The Identification to the Palm Color Spots Based on Improved HSV Model

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Abstract. Palm color [1] is of important significance for the clinical auxiliary diagnosis [2]. The extraction [3] of palm color feature used HSV colormodel [4]. The interval of three color components are extracted and enlarged after experimental analysis. To reduce the processing complexity, each component has been quantized according to color density. Extract the color spots used watershed segmentation algorithm based on control tags and the spots have been divided into several categories. It provides high performance with recognition rate, and reduces the running time, which can identify the palm color spots quickly.

Keywords: HSV color model · Image processing · Feature extraction [5]

1 Introduction

Palm color reflects people's health [6]. Healthy palm color is uniform light red; diseased palms will appear a variety of significant abnormal color spots, the cancer patient's palm will appear brown, white or dark red spots [7]. Identification of color spots on palms can help people discover disease as early as possible. Therefore, using it to provide reasonable health information timely do have a sense of social applications [8]. So far, there are few studies on palm color spots recognition. In 2003, Professor Wang conducted the first attempt to classify the cancer and non-cancer palm images [9], but this algorithm is of high computational complexity and large amount of computation, not easy to achieve detection quickly. This paper does researches on the features of color spots, using its distribution characteristics in the HSV color space, and proposes a monitoring method of H-S-Gray features color spots recognition.

2 Distribution of Palm Color Spots [10]

For identifying the color spots quickly and accurately, it is very important to select the appropriate color model [11]. In order to make the process of color image processing similar to expert medical consultation, it is HSV color model appropriate human visual perception when dealing with palmprint images.

Color parameters in the HSV color model [12] are Hue(H), Saturation(S) and Value (V). Palm color distributes within a very small range in RGB color space [13], therefore

F. Bian and Y. Xie (Eds.): GRMSE 2015, CCIS 569, pp. 620–628, 2016.
DOI: 10.1007/978-3-662-49155-3_65

it isn't suitable for palmprint extraction. HSV color model is mainly user-oriented design, which is suitable for color perception of people. Each component in HSV space is independent, and is suitable for computer processing separately. Hence the method using HSV color model can reduce the complexity and accelerate the speed of image processing.

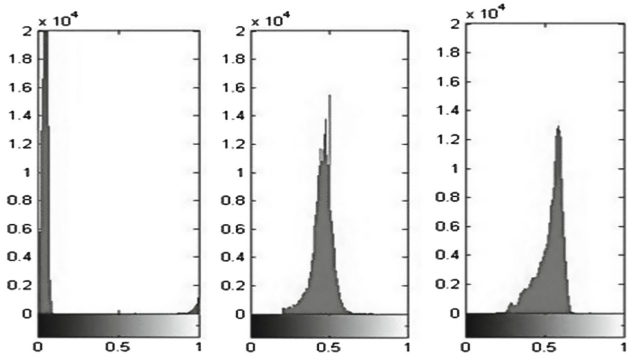
HSV model is a three-dimensional model, evolved from RGB color model. When k1 = max{r, g, b}, k2 = min{r, g, b} and r, g and b are greater than 0 but less than 1, the conversion from RGB color model to HSV color model can be accomplished using the formulas as follows:

$$v = k_1 \tag{1}$$

$$h = \begin{cases} 0^\circ & if \quad k_1 = k_2 \\ 60^\circ \times (g-b)/(k_1-k_2) + 0^\circ & if \quad k_1 = r \quad and \quad g \geq b \\ 60^\circ \times (g-b)/(k_1-k_2) + 360^\circ & if \quad k_1 = r \quad and \quad g < b \\ 60^\circ \times (b-r)/(k_1-k_2) + 120^\circ & if \quad k_1 = g \\ 60^\circ \times (r-g)/(k_1-k_2) + 240^\circ & if \quad k_1 = r \end{cases} \tag{2}$$

$$s = \begin{cases} 0 & if(k_1 = 0) \\ (k_1-k_2)/k_1 & if(k_1 \neq 0) \end{cases} \tag{3}$$

H is the main characteristic component to detect the color spots on palm, because H is less susceptible to the influence of light intensity; S represents color saturation, and its value is from 0 to 1; V represents color brightness, and its value is from 0 to 1. Collect a lot of palmprint images [14], remove the background and convert them to the HSV color space, then make statistical histogram of three components (H, S, and V) as shown in Fig. 1.



(a)H component (b) S component (c) V component

Fig. 1. H-S-V color component histogram

(1) The value of S, V is within consecutive intervals respectively: value distribution of S is in the continuous interval [0.2, 0.7]; value distribution of V is in the continuous interval [0.3, 0.72].
(2) The value of H distributes in the two discrete intervals: [0, 0.2], [0.8, 1].

3 H-S-Gray Features of Palm Color Spots

3.1 H Interval Translation and Combination

In order to combine both intermittent intervals into one continuous interval, use formula to translate H value and it is between [0.2, 0.6] after translation.

$$s(x,y) = T(r) = \begin{cases} r(x,y) + 0.4 & 0 \leq r(x,y) \leq 0.2 \\ r(x,y) - 0.6 & 0.8 \leq r(x,y) \leq 1.0 \end{cases} \tag{4}$$

$s(x,y)$ represents the brightness after conversion, $r(x,y)$ represents the brightness before conversion.

For the best effect, the image's histogram needs to be translated. Translation rule is to obtain its minimum value according to the histogram superimposed using the formulas as follows:

$$M = \min\left(\sum_{i=m}^{m+1} count(i)\right) \quad 0 \leq m \leq 255 \tag{5}$$

$$i = \begin{cases} i & if \quad 0 \leq i \leq 255 \\ i - 256 & if \quad i \geq 256 \end{cases} \tag{6}$$

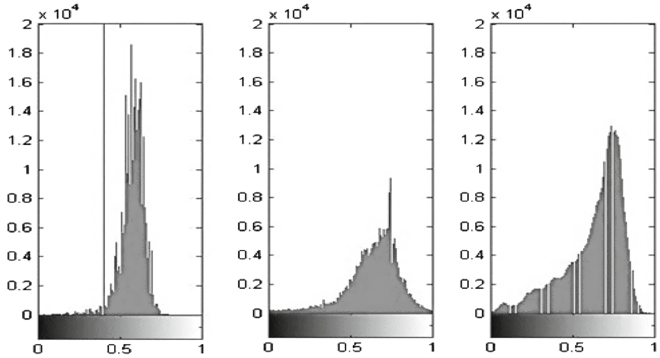
$count(i)$ records the normalized pixel number hue (H) which changes from 0 to 1, and M is the minimum one.

3.2 HSV Interval Stretch

Since the interval range of the three components is relatively narrow, in order to achieve a better effect for observation, each component value range will be stretched using formula 7. $r_{\max}$ represents the maximum value and $r_{\min}$ represents the minimum value before the conversion. After linear stretch, every component's value range becomes larger, the difference of the image than the original increase of k (as shown in formula 8) times, the effect is shown in Fig. 1. The performance in Fig. 2 is better than Fig. 1, which is important to the following palmprint image processing.

$$s(x,y) = T(r) = r(x,y) \times \frac{1}{r_{\max} - r_{\min}} \tag{7}$$

$$k = 1/(r_{\max} - r_{\min}) \tag{8}$$



(a) H component (b) Scomponent (c) V component

Fig. 2. Stretched H, S, V color component histogram

3.3 HSV Interval Quantization

The colors that human eyes can distinguish are much less than colors in HSV color model, so it is necessary to quantize [15] the HSV color model to simplify the number of colors to increase the operating speed and efficiency. To minimize color distortion and not change the original color of the contrast, this paper has taken the isometric quantization interval. Here the length and number of quantization interval are k and n, the quantized value of each component can be obtained by the formulas 9 and 10.

$$k = 1/n \tag{9}$$

$$s(x,y) = k \times [r(x,y)/k] \tag{10}$$

$s(x,y)$ stands for the new value and $r(x,y)$ stands for the original value, the operator [] represents the integer arithmetic. Through experimental data analysis, when n is 20, it takes good quantization effect. Figure 4 is n = 20, 10 and 0 for each component (Fig. 3).

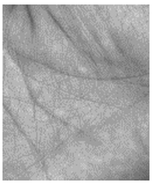
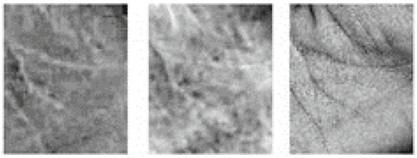
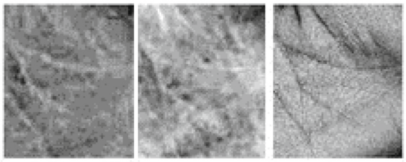


Fig. 3. Palm image

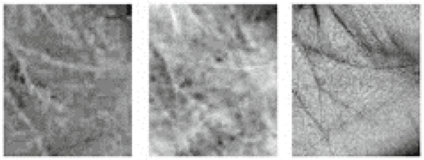
Figure 4(a–c) are the H, S and V component original images, (d), (e) and (f) are the corresponding component images after quantization (n = 20), (g), (h) and (i) are the corresponding component images after quantization (n = 10). When n is too large, the color of part region will be distorted, it is not conducive to identify the color spots on palms. Analysis of Fig. 4, in HSV color space, palm spot characteristic in H and S components of different quantization interval changes significantly, while in V of different quantization interval has been basically unchanged, so it's no need to use the V components. While gray feature significant impacts palm color spots extraction, so H-S-Gray feature extraction for palm color spots is proposed.



(a) H image(n=0) (b)S image(n=0) (c)V image(n=0)



(d) H image(n=20)(e) S image(n=20)(f) V image(n=20)



(g) H image(n=10) (h) S image(n=10) (i) V image(n=10)

Fig. 4. Different quantization interval images of H, S and V

3.4 Watershed Segmentation Algorithm

Assuming the range of image gradient value is $D = Z^2$, gradient value I is $[0, 1, \cdots, N] \quad 0 \le N \le 255$, definition 1 as follows:

$$I = \begin{cases} D \subset Z^2 \rightarrow \{0, 1, \cdots, N\} \\ p \rightarrow I(p) \end{cases} \tag{11}$$

Definition 1: In communication path between q and p, there are $l + 1$ points $(p_0, p_1, \cdots p_{l-1}, p_l), p_0 = p, p_l = q$, for every point, $\forall i \in [1, l], (p_{i-1}, p_i) \in G$, G is a communication path.

Definition 2: Polecell *(M)* of height (h) of image (I) is a communication region constituted by one or a plurality of gradient values of the pixels. Every point in M make a communication path(L) with a pixel (gradient value less than h), so there must be one point whose gradient value higher than h. The formula is shown as follows:

$$\begin{aligned} &\forall p \in L, \forall q \notin L, I(q) < I(p) \\ &\forall L = (p_0, p_1, \cdots p_{l-1}, p_l), p_0 = p, p_l = q \\ &\exists i \in [1, l], I(p_i) > I(p_0) \end{aligned} \tag{12}$$

In the formula, p and q are two points, I is gradient value, and L is communication path.

Definition 3: Geodesic distance: Point a and b are in communication path (A), the communication path belongs to A completely and is the shortest path.

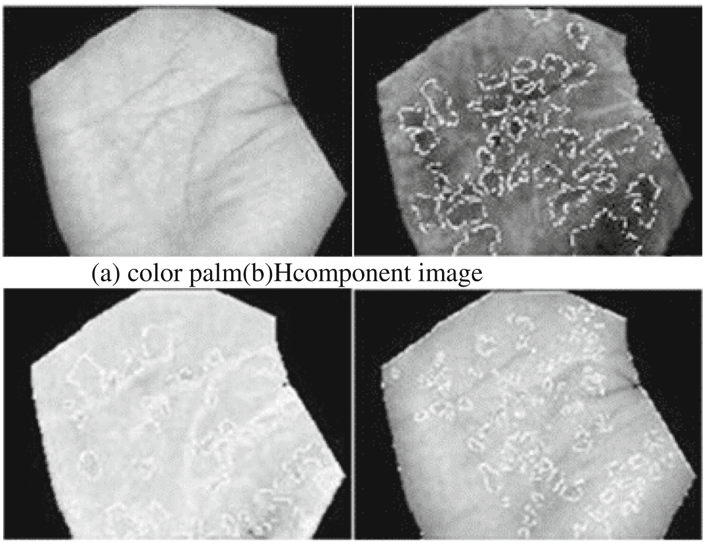
$$d_A(a, b) = \inf\{l(P)\} \tag{13}$$

P is a communication path between a and b and belongs to A. In the formula, d stands for distance.

Definition 4: Geodesic influence zone: Assuming A contains B, B is composed of $B_1, B_2, \cdots, B_k$, $B_1, B_2, \cdots, B_k$ are disconnected region with each other. Define geodesic influence zone of B is $iz_A(B_i)$.

$$iz_A(B_i) = \left\{p \in A, \forall j[1, k]\, and \quad j \neq i, d_A(p, B_i) < d_A\left(p, B_j\right)\right\} \tag{14}$$

If we use the watershed segmentation algorithm for image segmentation directly, it is usual to produce more serious over-segmentation phenomenon, in order to control the over-segmentation, we use a watershed segmentation algorithm based on control tags to segment spots [16]. In Fig. 5(a) is a color palm image, (b) is the extracted spots



(a) color palm(b)Hcomponent image

(c) Scomponent (d)Gray component

Fig. 5. The extracted spots on different component image

Table 1. Spots color data

n	h	s	gray	n	h	s	gray
1	0.2772	0.3976	102.8396	23	0.2726	0.0685	151.9878
2	0.0011	0.1376	142.7692	24	0.6192	0.3369	121.2536
3	0.3353	0.2969	114.4231	25	0.6140	0.7077	93.6108
4	0.6469	0.8672	112.6296	26	0.6195	0.7186	120.0814
5	0.6937	0.8812	110.0212	27	0.6445	0.7026	130.3751
6	0.6368	0.9965	99.35000	28	0.7384	0.4953	126.7238
7	0.4052	0.6481	118.2409	29	0.7451	0.5437	153.1752
8	0.4311	0.5233	112.0158	30	0.6538	1.0000	108.5522
9	0.4103	0.2689	132.0925	31	0.6752	0.9989	98.4457
10	0.3674	0.3663	114.2545	32	0.6616	0.9945	93.5818
11	0.6068	0.6180	107.7848	33	0.7028	0.8335	102.4404
12	0.6479	0.9485	110.0932	34	0.6344	0.8528	97.0595
13	0.6859	0.9047	109.4058	35	0.7385	0.7318	117.3972
14	0.6268	0.3997	210.1595	36	0.5729	0.8831	80.66090
15	0.5708	0.6134	179.7918	37	0.7090	0.7887	98.35600
16	0.6106	0.4646	194.8241	38	0.6322	0.7193	104.6517
17	0.5724	0.6148	180.3913	39	0.5980	0.7756	101.1048
18	0.5621	0.6031	165.2969	40	0.6268	0.8179	102.4740
19	0.5503	0.5357	168.9005	41	0.5529	0.7604	83.3614
20	0.6432	0.3927	150.9147	42	0.5966	0.7039	115.7219
21	0.5251	0.6194	119.5629	43	0.4467	0.5307	123.1703
22	0.4636	0.5168	118.3917	44	0.5263	0.5401	116.1521

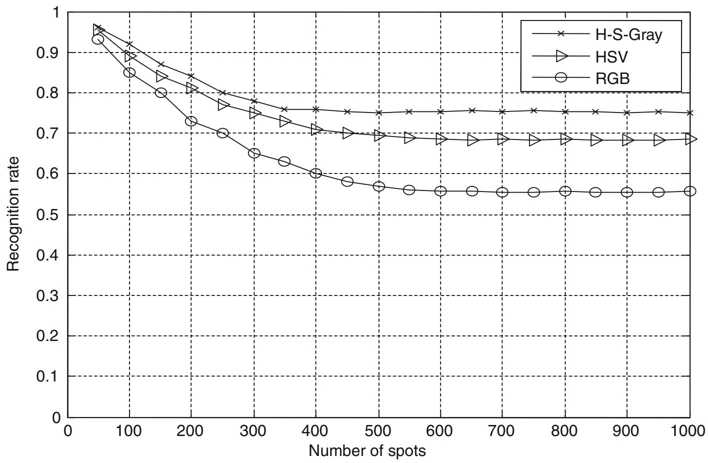


Fig. 6. The comparison of recognition rate

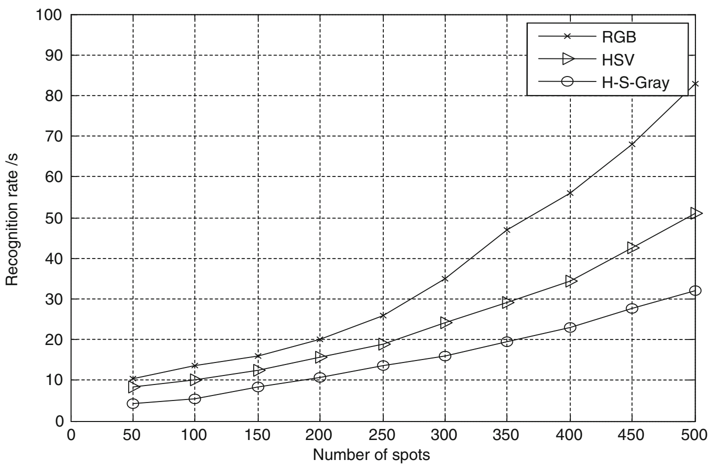


Fig. 7. The comparison of running time

on the H component, (c) is the extracted spots on the S component and (d) is the extracted spots on the Gray component.

4 Conclusions

In this paper, the pixel area of the spots between 20 and 90 are selected to be analyzed. Respectively, use the RGB color model, HSV color model and the H-S-Gray model proposed in this paper to extract each component image, use the watershed segmentation algorithm based on control tags to identify the palm color spots from the various components of the images, Table 1 is part of spot color data.

From the Fig. 6, the final recognition rate of RGB color model, HSV color model and H-S-Gray is 53 %, 68 % and 75 %. Obviously, H-S-Gray's performance is better than the first two. And with the increasing number the performance is better.

In Fig. 7, from up to down they are followed by RGB model, HSV model and H-S-Gray model. The running time of RGB model is 10.25 s, that of HSV model is 8.33 s, and the H-S-Gray is 4.25 s when the number of spots is 50. Contrasted to RGB model and HSV model, the running time of H-S-Gray is 41.5 % and 51 % of RGB and HSV. When the number becomes larger, the performance become more obvious.

This paper mainly studies the fast identification of palm color spots. Because palmprint color is rich, and spots species is relatively concentrated, this paper has stretched HSV color space interval to expand the color range of the palm spots, and according to color characteristics the of abnormal spots, quantifies the color interval and improves the extraction efficiency of the color components; uses watershed segmentation algorithm based on control tags to segment H, S and Gray quantified component image respectively, and it turns to be efficient to identify spots; compares the H-S-Gray model algorithm with the RGB and HSV color model algorithm, it is obvious that recognition rate significantly improves and the running time significantly reduces, which is able to basically meet the timely requirements of palm color spots recognition. The proposed H-S-Gray model is simple and efficient, it not only can meet the needs of human visual perception of color spots on the palm, but also improve the speed of segmentation to identify the palm color spots.

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