | ![Image](image4) |
| 2 (big bulge around SP (shoulder point))                                 | ![Image](image5)    | ![Image](image6)    | ![Image](image7) | ![Image](image8) |
| 3 (small bulge around SP, fold pointed from neck to SP)                   | ![Image](image9)    | ![Image](image10)   | ![Image](image11) | ![Image](image12) |
| 4 (tiny folds pointed from neck sloping angle)                           | ![Image](image13)   | ![Image](image14)   | ![Image](image15) | ![Image](image16) |
| 5 (smooth seam without folds)                                            | ![Image](image17)   | ![Image](image18)   | ![Image](image19) | ![Image](image20) |
As shown in Table 3, in accordance with the variation of shoulder seam angle, the shoulder segment of shirt can have the best fit without defects and the worst fit with distinct defects on real and virtual shirts. Moreover, the responsible BM and PB demonstrated the structural reasons of the corresponding misfit on the shirt. In the similar way, the fit criteria for other segments (neck and collar, armhole, sleeve and bodice) were proposed. The criteria can be applied for accurately evaluating the fit of a men’s shirt, and for ratiocinating the reasons of existing misfit of different segment in both real and virtual environments.

4. Conclusion
This study developed the procedure of fit evaluation for virtual men’s shirts with integrating the photos of shirts, body measurements, pattern block, virtual images and specific descriptions. These criteria can be not only used for exactly evaluating the fit of sewed shirt, but also for predicting the fit and providing concrete recommendations. In the future, more virtual clones and textile materials will be involved to further improve the accuracy of the criteria.

References
[1] Fan J, Yu W and Hunter L 2004 Clothing appearance and fit: Science and technology (Cambridge: Woodhead Publishing) pp 31–71
[2] Kuzmichev V E 2020 Evaluation of pattern block for fit testing Anthropometry, Apparel Sizing and Design (2nd ed.) ed N Zakaria and D Gupta (Cambridge: Woodhead Publishing) chapter 9 pp 217–251
[3] Real Men Real Style. How A Men’s Dress Shirt Should Fit https://www.realmenrealstyle.com/proper-dress-shirt-fit/ (2020, accessed 4 October 2020)
[4] Yan J and Kuzmichev V E 2020 A virtual e-bespoke men’s shirt based on new body measurements and method of pattern drafting 2020 Text. Res. J. 90 (19-20) 2223-2244