A Method to Evaluate Accumulated Stress Using Nail Image

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ABSTRACT

In this paper, we propose a method to evaluate accumulated stress by extraction the height of the lunula of the nail from a nail image. The proposed method consists of three stages: measurement, preprocessing, and stress evaluation. In the measurement, we take a nail image. In the preprocessing, we extract the height of the lunula of the nail. Then, we carry out edge detection using a hue histogram in a rectangle. In the stress evaluation, we evaluate accumulated stress at 0 to 1 using fuzzy reasoning. In order to show the effectiveness of the proposed method, we conducted experiments. These results suggested that the difference between the minimum and maximum values of the height of the lunula while the experiment might be able to determine the presence or absence of accumulated stress.

KEYWORDS

image processing, fuzzy reasoning, stress evaluation, nail image, social system

1 INTRODUCTION

In recent years, there are any methods or systems for stress evaluation[1][2]. However, most of them may evaluate acute stress. Ideally, it is necessary to construct a system to evaluate accumulated stress. However, there is no way to evaluate accumulated stress. Furthermore, stress patients are often difficult to undergo a medical examination. Thus, we propose a system to evaluate accumulated stress on a daily basis using nail images. In the previous study, the cortisol in a nail was measured for accumulated stress[3]. Similarly, it has been confirmed that superficial changes in nails occured in stress disorder patients[4]. However, there is no relationship between the change of the nail and accumulated stress[5]. The proposed method extracts the change of the lunula because the shape of the lunula can change when he/she feels stress for a long term. Then, we evaluate accumulated stress to apply fuzzy reasoning to the height of lunula.

2 RELATED WORKS

Nomoto et al. proposed a system to evaluate a color of toenails using HSV color system conversion[6]. The system decomposed an image into Red, Green, and Blue components. Each components were convert into HSV color system and save on a server. The system evaluated by comparing the current data and the average of the data on the server. Trupti S. al. introduced a system to diagnose early stage disease using human nail image processing[7]. This system trained data on patient nail images for disease classification. This system used nail color values can predict probable disease in people including healthy cases. In the experiment, this system classified human condition into 5 classes (4 diseases and healthy). The average match rate for the five classes was 65%. Izawa et al. proposed the method to measure cortisol using fingernail[3]. It was thought that cortisol diffuses from capillaries when the nail was formed[8]. This study investigated the effects of ground-fingernail grain size and cortisol extraction time on the measurement of fingernail cortisol. Then, four-teen healthy males provided fingernail samples. The results indicated that finer grading and longer extraction time were associated with higher cortisol levels.

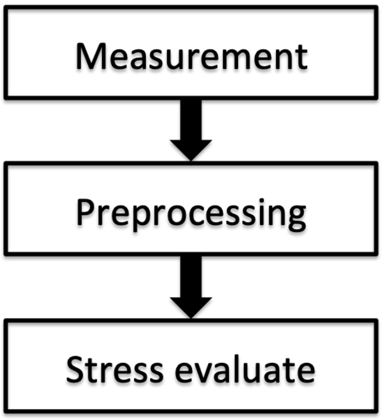
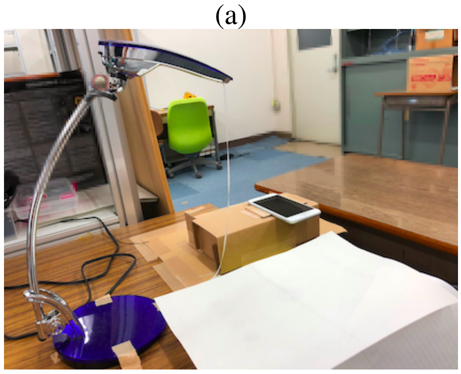


Figure 1. Flowchart of the proposed method.

(a)



(b)

Figure 2. Experimental conditions. (a) and (b) are a top-down view of photographing and photographing environment from a lateral view, respectively.

3 EXPERIMENTS

3.1 Proposed method

The proposed method consists of measurement, preprocessing, and stress evaluation stages. Figure 1 shows the flowchart of the proposed method.

In the measurement, we take nail images of thumb. We use a standard camera on an iPhone 6s to take nail images. The photographing environment is fixed. Then, we put a table lamp to make the same illumination state. Figure 2 shows the experimental conditions.

In the preprocessing, we extract the lunula of the nail to calculate the height. We convert the RGB color system into the HSV color system. Then, the proposed method decomposes the HSV color image into Hue, Saturation, and Value components. Thus, we carry out a binarization and labeling to detect finger position. Finally, we carry out edge detection using a change of hue histogram in a rectangle. Figure 3 shows the flowchart of the edge detection. We calculate the hue histogram. Then, we check the conditions. The conditions for judging the end of the edge detection are as follows:

$$CF_{max} - CF_{semi} < \alpha \quad (1)$$

$$|H_{cf_m} - H_{cf_s}| > \beta \quad (2)$$

where CF_{max}, CF_{semi}, H_{cf_m} and H_{cf_s} are the maximum value of cumulative frequency, the second largest value of cumulative frequency, the Hue value at which cumulative frequency becomes maximum and the Hue value at which cumulative frequency becomes second largest. The parameters α and β are set to 200 and 10, respectively. The rectangle position is added 1 pixel to the y coordinate, when the two conditions are false. We calculate the height of the lunula, when the two conditions change to true. Figure 4 shows the initial position of rectangle in edge detection and the end position of rectangle in edge detection, respectively.

In the stress evaluation, we employ a fuzzy reasoning technique. The proposed method creates membership functions for the fuzzy reasoning based on the changes of height during experiments. The membership functions composes of three factors; a difference between max-min height, a slope of regression line on the changes of height, and a degree of the accumulated stress. Figure 5 shows the membership functions. The difference values between max-min height (DMM) are calculated by computing the difference between the maximum and minimum values of the lunula height during experiments. The pro-

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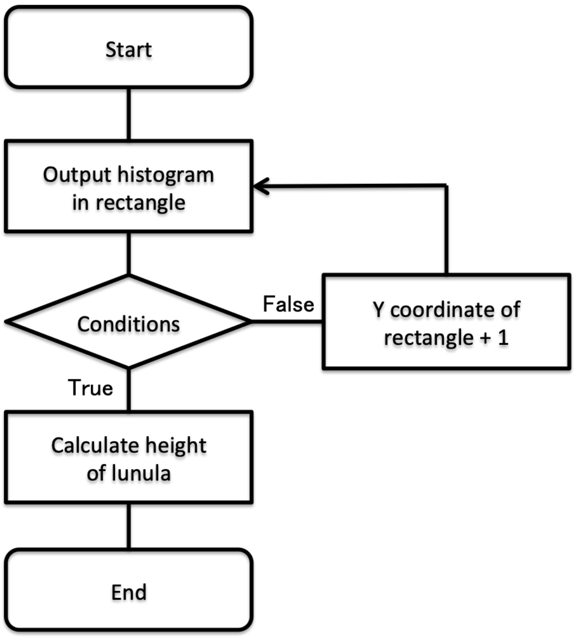

Figure 3. Flowchart of edge detection.

posed method has two membership functions for the DMM(Figure 5(a)). The membership function whether the DMM is large or not is as follows:

Listing 1. DMM1

```
if (DMM <= CP1)
    grade = 0.0;
else if (DMM <= CP2)
    grade = ang * DMM + b;
else
    grade = 1.0;
```

where DMM, ang, and b are the DMM, the slope of the membership function, and the intercept, respectively. The variables ang, b, $CP1$, and $CP2$ are set to $1.0/30.0$, $-2.0/3.0$, 20, and 50, respectively. The membership function whether the DMM is small or not is as follows:

Listing 2. DMM2

```
if (DMM <= CP1)
    grade = 1.0;
else if (DMM <= CP2)
    grade = ang * DMM + b;
else
    grade = 0.0;
```

where DMM, ang, and b are the DMM, the slope of the membership function, and the intercept, respectively. The variables ang, b, $CP1$, and $CP2$ are set to $-1.0/30.0$, $5.0/3.0$, 20, and 50, respectively. The slopes of the regression lines (SLOP) are calculated by computing on all height values of the lunula during experiments. The proposed method has two membership functions for the SLOP (Figure 5(b)). The membership function whether the SLOP is large or not is as follows:

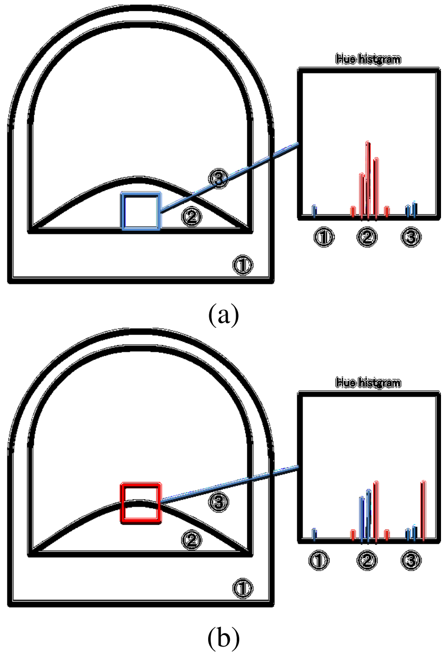

Figure 4. Rectangle search. (a) and (b) are the initial position of rectangle in edge detection and the end position of rectangle in edge detection, respectively.

Listing 3. SLOP1

```
if (SLOP <= CP1)
    grade = 1.0;
else if (SLOP <= CP2)
    grade = -1 * ang * SLOP + b;
else if (SLOP <= CP3)
    grade = 0.0;
else if (SLOP <= CP4)
    grade = ang * SLOP + b;
else
    grade = 1.0;
```

where $SLOP$, ang, and b are the slope of the regression line, the slope of the membership function, and the intercept, respectively. The variables ang and b are set to 1.0 and $-1.0/2.0$, respectively. The variables $CP1$, $CP2$, $CP3$,

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and $CP4$ are set to -1.5, -0.5, 0.5, and 1.5, respectively. The membership function whether the SLOP is small or not is as follows:

Listing 4. SLOP2

```
if (SLOP <= CP1)
   grade = 0.0;
else if (SLOP <= CP2)
   grade = ang * SLOP + b;
else if (SLOP <= CP3)
   grade = 1.0;
else if (SLOP <= CP4)
   grade = -1 * ang * SLOP + b;
else
   grade = 0.0;
```

where $SLOP$, ang, and b are the slope of the regression line, the slope of the membership function, and the intercept, respectively. The variables ang and b are set to 1.0 and $3.0/2.0$, respectively. The variables $CP1$, $CP2$, $CP3$, and $CP4$ are set to -1.5, -0.5, 0.5, and 1.5, respectively. All parameters related to the membership functions determined by trial and error. In the proposed method, three rules are used. Listing 5 shows the source code of the fuzzy Rules.

Listing 5. Fuzzy Rules

```
LittleOrNoneGrade = AND(DMMSmall, SLOPSmall);
aLittleGrade = AND(DMMLarge, SLOPSmall);
ExistGrade = AND(DMMLarge, SLOPLarge);
```

where the $DMMLarge$, $DMMSmall$, $SLOPLarge$, and $SLOPSmall$ are the degree of conformity whether the DMM is large or not, the DMM is small or not, the SLOP is large or not, and the SLOP is small or not, respectively. The $LittleOrNoneGrade$, $aLittleGrade$, and $ExistGrade$ are the degree of conformity: the accumulated stress is little or none, a little, and existent, respectively. In the degree of the accumulated stress, the degrees are calculated by computing the center of trapezoid in Figure 5(c). Listing 6 shows the source code of center calculation trapezoid. The center of trapezoid is calculated as follows:

Table 1. The DMM, SLOP, and accumulated stress amount of each subjects.

Subject	DMM	SLOP	Ac. stress
A	48.7	-0.886	0.57
B	48	0.3599	0.43
C	42	-0.2499	0.37
D	48.3	-1.4103	0.74
E	24.3	0.0426	0.18
F	36.5	-0.4175	0.31
G	24.4	0.7277	0.40

Listing 6. Center calculation of trapezoid

```
for (double i : setSynthesis)
   num = num + i * size;
   den = den + i;
   size += 0.05;
if (den != 0.0)
   center = num / den;
else
   center = 0.0;
```

where $setSynthesis$ and $center$ are the synthetic trapezoid and the center of the trapezoid, respectively.

3.2 Experimental conditions

The number of subjects was 7 males (average age 22.4 years). All subjects consented to take pictures of the nails of thumb of Dominant hand.

4 RESULTS AND DISCUSSIONS

Figure 6 shows the successful data and failure data of height extraction of lunula, respectively. Figure 7 shows the graphs of extracion results of the lunula height of subjects, respectively. The red points in the graph were average values in a week of experiments. Table 1 shows the DMM, SLOP, and accumulated stress degree (Ac. stress) of each subject. We imposed the stress task on the subjects A-D, and did not impose the stress task on the subjects E-G, respectively. The subject A had the DMM of 48.7, the SLOP of -0.886, and the accumulated stress degree of 0.57. The subject B had the DMM of 48, the SLOP of 0.3599, and the accumulated stress degree of 0.43. The subject C had the DMM of 42, the SLOP of -0.2499, and the accumulated stress degree of 0.37. The

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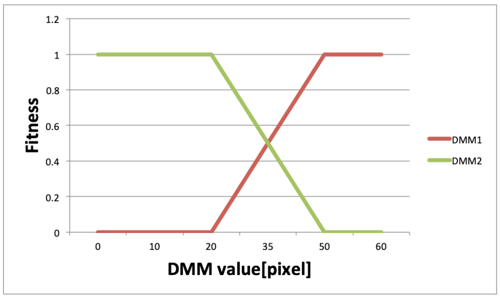
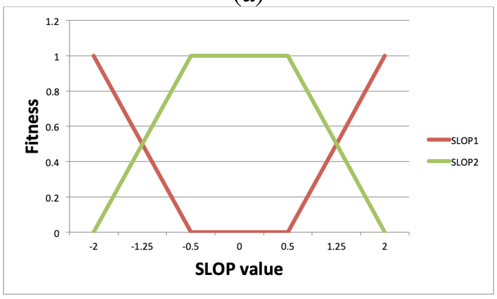
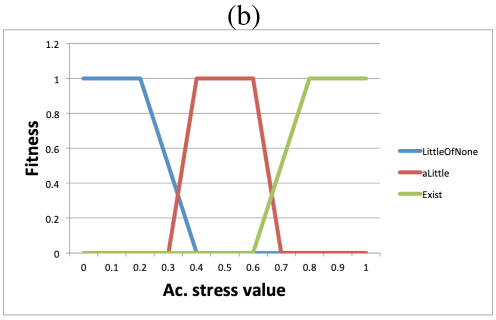


(a)



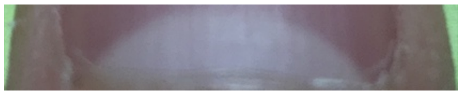
(b)



(c)

Figure 5. Membership functions. (a)-(c) are for membership functions of the DMM, SLOP and the quantitative evaluation to accumulated stress, respectively.

subject D had the DMM of 48.3, the SLOP of -1.4103, and the accumulated stress degree of 0.74. The subject E had the DMM of 24.3, the SLOP of 0.0426, and the accumulated stress degree of 0.18. The subject F had the DMM of 36.5, the SLOP of -0.4175, and the accumulated stress degree of 0.31. The subject G had the DMM of 24.4, the SLOP of 0.7277, and the accumulated stress degree of 0.40. The average of the reasonable results in the subjects who gave the stress task was 0.53. Then, the average of the reasonable results in the subjects who did not give stress tasks was 0.29. These results suggested that the proposed method can distinguish the tendency of the presence or absence of stress task. Table 1 shows the subjects A-D who gave the stress task had the DMM



(a)

(b)

Figure 6. Results of the extract the height of lunula. (a) and (b) are the samples of successful data and failure data, respectively.

value of 42-48.7. On the one hand, the subjects E-G who did not give the stress task had the DMM value of 24.3-36.5. These results suggested that the DMM were useful in determining the presence or absence of stress tasks. However, it was considered that only DMM was not possible to evaluate accumulated stress among the subjects who gave a stress task and the subjects who did not give a stress task. Table 1 shows the accumulated stress degree of the subject G exceeded the value of the subject C. It is thought that the fuzzy reasoning using the SLOP has an adverse effect on the accumulated stress evaluation.

5 CONCLUSION

In this paper, we proposed a method to evaluate accumulated stress by extracting the height of the lunula of the nail using nail image analysis. The proposed method consisted of three stages: measurement, preprocessing, and stress evaluation. In the measurement, we took nail images. In the preprocessing, we extracted the height of the lunula of the nail. Then, we carried out the edge detection using hue histogram in the rectangle. In the stress evaluation, we evaluated accumulated stress at 0 to 1. In order to show the effectiveness of the proposed method, we conducted experiments. The average of the reasonable results in the subjects who gave the stress task was 0.53. Then, the average of the reasonable results in the subjects who did not give stress tasks was 0.29. These

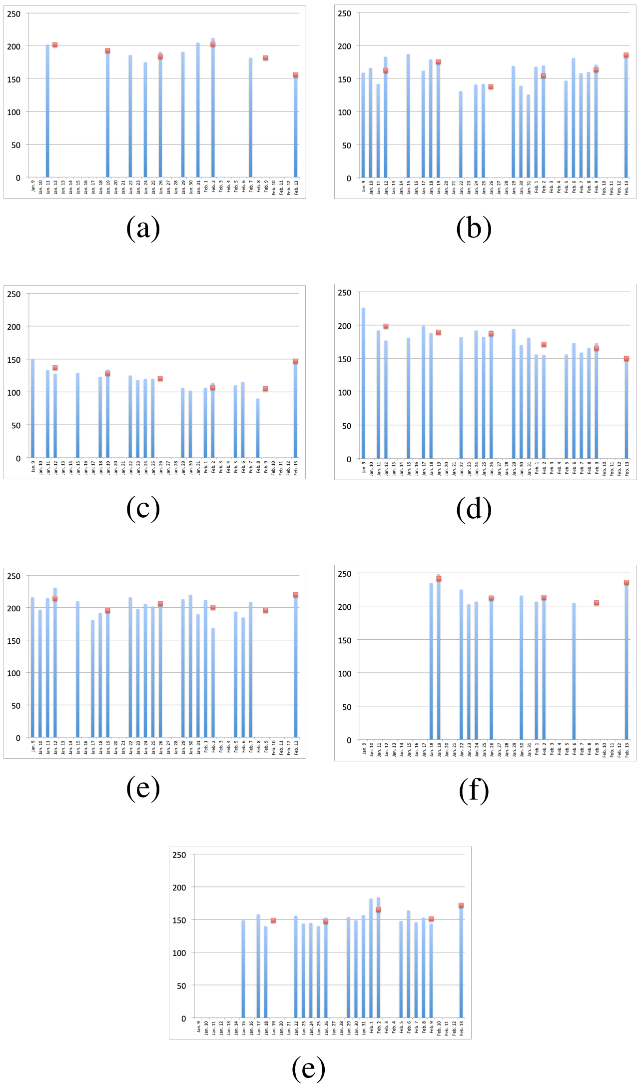


Figure 7. Extracted change of lunula. (a)-(f) are graph of subjects, respectively

results suggested that the proposed method can distinguish the tendency of the presence or absence of stress task. We confirmed that the subjects who gave the stress task had higher DMM values. Furthermore, the experimental results suggested that the difference between the minimum and maximum values of the height of the lunula during the experiment might be able to determine the presence or absence of accumulated stress.

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