Automatic Estimation of Body Measurements to Extract the Size and Body Shape

Mong Hien Thi Nguyen, Minh Hieu Tran

Abstract: This paper presents the research results of automatic estimation of the neck girth and inside leg to extract the size and body shape from the male sizing system table. The data used in the study is the 3D scan file *.obj from the 3D body scanner. The author uses the interpolation and optimization method in the algorithm to automatically extract 2 primary dimensions combined with the fuzzy logic method to extract sizes, body shapes. Besides, rotate matrix method combines with the optimal function used to write an algorithm to estimate the neck girth, inside leg measurements. Furthermore, a simple approach based on vertices and surface normal vectors data and optimal search was adapted to estimate the neck girth and inside leg measurements. These extraction results will be linked to the algorithm of the fuzzy logic to run for the automated process. This automatic algorithm will be very useful in face-to-face clothing purchases or online or for garment manufacturers in reducing shopping time and choosing sizes to design samples for customers.

Index Terms: Algorithm, Fuzzy Logic, Automatic estimation, Extract the size, 3D body scanner.

I. INTRODUCTION

The measurement of human body size in an industry usually uses two measurement methods, which are direct measurement method and indirect measurement method. Each measurement method has its advantages and disadvantages, depending on the purpose and conditions that the researcher chooses which method is suitable.

In the indirect measurement method, when taking measurements, measuring tools do not come into direct contact with the human body such as cameras, 3D body scanners, and then connect with supporting software to extract measurements. and save the body image [1], [2], [3], [4], [5], [6]. It can be said that 3D body scanning technology is increasingly being developed and applied in areas in the garment industry such as establishing the size chart, analyzing the body shape, researching the fit clothes, simulation, and pattern design, virtual costume design [7], [8], [9].

Results of the scanning depend on the scanning method and different phases of the scanning software such as camera accuracy, sensor, marker position.

Linear measurements are used when extracting measurements in costume research [10], [11]. Extracting body dimensions from 3D scans will contribute to clothing design, online sales, and virtual try [12], [13], [14], [15].

As well as updating anthropometric data, it will help garment companies ensure the good quality of their products [16], [17], [18]. Another study that is directly related to size extraction in this paper is the determination of the body's neck girth position for different types of neck shapes [19]. The authors use the data of the point coordinates on the mannequin, performs the plane, the cross-section of the collar position on the 3D scan. It shows that extracting measurements through 3D scanners is very practical. Therefore, automatic estimation of body measurements to extract size and body shape will be selected in this study.

II. MATERIALS AND METHODS

A. Material

This study uses images having format *. obj from the 3D data of young men arrange 18 to 25 years old. The men's size chart in the Vietnam Southern arranges from 18 to 25 years old [20]. The coding sizing system table.

B. Methodology

The methods are used in this study include the method of simulation, which is used to extract the size and the shape. Next, the method of the optimization function with the interpolation function is used to extract automatically the neck girth and the inside leg dimensions.

III. RESULTS AND DISCUSSION

A. Images from the 3D scanner

The 3D *.obj files used in this study were scanned from the SIZE STREAM brand 3D body scanner at the Industrial University of Ho Chi Minh City.

The person being scanned stands up straight, relaxes, his hands are on his side, his legs are creating a V-shape at an angle of 60°. In this position, when scanning, the machine's sensors will not scan hidden locations such as the inside leg and the crotch (Fig.1-a). Therefore, most scanners require the person being scanned to stand with shoulder width, arms not touching the hip (Fig.1-b).

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Fig.1 (a). The true posture; (b) The wrong posture.

B. The coding sizing system table

The coding sizing system table will be added to two information columns that are coding size column and the inside leg measurement column. The coding size column will be numbered from number 1 to number 24. Inside leg measurement is coded following the group, group A is 65cm, group B is 70cm, group C is 75cm, group D is 80cm and group E is 85cm. In this table, every group has the range of the inside leg is different (Table 1). This range is the standard deviation of the inside leg.

Table 1. The code of the size chart.

Group A: Inside leg length [62.5-67.5] (cm)				
Sign size	65/A1-1	71/A2-1	77/A3-2	83/A4-2
Code size	1	2	3	4
Code shape	1	1	2	2
Group B: Inside leg length [67.5-72.5] (cm)				
Sign size	65/B5-1	71/B6-1	77/B7-2	83/B8-2
Code size	5	6	7	8
Code shape	1	1	2	2
Group C: Inside leg length [72.5-77.5] (cm)				
Sign size	65/C10-1	71/C11-1	77/C12-2	83/C13-2
Code size	10	11	12	13
Code shape	1	1	2	2
Group D: Inside leg length [77.5-82.5] (cm)				
Sign size	65/D15-1	71/D16-1	77/D17-2	83/D18-2
Code size	15	16	17	18
Code shape	1	1	2	2
Group E: Inside leg length [82.5-85] (cm)				
Sign size	65/E20-1	71/E21-1	77/E22-2	83/E23-2
Code size	20	21	22	23
Code shape	1	1	2	2

C. Flowchart to automate to extract the body size, shape

Researching on extracting the size and body shape from the results of establishing the size chart is done through the flowchart of the algorithm to estimate the neck girth and the inside leg to automatically extract on Matlab software (Fig. 2).

Fig.2. Automated flowchart for extracting size and body shape from 3D scanner data.

D. The process of automating the body scan to extract the size and body shape

The automation of the process of extracting the size/body shape is written by the algorithm to estimate the neck and the inside leg measurements on Matlab software. In the options, theta is the angle between the plane D and the floor, the D-plane contains the neck hollow and is perpendicular to the model's symmetry plane.

Estimating the neck girth by scan neck hollow

From 3D scanning of data by taking data point, a legal vector of the file *.obj (Fig.3). A point on scan data about the model is being defined by a vector $p = [v_x \ v_y \ v_z \ v_{n_x} \ v_{n_y} \ v_{n_z}]^T$ with v_x, v_y, v_z are elements of the point's position vector, $v_{n_x}, v_{n_y}, v_{n_z}$ are the elements of the point's vector norm corresponding to the underlying coordinate axes, x, y, z . The process of estimating the neck girth in the first case will be done through 4 stages (Fig.4).

Fig.3. (a) The original coordinate system and the co-ordinate system at the cervical point; (b) The point coordinates and the vector on the scanned model are scanned.

Fig.4. The algorithm to estimate the neck measurement according to the first case.

The first stage: Preparing scanned model data and limiting data in the neck area. Next, looking for the neck hollow point. Assign the original scanning angle (Fig.5).

Fig.5. Limit scanning data at the neck area.

The second stage: Calculating the rotation matrix $Rot(x, -\theta_1)$. In there:

$$Rot(x, -\theta_1) = \begin{bmatrix} R_1 & O \\ O & I \end{bmatrix}, \quad R_1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(-\theta_1) & -\sin(-\theta_1) \\ 0 & \sin(-\theta_1) & \cos(-\theta_1) \end{bmatrix};$$

$O_{3 \times 3}, I_{3 \times 3}$ corresponding are the zero vector and the unit vector with θ_1 is the angle from the OXZ plane to an plane having OX and through neck limit. Then looking for set S (set of neighborhood points intersecting the 3D scan and the D plane). Projecting the points of the set S on the D plane results in set $S1$. Next, convert the points of $S1$ to the horizontal plane (by rotating $S1$ by $Rot(x, -\theta_1)$), there is set $S2$. During the creation $S2$ phase will assign the distance to

the limit point of 0 and then calculating the distance from point $N1$ to D plane, resulting in the number of points within the allowable distance (not more than 6). If this requirement is good, a set of points S in the locus will be given. Conversely, if it does not good, will increase the allowable distance of the limit, then start to refine the distance from the point $N1$ to the D plane until finding points S in the vicinity.

The third stage: Finding C center point of the $S2$ points' set

Convert the points in $S2$ to the H center polar coordinates, this will become $S3$. In the third stage, will be looking for the C center point having the sum of squared distances to the points $S3$ minimum is min.

The fourth stage: Interpolating neck curve

Interpolating the curve through the $S5$ points by the Spline / Hermite curve corresponds to a θ_1 value. Calculating the neck girth through measuring the length of the closed Spline which is just determined. Next, checking the scanning angular satisfies the conditions $\theta_1 = \theta_{1max}$. If satisfied, end the fourth stage. On the contrary, $\theta_1 = \theta_1 + d\theta_1$ this section will go back to the matrix calculation $Rot(x, \theta_1)$ and follow the steps until the correct results are obtained to finish the process of measuring in this phase.

The fifth stage: Estimating the neck girth

Averaging the perimeters of the necks corresponding to the changes in θ_1 angular positions, then finding the smallest value within the limit θ_1 corner.

The algorithm to find the dimension of the inside leg

The first is to limit the points of the inside leg dimension range, then look for the point with the normal vector in the y -direction that has the maximum value. Next, calculate the height from the found result in the floor (Fig.6). This is the inside leg dimension height. The codes estimate the neck girth and the inside leg that is embedded in the algorithm extracting by the fuzzy logic to get the results about the size and body shape.

Fig.6. The algorithm of the estimation of the inside leg measurement.

E. The result of the automation for extracting the size and the shape

The results of dimensions and extraction body's size/shape by the method of inputting data directly into the simulation program and the automating method. The results after running the algorithm have samples with the same results as the body size data. However, there are other samples with body size data. The cause is usually people with incorrect scanning posture, making the algorithm scan the wrong position of the collar or the measurement is out of boundary conditions, or overweight people standing with legs are not wide enough, leading to incorrect measuring distance (Fig.7).

Fig.7. The sample's images in the head of the forward-leaning.

IV. CONCLUSION

The study on automating estimates the neck girth and inside leg measurements to extract the size and body shape. Firstly, an algorithm model to extract according to the simulation method on Matlab software with 2 input variables, size girth and inside leg. Secondly, the process of automating the extraction of the body's size and shape on the 3D scan data through the algorithm estimates neck girth, inside leg measurements are done. The neck girth is to perform a scan of the neck area through the scan angle created by the plane containing the neck hollow point with the plane of the floor. The inside leg area is defined from the crotch to the floor. Next, calculating the perpendicular distance from the crotch to the floor. Besides, the study has analyzed the results when the automation method compared with the results by the simulation method, showing that the scan samples with correct scanning standing posture will give the same results. On the contrary, the different results are due to incorrect positions to scan the sample, there are samples with small size deviations.

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