International Journal of Image Processing Techniques – IJIPT
Volume 1 : Issue 1
Publication Date : 09 January 2014

Improvement of Finger Vein Verification by Blocked Filtering Method

[Yuhei Harada, Tsukasa Kato, Ryo Taguchi, Masahiro Hoguro and Taizo Umezaki]

***Abstract*—We manufactured compact personal verification device using finger veins. We already have developed a personal verification device. Doing verification experiments on a new device using the conventional verification method, the result of verification rate was 99.5[%]. Therefore, we find problems of conventional verification method and propos new method. Specifically, we propose a method emphasizes edge of finger on the purpose of improving the accuracy of lean correction and method of emphasizing the vein with higher accuracy. Verification rate on the verification experiments increased to 99.9% by incorporating two methods.**

***Keyword*—finger vein verification, compact, emphasizing edge, blocked filter method**

I. Introduction

Security has attracted more interest and variety of researches for personal certification has been done in recent years [1]. Biometric certification is known for having few risks of forgetting and missing and for high quality of security. Fingerprint certification and finger vein certification (of fingers, palms and backs of hands [2] ~ [4]) especially attract peoples' attention and, above all, biometric certification do. These cause users few troubles and can certificate with high-precision, so these have already been put into use at many places like banks. We have developed contactless fingerprint input devices and algorithms of fingerprint certification so far [5]. In addition, we have developed photograph devices of finger vein by using near infrared LED to realize contactless hybrid certification [6] [7]. But devices are big to be used in small devices such as mobile phones.

Therefore, the purpose in this research is developing the compact finger vein verification device with high accuracy of verification.

II. Photographing Device

The size of this device is 12×12×5[cm]. In this photographing device we get the image of finger vein by using near infrared LED as the light source, and photographing by a CMOS camera. A series of 6 LEDs of near infrared light are attached to both sides of the fingerin order to irradiate the whole parts of the finger.

Yuhei harada, Tsukasa Kato, Ryo Taguchi, Taizo Umezaki
Nagoya Institute of Technology
Japan
harada@ume.mta.nitech.ac.jp

Masahiro Hoguro
Chubu University
Japan

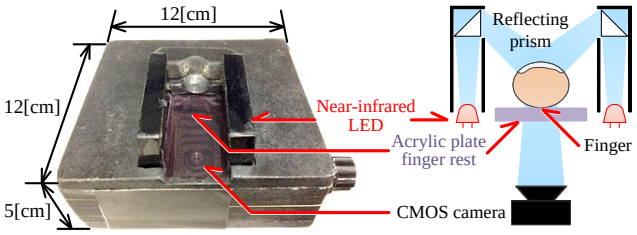
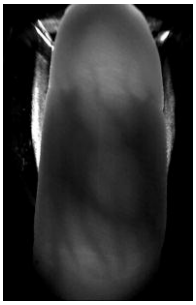


Figure 1. Photographing device.



(a)photographed image.

(b)emphasized vein image.

Figure 2. Vein image photographed by device.

These lights reflected by the reflection prism and transmitted through the finger are photographed by the camera and, finger veins of the ball of finger are projected. The wavelength which the device adopts is selected by traditional research[6]. Nine kinds of wavelength light sources, 710, 760, 810, 850, 870, 890, 910, 940, 970[nm], are tested in the research, and the verification rate reach the highest using 890[nm] wavelength source. The device adopts the same light source with the research. Figure 1 shows the device we developed. An example of taken image by the device is shown in Figure 2.

III. Conventional Method and Problems

A. *Conventional Verification Method*

Matching registered and input images is done as certification method. The certification is divided into 3 steps, trimming, emphasizing finger vein, and verification. A series of these steps of personal certification is shown below (Figure 3).

1) Trimming

The edge of a finger in the captured image is extracted and its center line is detected. Its inclination is corrected based on the detected center line (Figure 3(a), (b),(c)). Constant size(170×440) of image from the center line is trimmed (Figure 3(d)).

2) Emphasizing finger vein

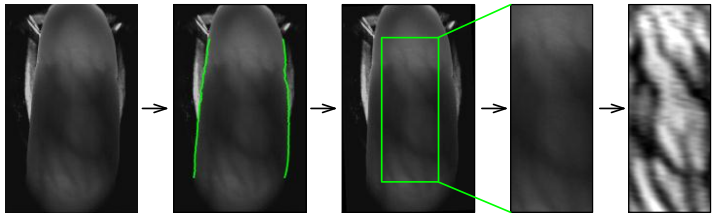
The data of a horizontal line is taken from trimmed image in 1), high frequency component over m in spatial frequency domain is filtered out, and finger vein is emphasized (Figure 3(e)). Filter of equation 1 weighted by m is used. Provided that m is arbitrary constant to decide cutoff frequency. It is confirmed that the maximum verification rate is obtained in the m of 15 by prior experiment so this value is adopted.

$$H(i) = \begin{cases} i & (i \le m) \\ 0 & (i > m) \end{cases} . \quad (1)$$

$$G(I, J) = \min \left(\frac{g(I, J, a)}{I + J} \right) . \quad (2)$$

$$g(i, j, a) = \min \begin{Bmatrix} g(i-1, j-2, a) + 2d(i, j-1, a) \\ g(i-1, j-1, a) + d(i, j, a) \\ g(i-2, j-1, a) + 2d(i-1, j, a) \end{Bmatrix} + d(i, j, a) . \quad (3)$$

$$d(i, j, a) = \frac{1}{W - |a|} \sum_{k=0}^{W-|a|-1} \left(x_{ref}(k + a, j) - x_{test}(k, i) \right)^2 . \quad (4)$$



(a) Input. (b) Edge extraction. (c) Lean correction. (d)Cut. (e)Emphasize.

Figure 3. Flow of verification method.

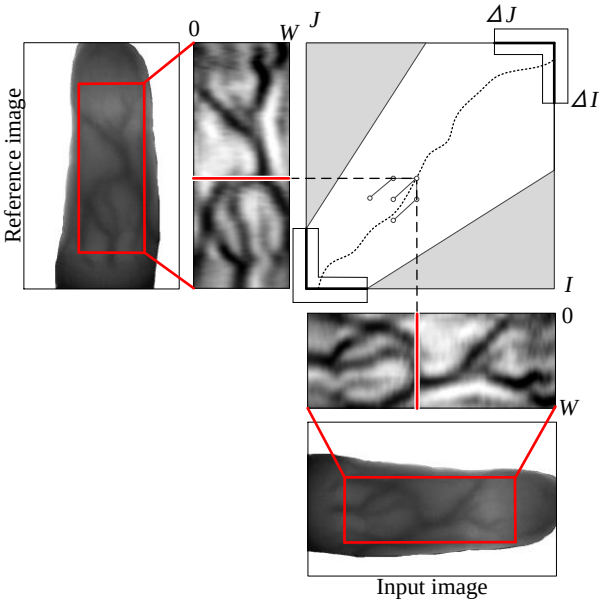


Figure 4. Free DP matching.

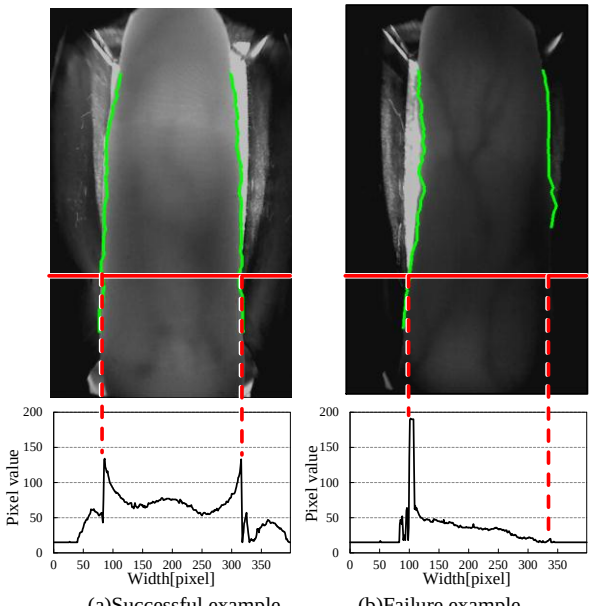
3) Verification

Emphasized image in 2) is used as input image and the distance between registered, the input image are calculated by endpoint free DP matching, and certificated is done by thresholding like Figure 2. Endpoint free DP matching makes it possible to calculate the similarity considering expansion and contraction of vertical pattern and misregistration. Moreover, horizontal misregistration which is caused by rotating finger is removed by including sifted width a (-p<a<p, p is the max width) in order to consider it. Normalized minimum accumulation distance G(I,J) between images is defined as the similarity of images. Personal certification is done based on this similarity. Each of normalized minimum accumulation distance G(I,J) and minimum accumulation g(i,j,a) distance is defined as equation 2 and equation 3. Distance between frames d(i,j,a) of registered and input pattern is defined as equation4. Provided that xref is the value of registered and input patterns, xtest is the width of the image, W is the width of image, I, J is searching ranges of input and registered images, and ◿I, ◿J is free endpoint range of input and registered images.

B. *Problems of Conventional Method*

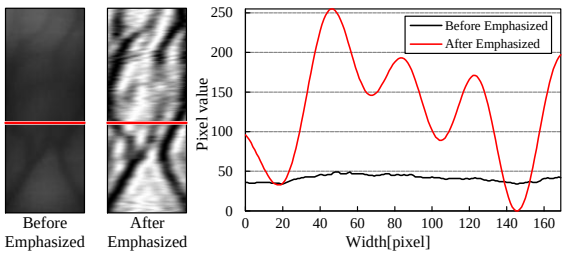
The first problem is failure in the edge extraction of a finger. To extract the edge of the finger whose edge is blurred is difficult. It is confirmed that the variation of pixel value is high on the successful example (Figure 5(a)), but that is low on the failure example(Figure 5(b)).

The second one is insufficiency on emphasizing vein. Especially, to emphasize vein on the image occurs saturation or occlusion in the left and right ends is difficult. Variation of the pixel value of the saturation part is emphasized strongly and that of the veins is not emphasized so much. (figure 6(a)). The contrast of the part is not a vein and the veins part should be high, but it is confirmed that is low on the failure example.

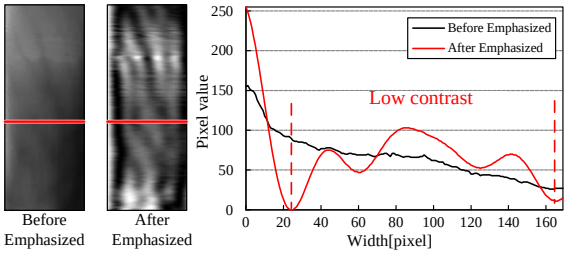


(a)Successful example. (b)Failure example.

Figure 5. Example of edge extraction.



(a)successful example.



(b)failure example

Figure 6. Example of emphasizing vein.

IV. Proposal Method

A. *Emphasizing Edge*

We propose a method to solve the problem that extracting edge ,if blurred, is difficult. The first one is the method of emphasizing edge by gamma transformation(figure7).Gamma transformation is defined as equation 5. *f* is input pixel value and *g* is output pixel value. It is confirmed edge extraction is successful in the Sample.1 and the Sample.2 in Figure7 by gamma transformation. But it is confirmed gamma transformation blurs the edge in the Sample.3 and Sample.4 in Figure8 and extraction is failure. This is because Gamma transformation has a property of hightening the contrast of the low pixel value, but has a property of lowering the contrast of the high pixel value also. Then, We propose a method of emphasizing edge by Reverse-S shaped transformation (figure7). Reverse-S shaped transformation is defined as equation 6. *f* is input pixel value and *g* is output pixel value. This transformation can emphasize the contrast of both the high pixel value and low pixel value. It is confirmed this transformation is more effective than emphasizing edge by gamma transformation in Figure8.

$$g = 255 \left(\frac{f}{255}\right)^{\frac{1}{\gamma}}. \quad (5)$$

$$g = 16 \left(\log_2 \frac{f+1}{256-f} 256\right). \quad (6)$$

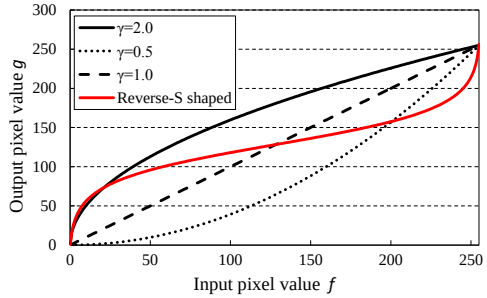


Figure 7. Gamma transformation and Reverse-S shaped transformation.

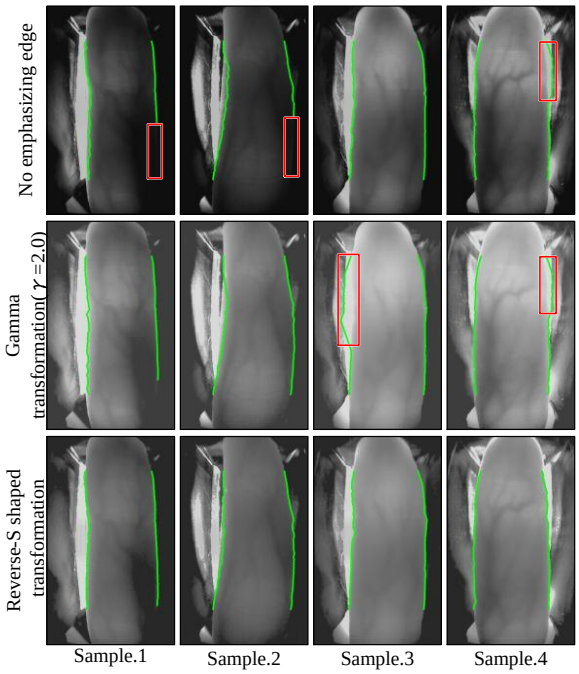


Figure 8. Example of emphasizing edge.

B. *Emphasizing by Blocked Filtering Method*

In this paper, Emphasizing by blocked filtering method does not emphasize the entire line but is dividing the one line into blocks overlap and emphasizing them and overlapping them. In addition, We calculated the average pixel value of a region overlapping. It is confirmed that the contrast of Image emphasized by blocked filtering method is higher. Figure.11 shows example of comparison of the images which are emphasized by conventional method with blocked filtering method.

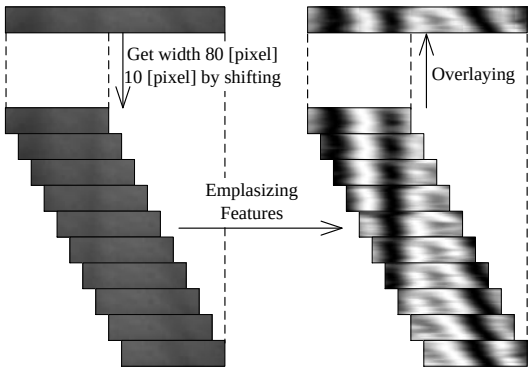


Figure 9. Emphasizing by Blocked Filtering Method.

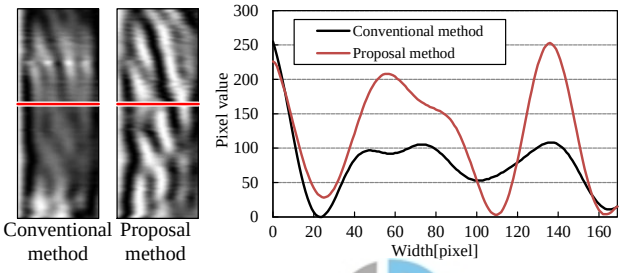


Figure 10. Comparison of the conventional method with the proposal method.

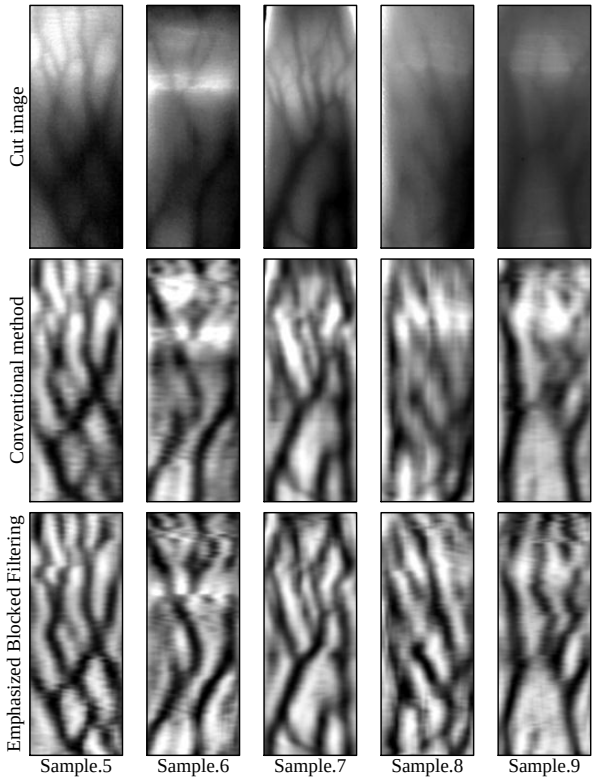


Figure 11. Example of comparison of the image emphasized by each methods.

v. Experiment of Verification

A. Database

We make a database for verification experimentation. We adopt twenty five examinees for this experimentation and capture five images of each examinee's ring finger and middle finger and index finger of the left and right (Table1). Experimenter modifies light intensity to fit each examinee's finger by experimenter's subjective decision. One image of the images is registered as a reference and certification rate is evaluated by the experimentation with other images. Also, we change the reference images and experiment again. Table II shows the number of combinations of comparison. We calculate FRR(False Rejection Rate) and FAR(False Acceptance Rate) with changing thresholds of the distance between reference and input images. We determine the best threshold of this device by intersection of two rates. In addition, verification rate is the error rate in the threshold when matching false acceptance rate and false rejection rate.

B. Result of experiment

We compare the verification rate by the presence or absence of Reverse-S shaped and of emphasis by blocked filtering method. To the method A, added from the emphasizing edge to the conventional method. To the method B, added from the emphasizing by blocked filtering method to the method A. Verification rate by verification experimentation in the conventional method was 99.5[%], but in the method A was 99.8[%], in the method B was 99.9[%](Figure12). Figure13 shows false verification rate of method B. FRR is false refection rate and FAR is false adaption rate.

C. Consideration

Difference of thereshold of distance between reference and input between conventional method and blocked filtering method is substantial. We think this is because, the contrast of image emphasized by block filtering method is more substantial. Figure14 shows example of false rejection. Two images don't seem to be similar but we think false rejection occurs because comparison of local region is carried out such as Figure15 by endpoint free DP matching and shifted width. In addition, emphasizing vein is not sufficient as shown in Figure16. In sample.9 two veins exist but only one vein is emphasized and in the sample.10 emphasizing of the vein which is thin and weak is insufficient. I think if these veins are sufficiently emphasized, verification rate will increase.

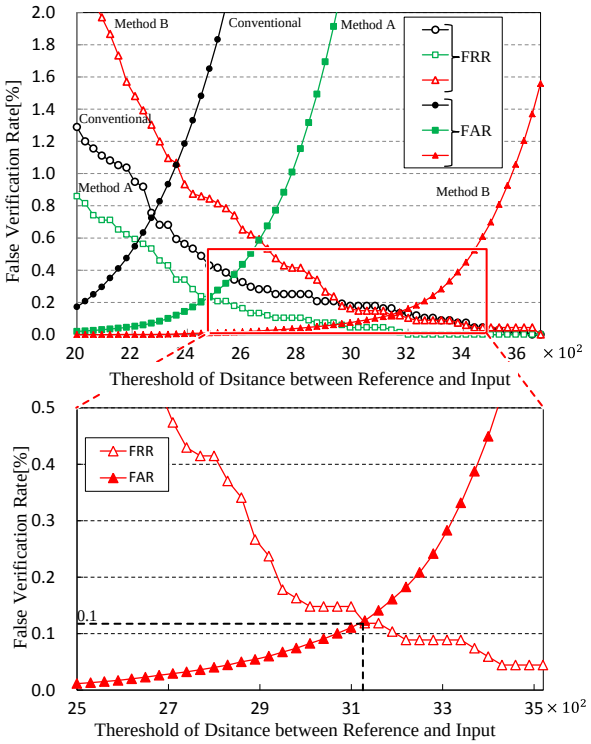


Figure 12. FRR-FAR with proposal method.

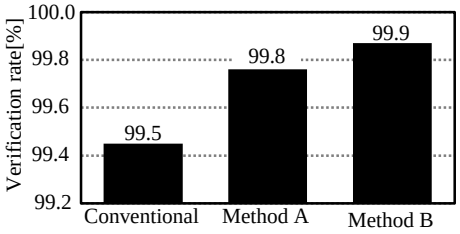


Figure 13. Verification Rate of each method.

TABLE I. DATABASE

Examinees	25
Fingers	150
Photographing each fingers	10
Total of data	1,500

TABLE II. COMPARISON THE NUMBER OF COMBINATIONS

Examinee compare	6,750
Others compare	1,117,500
Total compare	1,124,250

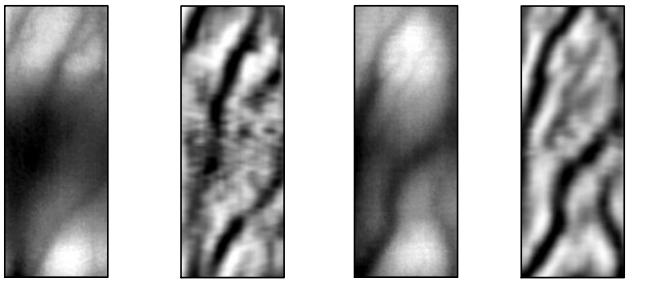


Figure 14. Example of false rejection.

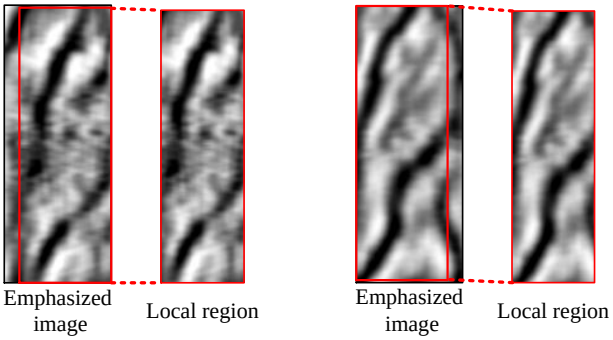


Figure 15. Comparison of local region by endpoint free DP Matching.

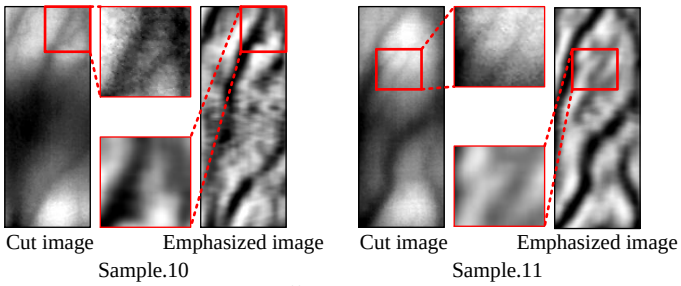


Figure 16. Sufficient emphasizing vein.

VI. Conclusion

We manufactured compact personal verification device using finger vein. When we carried out verification experimentation by conventional method, verification rate was 99.5[%]. Therefore, we found problem of conventional method and proposed methods for this problem. We proposed gamma transformation and Reverse-S shaped transformation that emphasize edge of finger for the problem of the failure of contracting edge which is blurred and we confirmed Reverse-S shaped transformation is more efficient. In addition, we proposed emphasizing by blocked filtering method for the problem that emphasizing vein of image with the occurrence of saturation or occlusion in the left and right ends is difficult. We could proposing verification rate from 99.5[%] to 99.9[%] by proposed method. It is possible to make the certification rate higher using some images as references.

We plan to construct a huge database to increase reliability of personal verification device. In addition, subject to improve verification rate is to propose a method which can also emphasize thin and weak vein.

References

[1] Hideyo TAKEUCHI, Taizo UMEZAKI, Noriyuki MATSUMOTO, and Katsumi HIRABAYASHI, "Evaluation of Low Quality Images and Imaging Enhancement Methods for Fingerprint Verification", The Transactions of the Institute of Electronics, Information and Communication Engineers , Vol.J87- D-II, No.2, pp.574-585, 2004.

[2] Morito SHIOHARA, "Movement of Face Recognition and it's Applications", The Japan Society for Precision Engineering, Vol.71, No.2, pp.163-166, 2005

[3] Masahiko HOSOYA, "Identification System by Iris Recognition", Medical and Biological Engineering, Vol. 44, No. 1, pp.33-39, 2006

[4] A. Jain, R. Bolle, and S. Pankanti eds, "BIOMETRICS Personal Identification in Network Society", KluwerAcademic Publishers, 1999

[5] Tomohide KUSHIDA, and Mikio KUZUYA, "Development of a Non-contact Finger- print Capturing Device III", The Institute of Electrical Engineers of Japan Tokai, P-014, 2008.

[6] Koosuke HATTORI, Ryoji ISHIKAWA, Ryo TAGUCHI, Taizo UMEZAKI, and Masahiro HOGURO, "Development of Verification System Using Vein Image", Meeting on Image Recognition and Understandeing 2010, IS3-61, pp.1985-1990, 2010.

[7] Koosuke HATTORI, Masashi KONDO, Ryo TAGUCHI, Taizo UMEZAKI, and Masahiro HOGURO, " Development of Penetrate and Reflection Type Finger Vein Certification", Information Processing Society of Japan, Vol.74,p.p.643-644

Yuhei harada received the B.E. degrees in electrical engineering and computer science from Nagoya Institute of Technology, Japan, in 2013. Currently, he is a M.E. candidate in computer science and engineering at Nagoya Institute of Techonology, Japan. His research interests are image processing.

Tsukasa Kato received the B.E. degree in electrical engineering and computer science, and the M.E. degree in techno-business administration from Nagoya Institute of Technology, Japan, in 2010 and 2011. Currently, he is a Ph.D. candidate in computer science and engineering at Nagoya Institute of Technology. His research interests are image processing and three dimension measurement. He is a student member of IEICE.

Ryo Taguchi received the B.E., M.E. and Ph.D. degrees in computer science and engineering from Toyohashi University of Technology, Japan, in 2002, 2004 and 2008. He has been an Assistant Professor at Nagoya Institute of Techonology since 2008. His research interests are conversation with robot and language acquisition. He is a member of JSAI, IPSJ, RSJ and ASJ.

Masahiro Hoguro received the B.E. and M.E. degrees in electrical engineering from Chubu University, Japan, in 1993 and 1995. In 2009, he received the Ph.D. in computer science and engeneering at Nagoya Institute of Technology. He has been an Associate Professor at Chubu University since 2010. His research intrests are speech and image processing. He is a member of IEICE and JSWE.

Taizo Umezaki received the B.E. degree in computer science from Toyohashi University of Technology, Japan, in 1982. He received the Ph.D. degrees in computer science from Nagoya University, Japan, in 1987. In 1990 he was a lecture and in 1992 an assistant professor. During 1993-1987 he was Visiting Scholar at Carnegie Mellon University. He was a Professor at Chubu University in 1999. Since 2003 he has been a Professor at Nagoya Institute of Technology. His research interests are speech and image processing, education for deaf children, and welfare robot. Dr. Taizo Umezaki received the best paper award from JSWE in 2003, and won the Good Design Award 2006. He is a member of IPSJ, ASJ, IEICE, JSWE, HIS of Japan, JSMBE, RSJ and JSPE.