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A Review on Subcutaneous Veins Localization Using Imaging Techniques

Amir Shahzad[1,]*, Mohamad Naufal Mohamad Saad[1,]*, Nicolas Walter[1], Aamir Saeed Malik[1] and Fabrice Meriaudeau[2]

[1]Centre for Intelligent Signal and Imaging Research (CISIR), Department of Electrical and Electronics Engineering, Universiti Teknologi PETRONAS, Malaysia; [2]Le2i Laboratory, University of Burgundy, 12 rue de la Fonderie, 71200, Le Creusot, France

Abstract: In daily medical practices intravenous (IV) catheterization is performed on the majority of patients to inject medication or to get blood samples. Patients whose veins are not visible require multiple attempts in order to insert the catheter accurately. Different techniques have been proposed and a few are in use at present to localize the veins in order to avoid the wrong catheterization and reduce the number of attempts. In literature, numerous imaging techniques can be found for subcutaneous veins localization. These techniques have dissimilar methods and applications. The aim of this paper is to present a review on the most commonly used techniques amongst all of them; these are Transillumination, Photoacoustic and near infrared (NIR) imaging. The basic working principle along with evolution of these techniques has been stated from the current state-of-the-art. Advantages and limitations are underlined in terms of effectiveness, simplicity in usage, portability and cost effectiveness.

Keywords: Intravenous catheterization, subcutaneous veins, imaging, near infrared (NIR), transillumination, photoacoustic.

1. INTRODUCTION

Intravenous (IV) catheterization is the first and most important procedure in common medical treatments for blood sampling and fluid injection. This process is required for anesthesia, labouring patients, trauma patients and patients requiring emergency medication. In the USA only, around 25 million catheters are placed each year. Studies have reported that around 80% of all hospitalized patients and several outdoor patients require catheters for the injection of medication and for blood sampling [1, 2]. The task of peripheral IV catheterization is performed manually by the qualified medical staff that localizes the veins by sight and/or by feeling with the fingers when they touch the targeted site of a patient's body; this procedure is typically used for the lower arm, hand or foot. The best vein for catheter injection is the vein having a large diameter and longitudinal orientation. Vein localization is difficult and a challenging task in patients having physiological characteristics like darker skin tone, deep veins, and the presence of scars, tattoos or hair on skin. Furthermore, in the case of elderly, infants, obese, or dehydrated patients or intravenous drug abusers, the task of veins localization becomes very tough [3]. Peripheral difficult venous access (PDVA) is the term used when veins are difficult to be localized in certain patients. In such cases, medical staff faces trouble in the veins localization process which results in an increased number of attempts and/or wrong catheterization. In a study [4], it was reported that the first attempt success rate in infants is about 45% and even fewer in the infant of an age less than 6 months. The situation can be even worse in an emergency department for children where a large number of children are admitted with chronic medical condition. Studies have revealed that on average, 2.18 venipuncture attempts are needed for a patient who needs IV medication [5]. It was reported that the first attempt failure rate can reach up to 12-26 % in adults and 24-54% in children [6].

Wrong catheterization results in some serious consequences like complex regional pain syndrome, infiltration and extravasation [7]. In the case of vein damage, medication can leak into the tissues, which could cause firm swelling, redness and could even be poisonous to tissues as in the case for most chemotherapy treatments. Surgical interventions are sometimes needed in cases of vein damage and medication delivered to surrounding tissues due to a wrong catheterization. Multiple numbers of IV catheterization attempts cause pain, trauma and emotional distress in patients, especially in children [8, 9]. A higher number of attempts also cause anxiety for the patients and to the parents in the case of a child. This results in a lack of confidence in medical procedures and the staffs performing them [10]. In order to minimize the risk of a wrong catheterization and to reduce the number of attempts, it is required to have some imaging mechanism to aid in subcutaneous vein localization.

In this review, attention has been given to the imaging techniques which are designed specifically and being used for subcutaneous veins localization. The devices like Computed Tomography (CT) scan, Positron emission tomography (PET) and Magnetic resonance imaging (MRI) are used for deep veins localization. These methods are expensive and are not suitable for customary subcutaneous veins localization for IV catheterization due to the high cost and large dimensions of the equipment. For the standard IV catheterization process, which is carried out in clinics and hospitals on a daily basis, it is required to localize the subcutaneous veins present in the third layer of skin, called hypodermis. The techniques to be used must be cost effective, light-weight,

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*Address correspondence to these authors at the Centre for Intelligent Signal and Imaging Research (CISIR), Department of Electrical and Electronics Engineering, Universiti Teknologi PETRONAS, Malaysia;
Tel: 03 85 73 10 77; Fax: 03 85 73 10 97;
E-mails: aamirsardar@gmail.com; naufal_saad@petronas.com.my

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portable and effective in terms of vein visualization. There are few techniques which have been found suitable for the said purpose; these are Transillumination, Photoacoustic, and NIR imaging. A detailed review of each of these techniques is presented in this paper.

2. TECHNIQUES

2.1. Transillumination Technique

It is a technique in which strong light is transmitted through skin tissues to visualize the venous structure inside the subcutaneous layer. A single or combination of wavelengths from the visible range of the electromagnetic spectrum is used to illuminate the targeted area of the skin. A portion of the incident light is absorbed by the tissue being illuminated; the remaining exhibits the phenomenon of scattering and transmission. Observations are made with the scattered or transmitted light. This technique is used in numerous noninvasive medical diagnosis processes like breast/ brain tumor detection and many internal organ monitoring procedures [11-13]. It can be used to visualize the subcutaneous veins in the process of IV catheterization. In most cases, the blood vessels absorb more light as compared to the surrounding tissues, hence appear darker than tissues.

The transillumination technique has been in place since the 1970s to visualize veins in patients especially in the pediatric units [14]. A fiber optic transillumination system was introduced for the physical examination of children and vein localization [15]. In this method, a high intensity light beam is made incident to the patient's body to illuminate the organs. In another paper [16], the use of transillumination for percutaneous arterial sampling was reported and a success rate of up to 96% was claimed. High intensity illumination through a fiber optic probe is applied and filtration is used to avoid heat buildup at the targeted area. In the performed experiment, 24 out of 25 selected arteries were reported to be visible, but 7 of these required 2 punctures failed while using transillumination. Failed attempts were reported in cases where patients were infants. These results are not different than the earlier mentioned statistics of multiple attempts due to PDVA.

A number of devices have been introduced since the 1970s to enhance the vein visibility but this technique has not gained a considerable acceptance due to a number of reasons. The most significant concern has been thermal burns on skin due to the high intensity of light used for the illumination. Light filtering methods have been used to reduce heat buildup in the skin during the vein localization process using transillumination [17]. This filtration process reduces the number of burn cases due to heat buildup during the procedure. However, few cases of blisters have been reported specially in new born babies [18]. Another method is to use a cold light source for illumination, which is reported in [19] where a 69% success rate was reported in a total of 107 babies.

Veinlite® (TransLite LLC) shown in (Fig. **1**), is a device which is designed for peripheral veins localization. It uses the side-transillumination method in which a bright ring is used to focus light in such a way that a virtual light source is formed below the skin. Light in the visible spectrum is used, typically red or orange, to illuminate the scene. In veins localization procedure, the ring is pressed against the skin to illuminate the targeted location. A few models of this device are readily available with a different number of LEDs and sizes of rings. Initially, it came with a light source connected with a fiber optic to the ring. It comes with disposable covers which are used to avoid infection when using it on different patients [20-22]. Due to the depth limitation in penetration of visible light, difficulties often result with patients having a darker skin tone, deeper veins due to high body fats and other physiological characteristics. Difficulty in usage has been observed since medical practitioners have to hold the device tight against the skin of the patient with one hand and insert the needle to the localized vein with the other hand, which may result in a wrong catheterization.

Fig. (1). Venlite®: (image taken from URL: http://enw.org/Review-Veinlite.htm, accessed date: 4-11-2013).

Venoscope® (Venoscope, Lafayette, LA), shown in (Fig. **2**), is a transillumination device similar to Veinlite and designed for veins localization. It has two arm shaped ends with three (two white and one red) LEDs in each. It is a battery operated and portable device. Different models come with small variations; these are Venoscope Special, VenoscopeII, and Neonatal Transilluminator. As in the case of Veinlite, the problem of different skin tones and deep veins cannot be solved by this device either [23 24].

Wee Sight® (Children's Medical Ventures, Monroeville, PA) and *Vein Locator*® (Sharn Inc., Tampa, FL) are two more examples of transillumination devices. These can also be used to localize the subcutaneous veins for the IV catheterization process.

Amongst the major drawbacks of transillumination devices, one is the need for the direct contact with the skin of patient, which may lead to the spread of viruses and bacteria from patient to patient. Hence, they require the costly process of cleaning after every use. Even if they come with disposable covers, it is less practical to change the covering each time. The illumination from the visible spectrum used in these devices may not be suitable for the veins localization process for patients having deeper veins due to a high amount of body fat.

It is due to limitation in the ability of the visible light to penetrate deeper into the skin tissues. Heat burns due to the high intensity of the light are reported in a few cases. These devices are cost effective, hence can be used in ordinary conditions, but for the intense situations like in emergency

Fig. (2). Venoscope® (image taken from http://www.cosmetic-vein-solutions.com/veintreatments.php, accessed date: 4-11-2013).

and pediatric departments, a much more effective technique is needed to visualize the veins in the patients of different physical characteristics and conditions.

2.2. Photoacoustic Technique

Photoacoustic imaging, termed Photoacoustic tomography (PAT) as well, is a hybrid technique which accounts for both optic and ultrasound systems. With non-ionizing optical illumination (short laser pulse of nanosecond scale), biological tissues are irradiated. These tissues absorb incident energy resulting in a temperature rise on the order of milli-Kelvin for a short period of time and expand. These thermo-elastic expansions and contractions (in the absence of incident energy), due to the temperature rise, produce acoustic waves from the tissue. The resulting acoustic radiation is detected with ultrasound detectors to form an image of the targeted organ in humans or animals. This Photoacoustic system incorporates the advantages of both optical and ultrasound imaging without adopting the major disadvantages from either [25]. In (Fig. **3**), the basic principle of this technique is shown. A laser is used as an illumination device and the acoustic waves are apprehended by the ultrasound detector.

The Photoacoustic (PA) phenomenon was first introduced by Alexander Graham Bell in 1880; when he has explained that acoustic waves can be generated from objects which are illuminated by light through some means [26]. However, due to the absence of ultrasonic transducers, lasers and computers at that time, the Photoacoustic technique has not been used as an imaging technique until the 1970s when Photoacoustic spectroscopy in the biomedical field was introduced in [27]. Nevertheless, the progress was slow until the last decade of the 20th century. The application of PA was widely found in biomedical field in 1990s when the effect of PA on biological tissues was elucidated [28-30].

Two medical imaging techniques combining light and ultrasound were explained in [31]. The first was optoacoustic imaging; in which, the tissues are made vibrate with light energy transmitted by a laser diode and a broad band acoustic signal is then detected using ultrasound to create an image. This technique incorporates high optical contrast since tissue contents exhibit strong contrast in the visible and NIR region. The second technique was the one in which a laser light is modulated with ultrasound to get a diffused optical tomography. In this technique, light is made incident to the region where an ultrasound transducer is focused. In this way, diffused light is modulated within the tissue and is collected at the receiver. Both of these techniques can be used to image the subcutaneous veins.

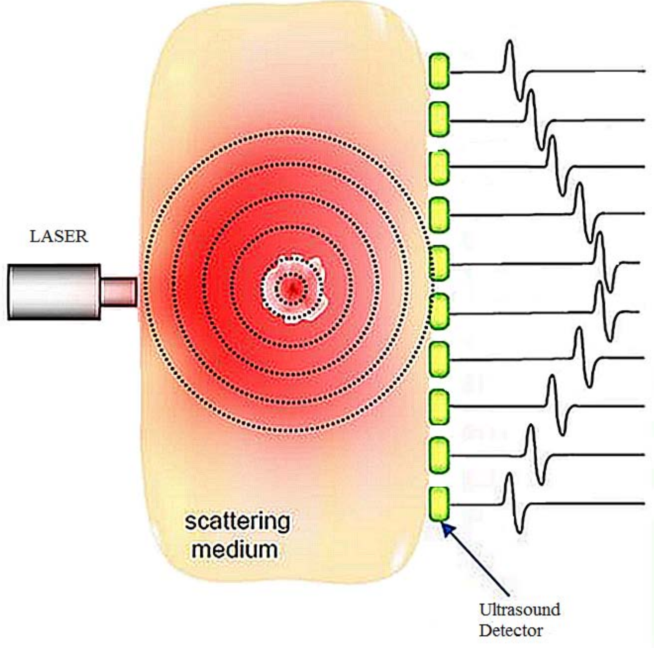

Fig. (3). Photoacoustic Imaging Phenomenon (image taken from: http://www.oldelft.nl/projects/hympact/item50, accessed date: 4-11-2013).

In later studies, the application of Photoacoustic imaging for human blood vessels has been reported. *In-vivo* Photoacoustic imaging for blood vessels is presented in literature [32]. A very narrow aperture sensor is used to acquire acoustic waves. A laser with a central wavelength of 1064 nm and pulse duration of 10 ns with a repetition rate of 10-Hz is used to irradiate the blood vessels. An ultrasound gel is needed to fill the gap between the skin and the acoustic sensor in order to avoid environmental noise. A real time reconstruction is carried out from 1-D depth profiles. Noise reduction is accomplished by using an average of 16 Photoacoustic time slices. (Fig. **4**) below depicts the resultant 2-D image of the blood vessels of the wrist region from this Photoacoustic system [32].

In 2005, another Photoacoustic vascular imaging system for small subcutaneous blood vessels was introduced [33]. A short laser pulse from the near-infrared range with a wavelength of 760nm is used to irradiate the blood vessel walls. Hemoglobin (Hg) present in the veins has high absorption spectra for this range of illumination. It absorbs the incident energy and as a result, the vessel walls exhibit thermo-elastic expansion. The high contrast images of the blood vessels from finger, arm and leg areas are obtained with a combination of ultrasound and optics. The technique uses light and ultrasound waves to obtain the real time high resolution image of the blood vessels. The images obtained from this technique provide information on depth and diameter but not

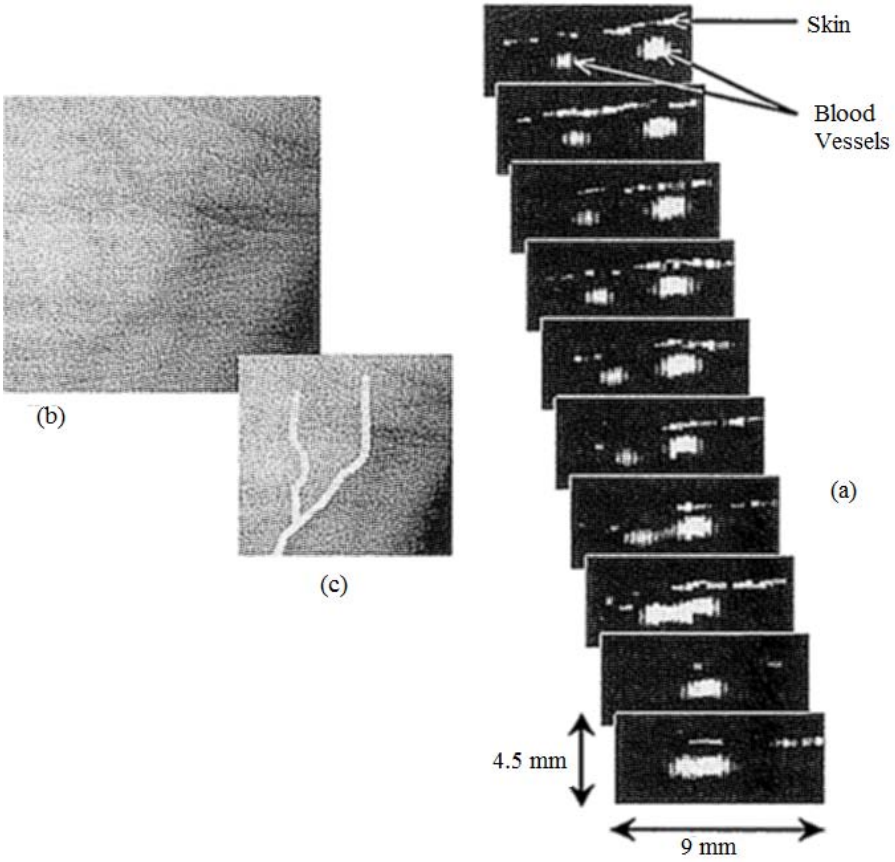

Fig. (4). a) Photoacoustic image, consisting of ten slices, 1-mm apart. Horizontal axis: Scan direction [mm]; Vertical axis: Depth [mm]. Each image consists of 61 measurement positions along a line, with a separation of 0.3 mm. At each measurement position, the Photoacoustic signals are averaged 16times. (**b**), (**c**) Photograph of measurement site; in (**c**) the course of the vessels is indicated with the white line. (Image taken from ref (32)).

about the position or shape of the longitudinal or the orientation. This technique is very sensitive to the echo signals produced from the blood vessels and tissues resulting in a significant reduction in the signal to noise ratio.

A US patent has been filed on a wearable Photoacoustic vascular imaging system [34] in 2010 which disclosed the method of vascular imaging with the use of a micro-display component. Similar to other Photoacoustic methods, the targeted location on the body is irradiated with optical illumination. Light from a laser source is made incident with the help of a cuff band which overlays the skin tissues and veins. Acoustic waves from the tissues and veins are collected and converted into the form of an image and sent to the wearable display with the help of an RF transmitter.

The Photoacoustic technique has several advantages over other imaging modalities. It is safe to be applied multiple times in a routine examination due to its non-ionizing property [35]. It incorporates higher optical resolution and higher spatial resolution of the ultrasonography. Nevertheless, in applications like vascular localization, it does not gain much attention due to the larger and more complex equipment needed. Operating procedures are difficult and costly, *e.g.*, ultrasonic gel is needed to acquire the ultrasonic signal, otherwise environmental noise will be added to the signal. The spread of an echo signal may occur which results in a low signal to noise ratio. In general, the Photoacoustic technique has many applications in the biomedical field, but for the simple task of subcutaneous veins localization it is not suitable due to its complex equipment. The portability of systems is another issue which is needed to be considered for daily clinical practices. A detailed survey on the application of Photoacoustic in the field of biomedicine can be found in literature [36].

2.3. Near Infrared (NIR) Imaging

NIR Imaging systems work on the principle of light propagation, *i.e.*, absorption, reflection and scattering in the tissues. It has vast applications in the field of biomedical imaging, and has several advantages over the other radiological methods used for medical spectroscopy. The radiations are non-ionizing, therefore, they can be applied several times on patients without any harmful effects to the subject on whom it is applied [37]. It is cost effective; hence, systems using this technique can be used in the majority of hospitals and clinics. Through optical methods, skin tissues can be differentiated from veins based on their respective reflection, absorption and scattering coefficients. The non-invasive capability of this technique leads to its wide acceptance in the field of biomedical applications. The main absorbers of human skin tissues, *i.e.*, water (H_2O), oxygenated hemoglobin (HbO_2), and de-oxygenated hemoglobin (Hb), have low absorption spectra in the range of around 740 nm to 940 nm

[38 39]. Melanin and fat absorb less radiation as compared to the previous three (H_2O,HbO_2 and Hb); hence, these have less impact on the light transported inside tissue. The region where the absorption spectra of the main absorbers of tissues are lowest is called the low absorption window or just, NIR window, which is depicted in (Fig. **5**) and highlighted with green arrows. In this low absorption window, light can penetrate deeper (up to 5mm) inside the skin tissues; hence, this window can be utilized for imaging the tissues and organs which lie closer to the upper layer of skin. Subcutaneous veins lie in the third layer of skin, hypodermis, at an average depth of 2-4 mm depending on the physical characteristics of a person and the location of skin analysed on the body. Persons having a high amount of body fat are more likely to have deeper veins. The vein depth is also dependent on the location on the human body; for example, the skin on the human back is much thicker as compared to the skin on the forearm.

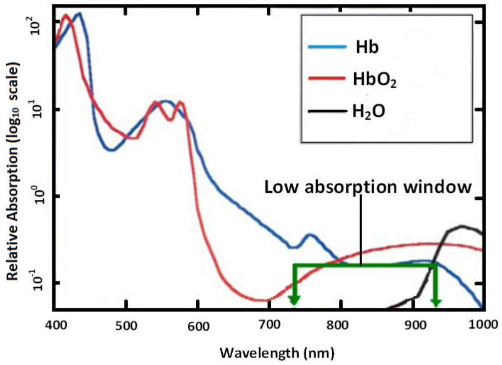

Fig. (5). Absorption factors of primary absorbers: Hemoglobin, Oxygenated Hemoglobin and Water [37]. Green arrows highlight the low absorption window.

NIR imaging has been used for brain imaging [37, 40, 41], the optical mammography for tumor detection [42-45], skin cancer detection [46, 47], measuring water /moisture content in skin [48] and optical detection of diabetes [49, 50]. A review on hand-held NIR imaging devices for the field of medicine has been presented in [51]. Several hand-held devices which provide maximum comfort and ease in the procedure were compared. These devices are mostly used in breast tissue imaging and brain imaging. The techniques used in these hand-held devices are continuous wave (CW), frequency-domain photon migration (FDPM) or time domain photon migration (TDPM). CW and FDPM are the two main techniques used in these devices; where, FDPM has an added advantage of measuring amplitude and phase information providing good contrast and depth information. Measurements can be effected due to the motion of the operator or the subject whilst using these devices. The depth limitation of the reflectance-based measurement has been observed in comparison to the transillumination-based measurement [52].

The application of NIR imaging to localize the human vascular structure in humans is relatively new. The early traces of literature on the use of NIR imaging for vascular structure can be found in the 1990s [53, 54]. Veins appear darker due to the high absorption coefficient of Hb in the NIR range as compared to skin tissues. Hence, the skin tissues can be easily separated from the veins in the NIR image. In visible light, the color of the veins appears blue despite the fact that the color of blood inside veins is red or dark red. This phenomenon was explained experimentally in [55], using tissue phantoms containing a model of blood vessels. It was reported that the color of blood vessels depend on the highly turbid medium (skin tissues) around the vessels. Light from the blue spectral region cannot penetrate as deep as light from the red spectral region. Although the absorption coefficient of Hb is much higher in this region, the reflectance of blue light is not affected due to the presence of the deeper veins. Furthermore, the absorption of the red spectral region is more likely to happen in the vessel region. Hence, veins appear blue in the visible spectrum.

A NIR imaging system for subcutaneous vein localization has been reported in [56]. Three different modes of illumination were used and the results were compared. They were the normal reflectance mode, reflectance-transillumination mode and local illumination with higher irradiation. In the first mode, the head mounted bar with LEDs of a central wavelength of 880nm was used; whilst, the second mode used the dual illumination approach. The illumination from the first mode and the light from an optical-coupled halogen lamp with the help of fiber optics were used. In the third mode, a parabolic orientated LED bar was used which contained high powered LEDs with a central wavelength of 875 nm. The local illumination with higher irradiation and spatial filtering provided relatively good contrast as compared to the other two modes of illumination. It was claimed that the veins with smaller diameters to the minimum of 0.2 mm can be visualized within a 0.5-1 mm depth and veins with relatively larger diameters, *i.e.*, 1-2 mm, can be localized up to a 3-4 mm depth.

VeinViewer® (Christy Medical Corporation, Memphis, TN, USA), previously known as Vein contrast enhancer (VCE), is a device which works on the principle of NIR imaging. It illuminates the subject's skin with the NIR illumination, captures the image using an NIR camera and projects back the enhanced image of the subcutaneous veins to the skin using a green light [57-60]. The idea was first patented by Zemen in [61]. It has been claimed that veins of a depth up to 8 mm can be localized and projected back to the skin with a marginal error of 0.06mm to their exact position. It has been reported in [62] that the diameter of the smallest vein detected was 0.2mm and the largest was 5.08mm. A negative correlation was found between the vein depth and the contrast, *i.e.*, for deeper veins a decrease in the contrast was observed. The illumination of 740 nm wavelength was used in previous models. Currently in the latest models, the range of the peak wavelength used is 840nm to 860nm. (Fig. **6**) depicts the Vein Viewer device readily available in the US and some European markets. Recently, a hand-held model, VeinViewer Flex, has been introduced to increase the portability of the device.

Different clinical trials of the Vein Viewer device have reported the decrease in time (45-second decrease on average) and the number of attempts required for peripheral intravenous access in children [63, 64]. In a recent study on the effectiveness of three Near Infrared devices including the Vein Viewer, it was concluded that the visibility of veins can be enhanced with these devices but the catheterization process cannot be improved [65]. We assume this conclusion was made because of the availability of highly trained nurses

Fig. (6). Vein Viewer Vision (images taken from http://www.christiedigital.com/enus/medical/products, and http://www.amarillovein.com/ Sclerotherapy.php accessed date: 12-11-2013).

who were specialized for the IV catheterization in the pediatric department. However, the availability of highly trained staff in every hospital is unlikely; hence, the conclusion of this study is not valid for all circumstances.

A system for hand veins detection based on the embedded System on a programmable chip (SOPC) has been proposed in [66]. A unique NIR illumination source was designed to ensure the uniformity of the illumination on the targeted dorsal hand. A CMOS imaging sensor is used to capture the image which is preprocessed for the recognition system. Another study revealed a cost effective device for the detection of veins using NIR imaging [67]. It was claimed that the device can be used in forensics, human recognition or in medical applications. The targeted site is illuminated by a single wavelength NIR illumination, the image is captured by a CCD camera and after a few image processing steps, the hand vein pattern is detected.

Two different illumination sources are used in the hand veins pattern detection system given in [68]. There are two infrared LED arrays on the frontal side and one at the back side of the hand to provide penetrating manner of the light for higher contrast. A simple CCD camera was used to capture an image with an NIR filter to filter out the visible light. A new algorithm for vascular detection was proposed and it was proclaimed to be able to detect thin veins.

Two methods to acquire hand vein patterns, reflection and transmission, are discussed in [69]. In the reflection method, the imaging sensor and illumination are on the same side; whilst in the transmission method both are on the opposite sides of the palm. Experimental results were compared to conclude that the reflection method is better for the biometric system as it provides the flexibility of a smaller size and is easy to use hardware. Further, it was observed that the 760nm wavelength produced good results in the reflection method whilst using an optical filter on the camera to block the visible spectra. The transmission method produces better results than using an 850nm filter, but the usage is limited to the blood vessel detection of the human body parts where light can be transmitted through them.

In [70], two methods, far-infrared (FIR) and NIR, were compared for hand vein pattern detection. For the FIR imaging, the thermal camera with a sensitivity of 800 – 1400 nm was used. Images in both indoor and outdoor environments were taken. It was reported that the contrast between skin tissues and veins is very low, due to the similar temperature of the tissues near veins. Hence, the separation of veins from the surrounding tissues becomes problematic since both have a similar grey level intensity. For NIR imaging, the illumination wavelength of 850nm was used with a CCD infrared camera. In comparison with FIR, the NIR imaging captured the images of relatively smaller veins with high contrast. It is concluded that the NIR imaging provides good results while capturing vein patterns in the palm, wrist and back of the hand area. Further, the change in the environment and the body condition has very less impact on the NIR imaging as compared to the FIR imaging.

With the aim for automatic catheterization using NIR imaging, a system for subcutaneous veins localization is presented in [71]. The structured light ranging and optical triangulation method was used to construct a 3D point cloud representing the surface of the skin. The NIR illumination with seven different wavelengths was used to get the vein pattern with good contrast. The veins are detected after the process of illumination correction and gray scale simplification. The best vein is chosen on the basis of longitudinal orientation, having the maximum length. In the study of the optimum illuminants for the vein structure detection [72], a combination of illuminants were tested on different subjects having different physiological characteristics. The hypothesis was made that different wavelengths in the NIR range can be combined to improve the contrast between veins and skin tissues. However, no general conclusion was made about the acquisition parameters for the different skin tones of the subjects. A 3D multispectral light propagation model based on MCML (Monte Carlo Multi-Layer) with addition of different physiological factors like fat, melanin concentration and layer thickness was presented in [73]. Veins with different depths were included in a three layer skin model and the results were compared with the current layered model for light propagation in tissues. The results found were claimed

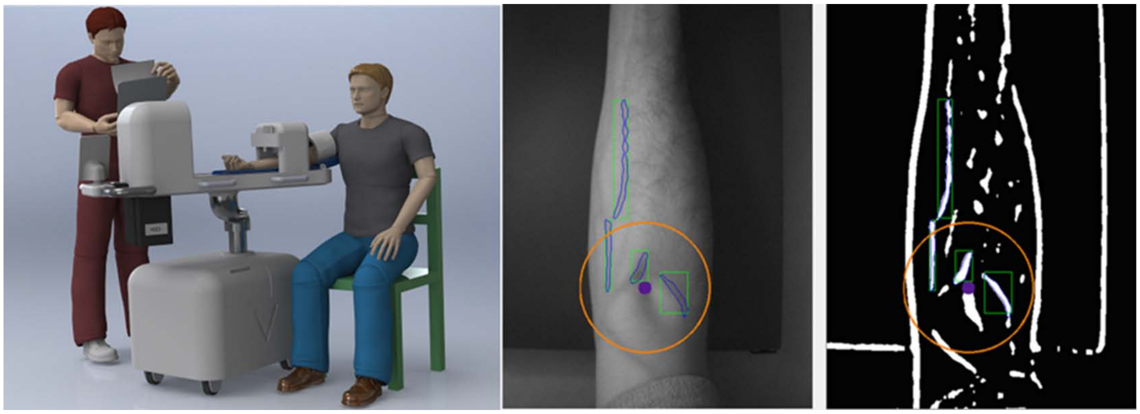

Fig. (7). Veebot, a robotic phlebotomist, the hardware and illustrated output. (Images taken from http://www.veebot.com/solutions.html, and http://www.sciencespacerobots.com: accessed date: 15-11-2013).

to be consistent with MCML whilst presenting a better model for the layered medium with a vascular structure. A multispectral analysis was presented for the optimum illumination selection in order to get better contrast for all types of skin tone [74]. A multispectral camera with a sensitivity range from the visible to NIR region has been used to capture the images in the range of 380 to 1055nm. Volunteers were divided into four different classes based on their skin tone [75], and the reflectance contrast was measured. It was proposed that the pre-selection of illuminants dependent on the skin tone of a subject will produce better vein-skin contrast.

An automatic venipuncture system named "Veebot" was developed in 2012 by a group of researchers from Stanford, shown in (Fig. **7**). Using the NIR illumination and image processing techniques, it detects the veins in the subject. Ultrasound technology is used to confirm the flow of blood in the targeted vein. The needle is inserted into the selected vein with a robotic arm. The accuracy of this system is claimed to be 83%, which is closer to a human phlebotomist [76]. The idea was to replace human staff with robotic phlebotomists, but medical staff is supposed to do the cleaning, disinfecting process and loading of the catheter to robotic arm after every use. This system is currently in development stages and will be tested and reviewed when available in market.

3. CONCLUSION

A review of three main techniques which can be used for subcutaneous vein localization has been presented in this paper. These have different advantages and disadvantages based on parameters like effectiveness, cost, portability and usage. Transillumination is cost effective and can be made portable but is less effective in PDVA situations especially in cases of deeper veins and darker skin tones. The Photoacoustic technique is effective and produces much promising results, but the cost and portability issues limit the usage of this technique in the veins localization process. Furthermore, sensitivity to environmental noise is a major drawback of this technique. NIR imaging is the most suitable technique for the process of subcutaneous veins localization. It is cost effective, can be made portable and is easy to use during routine medical practices. It is effective and can be applied in the majority of situations where veins localization in patients becomes problematic. Research is being carried out to optimize the NIR illumination in order to get good contrast for every skin type with a lesser amount of power and space used for the illumination system.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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