MAN AND WOMAN DISTINCTION 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.

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, the way of walking, foot pressure, voice, and so on, for and 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.

When the research of the face extraction using thermography was being done using the gray scale, the part of the cheek was specially reflected black (That temperature value is low as shown by the gray scale) by the woman's face is black, it was compared to the man. Consequently, the research of the man and woman distinction which was done after this research, thermography of the face was started.

A man is large, and a woman is medically small when considering amounts of foundation metabolic change. 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 medically1 higher than that of a man as a result. It causes

abundant cold constitution in the woman. 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 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 DISCUSSION OF THE TEMPLATE

2.1 Amount of characteristics

Statistical transaction is done to the temperature value inside the template, and this method does a man and woman distinction by using that result. The statistical amount of the characteristic is defined in this method to be used 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 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.

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n} X_i \qquad (1)$$

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

$\overline{X}$:mean

V :variance

n: pixel number inside the template

Xi: gradation value of each pixel(0-255)

2.2 U type template

The U type template that the part of the cheek was taken in first was made, and the part of the cheek was picked out by taking part of the U type template and the temperature was measured. This template is shown in Fig.1. It goes through with a temperature setup range by trial and error on most occasions; 22.42~ 40.34 deg. result. The fraction result depends on the setup value of the thermography camera.

The above figure shows a U type template except for the part where the nose is tried first. Though data were collected with this U type template in optional temperature, temperature data that was collected with the template inside when the surrounding temperature was high, too, only the temperature was compared, a good result was not available, with the distinction rates about 60%. This situation is shown in Fig.2

Surrounding temperature was made equal, and data taking was done because it was proven that the influence of surrounding temperature was taken from above, mentioning it with the temperature of the face. It was made to run for about 10 minutes at 27deg. temperature in the room at 60% humidity, after that, 10 images of men and women were taken concretely

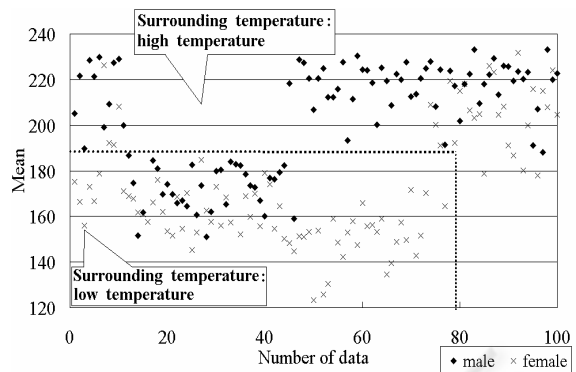Figure 1: U type template. Fig.3 Jaw type template and cheek type template

Figure 2: The mean data of the U type template

Table 1: Temperature of the U type template inside: Ambient temperature is constant. Numerical value is gradation value

data No	1	2	3	4	5	6	7	8	9	10
male	135	133	124	132	106	121	134	126	119	119
female	100	113	112	76	113	106	117	126	116	127

by thermography so that a subject might not have the influence of a difference in temperature to the environment with which it was in before taking the image. These results are shown in Table 1.

2.3 Cheek type and jaw type template

Because the size of the face has a difference, it may not fit with a U type template in the face. 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 Fig.3. The same is true with the man and woman distinction rate, where in the amount of each characteristic of these templates was used in the trial and error. Most of these results are distinction rates of cheek type template mean/jaw type template mean value [cheek data/jaw data]. The reason for this decision will be examined. This is discussed in the next chapter.

3 INFLUENCE OF THE SURROUNDING TEMPERATURE AND THAT ELIMINATION

Because the temperature value of the human face was being used, this method checked the quantitative temperature influence on the face of the surrounding temperature. 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 from the three men and women of the same age data concretely in the room where the surrounding temperature was fixed. It had a pocket warmer put to the cheek and the

jaw, and the 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 two 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.4. The [cheek data/jaw data] represents the mean of the cheek type template gradation divided by the mean of the jaw type template gradation.

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. For example, it can be said that the influence of the surrounding temperature is not taken about this value (But, there is a characteristic difference with each person as for the value itself.) if the value of [cheek data/jaw data] is fixed even if temperature of the cheek and the jaw rises with corresponding increase in the surrounding temperature as well. Two points are determined as shown in Fig.4.

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 (temperature is low.) tendency is that the value is small. 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.
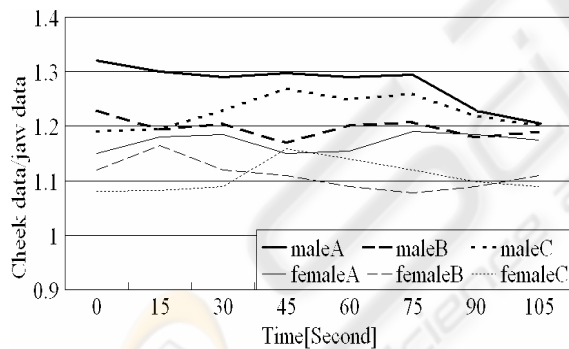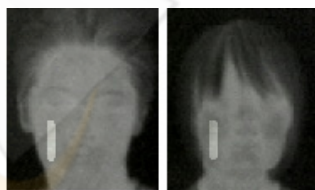

Figure 4: Cheek data/jaw data

Figure 5: Cheek template of the Emphasized variance value

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.5 of the heart was high.. Therefore, the distinction which the template of the Fig.5 was used for is discussed.

The temperature distribution example of man and woman's cheek is shown in Fig.6. 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 this figure. Paraphrasing, the temperature of the woman's cheek is low, and wide around the cheek, and it can be said that fat sticks about it.
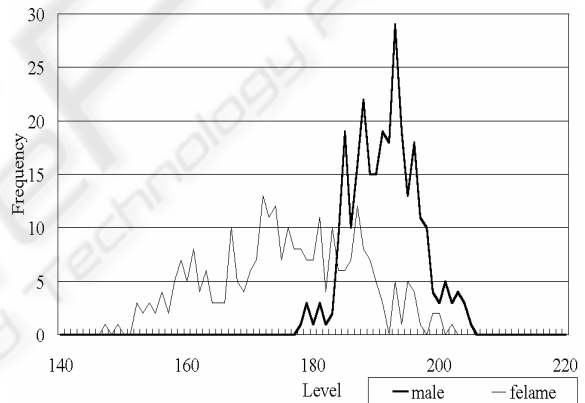

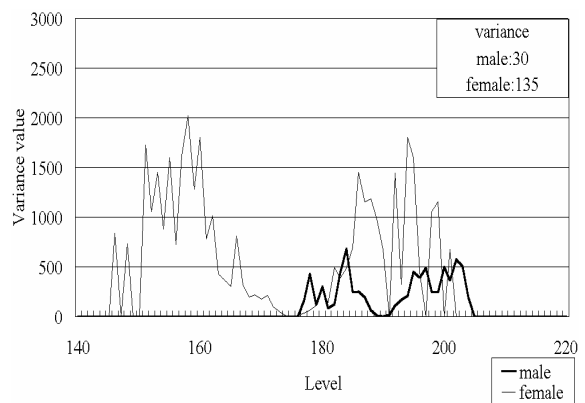Figure 6: Difference of the man and woman histogram

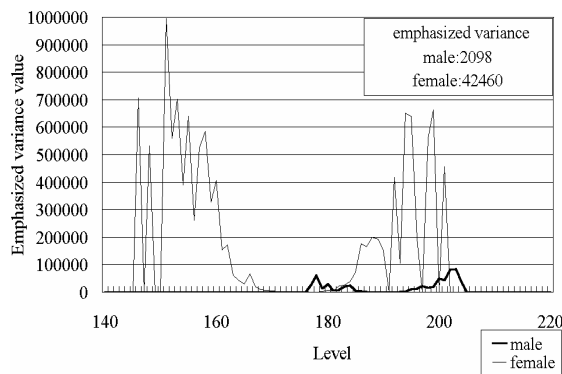Figure 7: Difference of the man and woman variance

Figure 8: Difference of the man and woman Emphasized variance

The difference in the variance of the man and woman can be thought of as shown in Fig.7. But, there is not so large a difference when comparing the result of the distributed value. So, more emphasis was put on the distributed value, so as to make the difference stand out. So, 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).

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

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. The woman's degree is larger though dispersion follows the neighborhood of the mean while leaving it small and it is large though Fig.7 is natural. Distances between the men and women increase by the Emphasized variance value, and it is shown that a man and woman distinction becomes easy by Fig.8. Fig.7 and Fig.8 shows the clause of square of xi-$\overline{X}$ of the dispersion and the Emphasized variance value and fourth power with Fig.8 corresponding to xi the histogram of the place. When the figures of Fig.7 and Fig.8 are compared, it is obvious that the distance between the men and women is large as shown by the Emphasized variance value.

Next, this paper discusses the influence of the Emphasized variance value by the surrounding temperature. Two men and two 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 27 times and data was collected. The data of 1 man, how it was obtained and collected is shown in Fig. 9. It follows from the surrounding temperature's rise from Fig. 9, 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. Therefore, the emphasized variance value is an
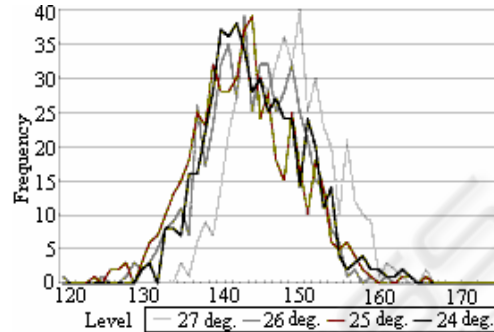

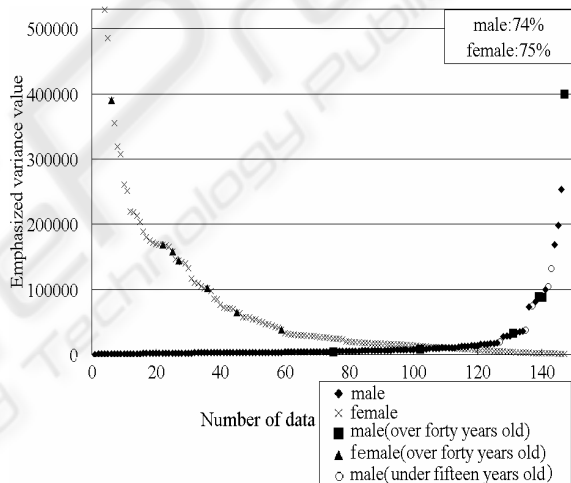Figure 9: Temperature distribution of the man when an ambient temperature was made to change

Figure 10: Distinction rate by the Emphasized variance value

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 by the Emphasized variance value is shown in Fig.10. When a woman makes a large 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 74%.

5 ELIMINATION OF THE INFLUENCE OF THE GLASSES

The template at the part of the cheek faced in the part of the cheek from under the eye, and the result discussed till now was given. The distinction rate decreased, because the radiation temperatures on the surface of a part of the face

can not be collected by the glasses when the glasses are put on in this case. So, the top of the template was shaved, and the template which was shortened in length in the vertical direction was carried out. Though the template, which was made wide at the same time was also discussed, the top of the existent oblong template of Fig.11 was shaved, and a shortened template was considered to be the best. A distinction rate by the Emphasized variance value in this case is shown in Fig.12. A decrease in the distinction rate to 66% for men occurred when the top of the template was

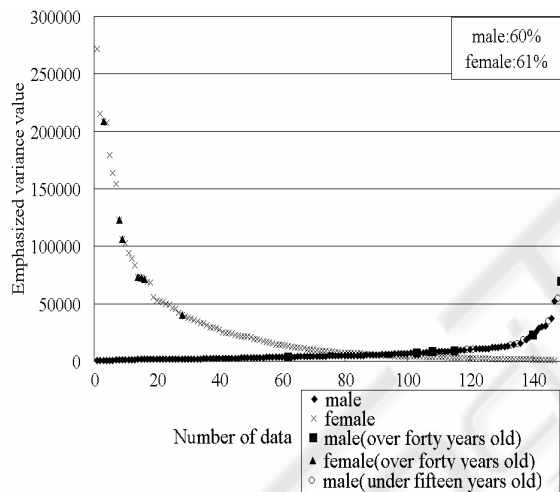Figure 11: Cheek template with the glasses

Figure 12: Distinction rate by the Emphasized variance value with the glasses

shaved and 61% for that of the women while getting rid of the influences of the glasses.

6 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. When the emphasis was made in the distributed area of the cheek only, it got the highest distinction rate of 74% and 75%. So, a distinction by Mahalanobis distance was applied in 3 ways for the next samples with the emphasized variance value of the

cheek to strengthen robustness.
1. Cheek Emphasized variance value.
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. The cheek Emphasized variance value-cheek data/jaw data graph is shown in Fig.13.These three 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 two 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 (a)(109[=74+13+17+5]/149) and 75% of the women (b)(110=[59+16+18+17]/147) in Table 3.

It is 73% for the man and 75% for the woman that could be distinguished with 2 or more methods with the template where 149 men were made the targets of these 3 kinds of methods of distinguishing. The influence of glasses was not taken in the 147 women samples as compared to the men samples. The woman's distinction rate without the glasses case is higher than that with glasses as shown in the right side of Table 2. This is due to the fact that the Mahalanobis distance is changed by the man's and woman's distribution which is influenced by the change of the template (from Fig.5 to Fig.11).

7 INFLUENCE OF THE AGE TO THE DISTINCTION

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 decline in hormonal secretion. Data was collected for those under 15 years old and another for men and women forty years old and over. Though the number of data was small, a discussion was done on this data. The Emphasized variance value of 13 men and 8 women is shown in Fig.14. The next two points can be said from this result.
1.The man and woman forty years old and over have the same tendency as that of the fifteen years old to the thirty years old.
2.The Emphasized variance value varies widely from high to low about the man under fifteen years old and therefore there is no tendency in the dispersion in the man.

Table 2: Result of a distinction by three methods.

Method \ Glasses	No glasses		With glasses	
	(a)male	(b)female	male	female
1. Emphasized variance value of thecheek	74%	75%	60%	61%
2.phasized variance value – cheek data /jaw data (Fig.13)	72%	65%	59%	74%
3.Gradation value [cheek data-jaw data]	68%	72%	68%	72%

Table 3: Result of a distinction

(a)male

Gradation value [cheek data-jaw data]	Emphasized variance value of the cheek	Emphasized variance value-cheek data/jaw data	
		○	×
○	○	**74**	**5**
○	×	**13**	10
×	○	**17**	14
×	×	3	13
○○○+○○		109/149	
Distinction rate		**73%**	

(b)femal

Gradation value [cheek data-jaw data]	Emphasized variance value of the cheek	Emphasized variance value-cheek data/jaw data	
		○	×
○	○	**59**	**17**
○	×	**16**	14
×	○	**18**	16
×	×	3	4
○○○+○○		110/147	
Distinction rate		**75%**	

Numerical values of this table are the number of the recognized persons.
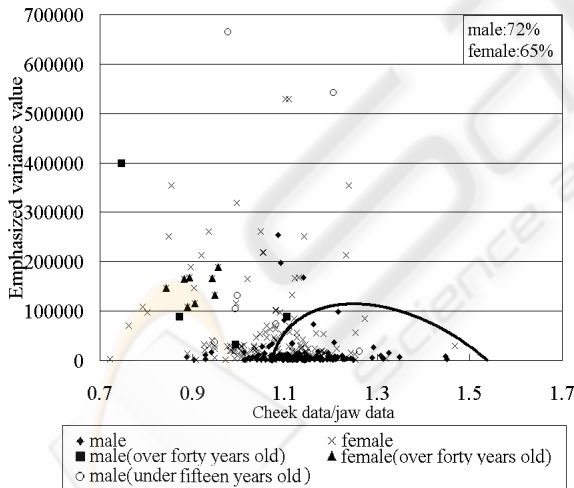
Figure 13: Graph of Mahalanobis distance: Emphasized variance value-cheek data/jaw data

Figure 14 : The Emphasized variance value of under 15 years old and 40 years old and over

As far as this method is concerned, for this point, it is understood that this method cannot be applied to those under 15 years old. Hormone secretion is not yet perfect at a young age, and this comes from the fact that those sex characteristics results do not appear remarkably as mentioned above. Therefore, this method applies only to humans from the target age group of fifteen years old to
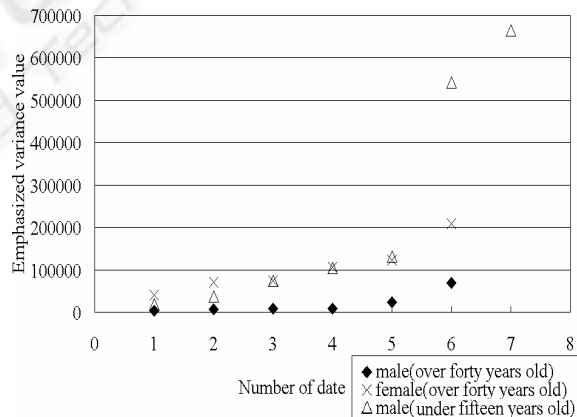
sixty years old. The result of a man and woman distinction by the Emphasized variance value is shown in Fig.15. From this Fig., the distinction rate of the woman becomes 75% and the man distinction rate is 75%. As previously mentioned, this method is not applicable to men and women under 15 years old. Thus, when 7 men under 15 years old were deleted from the target, these results become Table 4 and 5. Method 2 of Table 2 is shown in

Fig.16. The distinction rate without glasses becomes 75% for the men and 80% for the women. This value is the highest value of this method. When humans take glasses, these become 70% for the men and 76% for the women.

8 USE OF THE HAND

When a thermography camera takes an image, there is the opportunity to take the image of the hand without the face in the part exposed in a human. From this fact, the temperature distribution of the hand was used for the man and woman distinction. There are many automatic doors which are hand activated to open and are installed in stores and other places. Thus, thermography cameras can always be placed on door parts which humans touch. The face images examined in the previous method of the difference group in the previous man and woman groups were collected together with the hand images.

Table 4: Result of a distinction except under15 years old

Glasses / Method	No glasses		With glasses	
	(a)male	(b)female	male	female
1.Emphasized variance value of the cheek	77%	75%	63%	61%
2.Enphasized variance value – cheek data /jaw data (Fig.16)	71%	71%	62%	75%
3.Gradation value [cheek data-jawdata]	71%	73%	71%	73%

Table 5: Result of a distinction except under 15 years old

(a)male

Gradation value [cheek data-jaw data]	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

Gradation value [cheek data-jaw data]	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%**	

Numerical values of this table are the number of the recognized persons.

In order to determine that part of the hand that was good by trial and error, in this discussion, a lengthwise template was used as shown in Fig. 17.
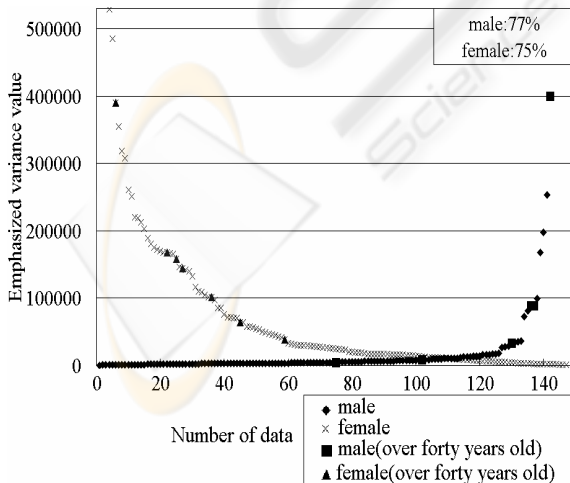
Figure 15: Distinction by the Emphasized variance value except the under 15 years old
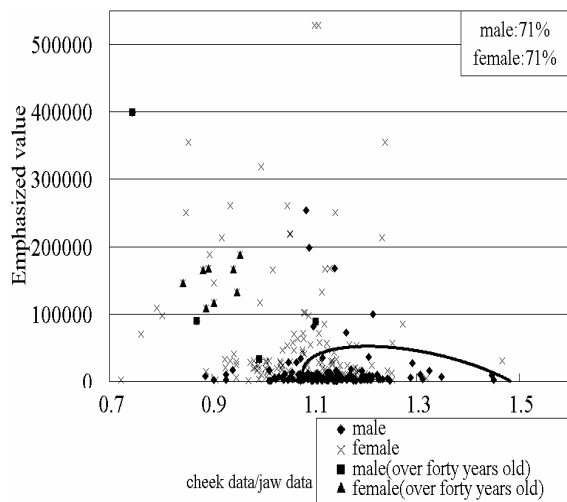
Figure 16: Graph of Mahalanobis distance except the under 15 years old

That template is inside the part of the palm. As a result, the discussion found that this method uses the gradation value, the dispersion and the Emphasized variance value of this part for the improvement of the distinction rate. When the Emphasized variance value of the cheek is distinguished from the Emphasized variance value of the hand by Mahalanobis distance, this result is shown in Fig.17. In the same way, when the cheek data/jaw data was distinguished from the Emphasized variance value of the hand, the result is shown in Table 6. These are the results except for the under fifteen years old. The face data without the glasses situation is shown in Fig.18 and Table 6. When only the Emphasized variance value of the hand is used excluding the under 15 years old, the distinction rate is 62% for the men and 57% for the women. Moreover, when the temperature of the hand and the face is used together, the distinction rate becomes 83% for the men and 70% for the women. These results are shown in Table 6.

9 CONCLUSIONS

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, a difference between the men and women is enlarged by its value. Consequently, the distinction rate obtained 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. The above method uses the amount of characteristics inside the template, the part of the cheek and the jaw in the face. The final distinction rate of this method is the total sum, that is, the case in agreement with the

results more for the combination of the two method than for the three methods case (1,2,3 of the Table 3). As a result, the distinction rate for a man became 75% and that for a woman became 80%.

Also the distinction rate became 62% for the men and 57% for the women using only the temperature of the hand. 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 in 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

Figure 19 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 Figure19 is the fat. It is understood that the template given to the part of the jaw of Figure 3 and the part of the cheek of Figure 3 and 5 cover on appropriately the part of the fat from those figures. Figure19 was found in literature in the research process, and the figure shows the validity of this paper.

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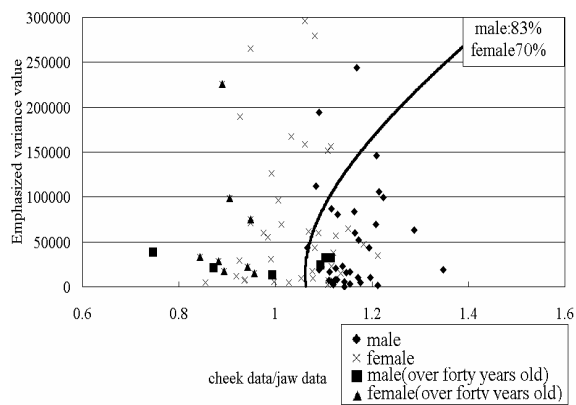
Figure 17: Palm type template

Figure 18: Graph of Mahalanobis distance Emphasized variance value-cheek data/jaw data

Table 6: Result of a distinction when a hand was combined except the under 15 years old

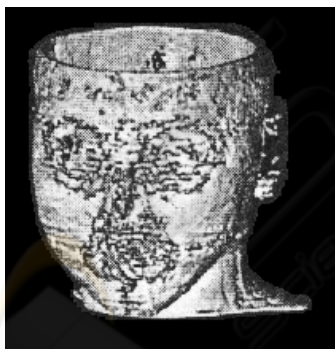| Method	male	female
Emphasized variance value of the hand	62%	57%
Emphasized variance value [hand –cheek]	60%	76%
Emphasized variance value of the hand- cheek data/jaw data	83%	70%

Figure 19: 3D display of fat