A Novel Body Feature Point Extraction Method Based on 2D Image

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Abstract: In non-contract anthropometric measurements, the accurate location of body feature points is the basis of body dimension data. The traditional corner based feature point location method may involve errors due to the body shape variations. In this paper, we propose a novel body feature points location method. First, the human body contour is extracted with Otsu algorithm and Canny edge detection algorithm. Then, human height is obtained by horizontal scanning algorithm. Furthermore, we propose the shoulder location algorithm based on shoulder slope and curvature to locate the shoulder points. Finally, the rest body feature points are determined with three factors: the proportional relationship between body parts and height, corners and symmetry of human body contour. The experimental results show that the proposed method can accurately locate the body feature points and solve the issue of the loss of feature points of human waist and chest.

1. Introduction

In recent years, due to the rapid development of modern digital cameras, the quality of photographed images has been improved, there are more and more researches on the measurement of the key points of human body. The traditional contact measurement method is based on the experience of experienced gauges and physiologists. Specifications for physical experience and long-established measurement techniques use a flexible ruler to measure the size of the subject. This method is easy to operate. Concept, low cost, but manual operation means uncertainty, diversity and huge human resources costs.

Non-contact anthropometric technology makes up for the shortcomings of manual measurement and makes the measurement results more accurate and reliable. Many research institute and the garment factories are committed to the study of contactless three-dimensional anthropometry. The most common non-contact three-dimensional anthropometric method by body scanner to achieve the digitization of human size, can accurately reflect the key to the human body, but the cost of scanning the human body instruments is expensive and difficult to popularize[1, 2].Kinect such devices are reconstructed from freely rotating objects using sensors3D Mannequin, however, special equipment is require for testing and experiment, which is costly[3]. In addition, with the continuous release of large-scale human body scan data sets, the use of human body model generation and data mining algorithms to reconstruct a personalized human body model can obtain rich body shape information and better restore the human body three-dimensional model. But the method involves the privacy of the user and the processing of a large number of image files is very slow [4, 5, 6].

Because the size information of the key parts of the human body plays an important role in the actual garment market industry, Therefore, the non-contact anthropometric method based on 2D images utilizes two photos of the front and side of the human body to quickly extract key points of the human body, thereby obtaining body size information. The human body key point extraction based on the 2D image encodes the human body contour obtained from the human body image, and then the human body contour coding sequence is processed to obtain the human body key points [7, 8], but due to the variability and uniqueness of the human body contour shape , often can not

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accurately extract the key points of the human body.

In this paper, a calibration method of human key points based on 2D image is presented. The key points of human body are calibrated by taking two pictures of the front and side of the human body. The key points of the human body can be used to calculate the relative size information of the human body. Compared with the previous methods of human key extraction based on 2D image, first of all, this paper is independent of the detection of human key points, and does not use the main human key points to extract the secondary human key points. Secondly, the key points of the key parts of the human body with practical production significance are extracted in order to further fit the circumference size of the human body. Calculate and apply the relevant human body size information needed in the actual garment production; Finally, combining human aesthetics with anthropometric, the range of key parts of the human body is determined by the proportional structure of the human body, and then the human body outline is used to calibrate the key points of the human body.

2. Key Point Extraction

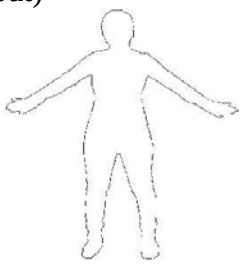
2.1. Shooting and Preprocessing.

In order to reduce the influence of human factors and light conditions, the SONYa6000 camera was set on a tripod with a distance from the background of 3 m and a height of 1 m, and the camera was photographed under bright and uniform white incandescent light. The image captured by the camera can remove some shadows and jitter, with a size of 6000 × 4000 pixels. In order to make the calculation of human outline simple, the front and side images were cut to 2000 × 2559 and 673 × 2670 pixels, respectively.

In order to reduce the influence of background on human outline extraction, the clothing color and background color of the photographers should have the maximum contrast relationship as much as possible. Therefore, the volunteers were asked to wear black suit and stand in front of the pure white background and take two photos from the front and side respectively. As shown in figure 1 (a), a female volunteer stands upright, with his arms straight and about 45 degrees with his body, and his legs separated at an angle of about 30 degrees, as shown in figure 1 (d) standing upright for the volunteer. A side image of your hands placed side by side at the seam of your trousers. The rest of this experiment is based on images taken by the volunteer carried out)

(a) Front view of human body

(b) Human face binary image



(c) Front profile of human body

(d) Human profile map (e) Binary image of human body side (f)Body side outline map.

Fig. 1 positive side view of human body

2.2. Human Body Segmentation and Contour Detection

When the front and side images of human body are obtained, the image is segmented by threshold processing, and the outline image of human body is obtained. For the image f (x, y), any

point satisfying f (x, y) ≥ T (x, y) becomes the front spot, and the other points are called the back spot. The threshold processed image g (x, y) is defined as:

$$g(x,y) = \begin{cases} 1 & if \quad f(x,y) \geq T \\ 0 & if \quad f(x,y) < T \end{cases}$$

In this paper, Otsu method is used to calculate the threshold, and the foreground part after segmentation is the outline of human body, as shown in figure 1 (b) (e), the front binary image of human body and the binary image of lateral human body are shown in Fig. 1

The edge outline of human body is extracted by Canny edge detection operator [9] for the segmented binary image of human front and side. The extracted edge outline of human body is single pixel and is a closed curve. As shown in figure 1 (c) (f). The edge outline of the front and side of the human body is defined by C^f and C^s, respectively:

$$C^f = \{f_1, f_2, \cdots, f_i, \cdots, f_m\}, \quad C^s = \{s_1, s_2, \cdots, s_i, \cdots, s_n\}$$

f_1 and s_1 are the starting points of the front and side contours of the human body, respectively, the first point in the upper left corner of the human contour; fi and si are the ***i***-th points of the front and side contours of the human body in the clockwise direction; The front contour of the human body has a total of ***m*** contour points, and the side contours have a total of ***n*** contour points.

In order to simplify the calculation and processing of human contour, Freeman's 8connected chaincords method[10]is used to code the human contour. The range of f_1 and s_1 is:

$$f_i \in \{0,1,2,3,4,5,6,7\}, \quad s_i \in \{0,1,2,3,4,5,6,7\}$$

The number from 0 to 7 represents each clockwise rotation of 45 degrees, encoding the outline of the human body in eight directions, and "0" represents the direction pointing to the right. Starting from f_1 and s_1 in a clockwise direction, the front contour C^f and the side contour C^s of the human body are encoded.

3. Calibration of Key Points of Human Body

According to the human body contour, because of the special geometric shape of the human body contour, the head point, the left foot point and the right foot point, the left hand finger point and the right hand finger point, the crotch point can be obtained by scanning. The head point on the side of the human body, the midpoint of the foot, as shown in figure 4. Among them, for the contour shape of the front human body, the head point F1 is the top left corner, the left foot F8 and the right foot F10 are the lowest and lowest right, respectively, the left finger point F4 and the right finger point F14 are the most left point and the most right point, the crotch point F9 is the highest point with a horizontal difference of no more than 20 pixels from the head point. For the profile of the lateral human body, the head point S1 is the highest point in the upper left corner, and the midpoint S7 in the foot is the lowest point in the lower left corner. The height difference between the front human head point, the left foot point and the right foot point is calculated separately, and the average value is the front human body height ***hf*** and ***hs***, and the average values of ***hf*** and ***hs*** are calculated as the final human body height ***h***.

In the previous study, Freeman's 8-connected chain codes method was used to detect all inflection points Tf and Ts in the frontal human contour and the lateral human contour. The condition that the contour point becomes the inflection point is:

$$|f_i - f_{i-1}| = 2\,,\ i = 2,\cdots m$$

$$|s_j - s_{j-1}| = 2\,,\ j = 2,\cdots n$$

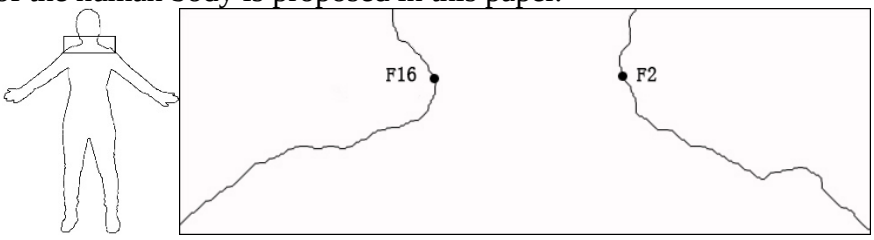
Among them, fi-1 and si-1 are the previous inflection points, respectively, and f1 and s1 are the starting points, that is, the head points F1 and S1 of the front and side human contours. The absolute value of the difference between the two inflection points is 2, that is, the angle between the two inflection points is different by 90 degrees. An inflection point in which the angles of the front and side human contours differ by 90 degrees are detected. Due to the variability of the contour of the human body, the inflection point obtained after the detection is not necessarily the key point of the human body, as shown in Fig. 2, therefore, it is necessary to further accurately calibrate the key points of the human body for the key parts of the human body where the key points of the human body are located.

Due to the special structure of the human body, there is a certain proportional relationship between the various parts of the human body and the height of the human body. In this paper, the fifth Size Korea database [11] is used to measure the average and range values of the ratio of height to height h of the human body obtained by 3DM random measurement of men and women aged between 20 and 60, as shown in Table 1. More than 99% of the subjects had a height within the ratio of height to height.

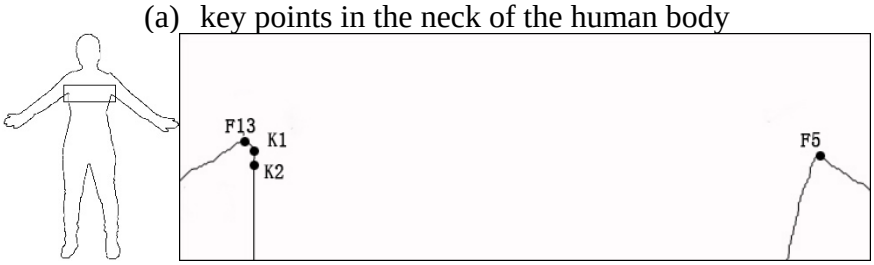
Table 1 ratio of height to height of key parts of the human body

Human body part	Woman	Man
Crotch	0.444(0.407-0.481)	0.441(0.401-0.481)
Neck	0.813(0.792-0.833)	0.815(0.794-0.835)
Shoulder	0.807(0.783-0.831)	0.808(0.781-0.836)
Chest	0.712(0.674-0.751)	0.716(0.688-0.745)
Loin	0.615(0.578-0.652)	0.612(0.575-0.649)
Buttocks	0.551(0.493-0.609)	0.567(0.510-0.624)

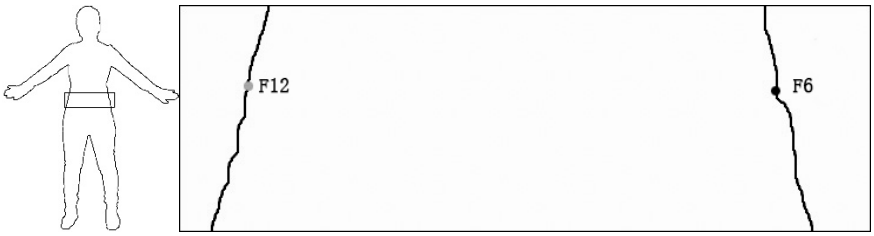
For the front profile of the human body, the left and right inflection points F2, F16 are detected within the height range of the human neck, and the two inflection points are marked as the right neck point F2 and the left neck point F16 of the human body, as shown in figure 3 (a). Because of the difference of shoulder muscle uplift degree, the human body forms three different types of shoulder shape: plane shoulder shape, upper convex shoulder shape and lower concave shoulder shape. In the inflection point detection, the key points of the human body can not be detected in the range of the outline of the shoulder. Therefore, a more accurate calibration method of the key points of the shoulder of the human body is proposed in this paper.



(a) key points in the neck of the human body



(b) Human chest key points.



(c) key points in the waist of the human body

Fig. 2 schematic diagram of key points in human body

The shoulder of the human body is provided with a certain inclination from top to bottom, and the angle between the lateral neck point and the shoulder point is indicated by the shoulder slope when the garment is measured, and the key point calibration of the shoulder point is performed by using the detected neck point and the shoulder slope. As shown in Fig. 3, N(x1, y1) is a key point of the human body neck, and the human shoulder point candidate point S(x, y) is detected by the following rules:

$$\tan^{-1}\frac{|y-y_1|}{|x-x_1|} = \text{Shoulder slope}$$

The shoulder slope of this article is set to 20 degrees, The point Si(xi, yi) that satisfies the condition as shown in Fig. 3 is marked as a candidate point for the human shoulder. Then, the shoulder candidate with the largest curvature in the range of the human shoulder contour {Si-m(xi-m, yi-m), ..., Si(xi, yi), ..., (xi+m, yi+m)} Point S(x,y) is adjusted to shoulder point:

$$C_i = \cos^{-1}\frac{((x_{i+n}-x_i)(x_{i-n}-x_i)+(y_{i+n}-y_i)(y_{i-n}-y_i))}{\sqrt{(x_{i+n}-x_i)^2+(x_{i+n}-x_i)^2}\sqrt{(x_{i-n}-x_i)^2+(y_{i-n}-y_i)^2}}$$

$$C = \max\{C_{i-m},\cdots,C_i,\cdots,C_{i+m}\}$$

In this paper, the m value is 30, the n value is 5.

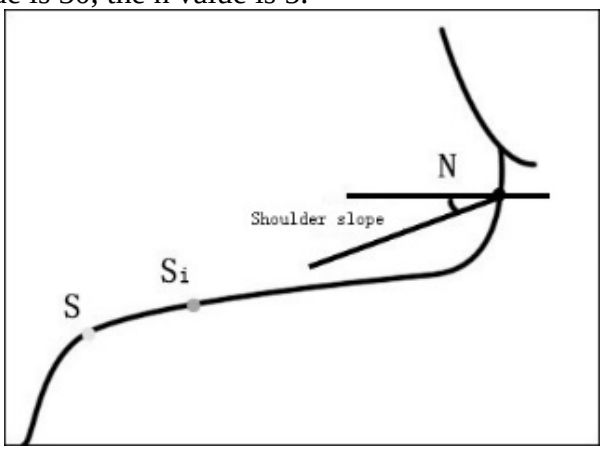
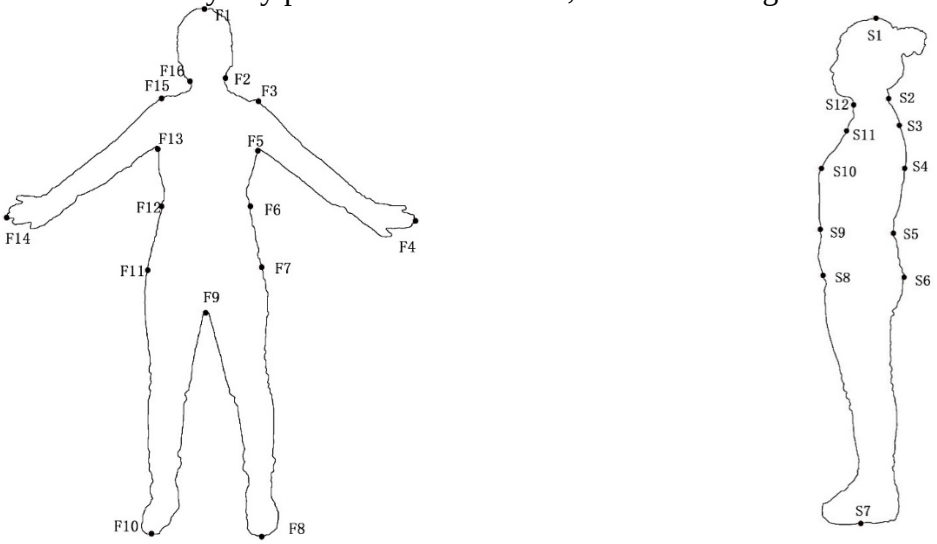


Fig. 3 schematic diagram of key points in human shoulder

Using the proportion relation of human body structure and symmetry of human body contour shape, the key points of human body are calibrated in the height range of other key parts of human body outline. For example, four inflection points F5, F13, K1, K2 are detected in the range of human chest height. The left inflection point F13, which is closest to the height of the human chest, is marked as the left chest point, and the right inflection point F5 is marked as the right chest point, as shown in figure 3 (b);. An inflection point F6 was detected in the range of shoulder height. The inflection point F6 was marked as the right waist point, and the human outline point with head height difference of h × 0.807 was marked as left shoulder point F3 according to the symmetrical relationship of human body, as shown in figure 3 (c). . Similarly, a total of 16 human body key

points and 12 lateral human body key points can be detected, as shown in figure 4.



(a) Human body Front Contour key Point (b) Human side Contour key Point

Fig. 4 key points of human body profile

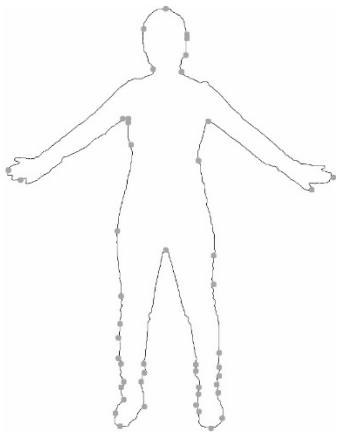
4. Evaluation of Key Points Extraction

In order to verify the robustness and practicability of the proposed method, 20 volunteers, including 10 women and 10 men, were tested to obtain nine groups of key human parts (head, neck, shoulder, fingertip). The chest, waist, buttocks, crotch, and sole of the human body total 16 key points, and the profile of the side human body includes seven groups of key parts of the human body (head, neck, shoulder, chest, waist, buttocks, sole) totaling 12 key points of the human body. The detection rate of all key points in the human body is 100%, and the results are shown in Table 2.

Table 2 Experimental results of 20 volunteers by this method

number of people	sex	age	Positive key point	Side key	Detection rate
5	Men	20-30	16	12	100%
5	Men	30-40	16	12	
5	Women	20-30	16	12	
5	Women	30-40	16	12	

In fact, the human body outline contains a lot of information about the key points of the human body, and a lot of inflection points of the human body outline can be detected by Freeman's 8-connectted chain codes method, such as figure 5, 48 inflection points can be detected by the front human outline. 24 inflection points were detected in the profile of the human body on the side. It can be seen that for the front of the human body outline, human shoulder, waist, chest and other parts of the human body outline fluctuation can not completely detect the human body key points, and the human legs, feet, armpits will have a large number of human body key points; This is also the case with the profile of the side. Utilization This method can accurately calibrate the key points of the human body, solve the lack of the key points of the human body in the waist, chest and other key parts of the positive human body, and is more in line with the proportional relationship of the structure of the human body. Under the condition of considering practicability, some redundant key points of human body are abandoned, which meets the needs of relevant human body characteristic information in the actual garment industry.



(a) Human body Front Contour inflection Point (b) Human body side Contour inflection Point

Fig. 5 inflection point of human body profile

In the actual application of clothing customization industry, only some key parts of the human body size information are usually needed. Therefore, in order to cater to the human body size information used in the actual garment production, this paper marks several groups of human body key points from the human body outline which contains a large number of human body data information. The position definition of the key points of the human body and the related human body size information of the International Organization for Standardization revised clothing size Standard ISO 8559 [12] are shown in Table 3, 4.

Table 3 definition of key points of positive human body and related human body dimensions

Body region	Feature points	Position	Related body size
Head	F1	The top of the head	Height
Neck	F2、F16	Lateral intersection of neck and head	Neck circumference
Shoulder	F3、F15	Later shoulder	Shoulder length
Hand	F4、F14	Fingers roots	Sleeve Length
Chest	F5、F13	Intersection human torso and arms	Chest length
Abdomen	F6、F12	Waist	Waist length
Buttocks	F7、F11	Hip	Hip length
Crotch	F9	Intersection of legs	Pants length
Foot	F8、F10	The tips of the foot	Height

Table 4 definition of key points on the side of the human body and related human body dimensions

Body region	Feature points	Position	Related body size
Head	S1	The top of the head	Height
Neck	S2、S12	Lateral intersection of neck and head	Neck circumference
Shoulder	S3、S11	Later shoulder	Shoulder thickness
Chest	S4、S10	Intersection human torso and arms	Chest thickness
Abdomen	S5、S9	Waist	Waist thickness
Buttocks	S6、S8	Hip	Hip thickness
Foot	S7	The tips of the foot	Height

5. Conclusion

In this paper, a calibration method of human body key points based on 2D image is proposed. By

using this method, 16 key points of human body and 12 key points of human body in seven groups of key parts of positive human body outline can be extracted from nine groups of human body contours. The robustness and stability of the method are verified by experiments on the front and side images taken by 20 male and female volunteers of different ages. In addition, the key points extracted by this method can be further used in the analysis and size calculation of human body circumference, and can be applied to actual garment production, online garment customization and online human body size. Measurement [13: 18].

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