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Effect of Exposure Time of Near Infrared Light Radiation (NIR) on Human's Vein Visualization

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Abstract*: Human blood specimen contains information about health and possible diseases that help the physician identifying the appropriate medical diagnosis. Venepuncture and intravenous cannulation are among the most common medical procedures that were performing on patients. However, there is difficulty to find the visualization of vein structures. The use of infrared radiation will be the right preference since it can penetrate the tissue and a non-invasive method. Many studies have focused on the characteristics of NIR on human skin, but the effects of exposure time as one of the design parameter in NIR exposure was not discovered. This research proposes studies that ease the handling operation and minimize the operating cost of NIR imaging in visualizing vein-structure. The study aims to measure and compare the effect of exposure time of the near infrared light emitting diodes on the vein visualization. The working principle is started with the haemoglobin in the blood absorbs the infrared light, so the vein appears darker than other areas. Then, a detection system consists of an infrared camera to capture the vein digital images. This study will then process the overall quality of the images with different exposure time by highlighting the vein-morphological structure using hessian and contrast method. The results revealed that increasing time of exposure does not increase the absorption of the NIR in both palm and arm area. Image processing further confirms this result by showing the extracted and highlighted vein. For all images, the numbers of vein appeared are the most significant factors that contribute to the vein visualization. This study can add to the process of developing a vein visualization system.

***Keywords* : Image Processing, Near Infrared Imaging, Vein Detection, Vein Visualization**

I. INTRODUCTION

Vein detection is crucial for medical purposes, especially in the hospital. Veins are used to take a sample of blood and for drugs delivery [1]. In a human blood vessel, it contains information about health and possible diseases that can be detected [2]. However, there is difficulty to find the visualization of vein structures [3]. Installation of a needle on a vein is required to match correctly and to provide comfort to the patient [1]. The use of infrared radiation will be a good preference since it can penetrate up to several centimetres into tissue [4].

NIR is an electromagnetic wave that simultaneously exhibits both wave and particle properties and is strongly absorbed by water, hemoglobin and myoglobin [1]. As a consequence, NIR can penetrate the skin including muscles and bone marrow, with both its wave and its particle properties [1]. NIR radiation consists of wavelengths from 700 nm to 900 mm [2]. In particular, infrared radiation induces molecular vibrations and rotations where it principally interacts with tissues [3]. The NIR can penetrate up to several centimetres into tissue [4]. Haemoglobin is the dominant absorber in the blood vessel [5] that causes the image of the blood vessel appear darker than other part of the human skin [6]. Near infrared also provides a less contact and non-invasive method for vein visualization [7].

Previous study related to NIR focus on design devices with biomedical capabilities [8]. For instance, the studies focus on the pattern extraction using low quality sensors, image acquisition techniques for veins and discuss technique using thermal IR imaging device. However, the stated research requires costly equipment [8] and focus on the type of sensor, and image processing technique to enhance the vein detection. To date, there is no research focus on the parameter related to exposure time of the NIR on the vein. In this research, the aim is to investigate whether the relative change in time of exposure could be used as a parameter to increase the absorption of NIR.

II. METHODOLOGY

A. Design Parameters

To enhance the structural features in vein visualization, we considered parameters that could affect vein visualization as shown in Table 1. The selected wavelength of the NIR exposure is 850nm and the matrix arrangement is used because of the better area of illumination. The time of exposure varies from the 20s to 180s with an interval of 20s. An evaluation of the different exposure time is carried out to assess skin absorption.

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For the ROI (region of interest) focus on the arm and palm area. The name is built according to the following scheme: wavelength, arrangement, ROI, exposure time (s).

Table- I: Scheme for name

Indicator	85	M	P	2
Description	Wavelength	Arrangement	ROI	Exposure Time

For the wavelength, 85 is used instead of 850nm for simpler remark. Next, the exposure time, 2 are used instead of 20 s for simpler remark and for ROI, P is used for palm and A is used for arm.

Table- II: Design Parameters

Name	Wavelength, λ (nm)	Arrangement	ROI	Exposure Time (s)
85MP2	850	Matrix	Palm	20
85MP4	850	Matrix	Palm	40
85MP6	850	Matrix	Palm	60
85MP8	850	Matrix	Palm	80
85MP10	850	Matrix	Palm	100
85MP12	850	Matrix	Palm	120
85MP14	850	Matrix	Palm	140
85MP16	850	Matrix	Palm	160
85MP18	850	Matrix	Palm	180
85MA2	850	Matrix	Arm	20
85MA4	850	Matrix	Arm	40
85MA6	850	Matrix	Arm	60
85MA8	850	Matrix	Arm	80
85MA10	850	Matrix	Arm	100
85MA12	850	Matrix	Arm	120
85MA14	850	Matrix	Arm	140
85MA16	850	Matrix	Arm	160
85MA18	850	Matrix	Arm	180

B. Image Acquisition and Processing

The first part is the image acquisition. The ROI in this research are the palm and arm area which consist of two different thickness of the skin. The distance between camera and ROI are constant at 15cm to ensure that the camera can focus on the ROI. The region will be illuminated with the NIR with 850nm wavelength because it has low affinity to water, so the wavelength absorbed more by the vein. The infrared source and camera are placed side by side to ensure perfect lighting system on ROI. The infrared LEDs are powered from the external battery so the illumination in a stable voltage of 9V. The light-emitting diodes (LED) need to have enough luminous intensity to achieve a homogeneous illumination inside the field of view (FOV) of the system. In this study, the tested LEDs diodes luminosity is 55mW. LEDs diodes with an angle of illumination <15° will be used to produce uniform illumination.

The lighting from the environment is kept constant with average luminous emittance, 27.1 lx. An image of the vein which absorbs the near infrared light is acquired with IR camera before transfer to the microprocessor, and the image will show the veins appear darker than other areas due to the infrared radiation absorption. Hence, this provides excellent visibility of the veins.

The second part is the image processing parts involve restoring and enhancing the morphological processing to extract the image components that are useful to represent the vein structure in real-time. Several noticeable techniques such as low pass filtering, high pass filtering, as well as Sobel edge detection techniques, are applied and integrated. The procedures and developed methods are written using Python programming language, and the libraries used are OpenCV and NumPy. The primary method for image processing is the hessian and contrast method.

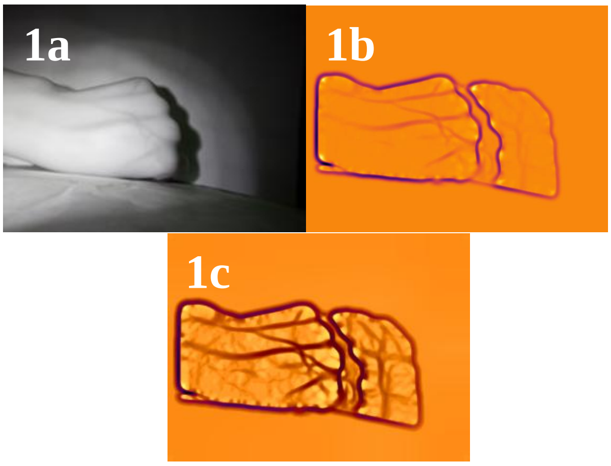


Fig. 1. 850nm wavelength at palm with matrix arrangement 1a) Raw image. 1b) Hessian method 1c) Contrast method

C. Vein Counting

The number of veins apparent in both palm and arm are counted by visual examination for both the Hessian and Contrast method. The numbers of vein counts were then compared. A branching vein, having a Y-shape, is counted as consisting of two [9]. If there is uncertainty whether the region of interest is indeed a vein or a shadow, it is not included in the count. Rules for counting is consistent both palm and arm.

III. RESULT

A. Evaluation of the effect of exposure times

Pictures with different exposure time were taken and processed to show the performance of each exposure time. The vein is captured as a black line on the picture when exposed to the NIR [10]. The exposure time starts from 20 s for the palm, as shown in Table II and III, the exposure time is enough to absorb the near infrared light in the skin, making the visualization possible. Table II and Table IV show that the vein images after processing by using the hessian method at both palm and arm ROI. Table III and Table V show that the vein images after processing by using the contrast method at both palm and arm ROI. The results clearly revealed that there is no significant difference in the images acquired.

Table II-Images of palm area after hessian enhancement at different exposure time ranging from 20s to 180s

Name	85MP2	85MP4	85MP6
Image			
Name	85MP8	85MP10	85MP12
Image			
Name	85MP14	85MP16	85MP18
Image			

Table III-Images of palm area after contrast enhancement at different exposure time ranging from 20s to 180s

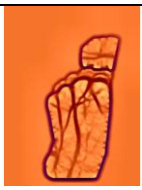
Name	85MP2	85MP4	85MP6
Image			
Name	85MP8	85MP10	85MP12
Image			
Name	85MP14	85MP16	85MP18
Image			

Table IV- Images of arm area after hessian enhancement at different exposure time ranging from 20s to 180s

Name	85MA2	85MA4	85MA6
Image			
Name	85MA8	85MA10	85MA12
Image			
Name	85MA14	85MA16	85MA18
Image			

Table V-Images of arm area after contrast enhancement at different exposure time ranging from 20s to 180s

Name	85MA2	85MA4	85MA6
Image			
Name	85MA8	85MA10	85MA12
Image			
Name	85MA14	85MA16	85MA18
Image			

Figure 2 shows the numbers of visible vein are consistent for both palm and arm area.

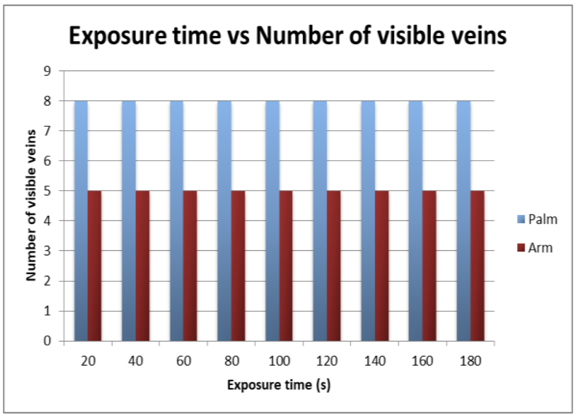


Fig. 2. Exposure time vs number of visible veins

Although the skin is naturally exposed to light more than any other organ, it responds well to NIR [11]. The current passes through NIR cause a spectrum of light is emitted, the emission intensity remained constant and independent of the applied voltage when it is above 3.5 V [12]. In this study, the applied voltage is 9 V which means it has the same intensity throughout the experiment and independent of the exposure time. Moreover, when the skin exposure to NIR it undergoes absorption, reflection and light transmission that occur at the same time [10] even though the light penetrates from one layer to another layer in the skin.

IV. CONCLUSION

This study reveals that the exposure time of the near infrared LEDs on human skin is not one of the significant design parameters. An exposure time of at least 20 s of near infrared light on the ROI has proven to work as effectively as exposure of 180 s on human veins. Nevertheless, in the current technology, safety on the exposure of infrared should be studied. Moreover, for image processing, the contrast method shows an excellent vein image enhancement compared to the Hessian method. This study is crucial in developing a vein visualizing system, particularly for medical procedures.

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REFERENCES

1. Y. Tanaka and C. Tanaka, "Impact of near-infrared radiation in dermatology," no. January, 2016.
2. Á. Azueto-ríos, "Forearm and Hand Vein Detection System for anInfrared Image Database," vol. 127, pp. 137–147, 2016.
3. N. Kourkoumelis and M. Tzaphlidou, "Eye safety related to nearinfrared radiation exposure to biometric devices,"ScientificWorldJournal., vol. 11, no. June, pp. 520–528, 2011.
4. N. J. Cuper et al., "Visualizing veins with near-infrared light to facilitateblood withdrawal in children," Clin. Pediatr. (Phila)., vol. 50, no. 6, pp.508–512, 2011.
5. E. Yaprak and S. Kayaalti-Yuksek, "Preliminary evaluation ofnear-infrared vein visualization technology in the screening of palatal blood vessels," Med. Oral Patol. Oral y Cir. Bucal, vol. 23, no. 1, pp. e98–e104, 2018.
6. R. Fuksis, M. Greitans, O. Nikisins, and M. Pudzs, "Infrared imagingsystem for analysis of blood vessel structure," Elektron. ir Elektrotechnika, no. 1, pp. 45–48, 2010.
7. L. Wang and G. Leedham, "Near- and far- infrared imaging for vein pattern biometrics," Proc. - IEEE Int. Conf. Video Signal Based Surveill. 2006, AVSS 2006, no. September 2014, 2006.
8. K. K. Nundy and S. Sanyal, "A low cost vein detection system using integrable mobile camera devices," Proc. 2010 Annu. IEEE India Conf. Green Energy, Comput. Commun. INDICON 2010, no. December 2010, 2010.
9. C. A. Mela, D. P. Lemmer, F. S. Bao, F. Papay, T. Hicks, and Y. Liu,"Real-time dual-modal vein imaging system," Int. J. Comput. Assist. Radiol. Surg., vol. 14, no. 2, pp. 203–213, 2019.
10. F. Chandra, A. Wahyudianto, and M. Yasin, "Design of vein finder withmulti tuning wavelength using RGB LED," J. Phys. Conf. Ser., vol. 853, no. 1, 2017.
11. D. Barolet, F. Christiaens, and M. R. Hamblin, "Infrared and skin:Friend or foe," J. Photochem. Photobiol. B Biol., vol. 155, no. January 2016, pp. 78–85, 2016.
12. K. S., "Luminous Intensity of an LED as a Function of Input Power," ISB J. Phys., vol. 2, no. June, pp. 1–4, 2008.

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