Design and enhance the vein recognition using near infrared light and projector

Tran Van Tien, Dau Sy Hieu, Nguyen Tri Dan,
Huynh Quoc Sang, Huynh Quang Linh*

***Abstract* — The difficulty of intravenous access in patients is an important clinical issue. Recently, many studies and several devices have been developed to assist physicians, nurses and surgeons in finding veins. Amongst them, near infrared imaging technology is one of the new technologies being widely used in the biomedical. NIR imaging allows visualizing veins underneath the skin of those having non-visibility of veins problem, mapping the normal and abnormal veins in treating disorders, or diagnosing related diseases. In this paper, we will introduce a portable device which can help doctors and nurses visualize blood vessel maps of their patients. On basic of combining a vein infrared imaging method and a projector system, this vein instrument can be optimally designed for viewing veins in the monitor or displaying vessel maps of patients directly on their skin.**

***Index Terms*— vein viewer, near infrared, projector**

1. INTRODUCTION

Near infrared (NIR) imaging of vein has many applications in biomedical fields. Recently, many studies [1-5] and several devices [6-9] have been developed to assist physicians in finding veins. Especially, NIR light are non-ionizing radiation and non-invasive so it can be used for a long time without harm to patients. Near infrared imaging technologies display subcutaneous veins based on the principle of light propagation, absorption, refraction, reflection and scattering in the different layers of skin. When using near-infrared LED with wavelength of 850 nm to illuminate, this near-infrared light infiltrates the skin and subcutaneous fat efficiently because of the low absorption of the tissue in this NIR-wavelength. Blood is scattered in the skin and subcutaneous fat, will be absorbed or scattered near-infrared light in the forward direction. Unlike skin and fat [5] blood appears darker regions because hemoglobin in blood absorbs significantly more NIR light than the surrounding tissue. In addition, NIR light is scattered by all tissues. To capture better vein images and enhance vein contrast between skin tissues and veins, three main illumination methods have been studied in recent years: transmission method, reflection method and combination of transmission and reflection method. These researches has achieved success in improving the source illumination by combining multiple illuminants with different wavelengths [9] or used cross polarizer and neutral density filters to eliminate amount of glare lights. Therefore, in this paper, the transmission mode which high power led 850 nm lighting was used to display vein images with maximizing the contrast between skin tissues and veins. The strong glare occurring on skin surfaces during illumination process is one of the reasons causing contrast deterioration in NIR images. The optical system with near infrared filter and neutral density filter were used to eliminate the amount of glare light that can pass through the camera. The image processing algorithms are also used to enhance the quality images and the contrast of venous imaging. Finally, on basic of combining a vein infrared imaging method and a projector system, the vein instrument can be optimally designed for viewing veins with high-definition and in real-time on surfaces of the skin.

Manuscript Received on July 13th, 2016. Manuscript Revised December 06th, 2016.

This work was supported by National Key Laboratory of Digital Control and System Engineering, and the department of Biomedical Engineering, HCMUT-VNU HCM.

Tran Van Tien, Dau Sy Hieu, Nguyen Tri Dan, Huynh Quoc Sang, Huynh Quang Linh are with Department of Applied Physics, Faculty of Applied Science, Ho Chi Minh City University of Technology - VNU-HCM. Email: Huynhqlinh@hcmut.edu.vn; tranvantien@hcmut.edu.vn.

2. METHODS

2.1. Optics System

In this research, optical system is composed of a NIR high sensitive CCD camera with a resolution set to 640 x 480 pixel at 60 fps, a NIR illumination source with wavelength 850 nm, an IR bandpass filter (F.IR) (Edmund optics, USA), a neutral density (N.D) filter (Edmund optics, USA). In the

transmission method, the hand is placed between the optical system and the LED infrared illuminators. When this light passes through the hand, the image is captured by the camera. Digital image processing was used to segment blood vessels out of the image. After that, processed blood vessel image is projected back to the patient's skin right into the position where is corresponding blood vessels.

To display the vein image into patient's skin, we use a mini projector with Texas Instrument's DLP ® Technology. This technology enables to create a projector with small profile and suitable for a device required portability. The projector and the CCD camera are optically aligned to point into one area. There are placed perpendicular and have a beam splitter placed between. The image from subject goes into the beam splitter and is reflected at the base of two prisms which glued together into the camera. And the image after processing is come from the mini projector, goes through the beam splitter and is projected into the skin of the patient.

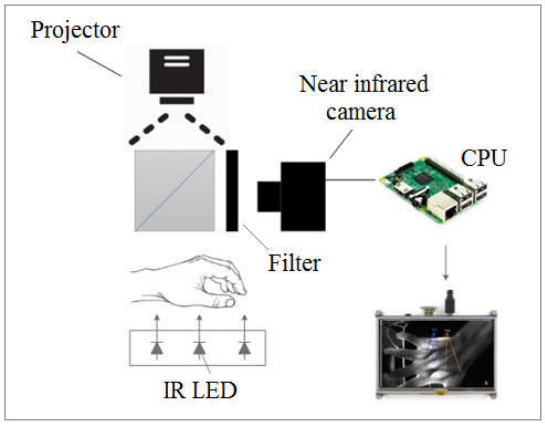

Figure 1. The optical diagram of the vein projector system

2.2. Image Processing Algorithm

We identify and enhance the contrast between venous and background regions. The processed images are presented below (Fig.2). Vein raw images after the pre-processing steps (which reduce salt-pepper noise by median filter, increasing contrast and properly cropping) are converted into grayscale images. Then, the Otsu or K-means algorithm is used to calculate the threshold and segmentation for this images.

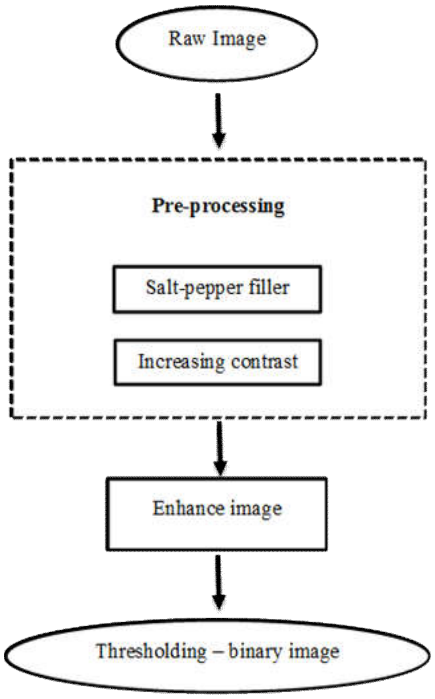

Figure 2. The algorithm diagram of vein projector

3. RESULT

We concern in the output image projecting into patient's skin is the shape of the blood vessel segmented from original infrared image obtained by the CCD camera. The speed of these algorithm is also important to make this system can run in real-time. To do this, we use adapthisteq algorithm to enhance the contrast betweenblood vessels and others surrounding tissues. The contrast-enhanced images are then converted into binary images by thresholding algorithm. Blood vessel are appeared significantly darker than surrounding tissues. By thresholding, we can segment veins out of the images, mark it by the bright color to ready to display into the patient's skin by the projector (Fig.3).

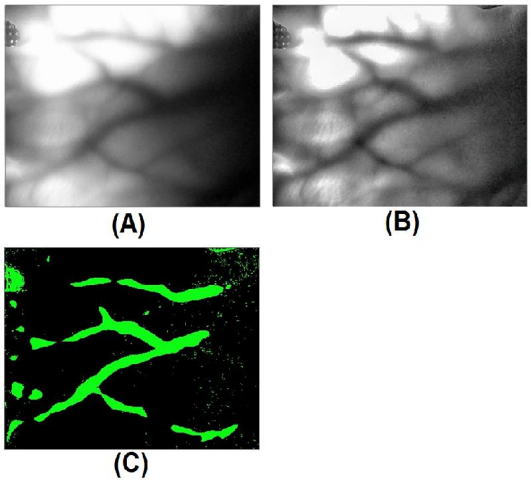

Figure 3. Vein image processing: (A) Raw image; (B) Enhanced image; (C) Thresholding image

With requirements to create a portable device that can help doctors and nurses detect bloods vessel directly, we created a vein viewer model which can project the vein into patients' skin. It has some advantages than others infrared vein viewing devices [6-8] which require an monitor to observe vein images, this system can project the image in real-time directly to the surface where the blood vessels lie below. The system including: an optics system including a beam splitter for the CCD camera to observe images for the projector on projecting the veins image to the surface; a Raspberry Pi 3 mini computer to receive the image captured by the CCD camera for performing image processing and segmenting procedure and sends them to the projector. We test this system with our volunteers in the back of hands and wrisst. In figure 4.A we can see the distribution of blood vessel in volunteer's back of hand and in figure 4.B is the vein image in the arm of the volunteer. The position and the size of the image and the actual size of the vein is calibrated.

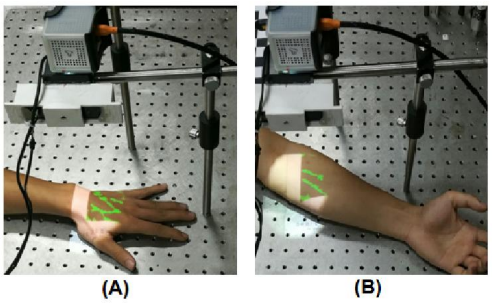

Figure 4. Projection vein imaging: (A) In the back of hand; (B) In the arm

4. CONCLUSION

The NIR imaging of human hand has many advantages in biomedical field, which not only locates vein imaging but also maps normal and abnormal veins in treating disorders, or diagnosing related diseases with high contrast easily, exactly, and safely. On basic of combining the vein infrared imaging method and a projector system, a simple non-invasive vein finding system is designed which can be facilitated peripheral venous access for patients with difficult veins, which enhanced first-attempt success rates.

REFERENCES

[1] Fengtao W, Ali B et al, "High-contrast subcutaneous vein detection and localization using multispectral imaging", Journal of Biomedical Optics 18(5): 050504-1, 2013.

[2] Anup P, Sam M, "Enhancement of Infra-Red Images of Human Hand", *American Journal of Biomedical Engineering*, 1(1): 59-61, 2011.

[3] Vincent C. P, Kenneth W. T, et al, "3D and Multispectral Imaging for Subcutaneous Veins Detection", Optics Express, 17 (14): 11360-11365, 2011.

[4] H.D. Zeman, G. Lovhoiden, et al. "Prototype Vein Contrast Enhancer", *Proc. SPIE*, vol. 5318, in press, pp 39-49, 2004.

[5] Nabila B, Abdel H et al. "Near-infrared image formation and processing for the extraction of hand veins", *Journal of Modern Optics*, 57 (18): 1731–37, 2010.

[6] Xiaobin Dai, Ya Zhou, Xiaoming Hu, Meiqing Liu, "A Fast vein display device based on the camera-projector system", *Imaging Systems and Techniques (IST)*, 2013 IEEE International Conference, pp.146-149.

[7] Jinfeng Y, Ben Z, Yihua S, "Scattering Removal for Finger-Vein Image Restoration", Sensors 2012, 12, 3627-3640, DOI:10.3390/s120303627.

[8] Zeman HD, Lovhoiden G, Vrancken C, "The clinical evaluation of vein contrast enhancement", *Conf Proc IEEE Eng Med Biol Soc. 2004*, 2:1203-6.

[9] Eui Chul Lee, Hyunwoo Jung, Daeyeoul Kim, " New Finger Biometric Method Using Near Infrared Imaging", Sensors 2011, 11(3), 2319-2333; DOI: 10.3390 /s110302319.

[10] Vincent C.P, Jeffery R. P et al. "Combining near-infrared illuminants to optimize venous imaging", *Proc. SPIE* 6509, Medical Imaging 2007: Visualization and Image-Guided Procedures, 65090H (March 21, 2007); DOI:10.1117/12.712576.

Tran Van Tien is currently pursuing the Ph.D. degree in Engineering physics at Hochiminh City University Of Technology. He is now with the Department of Apply Sciences, Hochiminh City University Of Technology - 268 Ly Thuong Kiet Street, District 10, Ho Chi Minh City, Viet Nam. His research interest includes the tissue optics and photonics, image processing in biomedical and fabrication of medical equipment. (Email: tranvantien@hcmut.edu.vn)

Dau Sy Hieu received the PhD Degrees in Physics and Mathematics and Natural Sciences of People's Friendship University of Russia (RUND). He is now with the Department of Applied Sciences, Hochiminh City University of Technology - 268 Ly Thuong Kiet Street, District 10, Ho Chi Minh City, Viet Nam. His research interest includes the optics and photonics, image processing in biomedical and fabrication of medical equipment. (Email: dausyhieu@gmail.com)

Nguyen Tri Dan is the final- year student in Biomedical Engineering, engineering physics, at Hochiminh City University of Technology - 268 Ly Thuong Kiet Street, District 10, Ho Chi Minh City, Viet Nam. (Email: ntridan@gmail.com)

Huynh Quoc Sang is the final- year student in Biomedical Engineering, engineering physics, at Hochiminh City University of Technology - 268 Ly Thuong Kiet Street, District 10, Ho Chi Minh City, Viet Nam. Email: huynhqsang2905@gmail.com)

Assoc. Prof. PhD. Huynh Quang Linh is now Dean of the Faculty of Applied Sciences, Hochiminh City University of Technology - 268 Ly Thuong Kiet Street, District 10, Ho Chi Minh City, Viet Nam. His research interest includes the basic research: Modeling and simulation of photon and ionizing radiation penetration through matter, biomedical cybernetics, optical polarization etc and application research: Biosignal processing (ECG, EEG), biomedical image processing, bioinstrumentation etc. (Email: huynhqlinh@hcmut.edu.vn)

Nâng cao khả năng nhận diện tĩnh mạch với hình ảnh chiếu trực tiếp

Trần Văn Tiến, Đậu Sỹ Hiếu, Nguyễn Trí Dân,
Huỳnh Quốc Sang, Huỳnh Quang Linh

***Tóm tắt* - Sự khó khăn trong việc xác định mạch máu đã và đang là một vấn đề quan trọng cần giải quyết trong y tế. Gần đây, nhiều nghiên cứu và một số thiết bị đã được phát triển để hỗ trợ cho các y bác sĩ trong việc xác định mạch máu. Trong đó, công nghệ hình ảnh hồng ngoại gần (NIR) là một trong những công nghệ mới được sử dụng rộng rãi trong y học. Ảnh NIR cho phép quan sát những mạch máu không nhìn thấy được dưới da, xác định được những bất thường trong cấu trúc mạch máu, hoặc chẩn đoán các bệnh khác có liên quan. Trong nghiên cứu này, chúng tôi đưa ra một thiết bị cầm tay có thể giúp các bác sĩ và y tá quan sát được đường mạch máu dưới da bệnh nhân. Bằng cách kết hợp phương pháp chụp ảnh hồng ngoại gần và máy chiếu, thiết bị soi tĩnh mạch này được thiết kế tối ưu để người dùng có thế quan sát được hình ảnh mạch máu bệnh nhân được hiển thị trên màn hình hoặc được chiếu trực tiếp lên da người bệnh ngay tại vị trí mạch máu bên dưới.**

***Từ khóa* - Thiết bị soi ven, ánh sáng hồng ngoại gần, máy chiếu.**