PROCEEDINGS

of the

2018 Symposium on Information Theory and Signal Processing in the Benelux

May 31-1 June, 2018, University of Twente, Enschede, The Netherlands

https://www.utwente.nl/en/eemcs/sitb2018/

Luuk Spreeuwers & Jasper Goseling (Editors)

ISBN 978-90-365-4570-9

The symposium is organized under the auspices of

Werkgemeenschap Informatie- en Communicatietheorie (WIC)

& IEEE Benelux Signal Processing Chapter

and supported by

Gauss Foundation (sponsoring best student paper award)

IEEE Benelux Information Theory Chapter

IEEE Benelux Signal Processing Chapter

Werkgemeenschap Informatie- en Communicatietheorie (WIC)

UNIVERSITY OF TWENTE.

IEEE

A Prototype of Finger-vein Phantom

P. Normakristagaluh[1,2] L.J. Spreeuwers[1] R.N.J. Veldhuis[1]
[1]Data management and Biometrics (DMB) Group
Faculty of EEMCS, University of Twente, Netherlands
[2]Indonesian Institute of Sciences, Indonesia
[1](p.normakristagaluh; l.j.spreeuwers; r.n.j.veldhuis)@utwente.nl
[2]pesi001@lipi.go.id

Abstract

This paper describes the developing a prototype of finger phantom to get modeling on a physical vein pattern. This physical model could help us to get a better understanding of the image formation, since the imaging process seems to be the cause of the poor image quality. The phantom of finger-vein images have been captured using a custom designed capturing device[1]. The set of material considered in this paper consists of 3D printing, soap and titanium dioxide (TiO_2) powder. The prototype of fake bone and tissues within the phantom have already been made from those materials. The various of initial phantoms with and without bone are addressed in this paper as well.

1 Introduction

Finger-vein recognition as a promising biometric technique has drawn increasing attention from the biometrics community in recent years. Compared with other biometric traits, e.g., fingerprint, face or iris, finger-vein characteristics cannot easily be copied, leave no traces around, and are very convenient to use. In anatomy, the vascular pattern is a network structure of veins inside a finger that cannot be damaged easily unless some vein suffers rupture [2].

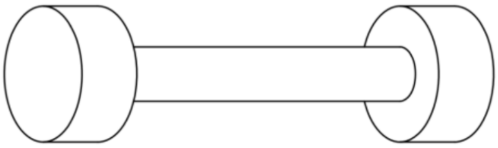
Obtaining a reliable vascular pattern in practice is quite difficult since the images are blurred and have different intensity areas (high-low contrast); for example, figure 2b shows an image of the veins of the middle finger. In fact, strong scattering of light in biological tissue during imaging is the main cause of contrast deterioration in finger-vein images [2]. Until now, knowledge of the image formation process has not really been used in finger vein recognition.

Since the imaging process seems to be the cause of the poor image quality, developing a physical model could help us to get a better understanding of the image formation. We expect that using this model will result in a new robust feature extraction method leading to better recognition performance, which will have an impact on the reliability and usability of finger veins as personal authentication in a real application. A further advantage of a physical model is being able to generate realistic images with a ground truth for the vein patterns, which in turn may lead to better feature extraction. Moreover, if we can improve modeling, we can work on better pre-processing and a better algorithm to visualize finger veins.

In this work, the experiment has three phase of developing the phantom. Developing a fake bone and tissues have already been done as the first two stages. This paper illustrates the preliminary results of those phases with the initial methods and does not describe in detail for the third phase that is creating a fake vein.

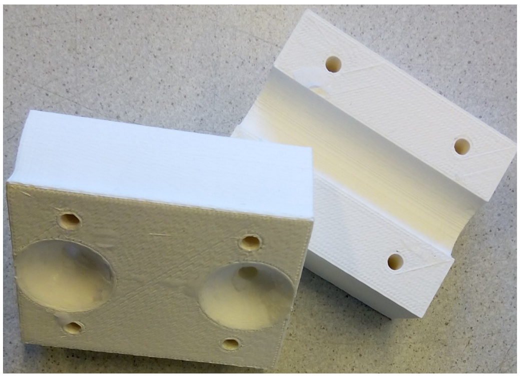
(a) Transparent and white soap material

(b) Titanium dioxide (TiO_2) powder

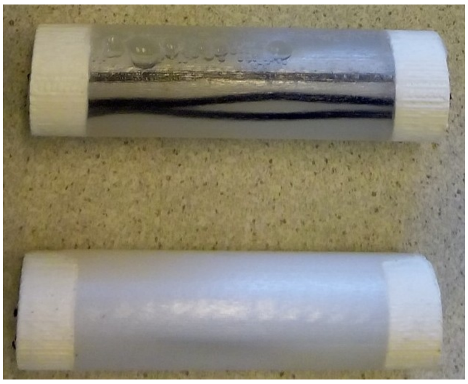


(c) Sketsa of the skeleton fake finger

(d) Skeleton of fake finger



(e) Mold



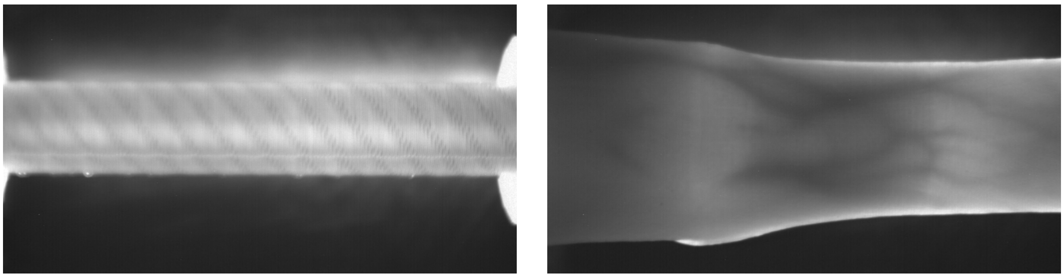
(f) A sample of fake finger

Figure 1: The basis of phantom material.

2 Methods

Tissues as in the case for human skin are heterogeneous and are often composed of different structures having different optical properties. It describes the penetration, absorption, scattering, and remittance of light at different wavelengths. In vivo, veins and arteries have a different sizes and at different depths [3]. Basically, human perception is limited to the visible (VIS) spectral range that is defined by the luminous efficiency functions ranging between wavelengths of $\lambda = 380$ nm and $\lambda = 780$ nm. However, near infra red (NIR) radiation in the tissue and the absorption by haemoglobin in the blood vessels is the best between $\lambda = 850$ and 900 nm. Therefore, in the NIR images, the observable size of the veins most probably is strongly increased [4].

In the same way, the tissue phantom should have optical properties close to the living tissue of human body and tissue components (e.g., epidermis and dermis) [5]. Besides that, phantoms also consist of a scattering medium, an absorbing medium, a diluent, and in some cases, fluorophores. For example, absorbing media include black India ink or/and some biological dyes, such as trypan blue and photofrin. The most common materials providing scattering were presented as: (1) lipid-based emulsions,



(a) The fake bone. (b) The left middle finger.

Figure 2: The Illumination process pass through the fake bone, and the left middle finger as image reference.

(2) titanium or aluminum oxide powders, and (3) polymer microspheres [6]. In fact, titanium oxide nanoparticles are excellent scatters and the most common choice for scattering in science and engineering [5]. In this experiment, titanium dioxide (TiO_2) powder has been used as scatterers, and soap material as an absorber in constructing phantoms. Apart from the finger, bone has been modelled by 3D printing as a base material. All materials supporting in this experiment are presented in figure 1.

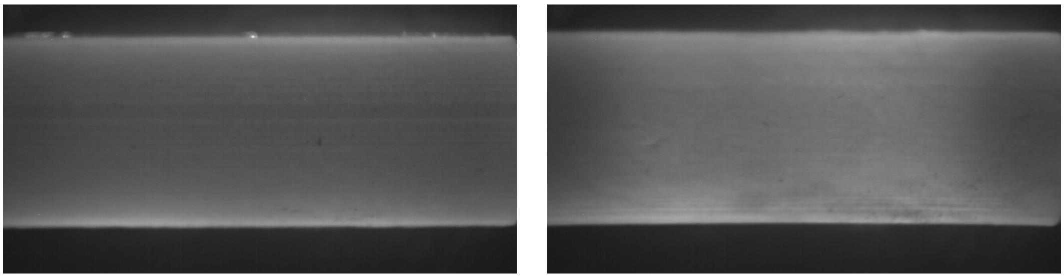
Fabrication of the phantom samples with and without a fake bone was provided by the following steps: melting the soap material in the pan at 90^0C, advanced manual mixing of soap with TiO_2, further mixing of TiO_2/soap solution in room temperature during 5 minutes, pouring of prepared solution into mold finger form and drying the sample in the same temperature within 1 hrs. This phantom, which is mimicking the tissue with and without a fake bone, is the initial phase to get a similar properties with the real tissue of the finger.

3 Preliminary Results and Discussion

The first artificial finger was made from a mixture of white and transparent soap materials, which have a bit similar properties to the biological tissues of the finger. Nevertheless, the illuminations penetrate through this fake tissue within the fake finger. Apart from a fake finger, we have also created a fake bone and a fake vein from thin wire. Figure 1f shows a sample of the first fake finger.

Three issues were encountered during making the phantom. The first was related to uniform the illumination. This can be dealt with by setting the LED on capturing device. Figure 2 shows the images, which have uniform the illumination, captured by the finger scanner device. The second stems from the physiology illumination of bone structure. Theoretically, the real bone should have properties, which is blocking the illumination through the finger. However, the results do not support the hypothesis: from figure 2a it can be seen that the light penetrate through the fake bone. This occurs because the bone material does not have a solid structure. A solution to this problem might be finding the massive material which can block the lighting.

The last issue emerged from scattering process within the fake tissue. These processes are presented in figure 3a and 3b. The images were generated by the same illumination as in figure 2b. It can be seen from figure 3b that the fake tissue without the fake bone inside have fairly similar properties with the joint area in the finger, which is the brightest area in figure 2b. Therefore, this material composition would be base of the fake finger. If all issues solved, the research would continue to obtain the fake of vein structure inside the fake finger.



(a) Fake bone inside

(b) No fake bone inside

Figure 3: The capturing fake finger images ware made up of 50 gram soap transparent and 0.5 gram TiO_2.

4 Conclusion

A new method for finger-vein pattern imaging, based on the physical model has been presented. The modeling finger with phantom has three steps on this research. The first and the second step have already been done. These steps are creating a fake bone and tissue. Even though the fake bone in the figure 2a have little bit similar properties with the real bone, but the fake tissues almost have the same optical structure as the biological tissue in the finger. However, this is still preliminary result of the research. The more accurate composition of materials should be developed to obtain the same properties as the real finger. The next step is developing physical model of vein to get the entire structure of finger phantom.

References

[1] B. T. Ton and R. N. Veldhuis, "A high quality finger vascular pattern dataset collected using a custom designed capturing device," in *Biometrics (ICB), 2013 International Conference on*. IEEE, 2013, pp. 1–5.

[2] J. Yang and Y. Shi, "Towards finger-vein image restoration and enhancement for finger-vein recognition," *Information Sciences*, vol. 268, pp. 33 – 52, 2014, new Sensing and Processing Technologies for Hand-based Biometrics Authentication. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0020025513007342

[3] N. J. Cuper, J. H. Klaessens, J. E. Jaspers, R. de Roode, H. J. Noordmans, J. C. de Graaff, and R. M. Verdaasdonk, "The use of near-infrared light for safe and effective visualization of subsurface blood vessels to facilitate blood withdrawal in children," *Medical Engineering and Physics*, vol. 35, no. 4, pp. 433–440, 2013.

[4] K. Mangold, J. A. Shaw, and M. Vollmer, "The physics of near-infrared photography," *European Journal of physics*, vol. 34, no. 6, p. S51, 2013.

[5] V. Tuchin, A. Bashkatov, E. Genina, V. Kochubey, V. Lychagov, S. Portnov, N. Trunina, D. Miller, S. Cho, H. Oh *et al.*, "Finger tissue model and blood perfused skin tissue phantom," in *Dynamics and Fluctuations in Biomedical Photonics VIII*, vol. 7898. International Society for Optics and Photonics, 2011, p. 78980Z.

[6] V. V. Tuchin and V. Tuchin, "Tissue optics: light scattering methods and instruments for medical diagnosis," 2007.