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Modified Algorithm of Figure Girth Calculation

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ABSTRACT: The article describes a method of measuring anthropometric parameters based on projection images. For improving measurements accuracy, it is proposed to modify the analytical expressions that more precisely describe the girth characteristics of the figure. Calculation of girth cut length is produced by the Ramanujan's formula of approximate contour length. On the basis of the proposed approach, algorithms and program software were devised for the remote measurements system of the human figure anthropometric characteristics based on its images at various angles. The sphere of use of the developed software is the organizations of light industry engaged in the development and application of automation tools for mass anthropometric studies of the population, automation of clothes (garment) designing and construction.

KEYWORDS: contactless method, girth measurements, cut outline, contour asymmetry.

I. INTRODUCTION

Methods for determining anthropometric parameters from human figure images are an important component of contactless figure measurement systems, anthropometric research and automation of clothing design. Despite a large number of technical means of 3D scanning, measurements of anthropometric parameters based on projection images do not lose their relevance due to their simplicity and sufficient accuracy. A distinctive feature of such methods is the use of analytical dependencies for the calculation of anthropometric parameters.

One of the key anthropometric characteristics of the figure is the girth length, measured in different cuts (sections) of the figure. The most important ones are the cuts of the neck, chest, waist and hips. Analysis of cut contours shows that the greatest variety of cuts shapes has a waist girth. This is due to the influence of various factors on the shape of the cut, which determines the type of body of the figure, the height-dimensional characteristics, the degree of fat deposits development and their distribution along the figure (body).

The present article is devoted to the development of the method of describing the waist cut shape from projection photographs taken from frontal and lateral projections, and the calculation of the corresponding girth parameters, taking into account the various factors of the composition of the figure.

II. LITERATURE SURVEY

A great deal of works [1-5] has been devoted to the development of methods for computing girth parameters. Various methods for calculating the length of the girth are proposed on the basis of the representation and approximation of the cut contours by various enclosed curves of the second and higher orders.

In work [1], a waist cut representation with help of an ellipse is considered. This representation can be used for standard figures, distinguishing by small growth sizes, asthenic body type. In work [2], the accuracy of describing the waist cut of a figure with the help of an ellipse was studied and it was shown that in a number of cases this approach gives a fairly acceptable accuracy. In work [3] the method of approximation of girth cut contours of the figure by circle

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arcs with different curvature was presented. The initial information for calculations is the 3D model of the measured surface of the figure. In work [4], regression models for calculating the girth parameters of a figure from front and side shots are proposed.

The representation and method for calculating the waist girth of an approximated enclosed curve, consisting of straight line segments and curves, for standard figures of small and medium sizes, was considered in work [5]. It is assumed that the outline of the contour is symmetrical with respect to the anteroposterior and frontal diameters of the cut, and their ratio is limited to a certain value. For calculation, only the anteroposterior and frontal diameters of the cut are used. Experiments have shown that the acceptable measurement accuracy is ensured.

Analysis of the cut contour shows that, as a rule, the outline of the waist contour is symmetrical only with respect to the sagittal (anteroposterior) diameter of the cut, and considerable asymmetry is observed with respect to the frontal diameter. It should be noted that the standard calculation technique recommends using the frontal plane of the figure gravity center [6].

In this paper we consider the approach to solving the problem of approximating the contour of a cut by second-order curves that overcomes this problem. At the same time, the asymmetry of the cut contour relatively to the frontal plane, as well as its displacement relatively to the observed center of the figure, is taken into account in the calculation.

III. ALGORITHM FOR WAIST GIRTH CALCULATION

As an example, in Figure 1, the outline of the waist cut of a real female figure of size 158 -96-108 (height, chest girth - the third, hip girth) was presented and developed on the basis of cuts obtained with stereo photogrammetric surveying for creating maquette of standard figures and industrial mannequins [7].

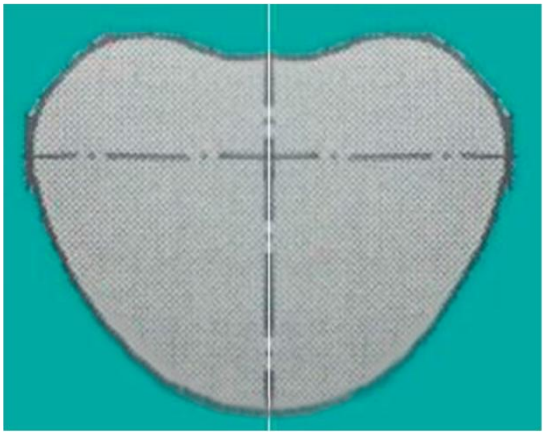

Fig1. The outline of the waist cut of a real female figure

In work [5], a method is proposed for calculating the waist for standard figures of small and medium sizes on the basis of the representation of the waist cut of a symmetric curve consisting of fragments of circles and straight segments (Fig. 2)

In this study, when calculating the girth length of the waist cut, it is assumed that the outline of the cut contour is asymmetric with respect to the front diameters of the cut, while the frontal plane of the figure passes through the most protruding lateral points of the figure, and the front axis is displaced posteriorly with respect to the observed center of the figure. Cut of the figure (neck, chest, waist hips) is represented as a curve, conjoined segments of a straight line and contours of ellipses.

For calculations, the data obtained from the images of figure in the frontal view (front and rear view) and profile view (the view from the left with the arm bent in the elbow) are used. The main vertical line passes along the line of the mid-

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sagittal cut of the figure on the frontal image and along the line of the front cut determined by the parameter T_{112} on the profile (lateral) image. Measurement of dimensional features from the photographic images of the figure and calculation of the waist girth is made by measuring the parameters:

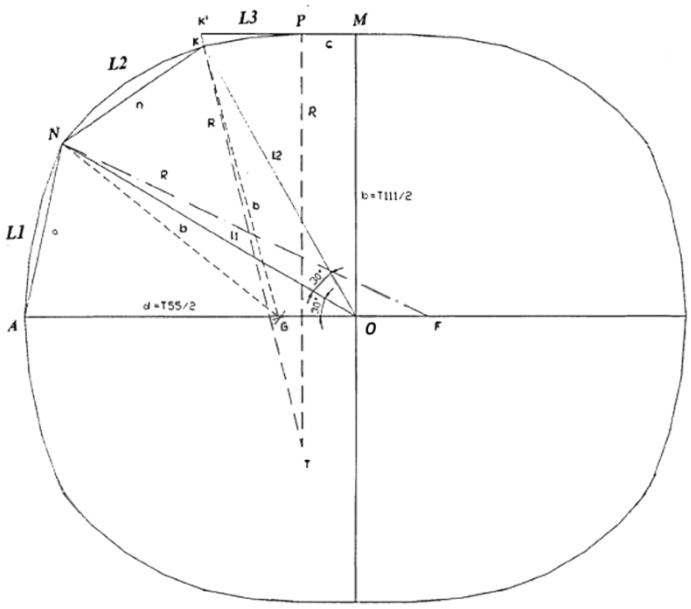

Fig2. The waist cut outline by method [5].

Sagittal (anteroposterior) waist girth diameter - T_{111}

Frontal (transverse) waist girth diameter - T_{55}

To determine the position of the frontal axis, an anteroposterior diameter is used, defined by the protruding points of the buttocks and abdomen T_{112}.

The displacement of the front axle is taken into account and the non-symmetry of the cut of the figure relative to the observed center of the figure is considered in work [8] when designing clothes. In this case, the calculation of the waist girth parameter of the figure is not considered. Figure 3 shows the contour of the cut used to calculate the length of the girth.

The front plane divides the anteroposterior diameter with respect to h_1: h_2, $h_1 + h_2 = T_{111}$, where h_1 is the distance from the back point of the anteroposterior diameter till the front axis, h_2 is the distance from the front point of the anteroposterior diameter till the front axis. Figure 4 shows the contour of the cut used to calculate the girth length.

Let L_1, L_2, L_3 be the length of the contour fragments enclosed respectively between the points A-B, B-C, C-D.

Let assume the waist cut contour to be the segments:

L_1 is a line segment of the straight line A-B,

L_2 is the contour fragment of the ellipse L_2 between the points B-C, the major axis of which is parallel to the minor axis of the figure, and the small aperture is parallel to the major axis of the figure and passes through the most protrusive side point of the figure. In this case, the length of L_2 = ¼ of the contour length of the ellipse L_2.

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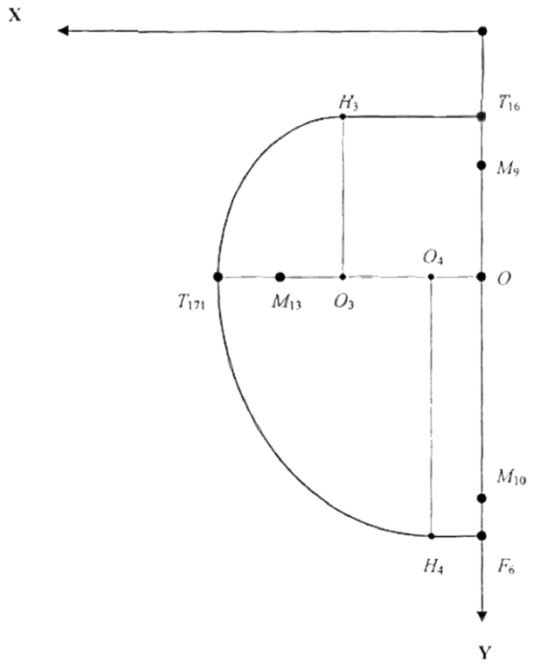

Fig3. Contour of the waist cut when designing clothes [8].

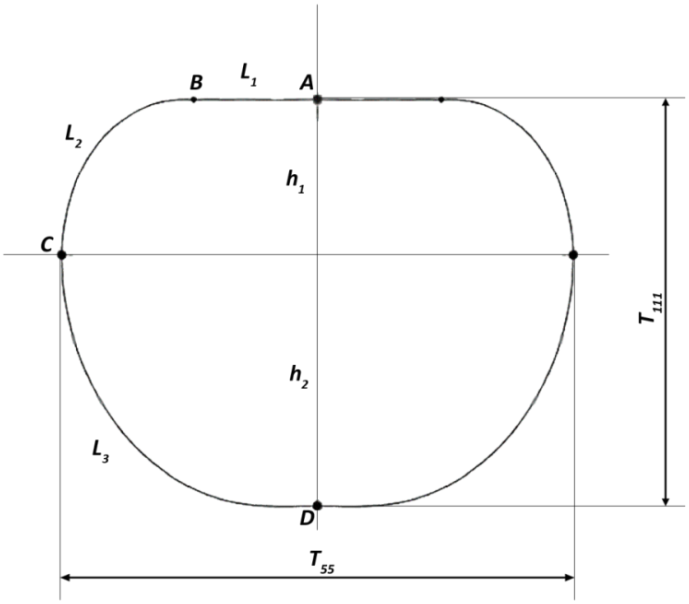

Fig4. The contour of the waist cut used to calculate the length of the girth.

L_3 is the contour fragment of the ellipse L_3 between the points C-D, the major axis of which is parallel to the minor axis of the figure, and the small aperture is parallel to the major axis of the figure and passes through the most protrusive side point of the figure. In this case, the length of L_3 = ¼ of the contour length of the ellipse L_3.

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The length of the contour is calculated by the Ramanujan's formula of the approximate length of the contour.

$$L=3,14\ [3(a+b)-((3a+b)(a+3b)\ )^{1/2}],$$

where, **a** - the length of the ellipse and **b** is the length of the small semi axes of the ellipse.

The algorithm for calculating the length of the contour consists of following:

let T_{18} be the sought-for length of the waist girth of the figure, T_{55}, T_{111} frontal and anteroposterior waist cut diameters, measured from the projection images of the figure in 3 angles - front, side, back.

For calculation, we determine the coordinates of the anthropometric points of the cut on the images and the displacement of the front axis of the figure. The position of the frontal plane and the axis of the figure are determined through the most protrusive lateral points of the figure. The front plane divides the contour of the cut into the front and back halves.

We apply the method of calculating the contour of the cut separately for the back and front half of the contour.

In the back half of the contour, we approximate the cut by two segments-a segment of the straight line AB and a segment of the curve L_2
we, set

$$L_{1=}T_{55}/4. \quad (1)$$

We define L_2 as an ellipse whose major axis passes through point B, parallel to the minor axis of the figure which is being studied, and the smallest part of the ellipse passes through the most protruding side point C of the figure, parallel to the major axis of the figure.

The projection of the point C on the sagittal plane of the figure divides the anteroposterior diameter of the figure with respect to h_1: h_2, $T_{55} = h_1 + h_2$, where h_1 is the distance from the extreme posterior point of the figure till the frontal plane and h_2 is the distance from the extreme anterior point of the figure till the frontal plane of the figure.

Define the semi axes of the ellipse L_2: the length of the major semi axis is **a** = h_1, the length of the small semi axis is **b** = T_{55} / 4.

The length of the curve L_2 is determined by the formula:

$$L_2=1/4 * 3,14\ [3(h1+ T_{55}/4)- ((3h_1+ T_{55}/4)(h_1+3\ T_{55}/4)\ )^{1/2}]. \quad (2)$$

In the front half of the contour, we approximate the cut of the ellipse L_3 with the center, which coincides with the topological diameter of the figure, the major axis coincides with the anteroposterior diameter, and the minor axis with the frontal diameter of the figure.

Define the semi axes of the ellipse L_3: the length of the major semi axis is a = T_{55} / 2, the length of the minor semi axis is b = h_2 / 2.

The length of the contour of the forward contour is determined by the formula

$$L_3= 1/4 * 3,14\ [3(T_{55}/2+ h_2/2)- ((3\ T_{55}/2+ h_2/2)(\ T_{55}/2+3\ h_2/2)\ )^{1/2}]. \quad (3)$$

Taking into account (1), (2), (3) we obtain an expression for the waist cut contour length

$$T_{18}= 2*(L_1 +L_2 +L_3) = T_{55}/2 +1/2 * 3,14\ [3(h_1+ T_{55}/4)- ((3h_1+ T_{55}/4)(h_1+3\ T_{55}/4)\ )^{1/2}]+ 1/2 * 3,14\ [3(T_{55}/2+ h_2/2)- ((3\ T_{55}/2+ h_2/2)(\ T_{55}/2+3\ h_2/2)\ )^{1/2}]. \quad (4)$$

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IV. EVALUATION

To evaluate the reliability of the derived formula, a comparison is made between the value of the calculated measurement of the T_{18} dimensional characteristic and its real value. As the initial data, the dimensional characteristics of T_{55} and T_{111} were used. The comparison was carried out on the example of 109 standard and experimental figures, the measurements of which were performed by a traditional contact method. The maximum relative error in the size of the waist girth dimensional feature measured by the contact method with its calculated value does not exceed 1%, which is permissible for the purposes of designing clothes [7].

On the basis of the presented method of calculating girth parameters, algorithms for determining the anthropometric characteristics of a person's figure from its images in different angles have been developed. Figure 5 shows the results of calculations of anthropometric characteristics. All coverage characteristics - the neck, chest, hips girths, are calculated according to the derived formula, using the determining diameters at the cut level. To distinguish the points, relative to which calculations are made, an approach based on the method of recognition of Viola-Jones [9] is proposed.

Fig5. Calculation Results.

V. CONCLUSION.

On the basis of the research on methods for calculating the coverage characteristics from projected images, we propose an approach for calculating the length of cut girth by Ramanujan's formula of the approximate contour length. In this case, the asymmetry of the cut contour relative to the frontal plane, as well as its displacement relative to the observed center of the figure is considered. The proposed algorithm for calculating the shape girths and its implementation allows to fully automate procedures for calculating anthropometric characteristics and to increase the productivity of the measurement system.

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