INFRARED VEINVIEWER
Ravi Varma N.*1, Sandip D. Sahane*2, Sachin S. Thakre*3
*1(Asst.Professor of Dr.Bhausaheb Nandurkar college of Engineering & Technology, Yavatmal, India) *2(BE Student, Dr.Bhausaheb Nandurkar college of Engineering & Technology, Yavatmal, India) *3(BE Student, Dr.Bhausaheb Nandurkar college of Engineering & Technology, Yavatmal, India) ravi.n.varma@gmail.com*1, sahanesandip7@gmail.com*2, sachinthakare1991@gmail.com*3

Abstract
Now a day it is very difficult to administer the medication or the fluid which is necessary for the treatment, and difficult to draw the blood and also to access the veins in patients at hospitals for the nurses and the doctors. It is very important to reduce the problem of locating the vein and minimize the time require for locating it. However, problems involved in accessing veins in pediatric and obese patients make it very difficult to perform a successful stick in a short time. The VeinViewer Imaging System is an infrared imaging device that provides the nurses and doctors a means for locating veins in the very first attempt and within a few seconds. A camera captures an image of the veins illuminated by infrared light and a contrast-enhanced image of the veins is projected back on to the patient’s skin in real-time using a projector, after being processed by the processing unit in the computer. The image obtain is a real time image. Each vein in the Vein Viewer image appears with different contrast against the background skin and hence can easily be differentiated.

Keyword:
Pediatric, Intravenous Vein, Infrared Light, Reflection, Absorption.

1. INTRODUCTION
While technology is constantly advancing, sometimes the medical imaging devices created can be too complicated to be useful to a significant number of people. The Veinviewer is a break through medical imaging device that is easy to use and is quickly becoming an indispensable tool for all health care professionals who perform venipuncture procedures.

Veinviewer technology started up in Cold Spring Harbor, NY in 2007 and invented a tool that literally illuminates veins. Small and portable the Veinviewer is a medical imaging device that allows you to quickly find a patient’s vein without undue hassle or trauma to the patient. This can be particularly helpful for those patients with difficult venous access (DVA). By simply holding the Veinviewer about seven inches above the skin, the vasculature is clearly displayed on the surface of the skin. Medical imaging device technology has finally provided a tool that can save valuable time for nurses and patients. Veinviewer is based on a simple concept, Human blood absorbs infrared light and visualize the veins.

2. VARIOUS METHODOLOGIES FOR VIEWING VEINS
According to a recent study, it has been estimated that there are nearly 500 million veinpunctures done every year. Other studies have shown that 95.2-97.3 percent of them are successful in the first attempt which indicates that it is difficult to find veins in around 14 million cases on the first try. Also, 15,000 patients per day are subject to 4 or more attempts to draw blood or other fluids from the vein causing them to experience a lot of discomfort and pain. Finding veins for intravenous access through peripheral, central, especially obese patients and those who have had multiple
intravenous drug injections is often found to be difficult by physicians. As many of these cases are not performed in an emergency setting, establishing vein access in a short time is not crucial, but the patient’s comfort takes priority and avoiding multiple needle sticks is essential. In Phlebology centers, the surgeons rely on an ultrasound machine for guidance on locating and mapping the abnormal vein to treat disorders. Factors like obesity and small sized veins pose a challenge to them since the veins are not palatable or visible. Several devices have been developed recently to aid physicians, phlebotomists and surgeons in finding veins to avoid unnecessary sticks. A few such devices work by transilluminating the patient’s skin using bright LEDs to show peripheral veins for access. These devices are very compact and cause no damage to the patient’s skin but require the lights to be turned off for the physician to view the veins clearly. Markers have to be used on the patient’s skin after identification of the vein for later access. High-resolution ultrasound scanners provide good quality images of the superficial and deep veins in obese patients and small veins in pediatric patients in real-time. A few ultrasound scanners provide the physicians with needle guidance tools for sticks such that they can also view the depth at which the needle is being inserted. However, the transducer has to be held in place during needle insertion, which makes it uncomfortable for accurate sticks. Also, the person performing the stick has to view the vein on the ultrasound display. Veinography provides an image of the veins after the patient is injected with a contrast dye. This x-ray image can be used for mapping veins in the body before surgery or treatment. Veinography offers a wide field of view and is used for identifying and treating numerous disorders, but necessitates the injection of a dye and, hence vein access must already be established. There is also a significant amount of radiation associated with the procedure.

2. How Vein Location Viewer Work?

Veinviewer projects an image much like a picture on a movie screen, but Veinviewer does this in real time making the patient’s skin the “screen”. Projected near-infrared light is absorbed by blood and reflected by surrounding tissue. We capture that information, process it, and project a digital real-time image of the patient’s blood pattern directly on the surface of the skin. This patented technology, using AVIN (Active Vascular Imaging Navigation), allows you to see through the skin up to 10mm deep viewing veins, bifurcations, valves, real-time refill/flushing of vessels and complications such as hematomas from an accidental puncture improving the total vascular access procedure, not just the needle stick.

3. Interaction of Light with Tissue

3.1 Skin Anatomy

The largest organ of the body is the skin, which is multilayered with its three main layers being epidermis, dermis and the subcutaneous layer, also called the hypodermis. Fig. 3.1 shows the cross-section of skin. The epidermis is the outermost layer and does not contain any blood vessels. It allows light to pass through it owing to its presence in the superficial section of skin. The middle layer known as the dermis contains capillaries, glands and hair follicles. Diffusion takes place between the dermis and epidermis to provide nutrient supply. The hypodermis lying above the muscle and bone is the lowermost layer in the skin consisting of fat cells, veins, arteries and nerves.
The amount of subcutaneous fat in this layer determines the penetration of light into tissue beneath it. Children possess skin of lesser thickness as compared to adults. The depth of epidermis ranges from 0.027 – 0.15mm and that of dermis ranges from 0.6 – 3mm. The hypodermal thickness can be between 0 – 3mm with the maximum in the abdomen.

3.2 Skin Optics:

Studying the phenomena of light transport in tissue will give a better understanding of the working of the Veinviewer system. Fig3.2 (a) depicts the scattering of light in human tissue. The light beam that is incident on the skin undergoes absorption, scattering and reflection by the various layers of tissue at different depths. The characteristics of light propagation differ with respect to each layer in the skin. The reflection of light from the skin surface is called specular reflection. Light that is specularly reflected does not permit light to propagate through internal tissue and can thus add glare to a vein image. A three-compartment model of skin is considered which consists of epidermis, dermis and subcutaneous layer. The epidermal layer absorbs some light and transmits light into the tissue layers beneath it after scattering. A lot of scattering occurs in the dermis before it propagates to the hypodermal layer while a part of the light is absorbed. Fat scatters a major portion of light and absorbs very little. Some of the light reaching blood in the vessels is absorbed by the hemoglobin present in it, while some is scattered mostly in the forward direction due to the large size of the red blood cells. It has been reported that the blood in the veins is dominated by deoxy-hemoglobin with the oxy-hemoglobin content concentration around 47% while that in the arteries contains more oxy-hemoglobin (90%-95%). Both types of hemoglobin possess different light absorption properties as shown in Fig2.2 (a) both types exhibit almost the same absorption characteristics till the wavelength of 600nm. It can be understood that the absorption of light by veins is higher than that by arteries between the wavelengths of 600nm-800nm. The curve falls rapidly for the deoxy-hemoglobin while it rises a little and then falls for the oxyhaemoglobin.

Light at different wavelengths reaches different depths when it travels through tissue as seen in Fig 3.2(a). The bars in Fig 3.2(b) indicate the extent of transmission of light in all layers of the skin at various wavelengths. Visible light wavelengths range from 400nm-700nm while infrared wavelengths range from 700nm – 106 nm. Light at wavelengths between 300nm and 400nm reach only the epidermal and dermal sections of the skin which do not contain any veins. Light at near-infrared wavelengths (700 – 1000nm) is less absorbed by other tissue and reaches the blood vessels in the subcutaneous tissue. The VV
utilizes this phenomenon to view veins which cannot be visualized in visible light. The principle of working of the Veinviewer system is based on tissue-light interaction in the body that has already been discussed above. Details of the device instrumentation and performance are given in the next chapter. The clinical utility of the Veinviewer system determined from prior studies on pediatric subjects is also discussed.

4. WORKING AND MECHANISM OF VEIN VIEWER

4.1 Block diagram:

Veinviewer is newer prototype and commercial system have been renamed the Vein Viewer. Fig 4.1 shows the schematic of the principle Vein Contrast Enhancer.

4.1.1 Camera

The camera used for the VCE was a Sentech STC-1000 CCD camera and the commercial LCD projector was an Infocus LP290 model. The camera was mounted on two goniometers for rotation in two directions. The hot mirror in front of the camera reflects infrared light hence, allows it to fall on the skin and also reflects the light emitted from the subject’s skin back to the camera for it to capture the images.

4.1.2 Projector

The hot mirror is transparent to visible light and transmits the light from the projector to the patient’s skin. The hot mirror was aligned so that it made a 45° angle with the optical axis of the camera for it to reflect infrared light and allow visible light from the projector to be transmitted. One hundred circularly arranged Light Emitting Diodes (LEDs) with a wavelength of 740nm were used to illuminate the skin. These were the ELD-740-524 model and were equally spaced. Infrared light emitted from these LEDs was diffused using two LSD20PC10-F10X10/PSA diffusers from Physical Optics Corporation since experimental studies proved that a diffused light source offers better enhancement of veins by providing even illumination. This light shaping diffuser offers good transmission efficiency with uniform emission. Two polarizers of the same kind were used; one in front of the LEDs for linear polarization while another was used in front of the camera lens at right angle to the first to eliminate glare in the image by cross-polarization. The colour of light for projecting the images back onto the skin was green in order to eliminate any interference with the infrared light used to illuminate and image veins. The veins appear dark on a green backdrop. The entire set-up was mechanically aligned for precision.

4.1.3 Processing unit
The processing unit contained a computer with a 12-bit video capture card that could capture the progressive scan analog video data from the camera. The images were processed using the computer’s Pentium IV processor to improve the contrast of the veins using the method of adaptive unsharp masking edge enhancement. Adaptive edge enhancement provided for an increase in the level of contrast near to image saturation at all places on the image, greatly improving the contrast offered by the original camera image.

5. RECENT MODIFICATION IN VEINVIEWER

The first generation vein viewer has some limitations such as it has large size, stationary and fixed on a place. The power consumption is more in first generation Veinviewer to overcome this limitation new portable device comes in existence named as Accuvein300 (AV300).

5.1 Accuvein AV300

The Accuvein AV300 device (Accuvein LLC, New York) was initially developed as an aid to venipuncture. It is a portable, handheld device that emits infrared light which is absorbed by haemoglobin, illuminating the position of superficial veins. In this article, we describe a novel application of this device in providing a map of superficial veins to aid vein graft harvest and other plastic surgery procedures.

This device is ideally suited to providing a map of the superficial veins to aid vein graft harvest and other plastic surgery procedures. Vein grafts are frequently used in microsurgical anastomoses to bridge vascular defects and to form vein conduits for nerve regeneration. For digital replantation, vein grafts are usually harvested from the volar forearm because of their size match, whilst larger vessels in the arm or leg may be harvested for major replantations of the hand or forearm. Accuven allows more accurate placement of incisions for vein graft harvest and reduces operative time by allowing more focused dissection.

This technique is particularly useful in dark skinned, obese and elderly patients in whom it is often difficult to identify a suitable vein. Another application may be the identification of superficial veins for free flap salvage.

5.2 Accuvein AV400:

The Accuvein AV400 displays a map of the vasculature on the surface of the skin allowing clinicians to verify patency and avoid valves or bifurcations. More effective venipuncture procedures with less patient discomfort result in higher patient satisfaction, making it clear why many facilities have chosen to incorporate Accuvein into their standard of care. In addition to the Accuvein vein illumination device, the following components are included in the vein viewing system:

- Battery (already installed)
- Charging cradle,
- Universal power supply, and
- Multinational adapters

5.3 Limitation of Accuvein:

In obese patients, the existence of substantial deposits of subcutaneous fat makes it difficult to
locate veins either by touch or vision. Also, the adipose tissue often tends to take the appearance of a vein leading to unsuccessful draws in the area. These misplaced sticks can be avoided if the nurse or phlebotomist is trained to be able to differentiate between adipose tissue and veins. Geriatric patients have veins which can collapse easily due to loss of their elasticity while paediatric patients possess veins that are taut but fragile and very small in size.

6. APPLICATIONS OF VEIN VIEWER

- Suited to providing a map of the superficial veins to aid vein graft harvest.
- Used for plastic surgery procedure.
- Used in microsurgical anastomoses to bridge vascular defects and to form vein conduits for nerve regeneration.
- Useful in dark skinned, obese and elderly patients in whom it is often difficult to identify a suitable vein.
- Provides a detailed map of the superficial veins following tourniquet application.
- Essential for venipuncture as a stethoscope is for examining the heart and lungs.
- It can be used to find valves and bifurcations.

7. CONCLUSION

For the ‘easy’ patients, there is no need of the device because the veins are easy to see or to feel. Even if the device can ‘illuminate’ the subcutaneous veins, the ones located deeper in the skin remain invisible to the device. But, from time to time, we cannot feel the veins and the patient has to be pricked two, three or even four times (by a different staff member). This is the situation when the device helped us to quickly locate the difficult veins and avoid the often painful trials.

8. REFERENCES