Virtual Design of System “Body-Dress” Improving with Scanning Technologies

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Abstract

This exploration is aimed to improve the database used 3D CAD design to get more realistic virtual systems by means of 3D body scanning technologies. In reality, systems "body - clothes" have changed much when the pattern blocks modified under influence of different fabrics and clothes construction, while the virtual systems showed diverse results[1,2]. In our research, to improve the process of virtual simulation and predict its results, the materials' mechanical properties were measured and air volume located between the body and clothes and other essential parameters of scanned dresses were calculated. To design more realistic virtual systems “female body-dress”, the database were especially promoted in accordance with demands of fit and balance influencing by the dress styles and textile materials. New database will allow to do more realistic simulation based on the synergy effect of significant factors combination including textile materials properties, fit indexes, and dress shapes.

Keywords: body scanner, clothes, pattern block, textile materials, fit, synergy, virtual reality

1. Introduction

3D simulation technologies, with its convenient and efficient characteristic, has been utilized frequently in apparel industry and selling market, such as the latest ULIQLO online virtual try-on system[3] in Chinese famous online shop Taobao, which allows people to see the virtual appearance with desired clothing and body. However, the limited feasibility of contemporary virtual design was proposed from previous research. On one hand, due to the limited database of textile fabrics, pattern blocks, clothes and styles, the results of 3D simulation are far from capable of every garments with particular fabric and patterns[2], which make it unrealistic and inaccurate comparing with the real clothes. On the other hand, current virtual environments lay more emphasis on visual emulation degree rather than on ergonomic comfort level, which is more fundamental for clothes manufacturing, as Fig. 1 shows. The reason why fit, comfort and clothing balance are absent in 3D simulation is that these indexes are processing of synergy effects concerning by pattern block construction, textile material properties and human body morphology with different results that depend from clothes styles.

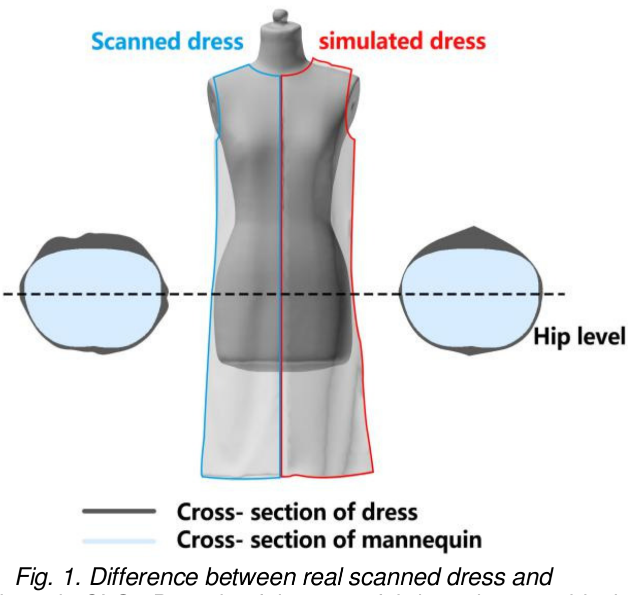


Fig. 1. Difference between real scanned dress and virtual one in CLO 3D made of the same fabric and pattern block.

Meanwhile, as an efficient instrument for anthropometric exploration, 3D body scanner enable new indexes and database for human body. Even though, 3D body scanning technology could have been more comprehensive except for anthropology, considering the case of clothing shape with it. With 3D body scanner, identical 3D models which "cloning" the real clothes are available for normally inaccessible indexes, such as cross-sections and air gap volume. Therefore, new detailed information about scanned clothes are developed referring to other accessible measurements, which are more accurate and valuable than traditional measurements.
The aim of this research is to improve the process of virtual system "body-dress" shaping by establishing new database concerning the pattern block construction, dimensions of human body, textile materials properties tougher with new indexes related to fit and balance of clothes. Fig. 2 shows the procedure framework.

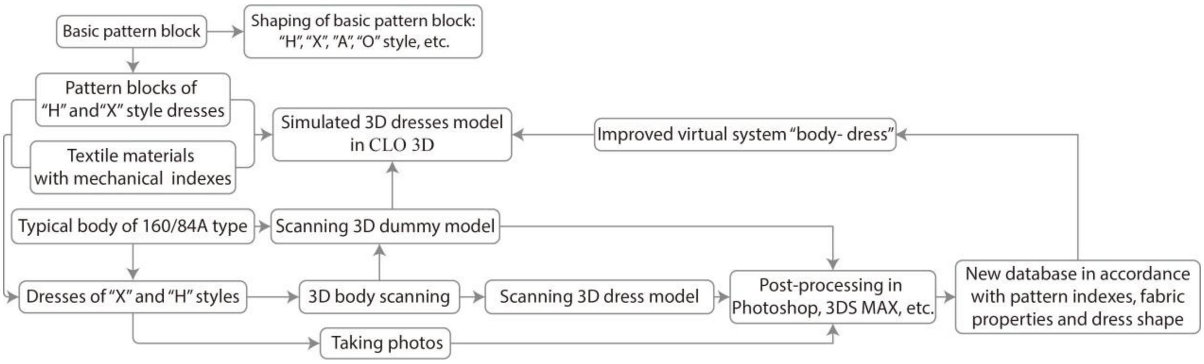


Fig. 1. . Procedure framework of this research.

2. Method of this research

2.1. Experimental devices

To explore different objects we used next devices.
1. 3D body scanner Vitus Smart XXL from Human Solutions GmbH (Germany)[4].
2. Digital camera for shooting different projection of dresses.
3. Mannequin for putting on dresses. Mannequin 160/84A of most average typical female body type in China (bust girth = 84 cm, waist girth = 66 cm, hip girth = 88 cm) was employed in this research, considering mannequin's stability and invariance in dressing, photographing and scanning procedures.
4. Testers for textile materials properties. They are YG41L Fabric Thickness Gauge - fabric thickness, YG028 All-purpose material tester - fabric tensile strength and elongation, XDP-1 Fabric drapability Tester - static draping coefficient and capture fabric draping photos, electronic scale - fabric quality.

2.2. Experimental software

Next softwares were used on the different exploration steps.
1. Anthroscan for collecting and converting 3D scanning data from 3D body scanner.
2. CLO 3D Enterprise for 3D garment simulation with a fabric simulation function called "emulator", which can calculate and save the fabric properties by some special tests.
3. ET 2012 CAD for sketching pattern block CAD as the raw patterns in CLO 3D.
3. 3DS MAX for processing and measuring the air gap parameters of 3D model files.
4. Photoshop CC for modifying photos of dress.

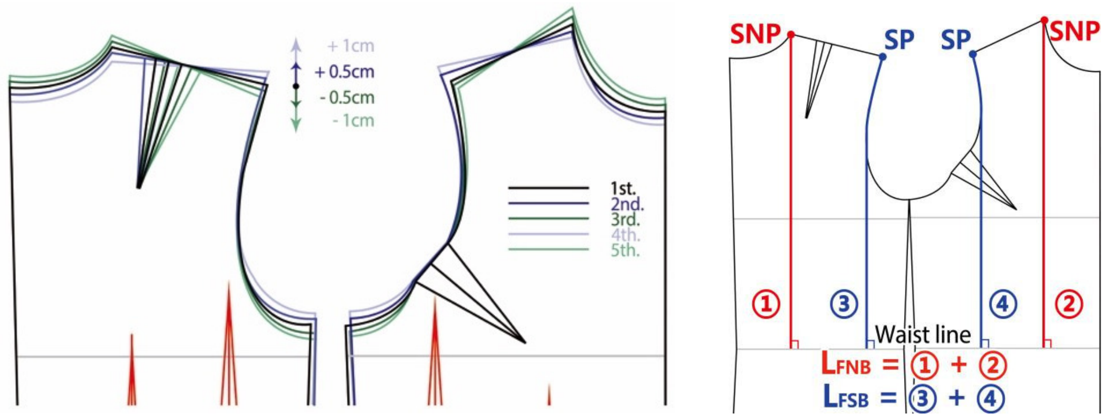
2.3. Main methods of research

2.3.1. Style of dresses

Female dresses in "H" and "X" styles were chosen to be the essential investigated objects. The silhouettes of "H" style were similar with straight tubular with their EBG (ease to half bust girth) = 6.8cm, EWG (ease to half waist girth) = 22cm and EHG (ease to hip girth) = 8.8cm, while "X" style dresses were close–fitting in waist level with EBG= 3.6cm, EWG= 2.8cm, EHG= 8.8cm. To get "X" style, we used some darts on the waist level. The reason why two styles were chosen as the objects is that shapes of two styles is disparate even under the same synergy effects of fabrics and pattern blocks. Furthermore, database of system "body-dress" were enriched with diversified results.

2.3.2. Pattern blocks

There were ten pattern blocks in total derived and modified from Japanese 8th generation basic block for female garment[5]. The foremost patterns of “H” and “X” style dresses evolved the subsequent eight modified patterns. All indexes of pattern blocks were constant except for the side seam position and shoulder line sloping, the neckline and armhole were specially kept identical. As Fig. 3(a) shows, for 2nd and 5th blocks the angle of shoulder lines were decreased by rising *SP* (shoulder point) and descending *SNP* (shoulder neck point) for 0.5 – 1 cm; meanwhile, for 3rd and 4th blocks the angle of shoulder lines were increased by descending *SP* and rising *SNP* for 0.5 – 1cm. All alterations in pattern blocks must influence on the fit and balance of dresses and will allow us to change the fit and balance of real dresses..



(a) (b)

Fig. 3. 1st - 5th Pattern blocks : (a) scheme of pattern modification; (b) measurement of LFNB and LFSB.

2.3.3. Textile materials

Five kinds of woven fabrics with plain structure were chosen for dresses making, which respectively are cotton cloth (fabric 1), artificial silk (fabric 2), calico (fabric 3), denim with Lycra (fabric 4) and elastic polyester fabric (fabric 5). These fabrics have different weight (from 69.6 to 294g/m²), thickness (from 1.6 to 4.6mm), tensile strength (from 5 to 205N/5cm when elongation is 8%), static draping coefficient (from 28.3 to 61.7%). These fabric mechanical properties were respectively tested by related testers in 2.2.

2.4. Evaluation of dress samples

2.4.1. Pattern block fit balance

To express fit balance (*FB*), we used the equation:

$$FB = LFNB - LFSB \quad (1)$$

where: LFNB is length from front waist line to back waist line across *SNP* [see Fig. 3. (b)],
LFSB is length from front waist line to back waist line across *SP* [see Fig. 3. (b)].
The indexes of fit balance are shown in Table 1.

Table 1. Fit balance indexes of pattern blocks

Item	Item value for pattern (cm)				
	Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5
LFNB	83.1	82.1	84.3	85	81.2
LFSB	76.1	76.6	75.6	75.1	79.4
FB	7	5.5	8.7	9.9	1.8

2.4.2. Measurements of real dresses

First, after all dresses have been made up and ironed, the photos of dummy and dresses were taken in front, profile and back projections. In order to keep the scale of photos, the dummy and camera were in a relatively stable position, and the height of camera was right at the dummy’s hip level. Besides, the distances between floor to dress bottom line were measured as *BH*, and average values were calculated (see Table 2). Second, the front center seams of all dresses were dismantled and ironed, then photographed in front and profile projections.

Table 2. Average bottom height of dresses

Measuring item (cm)		Dresses made of pattern 1	Dresses made of pattern 2	Dresses made of pattern 3	Dresses made of pattern 4	Dresses made of pattern 5	Average height
BH of "H" style	Front	46.9	47	46.4	46.5	47.2	46.8
	Profile	46.7	46.7	46.7	46.9	47.1	46.8
	Back	47	47.5	46.5	46.8	48	47.2
BH of "X" style	Front	47.3	47.7	47.2	47.3	47.8	47.5
	Profile	48.2	48.3	48.4	48.6	49	48.5
	Back	47.8	48.2	47.8	48.3	48.8	48.2

Because of slightly shake with camera in shooting process, all photos were imported to Photoshop CC software and modified to ensure that all dresses are in the same position and with the same scale. Moreover, photos of dummy and dresses were compounded together by changing their transparency. Angle between front edges (*AH* is the angles of "H" style dresses, *AX* is the angles of "X" style dresses) were measured in photos of dresses without front center seam (see Fig. 4). Through these photos, we can easily see the air gap volume between dresses and dummy as well.

Figure 4. The angle between front edges

2.4.3. Air gap calculations

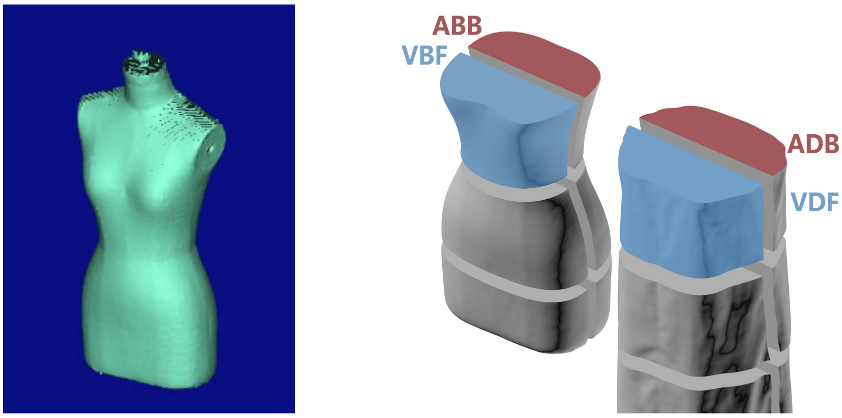
Mannequin 160/84A and mannequin with dresses were scanned separately by 3D body scanner for air gap calculating by 3DS MAX. Air gap in system "mannequin - dress" was described by two ways: first - by measuring full air gap volume, second - by calculating the parts of air volume located under the front and back.

(1) Under first way, four factors - *VD* (volume between bust level and hip level of dress), VB (volume between bust level and hip level of body), *AD* (acreage of dress' cross-section) and AB (acreage of body's cross-section) - were measured. *V* (air volume between dress and body) and A (average difference between dress and body) were calculated by equations:

$$V = VD - VB \tag{2}$$

$$A = AD - AB \tag{3}$$

The calculation were accomplished through several steps. First, 3D models after scanning were imported to 3DS MAX and adjusted to the same scale and position. Then, these models were sliced on front center line, profile center line, bust, waist, and hip levels to generate 16 separated cube pieces. In addition, internal planes were extracted from these cube pieces, which composed necessary cross-sections. Finally, with cube pieces and planes, any desired part in 3D models could be measured (with volume and acreage), *VD* and *AD* were calculated accordingly. Fig. 5 shows sliced 3D dress model.



(a) (b)

Figure 5. Air volume of dress: (a) raw scanning image; (b) sliced 3D models

(2) Considering that all dresses are tight above bust level, the torso part between bust level and hip level are chosen for calculation. Moreover, the proportion of front and back volume of dresses were changed because of variance of FB, the following indexes are consequently proposed:

$$VFBH_{x,y} = VDF_{x,y} - VBF_{x,y} \quad (4)$$

$$VBBH_{x,y} = VDB_{x,y} - VBB_{x,y} \quad (5)$$

where: $VFBH_{x,y}$ is the air volume of front part of system "body - dress" (x is pattern number, y is fabric number); $VBBH_{x,y}$ is the air volume of back part of system "body - dress". $VDF_{x,y}$ and $VBF_{x,y}$ are the volume of front part of dress and body, while $VDB_{x,y}$ and $VBB_{x,y}$ are the volume of back part of dress and body.

The ratio RV between $VFBH$ and $VBBH$ was calculated by equation

$$RV_{x,y} = VFBH_{x,y} / VBBH_{x,y} \quad (6)$$

Range of RV (from 0.89 to 1.35 for "H" style, from 0.62 to 1.08 for"X" style) depicts the distribution of front and back air volume.

2.5. Fit and balance evaluation

2.5.1. Balance of bottom line

When the bottom heights of three projection is at the seam level (distance is 0 ±0.5cm), the dresses are define as clothes with good fit. In all the samples, there were 13 from 25 "H" style samples in total had good fit in bottom height, while only 6 from 25 "X" style samples in total had good fit. Moreover, good fit "H" style samples were made of 1st, 3rd, 4th, 5th pattern. While "X" style dresses made of 3rd pattern shown better fit within "X" style samples. So, 1st, 3rd, 4th, 5th pattern (FB = 7 - 9.9cm) is better for "H" style dresses, while 3rd pattern (FB = 8.7cm) is better for "X" style dresses. Furthermore, "X" style dresses is more difficult to reach a fit condition comparing with "H" style.

2.5.2. Balance of front edges

When the angle is 0º (±1º), dress will keep two front center edges in the same position, which shows good fit of front center line. More samples of "H" dresses made of 2rd pattern block were fit, and all "X" style samples were not fit while samples made of 5th pattern block is closer to fit condition (2.3º). So, when FB = 5.5 cm, angle is closer to 0º in "H" style dresses; when FB = 1.8 cm, angle is closer to 0º in "X" style dresses. And "H" style dresses are easier to reach the best balance of front edge than "X" style dresses.

2.5.3 Balance of air volume distribution

When the value of RV is 1 (±0.2) , front air volume will be the same as back air volume, which shows balance of air volume distribution. "H" style samples made of 1st, 2nd, 5th pattern shown better balance, while "X" style samples made of 2nd and 5th pattern shown better balance. In addition, there are 8 "H" style samples (25 pieces in total) and 6 "X" style dresses (25 pieces in total) with good fit. So 1st, 2nd, 5th patterns (FB = 1.8 - 7cm) is better for balance of "H" style dresses, and 2nd, 5th patterns (FB = 1.8 - 5.5cm) is better for balance of "X" style dresses. Furthermore, "H" style dresses are easier to reach the best balance of air volume distribution than "X" style dresses.

3.1 Results and discussion

3.1. Results of photos

Figure 6 shows the relation between FB and angles between front edges from which it's evident that "H" and "X" style shown different reactions to FB. When FB is varying from 1.8 cm to 5.5 cm, AH and AX changes slightly with FB. However, AH changes around 2° while AX changes around 0°,which means that when the shoulder sloping is small AH shows more obvious reaction. Moreover, AX increases more acutely than AH when FB is varying from 5.5 to 9.9cm, which means more obvious reaction of AH. In conclusion, when FB is from 1.9 to 9.9 cm, AH is bigger than AX with the same FB value; when FB is from 1.9 to 5.5 cm, AH increases more conspicuously than AX; when FB is from 5.5 to 9.9 cm, AX increases more conspicuously than AH.

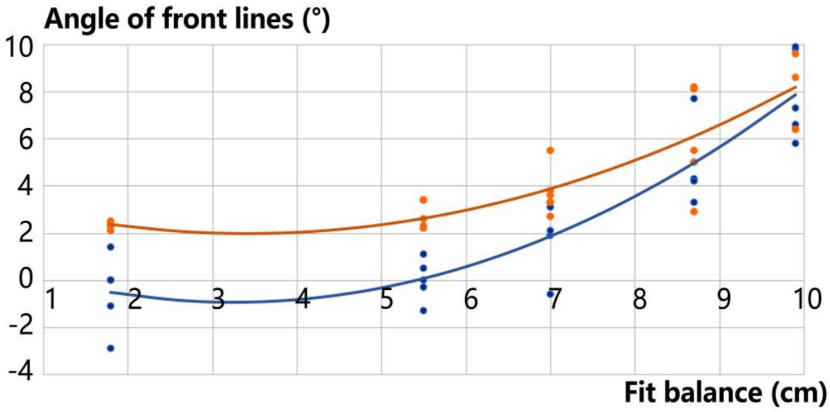


Figure 6. The diagram of reaction of AH and AX to FB

3.2. Results of real dress samples

Form the bottom height values in Table 3, dress shapes can be predicted as:

(1) With the same pattern block indexes, BH of "X" style is lower than BH of "H" style. So, when making "X" style referring from basic pattern block, it's necessary to increasing dress length for desired shape.

(2) With FB (from 1.9 to 9.9 cm) is increasing, BH of front, profile and back projection is inclined to decrease. So, dress length should be modified in accordance with shoulder line sloping.

3.3. Results of air gap volumes

Textile material indexes have been proved had have the influence on RV, meaning that front and back air volume distribution of dresses from different fabrics are disparate. Moreover, RV of "X" style gradually changes with these indexes while RV of "H" style is relatively stable. We describe the relation between RV and fabric mechanical property values with the following equations:

(1) With X_1 (X_1 is the weight from 69.6 to 225.4 g/m^2) increasing, RVX (RV of "X" style dress) increases accordingly, while RVH (RV of "H" style dress) is relatively stable at around value 1.27, which proved that fabric weight changes "X" style dresses more inclined to change. The equation is:

$$RVX = 0.4308 \ln (X_1) - 0.4407 \quad (7)$$

Moreover, when fabric weight becomes lighter, RVX are closer to value 1.27. So when utilizing light fabric in "X" style dress, front and back air volume distribution is nearly 1.27, but it will be much bigger when fabric is heavy, which means that misfit with a too big air volume distribution (up to 2) must be considered deliberately when making "X" style dresses with heavy fabrics.

(2) With X_2 (X_2 is static draping coefficient from 28.3 to 61.7%) increasing, RVX declines accordingly, while RVH hardly changes. The equation is:

$$RVH = - 0.088 \ln (X_2) + 1.16 \quad (8)$$

$$RVX = - 0.518 \ln (X_2) + 1.12 \quad (9)$$

So when utilizing fabric with low static draping coefficient, the air volume distribution of "X" style dresses will reach 1.8, which is possible to cause apparent misfit.

(3) With X_3 (X_3 is tensile strength from 5 to 205 N/5cm under an elongation is 8%) increasing, RVX declines observably, but RVH still maintain 1.29. The equation is:

$$RVX = -0.322 \ln(X_3) + 3.06 \quad (10)$$

So when using fabrics with a small tensile (especially when elongation is 8%) in dresses, we should use specific methods to balance the air volume distribution.

4. Conclusion and recommendation

1. There are much professional knowledge which is yet ignored by contemporary CAD of virtual simulation. Combination of pattern block parameters and textile material mechanical properties could bring the unexpected results as synergetic effects which couldn't be predicted in 3D CAD. To get more difficult formalized knowledge, the 3D body scanner should be used to generate the 3D models of real body and dresses. After processing in 3DS MAX, we can measure and calculate the air gap indexes, which make it possible to find solid relation and equation between pattern blocks, textile fabric and dress shape.
2. Different approaches for design of dresses in H and X styles are established with the measurements of real samples and calculations of air volume. All main differences should be added in programming modules of 3D CAD for more realistic simulation results.
3. With 3D scanner, CAD of 3D design should be adjusted to real "body-clothes" with the same database of synergy effects with different clothes styles, textile fabrics, pattern blocks and air volume parameters.

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