

Gender Determining Method using Thermography

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Abstract: Man and woman distinction is necessary to strengthen security and when various statistics on the visitor are taken in commercial facilities and so on. The conventional method of distinguishing a man from a woman is currently determined by using the person's appearance, the person's dress and in such cases, the way a person walks, the foot pressure, the hair type. But, these characteristics can be intentionally changed by human intervention or design. The proposed method gets the difference in the man's and woman's characteristics by taking images of the heat distribution of the person's face by Thermography. This is a man and woman distinction based on a new concept and idea which this is used for. Consequently, this can be used to distinguish a man from a woman even if a man turns himself into the woman intentionally (and vice versa), because this method involves biometrics authentication.

Index Terms-thermography, gender, man and woman distinction, foundation metabolic change, hormone, security

1. Introduction

A man and woman distinction is necessary to strengthen the security system and when statistics on the visitor are taken in places such as a store or in amusement facilities, etc.

How to make the distinction with the method, which dress and the hair type is used[1], the way of walking, foot pressure, voice, and so on, for [2] and [3] is usual for the usual man and woman. But, these are the characteristics which can be changed by human intervention. The method described in this paper is a method whereby the biometric characteristics used are those that cannot be altered even with the human aid or human will. It takes the image of a fever temperature of the human face concretely with Thermography, and the information that a difference exists in temperature between that of a man and a woman is used. Table 1 shows that a man is large, and a woman is medically small when considering amounts of foundation metabolic change[4]. Therefore, as for temperature, a man is high, and a woman is low.

Moreover, the estrogen of the woman hormone is secreted, and generally the fat rate of the woman is medically higher than that of a man as a result. Those facts are shown in Table 2[5]. As for the heat conductive rate, water has 0.01429[cal cm/cm² sec deg.], muscle is 0.00067-0.00092 and fat is 0.00035. It causes abundant cold constitution in a woman's body.

Table 1 Amount of basal metabolism[kcal/day].

Age	12-14	15-17	18-29	30-49	50-69	70-
Male	1480	1610	1550	1500	1350	1220
Female	1340	1300	1210	1170	1110	1010

Table 2 Body fat rate[%].

Age	10's	20's	30's	40's	50's	60's	70's
Male	16.3	20.5	23.4	22.3	20.0	19.6	19.3
Female	25.9	23.7	26.2	27.0	28.8	28.2	26.8

When the surface of the body is rich in fat, the radiation of temperature is interrupted, and temperature on the surface of the body lowers. It is the face and hand that shows these characteristics in exposure and that which is not covered with clothes. It goes through with the matter that these characteristics appear in the part of the cheek under the eye even at the face, remarkably by trial and error temperature distribution result. This difference in temperature between a man and a woman clearly shows that this is a characteristic that cannot be changed intentionally.

2. Amount of characteristics

Statistical transaction is done to the temperature value inside the template to measure the temperature, and this method does a man and woman distinction by using that result. The statistical amount of the characteristics is defined to be used with this method for that purpose. Numerical value (temperature = gradation value) to handle, though it is the same, as the fundamentally general statistic is limited. It is 255 (Temperature range : 22.42-40.34deg.) to make it the target from the gradation value 0 of the gray scale. A



Fig.1 Jaw type template and cheek type template.



Fig.3 Cheek template of the Emphasized variance value.

255 is a high temperature and 0 is a low temperature from white to black. This paper uses the mean and the

variance. The mean and the variance are defined by following formula.

$$\bar{X} = \frac{1}{n} \sum_{i=1}^n X_i \quad (1)$$

$$V = \frac{1}{n} \sum_{i=1}^n (X_i - \bar{X})^2 \quad (2)$$

\bar{X} : mean V : variance
 n: pixel number inside the template
 Xi: gradation value of each pixel(0-255)

A template was separated in the cheek and the jaw, and a template was made a little small to solve this. This state is shown in the Fig.1. The same goes through with the man and woman distinction rate which the amount of each characteristic of these templates was used for by trial and error. The reason for this decision will be examined. This is discussed in the next chapter.

3. Influence of the surrounding temperature and its elimination.

Because the temperature value of the human face is being used, this method checks the influence of temperature on the face from the surrounding temperature quantitatively. A change in temperature was given to the face by using the pocket warmer and the cooling material, and the cheek of the distinction point and jaws were collected of the three men and women of the same age data concretely in the room where the surrounding temperature was fixed.

A pocket warmer was put to the cheek and the jaw, and data was collected first after 5 seconds, and collected at 15 seconds interval until 105 seconds. A cooling material was placed in the same way and data was collected. The averages of these 2 results were taken [cheek data/jaw data] and was made the vertical axis, and the condition of the change against the time progress is shown in Fig.2. The [cheek data/jaw data] represents the mean of the cheek type template gradation divided by the mean of the jaw type template gradation in Fig.1.

The influence of the change in the surrounding temperature is determined in order to eliminate its effect with the [cheek data/jaw data] if cheek temperature is determined to be normalized in temperature of the jaw and this value is fixed. Two points are determined as shown in Fig.2.

1. Even if time progresses the value for man and woman is almost a fixed.
2. The value for a man is large (temperature is high.), while that of a woman, the tendency is that the value is small (temperature is low). From the above discussion, it can be said that [cheek data/jaw data] is the amount of characteristics of the man and woman distinction from which there is no influence of the surrounding temperature.

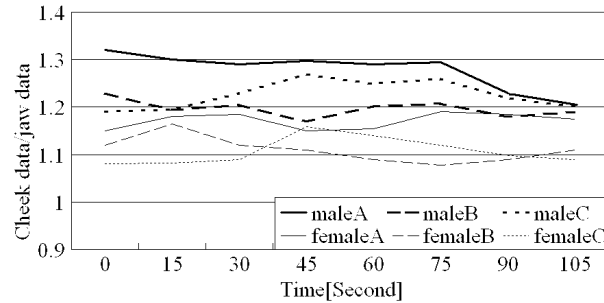


Fig.2 Cheek data/jaw data.

4. Introduction of the Emphasized variance value

A template was discussed more extensively in the discussion till now. This method discussed a man's and woman's thermography face image. Consequently, a woman's high part of the face spreads out in the circumference around the position of the cheek, while that of a man's face is almost constant. It was also found that the distinction rate of the cheek template oblong which made the cheek show in the bottom of the result of Fig.3 of the heart was high. Therefore, the distinction which the template of the Fig.3 was used for is discussed.

The temperature distribution example of man and woman's cheek is shown in Fig.4. As for the temperature (gradation value) distribution, the distribution range of the man is small at the same time with the man's mean being large, and as for the woman, it can be seen that the distribution range is wide from Fig.4. Paraphrasing, the temperature of the woman's cheek is low, and wide around the cheek, and it can be said that fat sticks around it. Thus, more emphasis was put on the distributed value, so as to make the difference stand out. Thus, the distributed value is generally defined as the fourth power as shown in formula (3) to put emphasis on the part of the square of formula (2).

$$E = \frac{1}{n} \sum_{i=1}^n (X_i - \bar{X})^4 \quad (3)$$

E : Emphasized variance value
 n: pixel number inside the template
 Xi: gradation value of each pixel

Formula (3) above shall be called the Emphasized variance value. Next, this paper discusses the influence of the Emphasized variance value by the surrounding temperature. 2 men and 2 women were made to stand for about 10 minutes in a room with a surrounding temperature of 24deg., and the air conditioning temperature increased by 1deg. each time for 27deg. times and data was collected. The data of 1 man, how it was obtained and collected is shown in Fig. 5. It follows from the surrounding temperature's rise from Fig. 5, that the form of the histogram and area (= dispersion = Emphasized variance value) hardly

changed. But the histogram moved slightly to the right whose gradation value (temperature) is high. Other man data are similar too, and the woman data shows the same tendency in the part where gradation value is smaller than that of a man. Therefore, the surrounding temperature does not have an influence, and it is understood that a man and a woman's characteristics are distinct as far as the Emphasized variance value is concerned. Hence, the Emphasized variance value is an effective measure of the amount of distinction in characteristics of a man or woman without the influence of the surrounding temperature. A result of a trial of the man and woman distinction using the Emphasized variance value is shown in Fig. 6. When a woman makes a larger value than a man, this becomes 75% of the distinction rate, a larger value than the point of intersection value of this figure. The distinction rate of a man becomes 77%.

5.Reinforcement of robustness

A template is hung on a part of the cheek. The distinction which the Emphasized variance value of that temperature was used for has the possibility of making errors in distinction for some reasons. This occurs when the emphasis was made in the distributed area of the cheek only, although it got the highest distinction rate of 77% and 75%. So, a distinction by Mahalanobis distance was applied in 3 ways for the following combinations with the Emphasized variance value of the cheek to strengthen robustness.

1. Cheek Emphasized variance value only.
2. Cheek Emphasized variance value – [cheek data /jaw data].
3. Cheek gradation value-jaw gradation value.

The gradation value of the above 3 is the mean of gradation in the template. These 3 kinds of results of the distinction rate are shown in Table 2. The results which could be distinguished by the sum of recognized persons of more than 2 kinds (the combination of 1-2-3,1-2,1-3,2-3)more in these 3 kinds of methods became 73% of the men “ $106=[73+12+15+6]/142$ ” in Table 3 and 75% of the women “ $117=[62+16+22+17]/147$ ”.

It is 75% for a man and 80% for a woman that could be distinguished with 2 or more methods with the template where 142 men were made the targets of these 3 kinds of methods of distinguishing.

6. Medical Discussion of Human Temperature

This method is a biometrics method, because the basic idea is a difference in the additional condition of the fat in the amount of foundation metabolic change by the secretion of the woman hormone and the man hormone. Therefore, there was a concern on whether this method could be applied to the higher age bracket but not to the lower age bracket considering that sex characteristics do not appear very much, and there is a

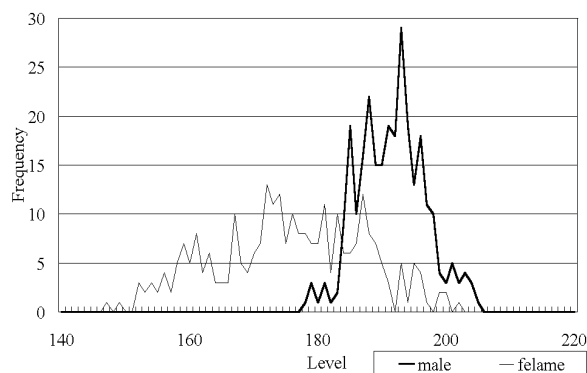


Fig.4 Difference of the man and woman histogram.

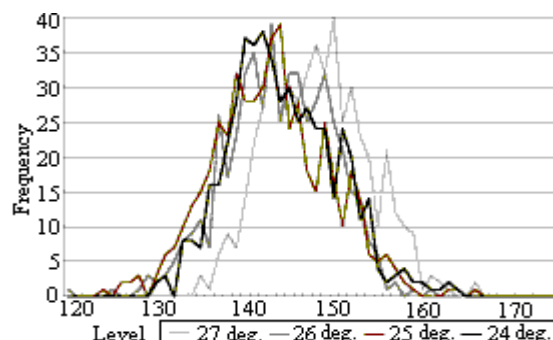


Fig.5 Temperature distribution of a man when the ambient temperature was made to change.

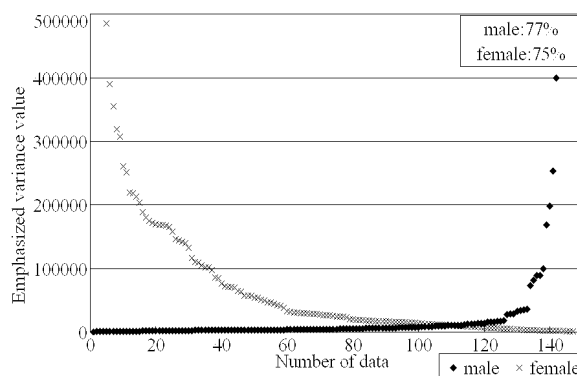


Fig.6 Distinction rate by the Emphasized Variance value.

decline in hormonal secretion. Also, as shown in Fig.8, temperature changes occur in humans during the day [6]. From Fig.8, when the normal temperature is 100, we understand that the temperature change shows about 5 which goes up and down between 8 a.m. and 11 p.m. When a 100 represents the normal temperature of 36deg., 5 is equivalent to 1.8deg. This method is possible enough because the difference in temperature being used is about 3.5deg (from Fig.7) for the man and woman distinction. It is higher in value and above human's change of 1.8deg. and that woman's change value 2.4deg.(=1.8+0.6). The 0.6deg. is the temperature change of the menstrual period. This method has a 0.01deg. accuracy. Moreover, this method uses Emphasized variance value with its temperature in order to increase accuracy.

Table 3 Result of a distinction.

(a)male

Cheek gradation-jaw gradation (Fig.7)	Emphasized variance value of the cheek	Emphasized variance value-[cheek data /jaw data]	
		○	×
○	○	73	6
○	×	12	10
×	○	15	16
×	×	1	9
○○○+○○		106/142	
Distinction rate		75[%]	

(b)female

Cheek gradation-jaw gradation (Fig.7)	Emphasized variance value of the cheek	Emphasized variance value-[cheek data /jaw data]	
		○	×
○	○	62	17
○	×	16	13
×	○	22	9
×	×	5	3
○○○+○○		117/147	
Distinction rate		80[%]	

7. Conclusion

This method used the human temperature that is influenced by sex characteristics of man and woman. The new concept idea of the Emphasized variance value is introduced, as a result, the distinction rate obtained a value of 77% for the men and 75% for the women. Moreover, this method established a robustness distinction method using three combinations of the temperature value of two parts that is the cheek and the jaw of the face. As a result, the distinction rate for a man became 75% and that for a woman became 80%. Moreover, when the method tried to use the hand and face combination, this resulted in the strengthening of the robustness of the above method, resulting to a distinction rate of 83% for the men and 70% for the women. In the future, the method used will make improvements in the distinction rate by using additional different combinations.

Appendix

Fig.9 is the image where fat distribution is displayed three-dimensionally from the CT image of the face. The part where swelling can be seen in Fig.9 is the fat. It is understood that the template given to the part of the jaw of Fig.1 and the part of the cheek of Fig.3 cover on appropriately the part of the fat from those figures. Fig.9 was found in literature [7] in the research process, and the figure shows the validity of this paper.

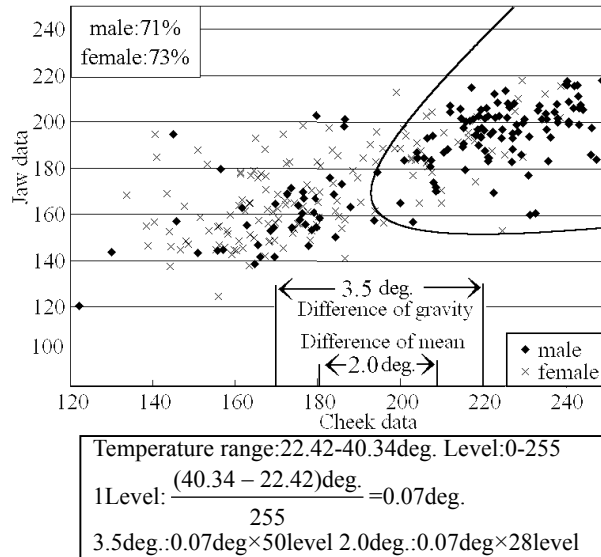


Fig.7 Cheek gradation mean -jaw gradation mean.

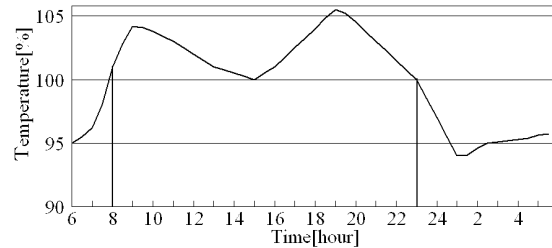


Fig.8 Temperature change of a human in a day



Fig.9 3D display of fat.

Quoted from [7]Y.Sakamoto, A.Otuka, Y.Itada, Y.Aoki, "Classification Method for Three Dimensional Images Using a Density-Gradient Histogram," IEICE Tras. D-II Vol.J-77-D-II No.4 April 1999, pp688 Fig8 (b): permitted.

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