International Journal of Control and Automation
Vol.7, No.5 (2014), pp.123-132
http://dx.doi.org/10.14257/ijca.2014.7.5.14

Pattern Automatic Generation for Men's Trousers

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Abstract

The traditional pattern design methods used in the apparel industry basically relies on designers' experience, which leads to the inefficiency of clothing production. In order to solve the problem, a pattern automatic generation process for men's trousers is studied in this paper. According to the generation rules, the pattern will be automatically generated from the body measurements and the style design parameters; therefore, it will fit the customer's body as well as meet the needs of design.

Keywords: *men's trousers, pattern, automatic generation*

1. Introduction

The garment pattern plays a very important role in clothing production, it is the key to realize the ultimate goal of the apparel industry which is to design and produce well-fitted personalized garments for individuals. However in practice, the pattern design methods used in the apparel industry relies in large part on designers' experience, therefore it cannot be straightforwardly transferred to a computational procedure [1]. Such a difficulty is reinforced by several levels of design complexities that have to be faced while defining shape, assembly rules and aesthetic/functional details of real tailored garments [2]. In order to improve the garment pattern design process, especially the efficiency of the pattern generation, the automatic process without any pattern designers' additional work is studied. Because of the diversity of clothing, the pattern for each category will be different from each other; therefore, the pattern automatic generation can be studied separately according to the clothing category. Men' trousers which have relatively simple structure and less design elements are the appropriate category for getting a general research idea of garment pattern automatic generation.

The pattern automatic generation for men's trousers will both solve the fitting problem and meet the needs of design. Therefore, the body measurement data, the measurements' changes in body movement and the design elements should be all considered. The main idea of the pattern automatic generation is to solve one problem at a time, so the fitting pattern generation will be studied firstly. On the basis of the fitting pattern generation, the style design parameters will be involved, and eventually the pattern automatic generation for men's trousers will fit the customer's body as well as meet the needs of design.

2. Fitting Pattern Generation for Men's Trousers

The main purpose of fitting pattern generation for men's trousers is to realize the pattern automatically fit for customer's body as long as the body measurement data are provided. There are many methods can achieve this goal, some of them are focus on the

ISSN: 2005-4297 IJCA

modification of 2D patterns, and the others are focus on the 3D approaches; however, inaccuracy is the common defect. In order to improve the accuracy of the generated pattern, the pattern should be generated directly from the body measurement data; therefore, for each body the pattern will be customized.

2.1. Relationship between trousers' pattern and body measurement data

The study of the relationship between trousers' pattern and body measurement data is the first step to realize the pattern generate directly from the body measurement data. With the development of 3D body scanner, the scan data of body measurement are easier to obtain than manual measurement data. This technology realized the acquisition of dozens of body measurements in a short time, and these data will play an important role to the accuracy of the pattern which is generated automatically.

The men's trousers pattern is usually divided into two parts: the front piece and the back piece. The key points or lines on both pieces are related to some body measurement data, the details are in Table1 and 2. In order to simplify the description, the abbreviation for each body measure data is given in the tables.

Table 1. Relationship between front piece pattern and body measurement data

front piece pattern	body measurement data
waist girth line	front waist girth(FWG), height of waist girth(WH)
abdomen girth line	front abdomen girth(FA), height of abdomen girth(AH)
leg width line	front thigh girth(FTG), height of inside leg(ILH)
front centre seam	length of front centre seam(FCSL)
front rise	length of front rise(FRL) ,length of front centre seam
patella line	front knee girth(FKG), height of knee girth(KGH)
leg opening	front ankle girth(FAG), height of ankle girth(AGH)
front waist dart	front waist girth, height of waist girth front abdomen girth, height of abdomen girth
front side seam	outside leg length(OLL)
front inside seam	inside leg length(ILL)

Table 2. Relationship between back piece pattern and body measurement data

back piece pattern	body measurement data
waist girth line	back waist girth(BWG), height of waist girth
hip girth line	back hip girth(BHG), height of hip girth(HH)
leg width line	back thigh girth(BTG), height of inside leg
back centre seam	length of back centre seam(BCSL)
back rise	length of back rise(BRL) ,length of back centre seam
patella line	back knee girth(BKG), height of knee girth
leg opening	back ankle girth(BAG), height of ankle girth
back waist dart	back waist girth, height of waist girth back hip girth, height of hip girth
back side seam	outside leg length
back inside seam	inside leg length

2.2. Numerical correspondence between pattern and body measurement data

The numerical correspondences between men's trousers pattern and men's body measurement data is the foundation of the fitting pattern generation. The numerical correspondences are very clear except the darts and the curves of front rise and back rise, therefore a lot of experiments were conducted to determine the specific numerical relationship.

The experiments started with a lot of body measurement, and large number of men's body measurement data ware collected. Then, all the data are analyzed by SPSS, and based on the result a series of mannequins were established for the draping experiments. The purpose of the draping experiments is to obtain the patterns of men's trousers corresponding to the mannequins, and the obtained patterns are measured in many ways to get a series of regression equations.

In order to solve the problem of the darts, the front abdomen girth, height of abdomen girth, front waist girth, height of waist girth, back waist girth, back hip girth and height of hip girth of the obtained patterns are measured. The darts problem is only related to two variables for both patterns. In the front piece pattern case, one is so-called AWG which is the value of front abdomen girth minus front waist girth; the other is so-called WAH which is the value of height of waist girth minus height of abdomen girth. And in the back piece pattern case, one is so-called HWG which is the value of back hip girth minus back waist girth; the other is so-called WHH which is the value of height of waist girth minus height of hip girth. The measurement data from the obtained pattern are analyzed by SPSS, and the results of regression analysis are as follows:

FWDA(amount of front waist dart)=-1.762+0.522×AWG;
FWDL(length of front waist dart)= -1.122+0.092×AWG+0.990×WAH;
EFSA(amount of ease in the front side seam)= 0.793+0.100×AWG-0.074×WAH;
BWDA1(amount of back waist dart which is close to the back centre seam)
= 2.916+0.106×HWG-0.105×WHH;
BWDL1(length of back waist dart which is close to the back centre seam)
=-4.856+0.995×WHH;
BWDA2 (amount of back waist dart which is close to the back side seam)
=2.931+0.105×HWG-0.107×WHH;
BWDL2(length of back waist dart which is close to the back side seam)
=-5.906+ 0.997×WHH;
EBSA(amount of ease in the back side seam)=1.121+0.038×HWG-0.040×WHH;
ESL(length of ease in the side seam)= -3.640+0.897×WHH.

As for the problems of the front rise curve and the back rise curve, in order to solve it, Cartesian coordinate systems are created on both patterns (Figure 1 and 2), but there are a little differences between them. Since the line of front rise is obvious curve form the point which 6 cm above the leg width line to the point at the leg width line and the rest part is nearly straight, the Y-coordinate range of the front rise curve which is from the point that 6 cm above the leg width line to the point at the leg width line is divided into five equal divisions. However, the whole line of back rise is curve; so the Y-coordinate range of the back rise curve is directly divided into five equal divisions. Therefore, there will be five sets of coordinates on the front piece pattern as well as the back piece pattern which will be used to determine the curves. All the coordinates of the obtained pattern are carefully marked and measured, and the measurement data are analyzed by SPSS.

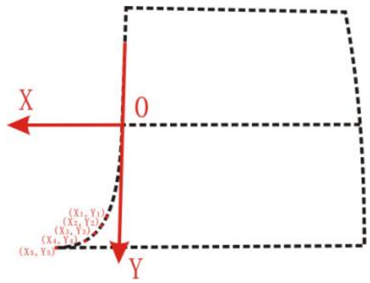

Figure1. Front rise

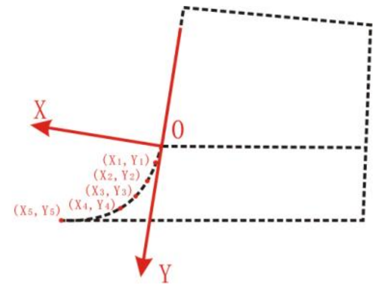

Figure2. Back rise

The results of regression analysis are as follows:

Front piece X_1= -0.051+0.026×FA;
Front piece X_2= -0.575+0.049×FA;
Front piece X_3=0.553+0.051×FA;
Front piece X_4= 0.466+0.076×FA;
Front piece X_5= 1.213+0.100×FA;
Front piece Y_1=23.918-0.985×WAH;
Front piece Y_n= Y_1×n, 2≤n≤5;
Back piece X_1=0.41cm;
Back piece X_2= 0.412+0.014×BHG-0.009×WHH;
Back piece X_3= 1.775+0.012×BHG-0.020×WHH;
Back piece X_4= -2.861+0.100×BHG+0.078×WHH;
Back piece X_5= 4.397+0.100×BHG+0.002×WHH;
Back piece Y_1=5.388-0.199×WHH;
Back piece Y_n= Y_1×n, 2≤n≤5.

2.3. Pattern adjustments

Since the changes in body movement will lead to the changes in body measurement data, four postures (Figure 3) such as leg rise 90°, bend 90°, leg back lift 45° and natural squat are considered in the measurement experiments to determine the maximum change of each key parts which will influence the circumference ease of the pattern.

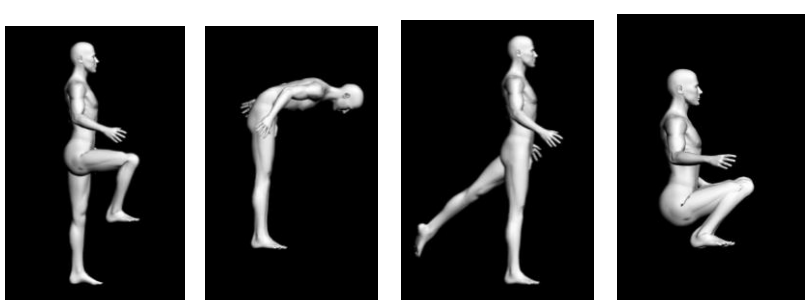

Figure 3. Four postures in experiments

The experimental data are analyzed by SPSS, and the pattern adjustments according to the results of regression analysis are in Table3.

Table 3. Adjustments of relative parts of men's trousers pattern

fitting pattern of men's trousers	men's body measurement data
abdomen girth of front piece pattern	0.013+0.220×AWG+FA
leg width of front piece pattern	0.073+1.050×FTG
patella line of front piece pattern	-0.689+1.115×FKG
hip girth of back piece pattern	-0.403+1.097×BHG
leg width of back piece pattern	-0.287+1.029×BTG

With all the numerical correspondences between men's trousers pattern and men's body measurement data, the fitting pattern generation rules can be formulated. Since the descriptions of the rules are very complex, and many rules will be repeated in the final generation rules, the specific descriptions are not given here. However, the patterns of men's trousers generated by the rules have been tested by fitting experiments, and the patterns are proved to be very suitable to the bodies.

3. Pattern Automatic Generation for Men's Trousers

The fitting pattern generation for men's trousers is the foundation of the pattern automatic generation for men's trousers, but to realize the goal of meeting the needs of design, several key elements of style design will be considered.

3.1. Key elements of style design for men's trousers

According to the analysis of the basic styles of men's trousers, the key design elements were listed as follows:

(1) Waist girth line: the variation is mainly in the height, and with the change of height the waist girth will change to some extend as well. The variation of the height of waist girth will be described as ΔWH.

(2) Hip girth line: the variation is mainly in the circumference ease and related to the fitting of the trousers. The variation of the ease in front hip girth will be described as ΔFHG, and the variation of the ease in back hip girth will be described as ΔBHG.

(3) Front rise and back rise: the variation is mainly in the shape of the curve which was determined by five sets of coordinates, so the coordinates will change with the curve.

(4) Leg width line: the variations are mainly in the width and the height of the Leg width line. The variation of the width will be described as ΔLW, and the variation of the height of leg width will be described as ΔLWH.

(5) Patella line: the variations are mainly in width and the height of the patella line. The variation of the width will be described as ΔPW,and the variation of the height of patella line will be described as ΔPH.

(6) Leg opening: the variations are mainly in the width and the height of leg opening. The variation of the width will be described as ΔLOW, and the variation of the height of leg opening will be described as ΔLOH.

3.2. Automatic generation rules for men’s trousers pattern

The automatic generation rules for men’s trousers pattern is based on the fitting pattern generation rules; however, due to the style design parameters is included, the final generation rules are much more complex than the fitting pattern generation rules. The final generation rules involved the determination of a series of key points’ positions and the connection methods of these points.

3.2.1. Generation rules for the front piece pattern of men’s trousers:

The generation rules for the front piece pattern is described based on the key lines and points of the front piece pattern of men’s trousers which are shown in Figure4.

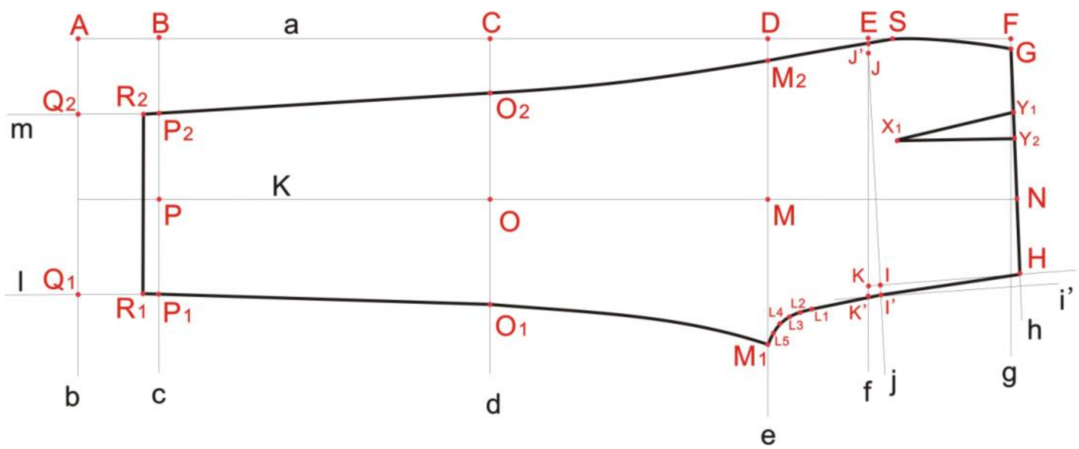

Figure 4. Front piece pattern of men’s trousers

(1) Line a is a horizontal reference line.

(2) Line b is vertical to line a; line b and line a intersect at point A.

(3) On the line a, AB= AGH+ΔLOH; line c is vertical to line a and through point B.

(4) On the line a, AC= KGH+ΔPH; line d is vertical to line a and through point C.

(5) On the line a, AD= ILH+ΔLWH; line e is vertical to line a and through point D.

(6) On the line a, AE= HH; line f is vertical to line a and through point E.

(7) On the line a, AF= WH+ΔWH; line g is vertical to line a and through point F.

(8) On the line g, FG= EFSA×(ESL+ΔWH)/ESL; line h is though point G and the angle between line h and line g=tan-1[(FCSL-WAH)/(FA-EFSA)]; on the line h, GH= (1.058×FWG+0.522×AWG-1.876)cm; connect point G, H with straight line.

(9) Line i is vertical to line h and through point H; on the line i, HI= FCSL.

(10) Draw a circle which center is point I and radius is (0.013+0.220×AWG+FA) cm; the arc and line f intersect at point J.

(11) Line f and line i intersect at point K. On line f, KK’=ΔFHG/2; line i’ is parallel to line i and through point K’; line i’ and line j intersect at point I’; connect point H, I’ with straight line.

(12) Line i' and line j formed a Cartesian coordinate system; line j will be X-axis and line i' will be Y-axis. In the coordinate system, the coordinates of point L_1, L_2, L_3, L_4 and L5 can be used directly, and in the initial state, the coordinates of point L_1 should be(-15.886+0.408 ×FWG,23.918-0.985×WAH);the coordinates of point L_2 should be (-16.841+0.437×FWG, 24.518-0.985×WAH); the coordinates of point L_3 should be (-20.168+0.516×FWG,25.118-0.985×WAH); the coordinates of point L_4 should be (-24.935+0.643×FWG,25.718-0.985 ×WAH); the coordinates of point L_5 should be (-34.716 +0.894×FWG,26.318-0.985× WAH); connect point I', L_1 with straight line, and connect Point L_1, L_2, L_3, L_4 and L_5 with smooth curve. Draw a circle which center is point L_5 and radius is (FRL -length of the curve I'L_5), the arc and line e intersect at point M_1; connect point L_5, M_1 with straight line.

(13) On the line e, M_1M_2= (0.073+1.050×FTG+ΔLW/2) cm.

(14) On the line e, point M is the midpoint of line M_1M_2; line k is vertical to line e and through point M; line k and line h, d, c intersect respectively at point N, O and P.

(15) On the line d, OO_1= (-0.345+0.558×FKG+ΔPW/2) cm; on the line c, PP_1= FAG/2+ ΔLOW/2. When point O_1 is on the right side of point P_1, connect point M_1, O_1 and P_1 with smooth curve; line l is vertical to line b and through point P_1; line l and line b intersect at point Q_1; on the line P_1Q_1, P_1R_1=ILL-ΔLOH-length of curve M_1P_1. When point O_1 is on the left side of point P_1, connect point M_1, P_1 with straight line; line l is vertical to line b and through point P_1; line l and line b intersect at point Q_1; on the line P_1Q_1, P_1R_1=ILL-ΔLOH-length of line M_1P_1.

(16) On the line a, FS= ESL+ΔWH; on the line f, JJ'=ΔFHG/2; on the line d, OO_2= (-0.345+0.558×FKG+ΔPW/4) cm; on the line c, PP_2=FAG/2+ΔLOW/4. When point O_2 is on the right side of point P_2, connect point S, J', M_2, O_2 and P_2 with smooth curve; line m is vertical to line b and through point P_2; line m and line b intersect at point Q_2; on the line P_2Q_2, P_2R_2=OLL-ΔLOH-length of curve M_2P_2. When point O_2 is on the left side of point P_2, connect point S, J', M_2 and P_2 with smooth curve; line m is vertical to line b and through point P_2; line m and line b intersect at point Q_2; on the line P_2Q_2 , P_2R_2=OLL-ΔLOH-length of curve M_2P_2. Connect point G, S and point R_1, R_2 with straight line,

(17) On the line h, the midpoint of line GN is the position of front waist dart, and FWDA=(1.762+0.522×AWG)×(1.122+0.092×AWG+0.990×WAH+ΔWH)/(1.122+0.092 × AWG+0.990×WAH)cm; FWDL=(-1.122+0.092×AWG+0.990×WAH+ΔWH)cm.

3.2.2. Generation rules for the back piece pattern of men's trousers:

The generation rules for the back piece pattern is described based on the key lines and points of the back piece pattern of men's trousers which are shown in Figure5.

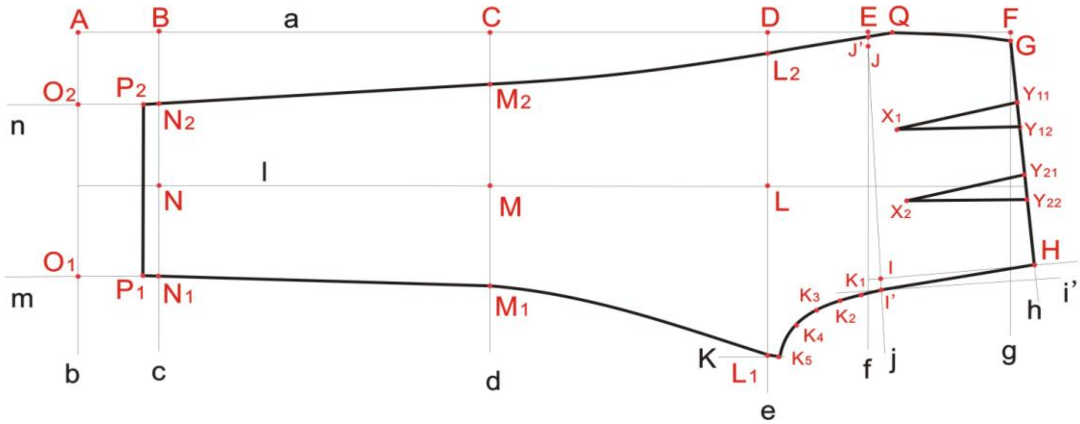

Figure 5. Back piece pattern of men's trousers

(1) Line a is the horizontal reference line.

(2) Line b is vertical to line a; line b and line a intersect at point A.

(3) On the line a, AB= AGH+ΔLOH; line c is vertical to line a and through point B.

(4) On the line a, AC= KGH+ΔPH; line d is vertical to line a and through point C.

(5) On the line a, AD= ILH+ΔLWH; Line e is vertical to line a and through point D.

(6) On the line a, AE= HH; line f is vertical to line a and through point E.

(7) On the line a, AF= WH+ΔWH; line g is vertical to line a and through point F.

(8) On the line g, FG= EBSA×(ESL+ΔWH)/ ESL; line h is though point G and the angle between line h and line g= $\tan^{-1}$[(BCSL-WHH)/(BHG-EBSA)]; GH=(1.057×BWG+0.211× HWG-0.212×WHH+5.647) cm; connect point G, H with straight line.

(9) Line i is vertical to line h and through point H; on the line i, HI= BCSL+ΔWH.

(10) Draw a circle which center is point I and radius is (0.047+1.189×BHG) cm; the arc and line f intersect at point J; line j is vertical to line i and through point I; on the line j, II'=ΔBHG/2; connect point H,I' with straight line.

(11) Line i' is parallel to line i and through point I'; line i' and line j formed a Cartesian coordinate system; line j will be X-axis and line i' will be Y-axis. In the coordinate system, the coordinates of point K_1, K_2, K_3, K_4 and K_5 can be used directly, and in the initial state, the coordinates of point K_1 should be (0.41,5.388-0.199×WHH); the coordinates of point K_2 should be (0.412+0.014×BHG-0.009×WHH, 10.776-0.398×WHH); the coordinates of point K_3 should be(1.775+0.012×BHG-0.020×WHH,16.164-0.597×WHH); the coordinates of point K_4 should be (-2.861+0.100×BHG+0.078×WHH,21.552-0.796×WHH); the coordinates of point K_5 should be (6.298+0.120×BHG,26.94-0.995×WHH); connect Point I', K_1, K_2, K_3, K_4 and K_5 with smooth curve. Line k is vertical to line e and through point K_5; Line k and line e intersect at point L_1.

(12) On the line e, L_1L_2= (-0.287+1.029×BTG+ΔLW/2) cm.

(13) On the line e, point L is the midpoint of line L_1L_2; line l is vertical to line e and through point L; line l and line d, c intersect respectively at point M and N.

(14) On the line d, MM_1= BKG/2+ΔPW/2; on the line c, NN_1= BAG/2+ΔLOW/2. When point M_1 is on the right side of point N_1, connect point K_5, M_1 and N_1 with smooth curve; line m is vertical to line b and through point N_1; line m and line b intersect at point O_1; on the line N_1O_1, N_1P_1=ILL-ΔLOH-length of curve K_5N_1.When point M_1 is on the left side of point N_1, connect point K_5, N_1 with straight line; line m is vertical to line b and through point N_1; line m and line b intersect at point O_1; on the line N_1O_1, N_1P_1=ILL-ΔLOH-length of line K_5N_1.

(15) On the line a, FQ= ESL+ΔWH; on the line IJ, JJ'=ΔBHG/2; on the line d, MM_2=BKG/2+ΔPW/4; on the line c, NN_2=BAG/2+ΔLOW/4. When point M_2 is on the right side of point N_2, connect point Q, J', L_2, M_2 and N_2 with smooth curve; line n is vertical to line b and through point N_2; line n and line b intersect at point O_2; on the line N_2O_2, N_2P_2=OLL-ΔLOH-length of curve L_2N_2 .When point M_2 is on the left side of point N_2, connect point Q, J', L_2 and N_2 with smooth curve; line n is vertical to line b and through point N_2; line n and line b intersect at point O_2; on the line N_2O_2 , N_2P_2=OLL-ΔLOH- length of curve L_2N_2. Connect the point G, Q and point P_1, P_2 with straight line.

(16) On the line h, the two trisection points of line GH are the positions of back waist darts, and BWDA1=(2.916+0.106×HWG-0.105×WHH)×(-4.856+0.995×WHH+ΔWH)/(-4.856+0.995×WHH)cm, BWDL1=(-4.856+0.995×WHH+ΔWH)cm; BWDA2= (2.931 +0.105×HWG-0.107×WHH)×(-5.906+0.997×WHH+ΔWH)/(-5.906+0.997×WHH)cm, BWDL2=(-5.906+0.997×WHH+ΔWH) cm.

4. Application of the Generation Rules for Men's Trousers Pattern

The generation rules for men's trousers pattern can be programmed, and since the body measurement data is the foundation of the pattern automatic generation, the interface of body measurement data input should be involved firstly in the program. And the input can be manually or use the data of 3D body scanner directly.

Due to the generation rules make the body measurement data and the style design parameters work together, the program should contain the style design interface in either 2D or 3D circumstance. In the 3D circumstance, the design interface will be more intuitive, there should be a 3D mannequin with a trousers prototype on it, the style design elements will be displayed in the form of feature points on the trousers prototype, and the design process is to decide the new position of these feature points. The original positions of the points in the space are saved, and will work with the new positions to receive a series of style design parameters.

In the 2D circumstance, since the mannequin and the trousers prototype are three-dimensional, the method applied to transfer them to fit for the 2D interface is very important. Because style changes of trousers can be seen clearly form the side, there are two methods for expressing the style design process for men's trousers in 2D forms; one is using both the front image and the side image which has more details in style design, the other is using the side image only which is relatively simple. The style design elements will be displayed in the form of feature points on the trousers image, and the style design parameters will be worked out by comparing the new positions to the original positions of the feature points. The feature points in the 2D circumstance will be less in amount and easier to adjust than in the 3D circumstance; therefore, a pattern generation system in 2D circumstance is programmed to verify the practicality of the generation rules, and the result is satisfactory.

As the foundation of the whole garment pattern automatic generation system, the pattern automatic generation for men's trousers still needs to be improved, especially in the style design aspect, and it requires some further work.

Acknowledgements

The work presented in this paper was supported by the Professor Guolian Liu and her research group at Soochow University.

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