Determination of anthropometric indicators of the hand of athletes on the basis of computer vision

UDC 611

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Abstract

In most sports, athletes interact with the outside world through various grips: holding their own weight (hanging on the bar, standing on the uneven bars), holding equipment (racquet, ball, paddle) or interacting with an opponent (martial arts). The linear dimensions of the hand in many sports determine the success of competitive activity. So, weightlifters have a longer hand than the average person, as this contributes to a stronger grip on the bar. In handball, a large hand size contributes to a stronger hold on the ball. Despite the long history of studying the anthropometry of the hand, the classical methods are still the main methods for changing its parameters - measurements using a centimeter tape and a ruler.

Objective of the study was to develop a method for measuring the anthropometric parameters of the hand based on computer vision.

The proposed method is based on the use of a neural network that allows you to automatically determine the coordinates of the nodal points of the palm. The developed computer application with the working title "PalmAnthropometry_1.0" is based on the use of the MediaPipe open source framework, namely the Mediapipe Hands neural network, which allows you to determine the nodal points of the hand by analyzing the video stream. To determine the anthropometric parameters, a hand skeleton is used, which includes 21 nodal points. Using the coordinates of the nodal points and the formulas of analytical geometry on the plane, the linear and angular characteristics of the hand are found.

Results and conclusions. The created application was tested on athletes and showed high speed and accuracy of measurements. The developed method makes it possible to identify eight linear and five angular characteristics of the hand in a few seconds. Based on the results of the study, the data are automatically saved to a protocol file with the .xlsx extension, which allows for mathematical and statistical processing. The proposed method for determining the size of the hand based on computer vision allows you to quickly (several seconds) and accurately find the anthropometric parameters of the hand. In the future, the proposed method can be used in many sports in order to determine the influence of the size of the hand of athletes on the success of competitive activity.

Keywords: *anthropometry, hand, neural network, MediaPipe, fine motor skills, computer vision.*

Introduction. The athlete interacts with the environment through various hand grips: holds his own weight (hanging on the bar, standing on the uneven bars), holds equipment (racquet, ball, paddle) or interacts with an opponent (martial arts). The linear dimensions of the hand in many sports determine the success of competitive activity. Thus, weightlifters have a longer hand than the average person, as this contributes to a stronger grip on the bar [5]. In handball, a large hand size contributes to a stronger hold on the ball.

In the scientific literature, more than 20 dimensional features of the hand are distinguished. However, in practice, only the main dimensional characteristics are used for biomechanical and ergonomic calculations. The following anthropometric indicators are most often used: mass, hand length, hand width, finger length, metacarpus length (to the center of the fist), hand length when writing, finger width, hand girth, finger girth [1, 3, 4].

Despite the long history of studying the anthropometry of the hand, the classical methods are still the main methods for changing its parameters - measurements using a centimeter tape and a ruler.

Objective of the study was to develop a method for measuring the anthropometric parameters of the hand based on computer vision.

Methods and structure of the study. The proposed method is based on the use of the MediaPipe open source framework, namely the Mediapipe Hands neural network, which allows determining the nodal points of the hand skeleton by analyzing the video stream [6]. To determine the anthropometric parameters of the hand, the hand skeleton was used, which includes 21 nodal points. After detecting the palm area in the frame, the neural network localizes 21 node points (Fig. 1). For convenience in the calculations, we designated each of them with the letters of the English alphabet and highlighted the most significant characteristics.

The measurement is carried out in the position of the arm extended forward, when the hand is in a straightened state. You can determine the linear dimensions of both the left and right hand. The hand is placed in front of the laptop camera in such a way that the palm completely enters the lens and is in a static position for at least 2 seconds. It is also necessary that in the plane of the hand there is a test object with known linear dimensions (ruler, pencil). The test object allows you to automatically convert hand sizes in pixels to millimeters.

The neural network is characterized by high speed and accuracy of point determination, as it has been trained on more than 20,000 images.

The proposed approach for determining the linear dimensions of a hand based on computer vision requires a revision of the classical approaches. The main difference of the new approach is that the linear dimensions are measured by the central points, and not by the points of the hand outline. This should be taken into account when comparing measurements obtained by different methods. At the same time, with a unified approach to measurement, the specifics of the method are leveled, and the results obtained accurately characterize the linear dimensions of the hand.

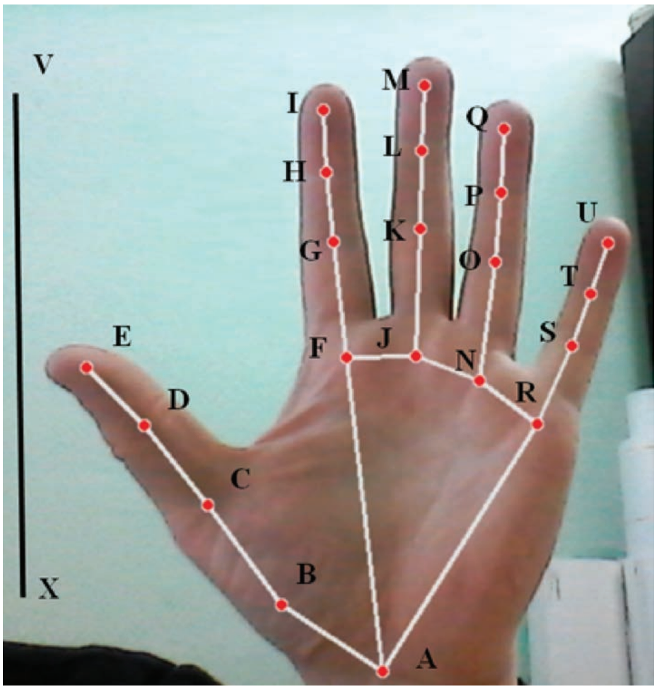

Figure 1. *Anchor points of the hand model*

Results of the study and their discussion. The proposed software application PalmAnthropometry_1.0 was tested to determine the anthropometric characteristics of athletes.

Upon completion of the measurements, the protocols with the results were uploaded to a separate file with the .xlsx extension for further mathematical and statistical processing in the Excel program.

To describe the hand, we have chosen the following linear characteristics: length of the 1st finger (BE), length of the 2nd finger (FI), length of the 3rd finger (JM), length of the 4th finger (NQ), length of the 5th finger (RU), palm width (FR) , palm length (AM), finger span (EU), as well as angular characteristics: the angle between fingers I and II (EAI), the angle between fingers II and III (IAM), the angle between fingers III and IV (MAQ), the angle between IV and V fingers (QAU), the angle between I and V fingers (EAU).

All mathematical calculations were carried out according to well-known mathematical formulas from analytical geometry on the plane [2].

To determine the length and width of the hand, we used the general equation of a straight line:

$Ax+By+C=0$

where, A, B, C are the coefficients of the equation

The distance between two points P_1 (x_1, y_1) and P2 (x_2, y_2) was defined as:

$d=\sqrt{(x_2-X_1)^2+(y_2-y_1)^2}$.

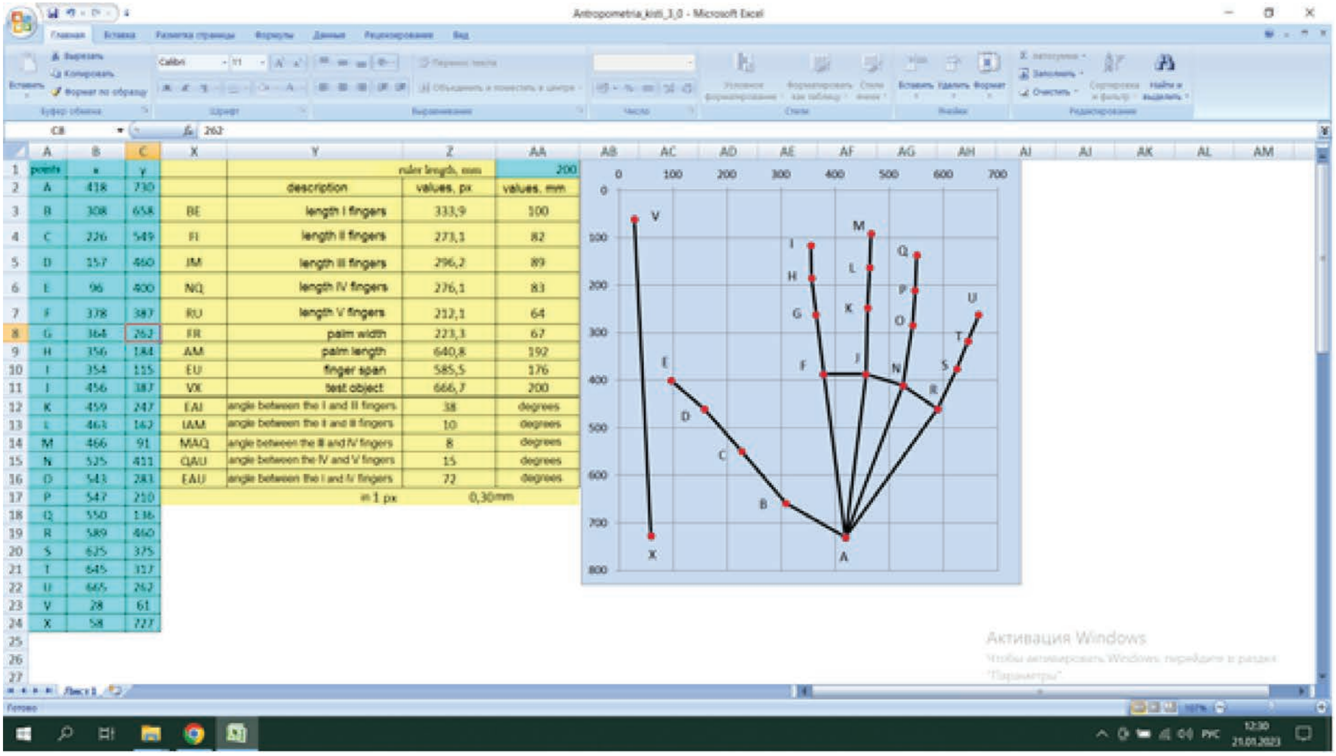

Figure 2. *Linear and angular characteristics of the hand (screenshot of the study protocol)*

To find the angles between the fingers, we found equations for each of the two straight lines (fingers) passing through two given points P_1 (x_1, y_1) and P_2 (x_2, y_2):

$$\frac{y-y_1}{y_2-y_1} = \frac{x-x_1}{x_2-x_1} .$$

The angle between two straight lines was determined through the coefficients of the equation of two straight lines:

$$tg\phi = \frac{A_1 \ B_2 - A_2 B_1}{A_1 A_2 + B_1 B_2} .$$

Figure 2 shows a screenshot of the Excel program with the study protocol.

Conclusions. The proposed method for determining the size of a hand based on computer vision allows you to quickly (less than 10 seconds) and accurately find the linear dimensions of the hand.

The results of this method differ from the results obtained using classical methods. The linear dimensions in the proposed method are calculated from the midpoints determined by the neural network. Classical methods involve determining the distances between the perimetric points of the contour. However, with a general approach to all measurements, this specificity will be leveled.

The proposed method is universal for conducting research, which reveals the influence of the linear dimensions of the hand on the results in various sports.

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