Features of human skin in *HSV* color space and new recognition parameter

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Features of human skin in *HSV* color space are widely applied in the area of image retrieval based on content. H is selected as the basic recognition parameter because its value has a narrow range for the skin color and can keep stable while the illumination intensity or the curvature of skin surface is changing. Rules of parameters with the change of illumination in HSV color space are studied. It is firstly found that the mean of saturation and value (*S*+*V*)/2 can keep stable when the illumination intensity is changed or the skin surface is inflected, and (*S*+*V*)/2 changes with skin color, but the tendency of change is contrary to that of H. Therefore, (*S*+*V*)/*H* can be used as a new recognition parameter which can enhance *HSV* ability to recognize human skin.

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HSV color model divides color into hue (*H*), saturation (*S*) and value (*V*), which apperceive color change independently. The hue, which has an obvious skin color clustering quality, has been widely used in image processing, image segmentation, face detection and so on.[1-5] The range of *H* is relatively stable and is cabined for the same color object, so *H* is often regarded as a basic recognition parameter. Because human skin color has a stable value of *H*, one can pick up the skin easily from photos. The hue can keep stable when the illumination intensity or the curvature of skin surface change. This character can reduce the influences that come from human individuality, illumination and illuminative direction.

Other parameters used in image processing have been investigated in many papers. Kawada A. et al used *H*, *S* and *V* to evaluate whitening effects of cosmetics with the change of skin reflectance of the colorimeter[6]. Osamu Ikeda presented a segmentation method using controlled weights on three *HSV* components and constructed a face detection and image retrieval system.[7] Gary L. Hansen et al used *H* and *S* to evaluate wound status.[8] Shang Keke et al introduced parameter *S*/*H* to recognize a skin disease.[9]

In this paper, we studied the rules of three coordinate quantities of *HSV* color space with the change of illumination intensity and found that the mean of hue and saturation (*S*+*V*)/2 has a narrow range for skin color and can keep stable while the illumination intensity or the curvature of skin surface is changing, and that (*S*+*V*)/2 changes with skin color, but the tendency of change is contrary to that of *H*.

The experimental setup is shown as Fig.1. The source is a 150 W halogen lamp (SCHOTT Co., ACE type, offering simulate CIE D65 illumination, 3200 K color temperature), and the annular light diffuser fixed around the camera is to guarantee good spatial homogeneity of the light field. An infrared filter is added in the light source box to reduce the effect of lamp-house temperature. A cylinder with a length of 270 mm was fixed in front of the lens (in front of the light source) to eliminate the effects from surrounding light. The receiver is a digital camera (Sony F717).

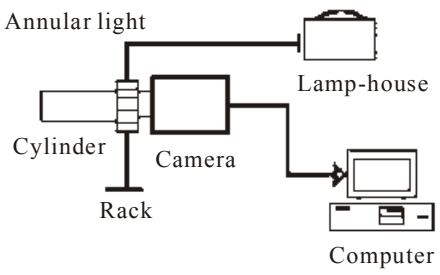

Fig.1 Diagram of the experimental setup

The camera is set for white balance with standard white panel before taking photos. The average values of parameters are calculated from the chosen part of picture pixels.

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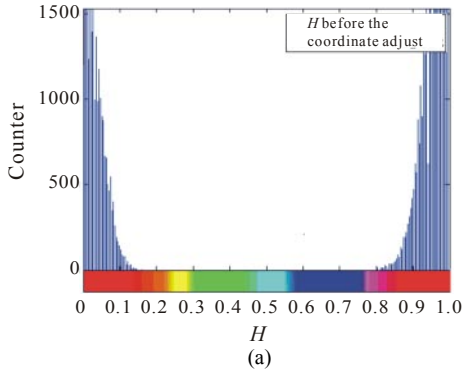
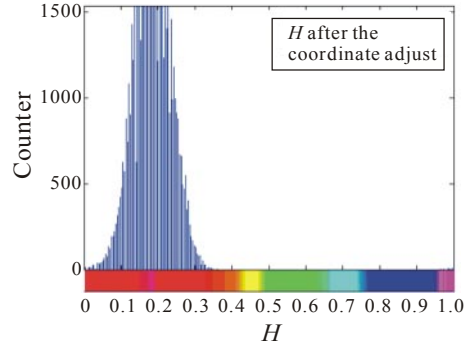
The value of *H* of Chinese skin is distributed over 0~0.2 and 0.8~1 regions, as shown in Fig.2 (a), so the statistical average of *H* will be located in non-red region. To avoid this wrong calculation, we move the hue axis in *HSV* coordinates by adding 0.2 to every value of hue and subtracting 1 if the value is larger than 1. As a result, the two separate parts are combined into one region from 0 to 0.4, as shown in Fig.2 (b).



(a)



(b)

Fig.2 Histogram of H for Chinese skin (a) before the coordinate is adjusted and (b) after the coordinate is adjusted

Fig.3 shows the curves of *H*, *S*, *V* and (*S*+*V*)/2 of a young woman skin being relatively white. The skin surface is relatively plane, but the illumination is changed from 1000 Lux to 20000 Lux in 1000 Lux spacing. Total 20 photos were taken. From Fig. 3, we find that S increases and *V* decreases with the illumination decreasing, and the two curves intersect at an illumination of 6180 Lux. The curve of (*S*+*V*)/2 is flat within the illumination region larger than the value of the intersection point, where (*S*+*V*)/2 changes in a small range from 0.5721 to 0.5761. The average of H and (*S*+*V*)/2 are 0.28 and 0.58, respectively.

We studied 40 sets of photos, which were taken from different individuals and different parts of body, and we obtained results similar to those in Fig.3. All of the curves have a flat region larger than the intersection, which changes with different objects, but the values of (*S*+*V*)/2 do not have obvious distinction. This character is similar to that of *H*, but (*S*+*V*)/2 has a smaller flat region than *H*.

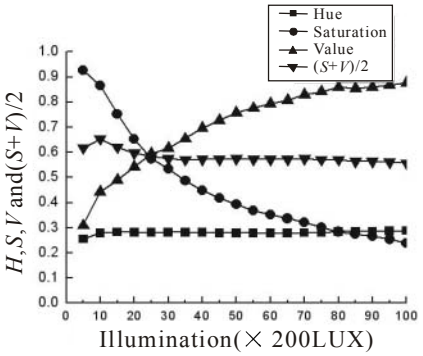
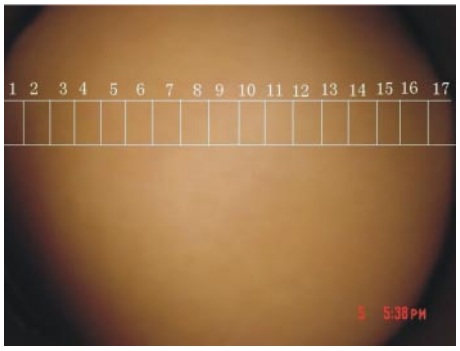
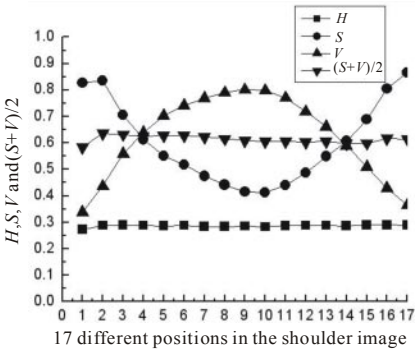


Fig.3 Curves of *H*, *S*, *V*, and (*S*+*V*)/2 for different illuminations

Fig.4 (a) is the photo of a man′s houlder with a large curvature. Under the condition of uniform illumination, the object was illuminated in different directions because of the large curvature. The abscissa of Fig. 4 (b) is the serial number in Fig. 4 (a). The curves of S and *V* have two intersections and the curve of (*S*+*V*)/2 has a flat region between the two points. This character of (*S*+*V*)/2 is also similar to that of *H* , but (*S*+*V*)/2 has a smaller flat region than *H*.



(a)



(b)

Fig. 4 (a) Photo of a shoulder with great curvature and (b) curves of *H*, *S*, *V* and (*S*+*V*)/2 for the shoulder

Above experimental results show that the characters of (*S*+*V*)/2 and *H* are very alike, so a thorough study of parameter (*S*+*V*)/2 is necessary. We studied the rule of (*S*+*V*)/2 when the hue of skin is changed. Fig.5 shows the results of measurements, where a skin with disease is considered, some photos are taken from the healthy areas, some photos are taken from the inflamed areas, and the abscissa is the serial number of samples. In Fig. 5, we can see that the healthy skins have larger *H* values than inflamed skins, but the change of (*S*+*V*)/2 is contrary to that of *H*, that is, (*S*+*V*)/2 is increasing while *H* is decreasing. Therefore, it is considerable to define a combined parameter (*S*+*V*)/*H*, which can enhance the ability of *HSV* to recognize human skin. In Fig. 6, the relative change of *H* for inflamed skin is 8.7%, while the relative change of (*S*+*V*)/*H* for inflamed skin is 23.0%.

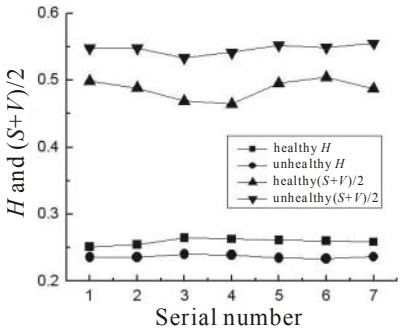


Fig.5 Contrast between (*S*+*V*)/2 and H

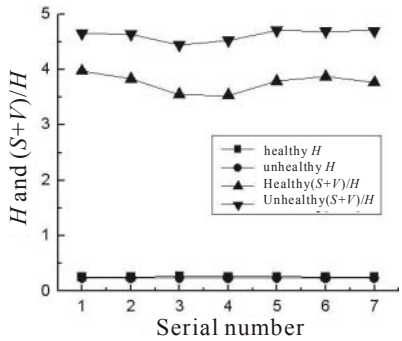


Fig.6 Contrast between (*S*+*V*)/*H* and *H*

In conclusion, it is firstly found that the mean (*S*+*V*)/2 of the hue and saturation of the Chinese skin in *HSV* color space can keep stable when the illumination intensity is changed or the skin surface is inflected, and (*S*+*V*)/2 changes with skin color. But the change of (*S*+*V*)/2 is contrary to that of *H*, that is, (*S*+*V*)/2 is increasing while *H* is decreasing. Therefore, it is considerable to define a combined parameter (*S*+*V*)/*H*, which is robust to illumination intensity and surface curvature like parameter *H*, and has better ability in differentiating human skin than parameter *H*. The future research on parameter (*S*+*V*)/*H* and its applications will be carried out.

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