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Recognition of Anthropometric Points of Human Figures

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ABSTRACT: The article describes the method of recognition of anthropometric points of a human figure according to the projective images of a human figure for getting anthropometric data. To identify the position of the anthropometric points an approach based on the Viola-Jones method is suggested. On the basis of the proposed method developed the image recognition algorithms of the anthropometric points of the figure and software system of remote measurements of anthropometric characteristics of human figures in her images from different angles are developed. The light industry organizations involved in the development and application of mass anthropometric study automation of population, automation design and construction of clothing take place in the sphere of the developed software tools.

KEYWORDS: Distance measurement, image processing, anthropometric point detection algorithm.

I. INTRODUCTION

Automation of anthropometric measurements is one of the most challenging and urgent tasks to a wide range of applications in the apparel industry - conducting mass anthropometric research, development of the dimensional typology of population, anthropometric automation software design on the purposes of targeted and mass manufacture of clothes. Anthropometric measurement systems are designed to identify the anthropometric points of human figures and determine the appropriate size of anthropometric parameters of the figure.
The problem of localization of anthropometric points on the image of human figures and is considered the position methods of pattern recognition are considered in the given paper.
To ascertain the localization of anthropometric points on the image is necessary to solve the problem the image fragments anthropometric figures location and determine the coordinates of the corresponding anthropometric points.
In [1, 2, 3] works are different approaches to solving the problem of localization of anthropometric points. Proposed in work [1] the method of determining the anthropometric points using the "dressing" of the virtual three-dimensional framework on flat images of human body on three sides (a side, front and rear), combining its extreme point with the corresponding figures of anthropometric points. At the same time, the full combination of all points is not pursued, considering their different roles in the process of construction. All anthropometric points, except the neck, serve as a guide when designing clothes. In [2] coordinates of anthropometric points are determined by means of an interactive on-screen. In work [3] the method for automatic detection of characteristic points of the pieces on the front and side images is proposed. Dedicated silhouette and outline shapes are used to represent curves contour shapes using 8 connecting chain Freeman is code. Developed rules allow to allocate 101 points of a human body totally that can be used to calculate some anthropometric parameters of shape when designing clothes. In work [4] a method of formal positioning of anthropometric points for standard shapes using a 3D scanner forming a cloud shape points. Is proposed, while in work [5] the localization algorithm, based on facial elements Viola-Jones is method [6] to address the problems of biometric identification is considered.
In this paper the issue of localization automation of anthropometric points of the figures on digital images for calculation the anthropometric parameters of the figure is observed. The solution to this problem is sues to the problem of setting fragment of anthropometric body figures identification and determination the point closest to the standard anthropometric point.
Object recognition process involves two stages: the first stage is - the training, or the formation of the recognition algorithm, the second phase is the - detection, or the identification of an object to the particular class.
The images of anthropometric figures are considered as the objects. The training set for the formation of the localization algorithm consists of the points of the images for which the localization of anthropometric points is. The

sequence of images with unknown localization of anthropometric points buildup the control sample. Anthropometric point control sample image is expressed as the point closest to the anthropometric image area with the defined recognition algorithm.

II. Feature Point Recognition

A. Method Viola - Jones

Method Viola - Jones [6] is the most popular method for defining objects in the image field, due to its speed and efficiency. It was originally designed to recognize people in an image and then used to identify of the anthropometric points of a person [5]. Detector Viola - Jones is based on three main ideas: the integral representation of the image, the method of constructing the classifier algorithm based on adaptive boosting (AdaBoost) and the method of combining classifiers to a cascade structure. Various modifications of Viola – Jones method, combined with other algorithms that extend its capabilities are suggested.
The developing approach is focused on the definition of anthropometric points on the projection images of the figure.
Solution object recognition task usually consists of two stages: the first stage is - training, extraction and reservation of known objects evidence in the database, the second stage - recognizing, comparing features of objects with the attributes contained in the database. An effective way of imaging performance and feature extraction is a wavelet transform. In this paper the wavelet transformation Haar and Daubechies are used to extract signs of recognizable objects. One of the most effective solution classification problem is to use cascade classifier based on Haar features [6].
The method uses a sliding window technique. The frame, which size is smaller than the original image, moves with a certain step in the image, and using a cascade of weak classifiers determines whether there is a recognizable object in the sliding window. The central element of the method implementation is to apply the table of sums, called the integral image. A generalized flow chart is as follows: the training recognition algorithm based on the reference image regions of different anthropometric scales is held, which results in a database of signs and recognition rules. Following that, the recognition algorithm is applied in search for the objects using the created database.
Viola-Jones is algorithm output gives the entire set of unintegrated found objects at different scales, among which, the objects following the recognition rule are determined.
Anthropometric characteristics of the figures given by determining anthropometric points and rules and are defined by the corresponding image pieces on the pictures in the front (frontal image), the side (side image) and rear (rear image) figures. Automatic extraction of anthropometric points from the front and side images of the figure is an important method of non-contactless methods of measurement, based on the images and building of a virtual model of the figure.
In this study, a method of determining the anthropometric points, such as neck, base of the neck, the shoulder, armpit, chest, and waist line are appointed on the projected image of a human figure. Determination of the exact position of these points requires a high skill and a qualification and considered to be difficult to formalize.
Figure 1 shows the image of the measured shape in the front, side and rear projections and corresponding to each image background. For the purposes of measuring characteristics of anthropometric figures halftone images which are pre-processed to improve image quality, noise filtering, separation and silhouette outlines are used. Figure 2 shows the marked contour and silhouette image figures used in the measurement process for the construction of measured original image.
One of the most important parts of the algorithms such as Viola-Jones algorithm is a set of the attributes. The most commonly used features are Haar is [7]. The work on the detection of pedestrians and vehicles in the stream used the Haars features, built on the luminance image. This approach allows us not only to solve the problem of detection (binary classification), but also the problem of multi-class classification of objects on the image.
The authors of [8] used a simpler set of features, which consist of the difference of brightness of two pixels (x_1, y_1) and (x_2, y_2), for all possible pairs of pixels:

$$\text{feature}(x_1, y_1, x_2, y_2) = \text{image}(x_1, y_1) - \text{image}(x_2, y_2) \qquad (1)$$

In [9] work wavelet Haar and Daubechies transformations [10] are used to extract image features of individuals and build Viola-Jones classifier.

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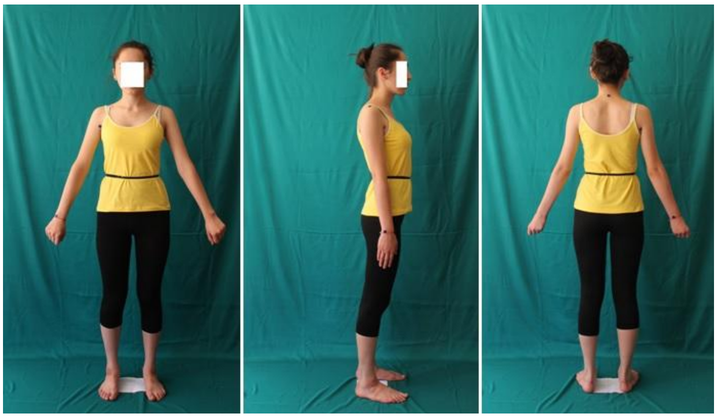
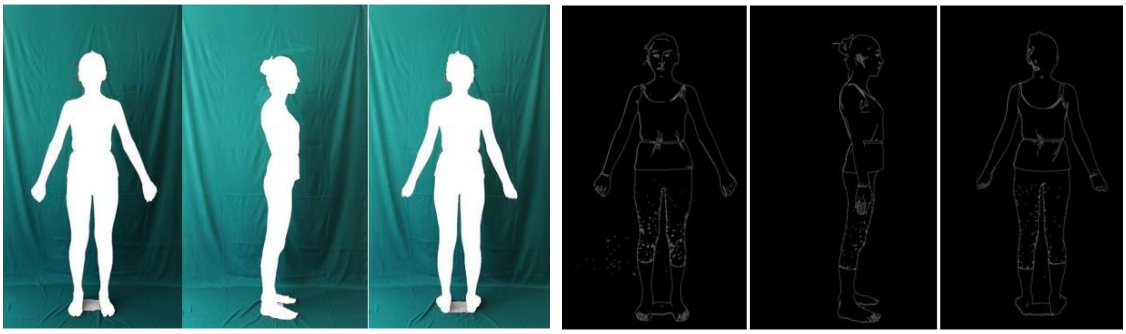


Fig.1. Images of the measured shape in the front, side and rear projections



(a) (b)

Fig.2. Silhouettes and contours of the figures after image processing: (a) the silhouette of a figure in the frontal, side and rear-projection; (b) the outline of a shape in the front, side and rear projection

The authors of the article [11] proposed a modification of the Viola-Jones method using features of detectors based on finite state Mealy machines [12].

In this paper we propose to use features such as Haar, constructed on the account of the edges directions. This approach allows us to train a classifier, which will be determined by the shape of the recognizable objects, rather than the brightness characteristic [13]. At the same time, the advantages that are typical of Haar features are retained, due to the method of fast characteristic evaluation regardless the scale, such features are not very sensitive to slight distortions of the training sample and linearly scalable, which makes it easier to find objects of different sizes.

As is known, Viola-Jones' classifier using Haar-like features, built on intensity images, is sensitive to the distortions of brightness - when one part of the image is always darker than the other (for example, the eye area is always darker than the forehead in the image).

For anthropological points detection it is advisable to use conversion of images in which the borders rather than luminance difference in are easier to be recognized them. This type of transformation is the Canny edge detector [14].

To construct the type Haar features on contour image will allocate the direction of the borders will be allocated. Then the result of Canny detector will recognize the borders according to certain directions. At the same time, there is its own determined anthropometric characteristic feature, taking into account the direction- vertical, horizontal, along the main or secondary diagonal, regarding each point of on the image.

Sets of images obtained with this detector are used to train the classifier viola-Jones. As features for the recognition algorithm is proposed by Haar features based on Haar wavelets.

Generalized scheme learning of algorithm is as follows. There is a selection of the reference image, the standard sample size may contain several thousand images. Figure 3 shows an example of recognized images of the objects studied.

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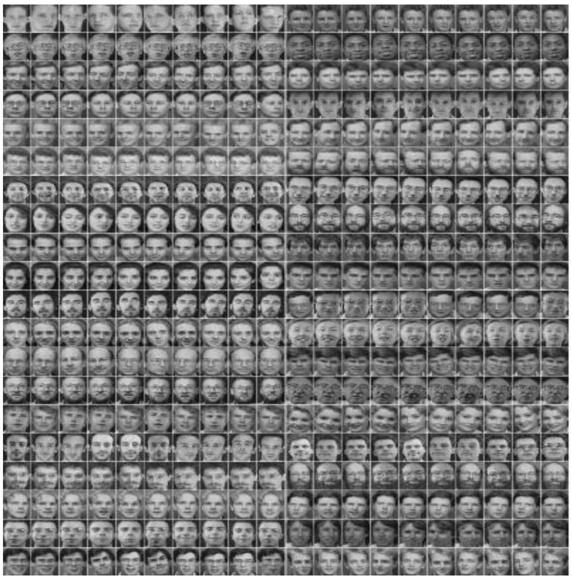

Fig.3. The training set of anthropometric area

The basic classification algorithm Viola and Jones each rectangular sign can be formally represented by a threshold function

$$h(x, f, t) = sign(f(x) - t), \qquad (2)$$

where f - forming the sign, t - threshold.
More effective basic classification algorithm can be set by a k-valued piecewise constant function

$$h(x, f, t_\mu) = t_\mu, \qquad (3)$$
$$t_{\mu-1} \leq f(x) \leq t_\mu, \quad 0 \leq t_{\mu-1} \leq 1,$$

where t_μ - the threshold for the interval μ, $\mu = 1,2, \dots, k$, k is the number of intervals of constant values of the function.
Integral representation of the image is calculated by the formula:

$$I(x,y) = \sum_{\substack{x' < x \\ y' < y}} i(x', y'), \qquad (4)$$

where *i(x', y')* - the brightness of the source image pixel.
For a description of the desired objects using cascade of Haar features are used. The algorithm of studying works with grayscale images.

B. Localization of anthropometric points

Recognition method of anthropometric points based on a comparison of the standard and recognizable image and determination of recognized images point to the nearest point of anthropometric reference image. The location of anthropometric reference image point determines the position of a point on a recognizable image. To identify the position of the anthropometric points it is necessary to form a diversity of reference images of the figure anthropometric fragments diversity in areas relevant to anthropometric points. This is regarded as the set of the reference for determining the position of a desired point. The number of reference images determined by the required accuracy of determining the coordinates of the desired point, and reaches several tens of thousands.

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Let $\{C_\alpha\}$ set of selected area anthropometric reference images standard curves in anthropometric field, x_α – antropometrich reference point on the curve $\{C_\alpha\}$. The set of images $\{C_\alpha\}$ creates training set recognition algorithm (localization) of anthropometric points.

Let P is a - recognizable curve of anthropometric test figures field, x_p is an anthropometric point on the curve of the P, $x_p \in P$ is , represented by a set of points (pixels) $P_i, i = 0,1, \dots, n$. Let

$$d(P_i, C_\alpha) = \min_{t\in[0,T]} d\big(P_i, C(t,\alpha)\big), \qquad (5)$$

the distance from $P_i \in P$ Je C_α curve to a certain metric, $C(t,\alpha) \in C_\alpha$.

Thus the recognition task (localization) of anthropometric point x_p test image consists of determining the curve C_{α^*}, such that

$$\alpha^* = \operatorname{argmin}_\alpha \mu(C_\alpha, P),$$

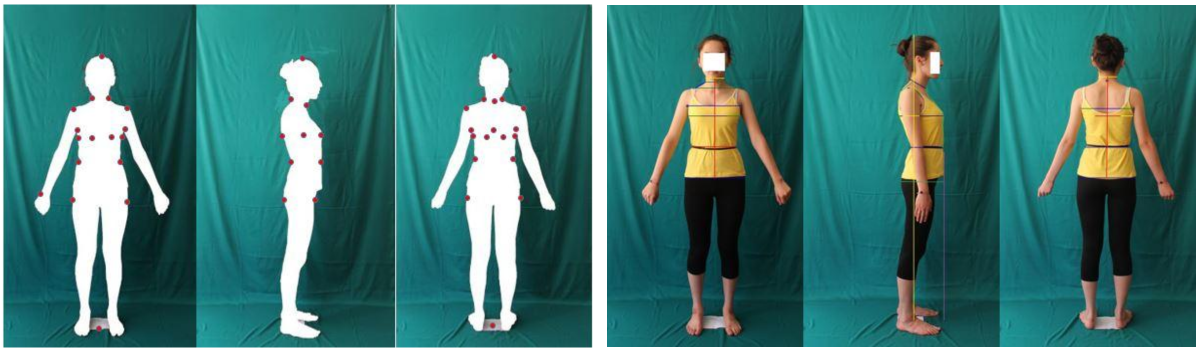
$$\mu(C_\alpha, P) = \sum_{i=0}^{n} \min_{t\in[0,T]} [d(P_i, C(t,\alpha)]^2 \qquad (6)$$

and separation point $x_p \in P$, such that

$$x_p = \min_{i\in[0,n]} d(P_i, x_\alpha) \qquad (7)$$

III. EVALUATION

On the basis of the method detection algorithms (localization) of fragments of images of anthropometric points of the figures are developed and the anthropometric characteristics of the human figure in its images from different angles are determined. The algorithm is realized on the base of C#. The anthropometric feature points are completely detected from figures. It proves that this approach is effective and robust. Figure 4 (a) presents the silhouette image figures with marks of anthropometric points. Dedicated anthropometric points are used for the calculation of anthropometric parameters (Figure 4 (b)). Images of figures and results calculations are stored in a database system.



(a) (b)

Fig.4. Silhouette image figures with marks anthropometric points (a); and the results of calculations (b).

The experimental results showed that the deviation of recognizable points is less than 3 mm, which corresponds to the requirements of state standard [15].

IV. CONCLUSION

Based on the study of methods for determining the position (recognition, localization) of objects in the image to identify the position of the anthropometric points the approach based on the method of recognition of Viola-Jones is suggested. Recognition aims to determine the portion of the image from the training sample with a maximum measure of proximity. The proposed algorithm of anthropometric points recognition, and its implementation will make it

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possible to automate the process of remote measurement of anthropometric parameters during mass population studies, dimensional typology of the development of the population, as well as the creation of automation systems design and clothing design.

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