Journal of Artificial Intelligence Practice (2021) Vol. 4: 23-29
Clausius Scientific Press, Canada

DOI: 10.23977/jaip.2020.040103
ISSN 2371-8412

Hair counting method based on image processing technology

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Keywords: image processing, Hot transformation, Piecewise linear transformation, Wright test, Hair count

Abstract: The number of hair per unit area of scalp is an important indicator of hair growth. In order to realize the understanding of head fur growing condition, this paper designs a hair counting method based on image processing technology. The color characteristics of the high definition scalp hair images taken by light microscope were analyzed and the Wright test was used to eliminate the shadow and subtle hair interference. Then the original image was preprocessed and pieceby-linear transformation was enhanced, and then the threshold segmentation was performed to extract the hair root image, and a single scalp hair image was counted, and the scalp hair counting function model was constructed to realize the scalp hair counting in the whole region. Analysis shows that the experimental results accord with the physiological characteristics of hair growth, and the method can avoid most of the noise interference of hair image, and meet the actual requirements of scalp hair counting.

1. Introduction

Hair is an important part of human morphological characteristics, containing human age, gender, identity and other information [1]. Hair besides the head that can protect the person on physiology, resist slight bump, still can increase the aesthetic feeling of the person, the instrument of adornment person. Therefore, the health of hair growth is related to everyone's morphological value [2], and the easiest way to judge hair growth is to count hair on the scalp to determine whether the number of hair reaches the standard number of healthy people's hair. The average adult has around 100,000 hairs, an average of 200 in one square centimeter of scalp. Due to the large number of hairs, small diameter, uneven density, and complex shape and structure, it is difficult to count scalp hairs.

Along with the development of image processing and computer calculation, image processing technology in crop target count has got good application, such as in grain count, proposed by [3, 8] BaoWenXia direction of more than one based on multi-scale decomposition of wheat grain counting method, the wheat grain image multiscale decomposition, more direction The average accuracy of ear counting by morphological operation was 90.28%. Xie Yuancheng et al. [4] proposed a wheat ear detection method (FCS R-CNN) based on deep learning, which combined shallow detail features and high-level rich semantic features, and achieved a detection accuracy of 92.9% for the number of wheat ears. Liu Zhe et al. [5] proposed a wheat ear counting method based on improved K-means. Based on color feature clustering, the number of wheat ears in local spatial regions was estimated, and the accuracy of ear counting reached 94.69%. Through the analysis of the above examples, the image processing technology in the complex crowded scene target detection has reached a high accuracy, so the use of image detection technology has been equipped with the condition of computer detection of hair.

Compared with crop image, fur image has great complexity. In the aspect of taking the image, generally need 80~200 times the optical microscope lens (more details even need 200~500 times the optical microscope lens), and must be in good light conditions for acquisition. In this paper, scalp hair images were preprocessed to reduce the influence of noise factors, and then piecewise linear transformation was used to enhance the image. The enhanced image was segmented by the optimal threshold [6] to count the hair roots of a single image, and finally the scalp hair counting function model was used to count the hair in the whole region [7].

2. Image acquisition and methods

2.1 Experimental samples and environmental characteristics

Scalp hair can be divided from top to bottom into four parts: the hair shaft, the hair root, the hair follicle, and the dermal papilla. According to the size of hair, hair can be divided into fine hair, ordinary hair and coarse hair. Most hair is slightly fine and the root is thick. According to its shape, hair can also be divided into straight hair, wavy curly hair and naturally curly hair [11, 12]. In this experiment, straight hair was mainly collected from the root to the hair shaft, which has obvious morphological characteristics and is convenient for calculation. Microscopic imaging technology makes the physical characteristics of hair more clear, accurate, three-dimensional display in front of people, so that people can observe the detailed structure of hair. In this experiment, the color and texture features of hair image were extracted by ordinary optical microscope.

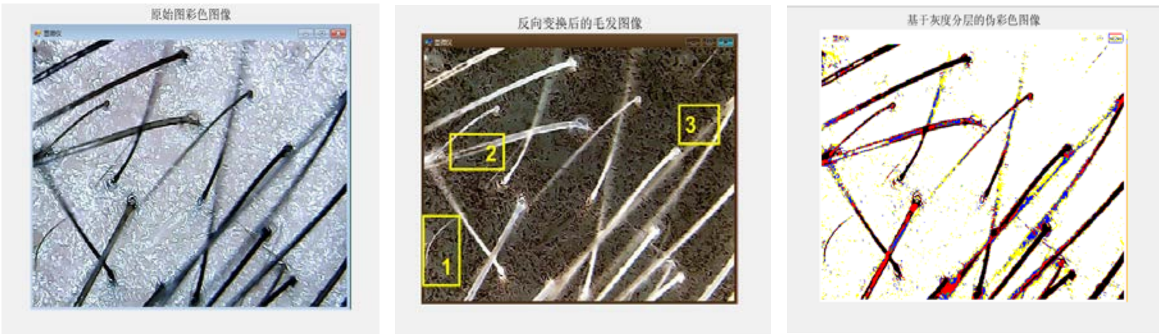
2.2 Image Acquisition

Hair images were collected from a 25-year-old volunteer. First of all, the head of the volunteers should be cleaned, dried and combed to avoid unnecessary interference, and the crossover of hair should be reduced as far as possible to prepare for the image acquisition. The collection time is from 12:00 to 14 on May 15 to 20, 2021: 00, the collection temperature range is 18~23℃, the collection humidity range is 40%~60%, and then 80-200 times of the optical microscope is used to carry out targeted uniform sampling of the volunteers' heads under good indoor light.

3. Image characteristic analysis

3.1 Color characteristic analysis

According to the analysis of Figure 1 (a), the scalp hair image is mainly composed of scalp, hair and shadow, with scalp occupying the largest area, hair in the middle and shadow occupying the smallest area. Because the color features of the images are clearly distinguished, that is, the scalp is white and the hair is black. There is only one disadvantage, that is, the shadow is close to the hair color. Therefore, further analysis of the color features of the hair images is required. Figure 1 (b) is obtained by using the imcomplement function in Matlab to invert the color of Figure 1 (a).

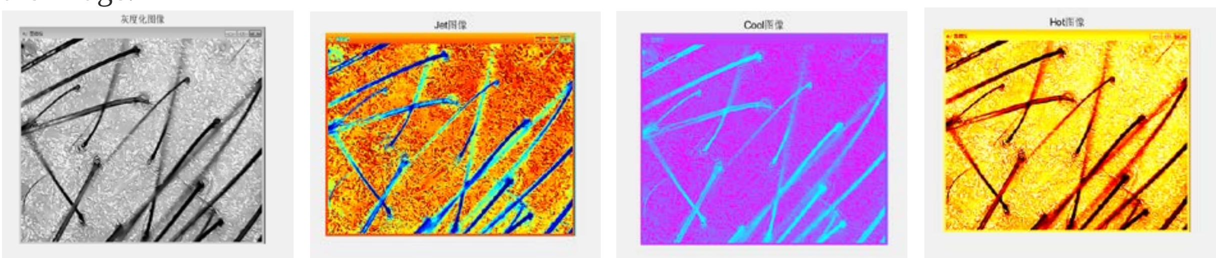


(a) (b) (c)

Figure 1

Combined with the inverted color images, it can be determined that the main factors affecting the count of hair images are as follows: 1) fine hairs with diameters far smaller than normal hairs, as indicated in the yellow box no. 1 in figure (b) above; 2) holes formed by reflection of light from hair, as shown in the yellow box no. 2 in figure (b) above; 3) The shadow caused by the resistance of hair to light, as shown in the yellow box no. 3 in (b) above.

Using the Rgb2gray function in Matlab, the color image is transformed into gray image, and then the Jet image, Cool image and hot image of gray image are obtained by pseudo-color transformation of the image.



(a) (b) (c) (d)

Figure 2

Through comparison, it is found that the hair root can be clearly seen in the Cool image, and there is a certain degree of difference between the root and the hair shaft, presenting circular bright colors or circular bright colors. In the Hot image, the light shadow is more obvious. Basically, every hair has a black line from the root to the hair, while the shadow in the yellow box no. 3 in Figure 2 (b) does not, so it can be judged that it is indeed the hair shadow rather than the hair. According to the analysis of Figure 3 (a), it can be seen that most of the contour connected regions of the binarization hair image are hair, and a small part are shadows and fine hair. Therefore, the binarization hair image has M connected regions, which are respectively used $m_1, m_2, \cdots, m_n$ to represent, connected regions m_i in the area of

s_i To say. Calculate the mean of all connected regions $\bar{s}$ and variance σ.

$$\bar{s} = \frac{1}{n}\sum_{i=1}^{n} s_i \ , \sigma = \sqrt{\sum_{i=1}^{n} \frac{(s_i-\bar{s})^2}{n-1}} \quad (1)$$

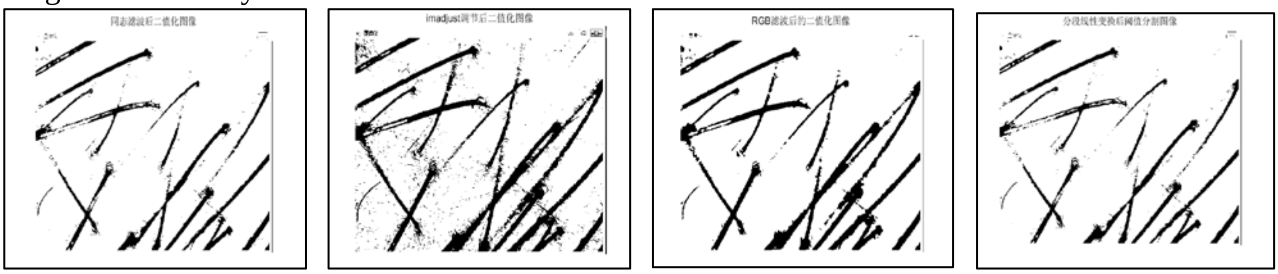
According to The Wright test method, when the residual v_i corresponding to the measurement value s_i of item I satisfies formula (2), the corresponding measurement value s_i is an abnormal value and should be excluded. Through this area filtering method [9, 10], the connected areas of shadows and fine hair are removed, and the remaining connected areas are normal hair.

$$|v_i|_{max} > 3\sigma_{\bar{s}} \;,\; v_i = s_i - \bar{s} \tag{2}$$

3.2 Texture feature analysis

Texture feature [13] is one of the main features of hair. Most of the hair texture presents a linear shape emitting slightly from the root to the hair, and the root of the hair is thick, and there will be a circular outline larger than the diameter of the hair shaft. On the whole, hair, shadow and fine hair have obvious differences in texture, so selecting texture feature value is an effective method to segment hair.

To further avoid the influence of the noise information, in order to gain more clear texture feature of the experiment on the original image using homomorphic filtering to compress the dynamic range of image gray level, and enhance contrast figure, the processing method of image brightness is because the human eye vision system has nonlinear properties, similar to the logarithmic Similarly, IMADJUST histogram adjustment can better enhance the image. Although the image binarization map after homomorphic filtering is clearer than that after imADJUST, there is still a lot of noise. Therefore, two other methods were selected for image enhancement and binarization analysis: (1) RGB filtering operation (filter the three channels of the color image respectively, and then merge to obtain the RGB filtered image) (2) Piecewise linear transformation operation (highlight the gray scale interval of interest, and relatively suppress the gray scale interval of uninterest) can achieve the enhancement effect of the image [14]. Figure 3 is obtained by unified threshold segmentation of the images enhanced by the above four methods.



Homomorphic filtering | Imadjust adjustment | RGB filtering | Piecewise linear transformation

Figure 3

Compared with the figure above, for further verification, texture property statistics are selected to analyze Figure 3, namely, five indexes of contrast, correlation, entropy, smoothness and second-order matrix (energy) are introduced as the main statistics.

Contrast $C_N = \sum_{i,j=0}^{N-1} P_{i,j(i-j)^2}$

The correlation $C_R = \frac{\sum_{i,j=0}^{N-1}(i,j)P_{i,j}-\mu_x\mu_y}{\sigma_x\sigma_y}$

Entropy $E_T = \sum_{i,j=0}^{N-1} P_{i,j} lnP_{i,j}$

Smooth degree $H_M = \sum_{i,j=0}^{N-1} \frac{P_{i,j}}{1+(i-j)^2}$

Energy $E_N = \sqrt{\sum_{i,j=0}^{N-1} P_{i,j}^2}$

Among them $\mu_x = \sum_{i=0}^{N-1} i \sum_{j=0}^{N-1} P_{i,j}$ $\quad \mu_y = \sum_{j=0}^{N-1} j \sum_{i=0}^{N-1} P_{i,j}$

$$\sigma_x = \sqrt{\sum_{i=0}^{N-1}(i-\mu_x)^2 \sum_{j=0}^{N-1} P_{i,j}} \qquad \sigma_y^2 = \sqrt{\sum_{j=0}^{N-1}(j-\mu_x)^2 \sum_{j=0}^{N-1} P_{i,j}}$$

Take any point in the image and mark it as (x, y), where i is the gray level of this point, j is the gray level of another point, and $P_{i,j}$ is the occurrence frequency of the pixel starting from (x, y) with a distance of d from (x, y) and a gray level of j.

Table 1: Texture feature values

Binary image texture	Contrast	The correlation	Entropy	Smooth degree	Second moment
RGB filtering	4.0013	3.4579	3.1110	3.8703	3.7144e+05
Homomorphic filtering	5.2567	3.2212	3.0742	3.8305	3.6704e+05
Imadjust adjustment	7.2321	3.1637	2.8024	3.7704	3.3459e+05
Piecewise linear transformation	4.2056	3.1856	3.2587	3.8598	3.8907e+05

According to the analysis in the above table

(1) Entropy is the measure of the information content of the image, which is the texture information of the image in this experiment. It can be seen from the above table that the entropy value of the image after piecewise linear transformation is the largest, that is, the image contains the most information, which also proves that the segmentation effect of the image enhanced by piecewise linear transformation is the best.

(2) the same energy is gray level co-occurrence matrix, the sum of the squares of the other element value reflects the degree of image gray level distribution and texture degree of thickness, the greater the energy table name texture was homogeneous and the rules change, the energy of the piecewise linear transformation in the above image were greater than other three methods, the enhancement and segmentation of reason also proves that this method works best.

3.3 Counting model and result analysis

Due to the complexity of the hair image itself and the interference in the acquisition of pictures, such as reflection, dust, hair fine, care weak, poor accuracy of the microscope, resulting in the acquisition of hair pictures, hair occlusion, crisscross, imaging is not clear. In view of the above problems, this counting model adopts the number of hair roots instead of the number of hair. Since this counting is aimed at the number of growth, other scene information except the hair roots can be ignored, such as the holes caused by the hair due to the reflection fiber. In most cases, the number of roots also represents the number of hairs, so the root count can be used instead of the hair count, and other factors can be avoided. Figure 4 shows the image of partial roots.

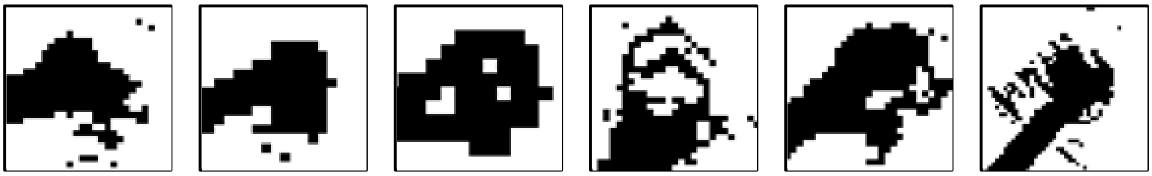


Figure 4: Image of root hair

In this paper, the Hot image analysis in the color features is used to eliminate the shadow interference of some hairs, and the Wright test method is used to further eliminate the outliers of fine hairs. Then, by comparing RGB filtering, homomorphic filtering, imadjust adjustment and subsection linear transformation, the texture feature values of grayscale images are processed. Piecewise linear transformation is selected to enhance the image. The image after piecewise linear transformation is set as 为$f(x, y)$, and its gray value range is [0,255]. Set P to be between 0 and 255, and the graythresh function in Matlab is used to automatically determine the threshold value, satisfying the condition $0 \ll P \ll 255$, for threshold segmentation.

$$g(x,y) = \begin{cases} 1, f(x,y) > p, \\ 0, f(x,y) < p, \end{cases}$$

The hair root was extracted from the segmtioned image and the number of hair in a single picture was counted by the hair root counting model. Finally, the scalp hair counting model was built by calculating the area of the single hair picture and the area of the scalp hair. The number of hair in the whole area of the scalp was counted. The specific flow chart is shown in Figure 5.

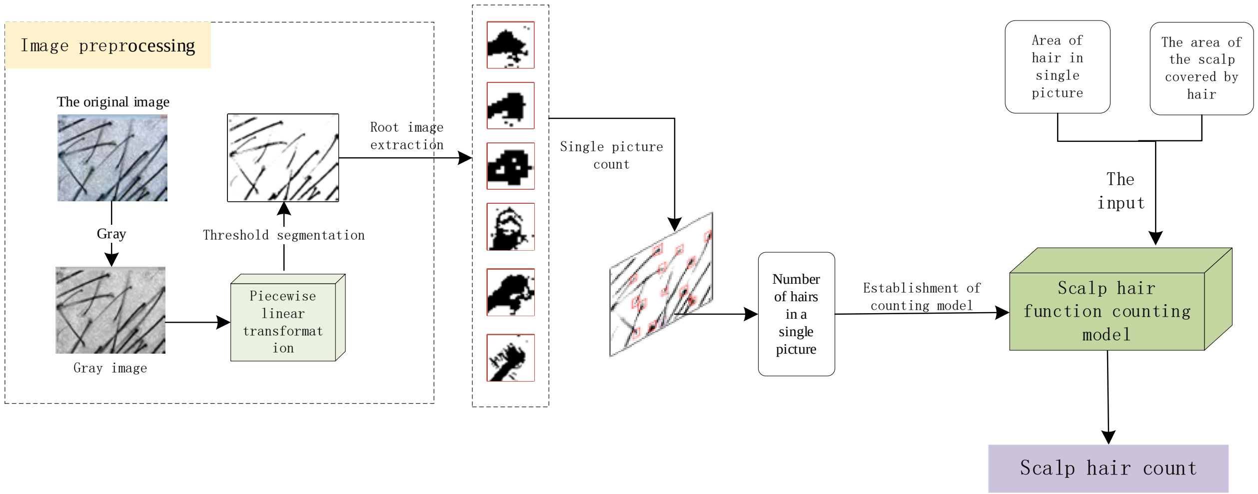


Figure 5: Flow chart of scalp hair counting

4. Discuss

Through image processing technology to achieve the count of scalp hair, the key question is whether to get a clearer image of hair, including volunteers scalp environment clean and tidy, dry, loose degree, the image acquisition process used in the precision of optical microscope, light intensity, temperature and humidity, and the most important is to obtain the image preprocessing, enhancement, segmentation method, Selection and improvement of counting model.

Paper puts forward the Hot hair image transformation and Wright test to distinguish and eliminate the abnormal disturbance, adopt the method of piecewise linear transformation for hair of gray-scale images, enhanced by threshold segmentation and extraction of hair root image, calculate the single image number hair hair, scalp hair counting model construction, finally realizes the complete area count of scalp hair.

Although there are many studies on target counting at present, it is difficult to obtain images suitable for the counting accuracy due to the feature of small targets in hair images, so there are few studies on the application of target counting to the field of hair counting. This article has carried on the preliminary research in this field, and will continue, to increase the use of the rapid development of the deep learning method, improve the accuracy of hair to count, establish suitable for more mature in the field of the counting model, to everyone for your hair growth condition have more accurate understanding, and in view of the problems in a timely manner to make corresponding treatment measures, It also hopes to provide some reference for researchers in this field.

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