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## New database for improving virtual system “body-dress”

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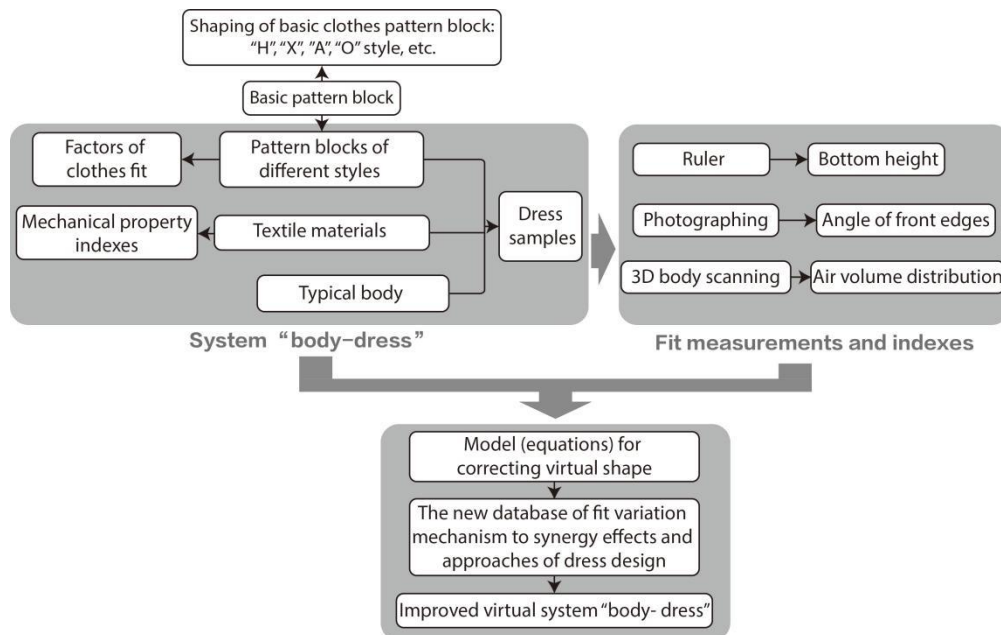
**Abstract.** The aim of this exploration is to develop a new database of solid algorithms and relations between the dress fit and the fabric mechanical properties, the pattern block construction for improving the reality of virtual system “body-dress”. In virtual simulation, the system “body-clothing” sometimes shown distinct results with reality, especially when important changes in pattern block and fabrics were involved. In this research, to enhance the simulation process, diverse fit parameters were proposed: bottom height of dress, angle of front center contours, air volume and its distribution between dress and dummy. Measurements were done and optimized by ruler, camera, 3D body scanner image processing software and 3D modeling software. In the meantime, pattern block indexes were measured and fabric properties were tested by KES. Finally, the correlation and linear regression equations between indexes of fabric properties, pattern blocks and fit parameters were investigated. In this manner, new database could be extended in programming modules of virtual design for more realistic results.

### 1. Introduction

Due to its superiority of efficiency and convenience, virtual clothing simulation becomes very popular in apparel industry and garment research. The results in virtual simulation environment looked realistically in general, however, these results were hardly trustful for exact clothing shape forecasting and research<sup>[1]</sup>. The reason of its inaccuracy is that virtual environment lacks the essential database of clothing fit with the synergy effects of combining textile materials, pattern block construction, clothing style, etc<sup>[2,3]</sup>. A small change of these synergy effect elements will conduct distinct fit or misfit of clothes, designs of collar, shoulder, armhole, etc could be the factors of clothes misfit. In order to analyze and describe the fit, we proposed and created identical parameters by correlations and linear regression equations with textile material mechanical properties, pattern block indexes, with which virtual design could be improved with realistic fit and simulation appearances.

The aim of this research is to improve the existing virtual database used for designing of system “body-dress” by adding new algorithms and relations between dress construction, fabric mechanical properties, and pattern blocks. Figure 1 shows the framework of improving the reality of virtual system “body-dress” by means of developing new database.





**Figure 1.** The framework of improving virtual system “body-dress” with new database

## 2. Methods of research

“Dress-body” was analyzed as a system because both elements - dress and body - influenced the final appearance and fit of dress. Three essential elements used to build this system were investigated: dress style, pattern block and textile material.

### 2.1. Dummy for experiment

Dummy 160/84A (A means difference between bust girth and waist girth are from 14 to 18 cm, bust girth = 84 cm, waist girth = 66 cm, hip girth = 88 cm, shoulder width = 12 cm, distance between bust and waist = 16.8 cm, distance between waist and hip = 18.5 cm) was chosen. It was used in the process of pattern making, dresses wearing and fit indexes measuring.

### 2.2. Pattern blocks of dresses in H-style and X-style

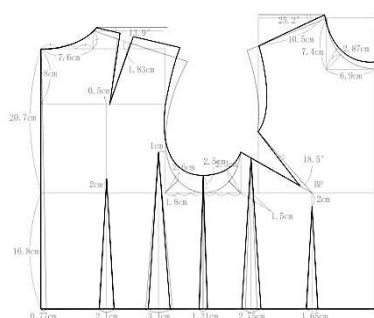
Derived from Japanese new cultural basic block<sup>[4]</sup>, through optimizing and sample wearing experiments, the basic pattern block was sketched as Figure 2. Basic pattern blocks of dress in H-style (PDH1) and in X-style (PDX1) shown as Figure 3. There were no darts around waist level on PDH1 while PDX1 has ones.

As more important factor of clothes fit, shoulder’s design will directly affect the whole shape of dress, the fit will be changed as well. Therefore, to get the misfit of dresses, the basic block was transformed by increasing and decreasing SP (shoulder point), SNP (shoulder neck point), FNP (Front neck point), ADP (armpit depth point) with other pattern indexes kept constant as shown in Figure 4.

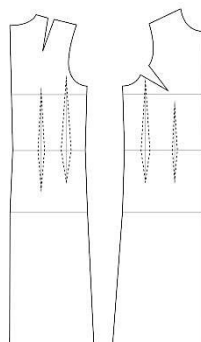
After these transformation, the shoulder sloping angles of transformed pattern blocks in H-style (PDH2, PDH3, PDH4, PDH5) and X-style (PDX2, PDX3, PDX4, PDX5) changed accordingly.

### 2.3. Textile material tested by KES

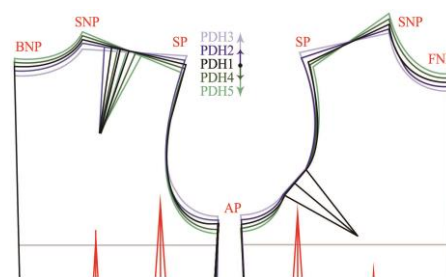
Five kinds of textile materials for dress making were selected: plain woven cotton thin calico (T1), plain woven polyester cloth (T2), plain woven cotton thick calico (T3), twill woven elastic denim cloth (T4), plain woven elastic polyester cloth (T5). Essential mechanical properties of these fabrics were tested by KES testers (KES-FB1, KES-FB2) four times. Then the interval of tensile, shearing and bending properties were calculated as shown in Table 1.



**Figure 2.** Shell of dummy in black (Japanese cultural basic pattern block in gray)



**Figure 3.** Basic pattern blocks of dresses in *H*-style and *X*-style (darts in dotted line for *X*-style)



**Figure 4.** Transformed pattern blocks with different neck, shoulder and armhole lines

**Table 1.** Mechanical properties of fabrics tested by KES

Instrument	Mechanical property index	Intervals
<i>KES-FB1</i> (Tensile)	Linearity of the strain curve <i>LT</i>	warp: 0.626 - 0.970, weft: 0.612 - 0.859
	Tensile energy (maximum load = 500cN/cm) <i>WT</i> (cN·cm/cm <sup>2</sup> )	warp: 6.513 ... 38.788, weft: 12.463 ... 44.250
	Tensile recovery following extension <i>RT</i> (%)	warp: 41.933 ... 60.785, weft: 37.893 ... 52.815
	Tensile strength <i>F</i> when elongation is 3% (cN/cm)	warp: 14.35 ... 414.94, weft: 19.85 ... 213.59
<i>KES-FB1</i> (shearing)	Shearing stiffness <i>G</i> (cN/[cm·(°)])	warp: 0.158 ... 2.998, weft 0.440 ... 2.405
	Shearing leg moment <i>2HG</i> (cN/cm)	warp: 0.170 ... 6.290, weft: 0.065 ... 5.148
	Shearing leg moment <i>2HG5</i> (cN/cm)	warp: 0.708 ... 10.383, weft: 0.610 ... 7.098
<i>KES-FB2</i> (Bending)	Bending stiffness <i>B</i> (cN·cm <sup>2</sup> /cm)	warp: 0 ... 0.145, weft: 0.026 ... 0.155
	Bending hysteresis moment <i>2HB</i> (cN·cm <sup>2</sup> /cm)	warp: -0.776 ... 0.390, weft: -0.025 ... 0.201

#### 2.4. Dresses for experiment

With five kinds of distinct fabrics and 10 pieces of patterns, 50 pieces of dresses in *H*-style and *X*-style with different fit were made. After measuring of bottom heights and 3D scanning (see 3.2, 3.4), the front center seams of all dresses were dismantled and ironed, then photographed in the front projection (camera installation was exactly the same).

### 3. Fit indexes of system “body-dress”

In order to express the fit of system “body-dress”, new indexes were proposed to be measured and analyzed.

### 3.1. Shoulder sloping parameter SS on dress pattern blocks

Shoulder slope is the angle between shoulder line and horizontal plane, which is one of the pivotal index to describe shoulder shape of a body or clothing. Considering that shoulder widths of all dresses

were constant in this experiment, shoulder sloping of pattern blocks ( $SS$ ) were expressed by the vertical difference between  $SP$  and  $SNP$ :

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

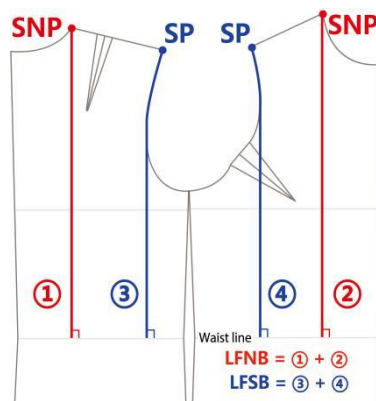
Where:  $LFNB$  is the length from front waist line to back waist line across  $SNP$ ,  $LFSB$  is the length from front waist line to back waistline across  $SP$ , as shown in Figure 5. The  $SS$  value (cm) of pattern blocks were respectively 7, 5.5, 1.8, 8.7, 9.9.

### 3.2. Bottom heights of dresses

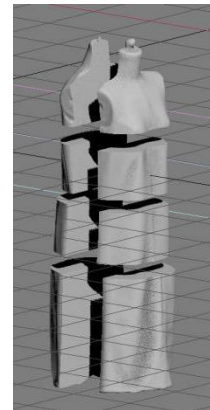
On  $PDH$  and  $PDX$  patterns, the bottom lengths were designed constant, too. However, the height from bottom to the floor varied when the patterns and the fabrics were changed. Therefore, bottom heights to the floor in front ( $BHF$ ), profile ( $BHP$ ) and back ( $BHB$ ) projection were measured. The differences between  $BHP$  and  $BHF$ ,  $BHP$  and  $BHB$  were calculated as  $\Delta BHF$  and  $\Delta BHB$ .

### 3.3. Angels of front contours

With dresses dismantling of front center seams, the angels of front contours ( $AFH$ ,  $AFX$ ) were measured in Photoshop.



**Figure 5.** Measurements of  $LFNB$  and  $LFSB$



**Figure 6.** Sliced segments of 3D scanned dress

### 3.4. Air volume parameters

Dummy and all dresses were scanned by VITUIS Smart XXL 3D body scanner and exported as 3D format file (.obj). These 3D files were optimized, sliced and measured in 3DS MAX (3D modeling software) as Figure 6 shows. Dress segments over bust level were closely fitted with dummy so that only segments between bust and hip levels were investigated. Thus, air volume indexes were obtained:

$$AVF_{x,y} = VSF_{x,y} - VDF_{x,y} \quad (2)$$

$$AVB_{x,y} = VSB_{x,y} - VDB_{x,y} \quad (3)$$

$$AV_{x,y} = AVF_{x,y} + AVB_{x,y} \quad (4)$$

$$RV_{x,y} = AVF_{x,y} / AVB_{x,y} \quad (5)$$

Where:  $AVF_{x,y}$  and  $AVB_{x,y}$  were respectively front and back air gap between dress samples and body.  $VSF_{x,y}$  and  $VSB_{x,y}$  were respectively front and back air volume of dress samples,  $VDF_{x,y}$  and  $VDB_{x,y}$  were respectively front and back air volume of dummy.  $AV_{x,y}$  expressed the full air gap.  $RV_{x,y}$  expresses the ratio proportion of front and back air volume ( $x$  is the pattern number,  $y$  is the fabric number).

## 4. Discussion of fit indexes

### 4.1. Discussion about fit indexes

When  $SS = 7 - 9.9$  cm, the dresses in *H*-style shown horizontal bottom line in three projection, but when  $SS = 8.7$  cm, the dresses in *X*-style were close to show horizontal bottom. And bottom heights of the dresses in *H*-style were inclined to be horizontal rather than the dresses in *X*-style.

In addition, the dresses from *PDH2* and *PDH3* ( $1.8 \text{ cm} \leq SS \leq 5.5 \text{ cm}$ ) shown *AFH* as  $0^\circ$ , which indicated that the front center lines were vertical and dress shape would be immobile after front contours were seamed. Moreover, the dresses from *PDH4* and *PDH5* ( $8.7 \text{ cm} \leq SS \leq 9.9 \text{ cm}$ ) shown bigger *AFH*, *AFX* ( $2.1^\circ \dots 10.5^\circ$ ).

### 4.2. New algorithms of fabric properties, pattern block parameter and fit indexes

Based on fabric properties, the pattern block parameters and the fit indexes, the linear regression equations were obtained after linear regression analysis as:

$$AFH = 4.3 - 19.3B_{\text{warp}} \quad (6)$$

$$AFH = 0.80SS - 2.69 \quad (7)$$

$$AFX = 5.4 - 12.0B_{\text{warp}} \quad (8)$$

$$AFX = 0.69SS + 0.04 \quad (9)$$

Where:  $B_{\text{warp}}$  is bending stiffness in warp direction of fabrics.

From equations (6) - (9), *AFH* and *AFX* were expressed with  $B_{\text{warp}}$  and *SS*. With  $B_{\text{warp}}$  increasing, fabrics were less flexible to bending, the front center lines were more inclined to keep vertical with the bending strength from shoulder part and back torso, the angles of front contours would be bigger. Furthermore, as *SS* increasing, the shoulder slope of dress changed accordingly, the supporting point of dress moved from *SNP* to *SP*, the dress shape changed, which led to bigger angle of front contours.

Taking dresses in *X*-style as example, the bottom height variance in front and back projections were described as:

$$\Delta BHF = -0.194 - 0.0007F_{\text{warp}} \quad (10)$$

$$\Delta BHB = -1.216 + 0.0007F_{\text{warp}} \quad (11)$$

$$\Delta BHB = -0.147 - 0.031SS \quad (12)$$

Where:  $F_{\text{warp}}$  is tensile strength in warp direction of fabrics.

From equations (10) - (12),  $\Delta BHF$  and  $\Delta BHB$  were described with  $F_{\text{warp}}$  and *SS*. With  $F_{\text{warp}}$  and *SS* varied, the length and proportion of front and back dress were changed, therefor resulting in changes of  $\Delta BHF$  and  $\Delta BHB$ . Furthermore,  $\Delta BHB$  were more inclined to vary with *SS* rather than  $\Delta BHF$ .

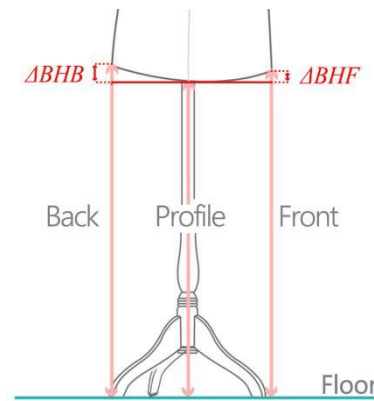
As figure 8 shows, with these algorithms of fabric properties, pattern block parameter and fit indexes, dress fit indexes were expressed by :

$$AF = f(B_{\text{warp}}, SS) \quad (13)$$

$$\Delta BH = f(F_{\text{warp}}, SS) \quad (14)$$

Where: *AF* is the angle of front contours as Figure 7,  $\Delta BH$  is the bottom height difference as Figure 8. With *AF* and  $\Delta BH$ , the fit of system “body-dress” were predicted as concrete indexes and values, which could be the convincing basic database for realistic virtual design.



**Figure 7.** Angle of front contours**Figure 8.** Bottom height difference

## 5. Conclusion

The synergy effects of textile materials, pattern block and clothing styles distinctly influence clothing fit, which are expressed by special algorithms of fit indexes. Fit and misfit can be predicted when shaping factors in system “body-dress” are fixed. The new database of fit variation mechanism to these synergy effects should be extended to virtual system “body-dress” to improve the simulation results.

In the future, we are going to increase the number of factors that affects clothes fit and misfit, the total database of fit variation mechanism of system “body-dress” will be investigated and utilized in virtual environments.

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