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Diagnosis Algorithm for Skin Texture and Stains Using Mobile Cameras

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***Abstract*—The conditiSon of skin represents human's health and that is one of the important things about beauty women are interested in. This research enables individuals to diagnose skin condition without any technical devices and knowledge. We suggest skin diagnosis algorithms for evaluating the texture and stains using mobile cameras. The precision of evaluating texture of face is 89.0%, that of back of hands is 93.2[%], and that of arm is 46.6[%]. The precision of extracting stains is 84.0[%]. A dermatologist says this algorithm can be used practically.**

***Keywords*—skin, diagnosis , texture, stains and mobile camera**

I. Introduction

"From the medical point of view, skin is related to blood circulation and mental states and consequently represents humans' health"[1][2]. Additionally, healthy skin makes humans look beautiful. The way to keep skin beautiful is one of the interests of women. It is important to find out your own skin condition and choose your skin-care cosmetics which are the most suitable to you. Diagnosis of skin has been done by dermatologists and experts of some cosmetic companies. However, it is impossible for the people without any technical devices and knowledge to diagnose skin condition. In order to solve this problem, some cosmetic companies developed some devices with cameras and systems to measure moisture of skin[3-10]. Although some of them have been sold actually, these devices are expensive.

Accordingly, we suggest algorithms for diagnosing skin condition by using mobile cameras and image processing. We refer to evaluating skin texture and extracting skin stains.

II. Photographic Device

We use a mobile camera to take skin images. It enables to show them almost the same as the images which are taken by technical devices. The mobile camera has 2 modes, i.e. taking images of diagnosing skin texture and stains, and controls the amount of LED light.

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III. Diagnosis of Skin Texture

A. *Database for Experiment*

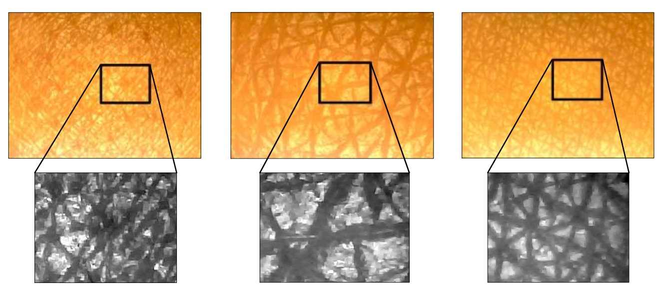
The database for the diagnose of skin texture is composed of 219 skin images of 73 Japanese women's faces, back of the hands, and arms. Fig. 1 shows some examples of those. The size of all the images are 480 [pixel] long by 640 [pixel] wide.

B. *Definition of Skin Texture*

Skin texture is mesh spreading on the surface of skin and consists of the ridge and depression(Fig. 2). "Smooth skin" has narrow and shallow depression (Fig. 1(a)) and "rough skin" has wide and deep one(Fig. 1(b)). The evaluation of skin texture generally depends on the fineness of that.

C. *Purpose of Image Processing*

The purpose of image processing is fitting the input images to the existing skin diagnosis algorithm we already suggested [11]. The existing algorithm can diagnose the skin images taken by a fingerprint certification device (Fig. 3(a)). Fig. 3(b) shows the taken image and the depression is emphasized, but that of the image of Fig. 1 cannot be seen. Therefore, we did preprocessing to emphasize the depression.



(a) Face. (b) Back of hands. (c) Arm.

Figure 1. Examples of Input Images.

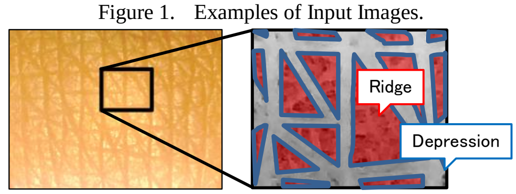
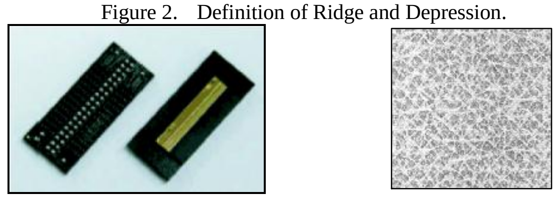


Figure 2. Definition of Ridge and Depression.



(a) Fingerprint Certification Device. (b) Former Input Image.

Figure 3. Former Device and Input Image.

D. *Emphasizing The Skin Depression*

In order to evaluate the feature and condition of skin precisely, we confirm whether some noise exists or not. Fig. 4 shows gradation existing on the whole image.

After confirming the gradation, we extract the depression from the input skin images. We convert those to grayscale by NTSC weighted average(Fig.5(b)). The depression on former input images are shown as white(Fig. 3(b)). Thus, we reverse the tone(Fig. 5(c)) and visually scale the size of the input images down into half by bilinear to fit the size of texture into almost the same as the former one(Fig.5 (d)).

Figure 4. Image of Confirmig Noises.

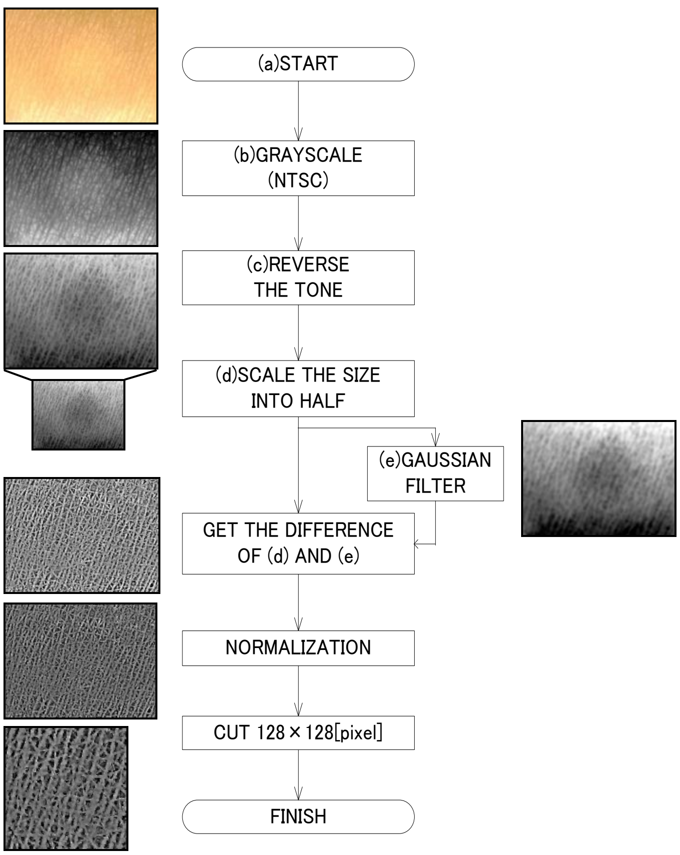


Figure 5. Flowchart and The Result of Proposal Technique.

1) Removing Gradation.

At first, in order to remove the gradation and get depression, we suggest getting the difference between the images which are scaled down(Fig. 5(d)) and the Gaussian filtered images(Fig. 5(e)). We examine the radius of Gaussian filter by increasing that one by one. When it is too short(Fig. 6(a)), the depression cannot be extracted. On the other hand, when it is too long(Fig. 6(c)), it has no difference between Fig. 6(b) and Fig. 6(c). The depression of Gaussian filtered image whose radius is 4 is extracted well.

Next, we examine normalization. We get the average($\overline{G}(x,y)$) and the standard deviation(σ) of the histogram from (1) and (2). h_r is higher value than the mode of histogram(μ) by r (a fixed number) times of σ and h_l is smaller value than μ by r times of σ following (3) and (4). The width of normalization is the difference between h_r and h_l. We define W as the width, H as the length of input images, N as the pixel number, and $G_n(x,y)$ as the luminosity value. We examine the value of r by increasing that from 1. Texture of all the input images can be extracted the best and the gradation can be reduced well when r is 3. Fig. 7 shows the image and histogram. Normalizing.

2) Cutting.

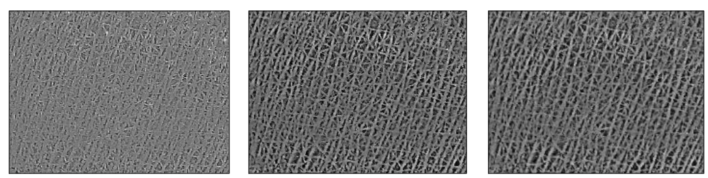
Even normalized Images have a little gradation. We consider that the darkest part of each images does not have the gradation, thus, we cut the part of 128 [pixel] length by 128 [pixel] width from those. That reveals the skin texture well and Fig. 8 shows some examples of the cut images.

$$\overline{G}(x,y) = \frac{1}{W \times H}\sum_{n=0}^{N-1} G_n(x,y), \quad (1)$$

$$\sigma = \sqrt{\frac{1}{W \times H}\sum_{n=0}^{N-1}\left\{\overline{G}(x,y) - G_n(x,y)\right\}^2}, \quad (2)$$

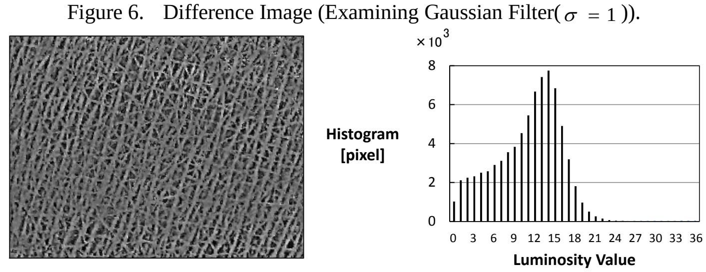
$$h_r = \mu + r\sigma, \quad (3)$$

$$h_l = \mu - r\sigma. \quad (4)$$



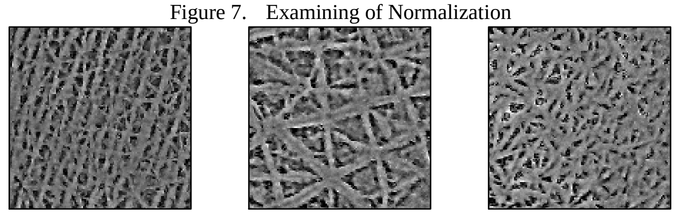
(a) Radius 1. (b) Radius 4. (c) Radius 10.

Figure 6. Difference Image (Examining Gaussian Filter($\sigma = 1$)).



(a-1) Normalized Image ($r = 3$). (a-2) Histogram ($r = 3$).

Figure 7. Examining of Normalization



(a) Sample Image. (b) Example1. (c) Example2.

Figure 8. Cutting Images.

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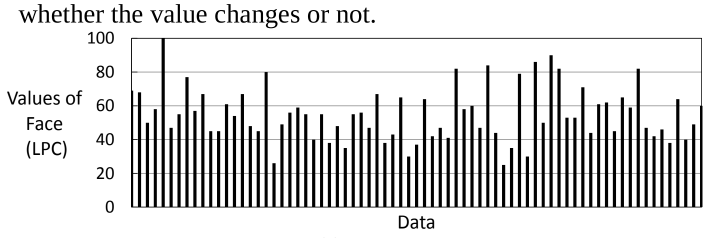
E. *Examining Diagnosis of Skin Texture*

When the pitch(resonant frequency) of an image is high, the skin texture is smooth. Therefore, we apply LPC analysis to evaluating skin texture, which we already suggested before[12]. With two-dimensional analysis we calculate the pitches of the image. Removing each direct current components from the horizontal and vertical lines of luminosity value, we apply a hamming window to them, calculate autocorrelation coefficients, calculate linear predictive coefficients, and then, calculate a pitch based on linear predictive coefficients. Finally, we calculate the average of all the pitches and normalize the value from 0 to 100. This is the value of skin. Fig. 9 shows all the values of the skins from face and back of hands. Based on the information that faces have smooth skin and back of hands have rough skin, we consider these values. According to Fig. 9, most of the values of faces are high and those of back of hands are low.

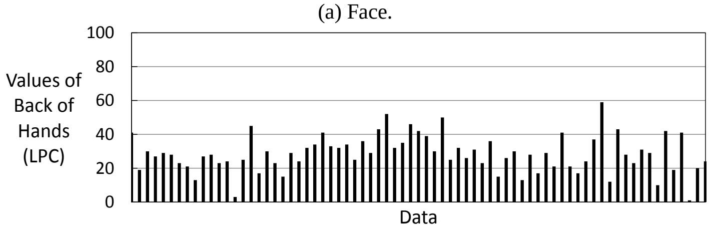
F. *Precision of Diagnosing Skin Texture*

At first, in order to get the correct value of all the images of texture database, we get 10 examinees to evaluate their texture value by method of paired comparison[13]. We apply an image whose value by the proposal technique is calculated as 50(average value) to the reference image. 10 examinees evaluate all the images as “smooth skin”, “normal skin”, and “rough skin” against this reference. On the other hand, we define the value which is calculated by the proposal technique as 3 groups. The value between 0 and 33 is “smooth skin”, 34 and 67 is “normal skin”, and between 68 and 100 is “rough skin”. We define the correspondence of both value as the precision of proposal technique and Table1 shows that.

As stated above, the precisions of proposal technique of face and back of hands are high although that of arm is low. In this experiment, the average value of 10 examinees is defined as a correct one. Although the value of face and back of hands have correlation and is almost the same, those of arm are not settled. We need to confirm the opinion by experts especially in the value of arm. Additionally, in the case of greatly increased number of the examinees, we also need to confirm whether the value changes or not.



(a) Face.



(a) Back of Hands.

Figure 9. Value of Skin Image by LPC Analysis.

TABLE I. PRECISION OF DIAGNOSING SKIN TEXTURE

Part	Input Image Number	Inconsistent Number	Consistent Rate[%]
Face	73	8	89.0
Back of Hands	73	5	93.2
Arm	73	39	46.6

IV. Diagnosis of Skin Stains

A. *Database for experiment*

The database for diagnosis of skin stains is composed of 50 Japanese women’s faces with stains out of 73women(the same as the experiment for skin texture). Fig. 10 shows some examples of the images. The size of all the images are 480 [pixel] long by 640 [pixel] wide.

B. *Definition of Skin Stains*

Skin stains are defined as depositing of pigmentation on the surface of skin. Fig. 11 shows an example of the images with stains.At first, we confirm which color channel stains have the most. We find all the stains have much blue channel and little red channel, and also find all the downy hairs have both blue and red channels(Fig. 12). Thus, we extract stains and hairs from blue channel, and extract only the hairs from red channel. And then, extract only the stains from the difference of blue and red channels.

C. *Extracting Stains and Hairs*

Fig. 13 shows the flowchart and the process images.

1) Removing Gradation.

First of all, we remove the gradation which also exists on the input images because of using the same devices as diagnosing skin texture. We add all the input images, find the average image of luminosity value (Fig. 14(b)), and reverse the tone. After that, the gradation is removed by finding the average image of Fig. 14(b) and Fig. 14(c).

2) Filtering.

Next, we make filters to emphasize stains. Considering stains as having rounded, not linear outlines, we make 4 filters shown in Fig. 15 and compose them. Fig.13(d) shows the filtered image. Stains and hairs are extracted well.

Figure 10. Examples of Input Images(Face).

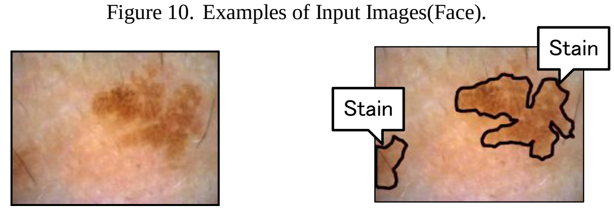
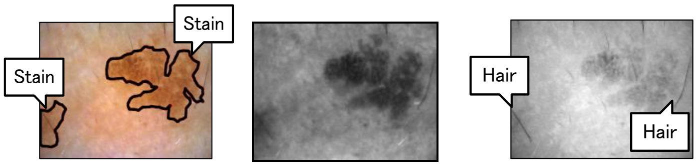
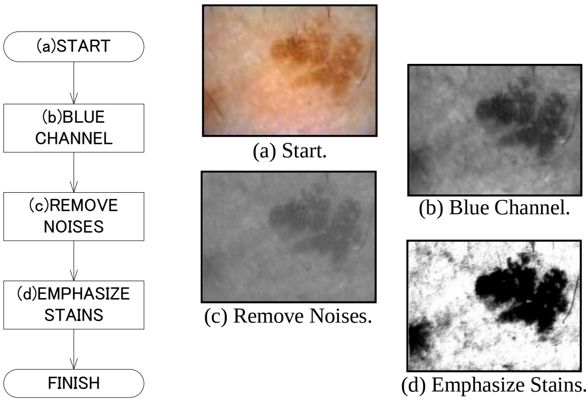


Figure 11. Skin Image with Stains.



(a) Input Image. (b) Blue Channel. (c) Red Channel.

Figure 12. Division of Color Channel.



(a) Start. (b) Blue Channel. (c) Remove Noises. (d) Emphasize Stains.

Figure 13. Flowchart and Result of Extracting Stains and Hairs.

(a) Blue Channel. (b) Average Image. (c)Remove Gradation.

Figure 14. Removing Gradation.

1	1	1
1	0	−1
1	−1	−1

(a) Upper Left.

1	1	1
−1	0	1
−1	−1	1

(b) Upper Right.

1	−1	−1
1	0	−1
1	1	1

(c) Lower Left.

−1	−1	1
−1	0	1
1	1	1

(d) Lower Right.

Figure 15. Filters before Composition.

D. *Extracting Hairs*

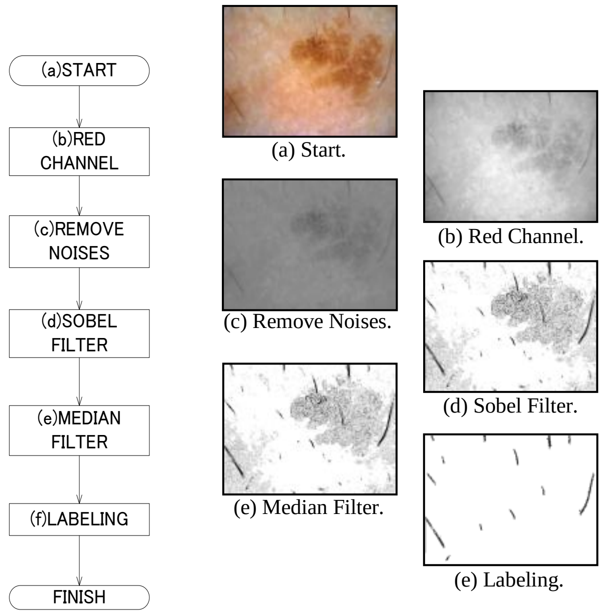
Fig. 16 shows the flowchart and the process images.

1) Filtering.

Considering hairs are having linear outlines, we use Sobel filter combining the Sobel filters of length and breadth(Fig 16(d). The image filtered by Sobel filter shows hairs , but especially thick ones outline have blanks inside. In order to solve this problem, we also use median filters and put black pixels on the blanks. Fig 17. Shows that. This process improves extracting hairs.

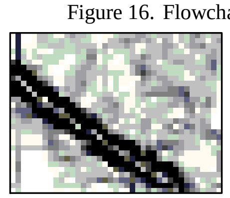
2) Labeling.

Defining black pixels excluding hairs as noises in the filtered images, we remove them. The size of them are small and scattered. We make the binary image, give labels to each of the black labels one by one, put them in order from small to large, and investigate the threshold of size between hairs and noises. Finally, we conclude that to be over 30 [pixel]. Fig. 16(f) shows the image which is composed by just hairs over the threshold.

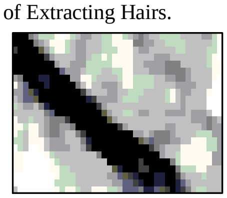


(a) Start. (b) Red Channel. (c) Remove Noises. (d) Sobel Filter. (e) Median Filter. (e) Labeling.

Figure 16. Flowchart and Result of Extracting Hairs.



(a)Before.



(b)After.

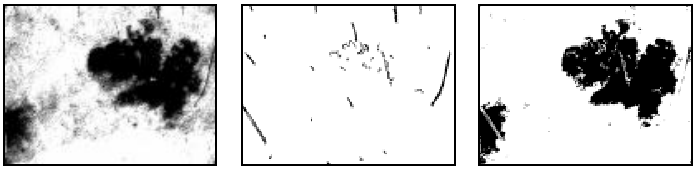
Figure 17. Comparing Before and After Median Filtering.

E. *Extracting Stains*

In order to get only stains, we remove the images of hairs from that of hairs and stains. And then, the same technique as 4.4.2 section can remove the noises. Fig. 18 shows the result.

F. *Precision of Extracting Stains*

We refer to the precision of extracting skin stains by proposal technique. At first, we define the correct numbers and places of stains against all the images with stains in reference to 10 examinees opinions who are the same as diagnosing skin texture. Considering the correct numbers and places, we reveal the precision of the proposal technique. We define the rate of extracting stains from the place and number of stains as positive rate, the rate of not extracting stains from the part of real stains, the rate of extracting stains from the part without any stains. Then, we calculate them. The denominator of the rate is sum of the number of positive, undetected, and negative numbers. Table2 shows the precision of extracting skin stains. Before extracting only the stains, we remove the noises several times. On the other hand, thin, small and short hairs cannot be extracted exactly. We need to confirm these processes and threshold to raise the precision.



(a) Stains and Hair. (b) Downy Hair. (c)Stains.

Figure 18. Process of Emphasizing Stains.

TABLE II. PRECISION OF EXTRACTING SKIN STAINS

Input Image Number	Rate[%]		
	Positive	Undetected	Misdetected
50	84	2.6	4.5

V. Conclusion

In this article, we suggest diagnosing skin texture and extracting skin stains from the images taken by a small camera. This system enables individuals without any technical devices and knowledge to diagnose their own skin condition. Our algorithm provides 76.3% for diagnosing skin texture and 85.0% for extracting skin stains. Although a dermatologist says it can be used practically, we need to solve the problems in order to raise these precision. In addition to these algorithms, we are considering diagnosing moisture and color of human skin. On the other hand, we need to adapt this algorithm to the images taken under various circumstances.

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