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# ИССЛЕДОВАНИЕ ВЛИЯНИЯ ПАРАМЕТРОВ ФИГУРЫ И ОДЕЖДЫ НА ДОСТОВЕРНОСТЬ ВИЗУАЛИЗАЦИИ ДЕФЕКТОВ В ВИРТУАЛЬНОЙ РЕАЛЬНОСТИ*

# AN EXPLORATION OF BODY AND CLOTHING SHAPES INFLUENCING ON RELIABILITY OF DEFECTS VIZUALIZATION IN VIRTUAL REALITY

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***Для улучшения виртуального проектирования одежды и повышения процедуры оценки качества посадки были исследованы чертежи конструкций женских блузок, виртуальные двойники типовых фигур и блузки с разной объемно-силуэтной формой. 132 чертежа были параметризованы и сгруппированы в X, H, A силуэты как прилегающие, полуприлегающие и свободные. Виртуальные двойники женских фигур сгенерированы в программе CLO3D 5.2 с использованием результатов экспериментальных антропометрических измерений. Складки на спинках блузок были взяты в качестве индикаторов посадки и были параметризованы с помощью шкалы серого цвета и технологии обработки изображений. Разработаны критерии качества посадки. Схема проверки чертежей конструкций перед виртуальной примеркой разработана с использованием процедуры оценки качества посадки и анализа изображений складок и может быть применена для разработки конкретных рекомендаций для разработки чертежей.***

***To improve virtual try-on of clothing and an efficiency of fit checking procedure, the sewing pattern blocks of women blouses, virtual twins of typical bodies and blouse styles were taken as research objects. 132 sewing patterns were parameterized and classified between X, H, A styles as fitting, semi-fitting and loose ones. Virtual twins of women bodies were generated in CLO3D 5.2 by adding experimental anthropometrical measurements. The folds on blouse back were taken as the indicator of fit and were parameterized by means of grey - white scale and image processing technology. Fit criteria were established. The scheme of pattern blocks checking before virtual try-on was developed by using the blouse fit evaluation and folds image analysis and can be applied for providing concrete recommendations for pattern making.***

**Ключевые слова: женская блузка, посадка, виртуальная симуляция, виртуальные двойники, анализ изображений, шкала серого цвета.**

**Keywords: women blouse, fit, virtual simulation, virtual twins, image analysis, grey scale.**

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*1. Introduction*

Nowadays, the accuracy of pattern block is widely regarded as an important way to influence an appearance and comfort of virtual clothing. In the meantime, there are many manuals of sewing pattern blocks making and some of them aren't good for the customization in virtual reality [1]. Well-known virtual technologies are CLO3D, Optitex, 3D Vidya, DC Suite, etc [2]. which are showing their own structural problems related to misfit, such as unreasonable distribution of ease allowance of pattern blocks, imbalanced clothes and so on. In addition, the existing criteria of patterns validation are still inadequate in predicting the fit in virtual reality.

In real practice many patternmakers are using own non-formalized workmencraft to improve the fit of clothes but these unique methods aren't included in program modules of CAD. Many CAD systems are applying simplest approach to patterns drawing without specific and very important know-how.

Therefore, in order to improve virtual try-on of women blouse and an efficiency of checking procedure, the sewing pattern block was taken as research object.

The main goal of research is to develop the scheme of patterns preparation for virtual try-on.

*2. Research methods*

*2.1 Pattern blocks*

132 women blouse sewing patterns were collected, digitized by using ETCAD software, and classified between X (71 patterns), H (29), and A (22) styles. The sewing patterns were further subdivided into fitting, semi-fitting and loose styles. The grouping of patterns were made in according to unique combination of the fitting effect, on one side, and an ease allowances to bust, waist, and hip girths, on the other side [3]. The patterns were measured including the dimensions and the ease allowances.

*2.2 Virtual twins*

Virtual twins of women bodies were generated on the base of experimental anthropometrical measurements to get full schedule of body measurements. New data base is necessary to add important body measurements to develop an existing avatar data base in CLO3D. This approach guarantees the adequacy between Chinese body types and its digital twins. 154 females aged 20 to 35 year measured by 3D laser scanner body VITUS Smart XXL and software Anthroscan were grouped as Y, A, B, C body types in accordance with the Chinese standard sizing systems [4] (GB/T 1335.1-2008). Based on an average measurements of Y, A, B, C body types, the software of CLO3D 5.2 were applied to establish virtual twins of each body types.

To get a virtual twin of blouse, the patterns were virtually stitched on the virtual twins of bodies [5].

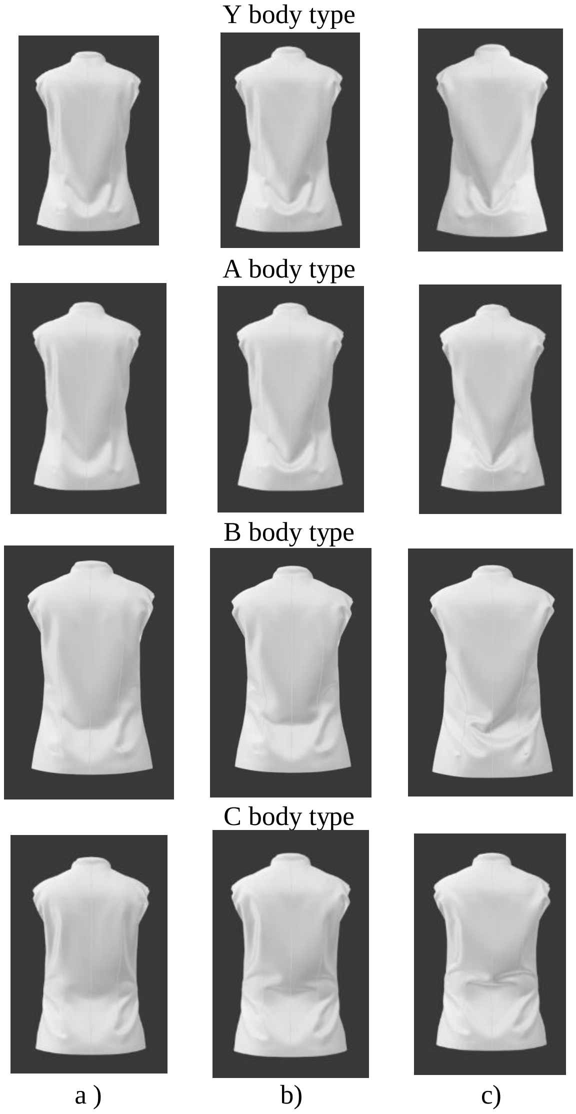



Fig. 1

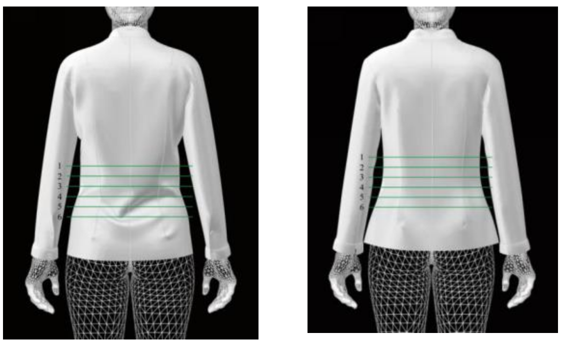
*2.3 Detection and evaluation of folds*

A fold is an important factor which visually reflects the ease allowance and clothing fit. To evaluate the folds, the image processing technology was used to analyze the change of grey value of image. It is known that under constant light conditions, the reflection effect of concave and convex parts of fold is different, and this difference can be represented by grey images. If the grey value is large, the fold is raised. The grey value is small, then the fold is concave. If the grey value is stable and unchanged, there is no fold in this part [6].

Figure 1 shows the fragment of established database of virtual women blouse with different defects.

As Fig.1 shown, the folds views (direction, location, concentration) differs from one body type to other. For example, the folds on the back of A body type are located in sloping direction, but for C body type - in horizontal direction. This conclusion indicates significant role of body type (drop) in clothing shaping and this influence of body contribution can be used for an identification of body morphology under wearing clothing.

To analyze the folds and its distribution, the horizontal cross-sections were made on waist level (WL), upper WL (WL+3, WL+6) and below WL (WL-3, WL-6, WL-9). Figure 2 shows the location of cross-sections.

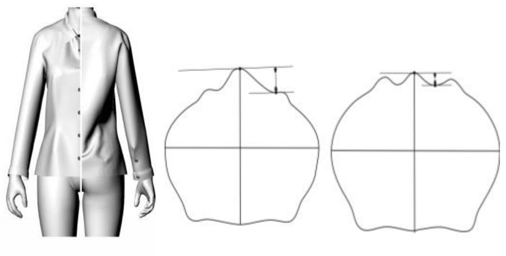


a) b)

Fig. 2

3D Rhino CAD was used to establish the folds database by intercepting the horizontal cross-sections mentioned and the fold depth measuring [7]. Figure 3 shows the scheme of fold depth measuring as distance from highest point to lowest point.

ImageJ software was used to perform grey processing to calibrate the grey values in pixels at above six horizontal cross-sections. Each pixel of image has 256 grey levels ranging from 0 to 255. Minimum level 0 represents the darkest part of grey image, that is black. Maximum level 255 represents the brightest part in grey image, which is white. Since the grey matrix takes into account for the both characteristics (fold position and fold parameters), the data of these grey values are accurate and reliable [8].



a) b) c)

Fig. 3

*3. Results and discussion*

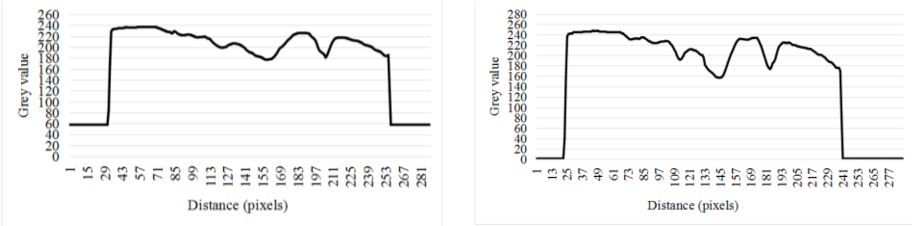
When the fabric folds are not obvious or close to situation yes-no folds, its grey characteristics will maintain a relatively stable value. When the fabric has folds, its grey value will fluctuate accordingly. The part with a large grey value represents the raised area of the fold, and the part with a low grey value represents the recessed place of the fold. The crests (valleys) in the grey curve represent the number of folds. The more crests or troughs that appear, the denser the number of folds. The difference between the maximum and minimum grey values of adjacent peaks and troughs represents the depth of the folds, and the distance between two adjacent peaks or troughs represents the width of the folds. Because the folds are not evenly distributed, the fit can be evaluated by two aspects: width and depth. Each fold can be evaluated by means of the width and depth. Among them, the unevenness of fold is smaller, the fold is more uniform. The unevenness of fold are defined by the following formulas:

$$VD = 100\frac{\sum_i \left| V_{Di} - \overline{V}_D \right|}{\overline{\overline{V}}_D}, \quad (1)$$

$$V_H = 100\frac{\sum_i \left| V_{Hi} - \overline{V}_H \right|}{\overline{\overline{V}}_H}, \quad (2)$$

where $V_{Di}$ is the width of the i-th fold, pixel; $V_{Hi}$ is the depth of the i-th fold respectively, grey value. $\bar{V}_D$ is the average width of fold, pixel; $\bar{V}_H$ is the average depth of fold, grey value [9].

The extracted grey values were exported to Excel. The grey curves as an examples from horizontal level WL-6 and two values of $E_{BL}$ are shown in Fig. 4. The grey value difference 20 was taken as set as the fold discrimination threshold [10].




a) b)

Fig. 4

After the treatment of statistical data base the number of folds, fold depth, fold width and unevenness of fold for defects for all objects explored were calculated. Table 1 shows the part of this huge data base for Y body type (the same tables were formed for A,B,C body types).

The information about the folds located on 6 horizontal lines was calibrated, as shown in Table 2.

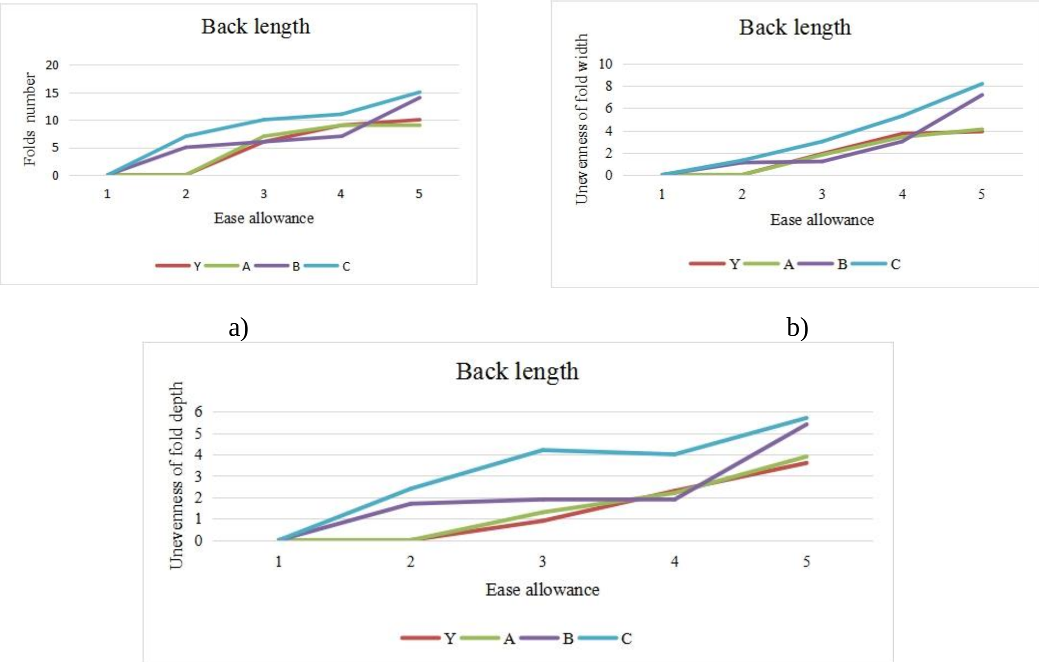
Table 1

| $E_{BL}$, cm | Cross-section | Folds parameter | | | Unevenness of fold, pixel/grey value | |
|---|---|---|---|---|---|---|
| | | number | Width (for each fold), pixel | Depth (for each fold), grey value | width | depth |
| 3 | WL+6 | 0 | 0 | 0 | 1.91 | 0.87 |
| | WL+3 | 0 | 0 | 0 | | |
| | WL | 0 | 0 | 0 | | |
| | WL-3 | 3 | 29/74/30 | 33/42/45.5 | | |
| | WL-6 | 2 | 57/32 | 28.5/45 | | |
| | WL-9 | 1 | 45 | 40 | | |
| 4 | WL+6 | 0 | 0 | 0 | 3.69 | 2.32 |
| | WL+3 | 0 | 0 | 0 | | |
| | WL | 1 | 77 | 38 | | |
| | WL-3 | 3 | 35/60/25 | 29.5/68.5/60 | | |
| | WL-6 | 3 | 19/39/21 | 36/55/60.5 | | |
| | WL-9 | 2 | 21/30 | 39/39 | | |
| 5 | WL+6 | 0 | 0 | 0 | 3.92 | 3.59 |
| | WL+3 | 0 | 0 | 0 | | |
| | WL | 1 | 96 | 76 | | |
| | WL-3 | 3 | 36/49/24 | 36/73.5/29 | | |
| | WL-6 | 4 | 22/21/38/28 | 30/22/69/40 | | |
| | WL-9 | 2 | 21/34 | 53/40 | | |

Table 2

| Cross-section | Depth of folds, depending on $E_{BL}$ | | | | | |
|---|---|---|---|---|---|---|
| | $E_{BL}$, cm | | | | | |
| | 3 | | 4 | | 5 | |
| | grey value | cm | grey value | cm | grey value | cm |
| WL+6 | 0 | 0 | 0 | 0 | 0 | 0 |
| WL+3 | 0 | 0 | 0 | 0 | 0 | 0 |
| WL | 0 | 0 | 38 | 1.9 | 76 | 3.8 |
| WL–3 | 33/42/45.5 | 1.65/2.1/2.3 | 29.5/68.5/60 | 1.5/3.4/3 | 36/73.5/29 | 1.8/3.7/1.5 |
| WL–6 | 28.5/45 | 1.43/2.3 | 36/55/60.5 | 1.8/2.8/3 | 30/22/69/40 | 1.5/1.1/3.5/2 |
| WL–9 | 40 | 2 | 39/39 | 2/2 | 53/40 | 2.7/2 |

The scheme of patterns checking before virtual try-on was further developed based on the fold analysis and calibration $E_{BL}$. The number of folds and its depth and width and were compared and analyzed respectively, as shown in Fig. 5.




a) b)

c)

Fig. 5

As shown in Figure 5, a, $E_{BL}$ is bigger, the number of folds is also bigger. The number of folds for body type C is significantly larger than other types. At the same time, when $E_{BL}$ is 1 cm, the folds for each body type are absent, which means that the blouses are very fit for Y, A, B, and C body types. When $E_{BL}$ exceeds 2 cm, the number of folds in clothing is greater than five for each body types.

Figure 5, b, c show that when $E_{BL}$ increases, the width and depth of folds also increase, especially for C body type. However, for B body type, the unevenness of fold width is smaller than that of Y and A body types excepting when $E_{BL}$ is within the range of 3-4 cm. In addition, in terms of fold depth unevenness, except for $E_{BL}$ of 4 cm, the garment fold width is smaller than the Y, A body type, and the rest of the ease allowance is greater than the garment fold width of the Y, A body type.

Furthermore, according to the comparison of the results of fold image analysis and $E_{BL}$, the fit criteria were established for X-style:

| body type | EBL, cm, arising the folds and forming the fit | |
|---|---|---|
| | fit | misfit |
| Y, A | 0–2 | more 2 |
| B, C | 0–1 | more1 |

So, the obtained results are the recommendation for pattern making and the prognosis for fit identification. The similar limitations could be established for other ease allowances such as to front and back width, arm girth, which depend on body morphology and should be separated not only between body sizes but body type also.

## CONCLUSIONS

By means of virtual technology, grey-scale image identification and pattern making, the complex exploration of influence of body type and ease allowances on women blouse fit was done. The number of folds and its distribution could be ruled during pattern making, on one side. On the other side, some features of folds (location, direction etc.) can be applied for identification of body morphological features and body measurements.

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