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Non-Invasive Vein Detection using Infra-red Rays

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Abstract: Vein identification is one of the most recent research topics in biomedical examination. Intravenous catheterization is most essential process in therapeutic medication in which practitioners find the appropriate vein for the process of with draw the sample of blood and injecting the medicine. Medical practitioners find difficulty to locate the vein, because of various physiological qualities, like skin tone, age, scars and burns. Therefore, improper location of veins, causes wounds, rashes, blood clot etc. To overcome this difficulty of vein detection we propose a new technique in this paper which consists of a ring of Near Infra-red (NIR) Light emitting diodes and a camera to capture the image of the vein structure. The image is captured by camera is processed using Visual studio with Open Computer Vision (Open CV). The processing of image is based on enhancement of image, segmentation of image and overlay method. This complete procedure helps the doctors in detecting the suitable veins for vein puncture.

Keywords: NIR, Open CV, Vein puncture, Histogram equalization, Adaptive Thresholding.

I. INTRODUCTION

The innovative research made in the field of biomedical imaging is yielding good outcomes but have high cost. In infrared imaging, strategies of imaging in diverse regions are used to carry out critical amount of work. The utilization of infrared imaging procedure is a moderately less investigated territory however guarantees to convey top of the line results at low improvement costs [1]. There are two infra-red imaging, Far Infra-Red (FIR) imaging ranges from 8-14μm which captures large veins but do not provide stable image quality. Near Infra-Red (NIR) imaging ranges from 700-1000nm, it provides good image quality. The major issue confronted by the doctors in hospitals is trouble to locate the veins for intra-venous medication and different purposes. The veins which are used for drug delivery of the forearm are cephalic vein, basilic vein and medial vein. Delay in medical treatments is noted if the location of veins is improper. It is pertinent on account of children, adult, obese and dark toned patients. Pointless vein puncturing will be carried out by the practitioners because of the invisibility of veins, which results in swelling, darkening of skin, irritation and bleeding in patients and mostly to aged and children. A lot of work has been carried on vein detection and equipment like Accuvien Vein Veiwer® has been developed, but the significant problem is they are very expensive.

A. Need For Vein Detection

Patients treated by doctors in emergency situations like trauma patients, time is precious. It is difficult to detect the veins and inject lifesaving drugs due to burns and other physical injuries. In these cases a device is required to locate the vein location. This device helps to get the location of vein during blood transfusion, blood withdrawal, blood donation, etc. Mostly medical professionals find difficulty in detecting veins in obese people. In different therapeutic circumstances, the precise area of veins should be distinguished. The circumstances where vein imaging is required are:

- Intravenous infusions: They are utilized for giving medications to the patients, by medical experts.
- Bruises and Burns: During Deep Vein Thrombosis and Varicose Veins bruises show up on the skin, subsequently recognition of veins is very essential. Accidents which causes burns leaves scars on the skin. Skin appear to be whiter or darker or their appearance get deterred. Hence to locate the veins in such cases is tough.
- Blood transfusions: It is defined as process of transferring blood intravenously to a person. The process which require vein identification are blood donation and Dialysis.
- Among children: Finding veins in children and new born child might be troublesome and puncturing them many times with a needle is extremely unpleasant for the child.
- Geriatrics: Numerous aged individuals regularly require various blood tests or infusions and an effective method for puncture would lessen unreasonable bruise and upgrade the patient comfort level.

In this paper an approach is proposed to detect the veins using infra-red rays using camera. A ring of infra-red LED is used for illumination of light on the forearm and the

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image is captured by camera. The image is processed using Open CV with visual studio software using C++.

B. Near Infra-Red Imaging
Human eyes are sensitive to light that occupies a very narrow band (400 - 700nm) in the entire electromagnetic spectrum [2]. NIR has a longer wavelength (700-upto 3000nm) compared to visible light. Hence NIR is invisible to human eye.

The special characteristics for vein detection using Near-Infrared imaging are:

- NIR penetrates to a depth of 3mm into the human tissue [1].
- The deoxy-hemoglobin present in veins absorbs infrared radiation than the neighboring tissue.

Infra-red light is illuminated to the desired body part with the wavelength of 700-900nm as shown in Fig. 1, where light in optical window passes deep into tissues. The image of vein is caught by the camera. In the captured picture, the veins seem darker because they have absorbed the infra-red light. Hence to detect veins infra-red light is used.

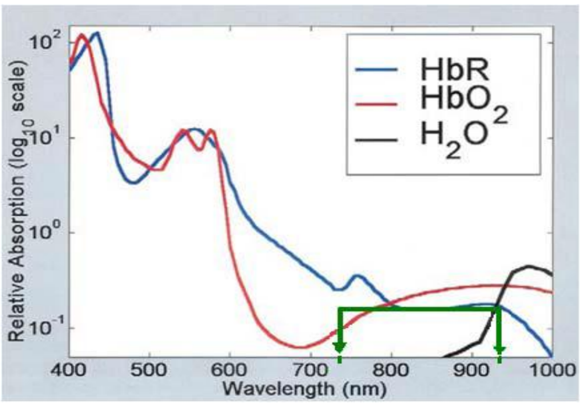


Fig. 1: Absorption factors of primary absorbers:

Haemoglobin, Oxygenated Haemoglobin and Water [1]. Green arrows highlight the low absorption window.

II. OVERVIEW OF SYSTEM DESIGN

The acquisition system is composed of VGA camera and NIR ring of LED for illuminating the light on the desired body part as shown in Figure 2a & 2b. VGA camera has a resolution of 0.3MP and 640 wide and 480 size height. There are 48 IR LED mounted in the form of concentric rings and it has wavelength of 850nm. The ring of NIR LED along with the camera are interfaced with the laptop using USB cable. CMOS sensor is used which converts the infra-red light projected back into information that results into image. The incident light falls on the lens which is converted into electrons. The electrons are transferred in the form of signal. The signal is amplified and fed into camera which gives results in the form of image. The image capture by the camera is processed and the veins detected are displayed on the computer screen.

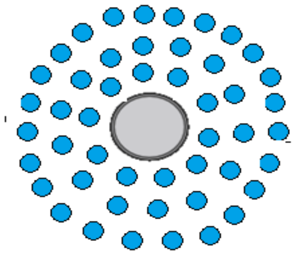


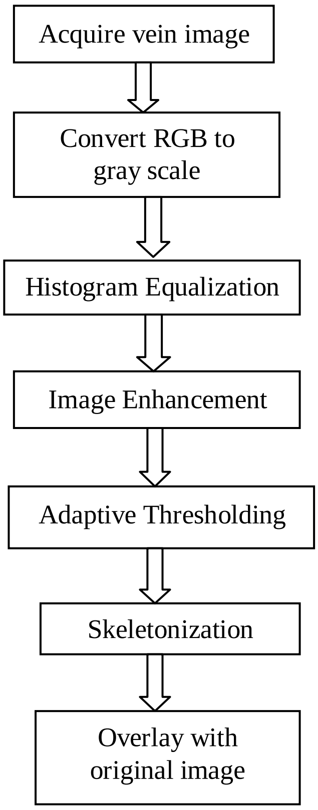
Fig. 2a: Concentric Rings of NIR LED

Fig 2b LED Ring with VGA camera

Visual studio using C++ with Open CV is used as software for processing the image. It is open source software which has many library files for medical image processing, user interface and Camera calibration; hence it becomes user friendly and cost effective.

III. ALGORITHM

The captured image obtained from VGA Camera is processed using the following Algorithm.



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A. Image Acquisition

The camera captures the image of vein. The vein imaging is done in real-time in the form of video and the veins are visible darker than the background image. The captured image appears as shown in Figure 3. The required vein image is captured in the form of frame which gives a still image for processing of image. The image acquired is a 24-bit image.

Fig 3. Vein Image Acquired by the Proposed System

B. Conversion from RGB to Gray scale Image

This operation converts the colour image into gray scale image. There are three colours present red, green and blue. The green channel gives better view of vein image. Since the green channel increases the brightness in veins and lower in the background. This is an 8-bit image.

Fig 4. Gray scale image

C. Histogram Equalization

The image of gray scale is blurred using Gaussian blur. This is used to reduce the noise present in the image. Histogram equalization is performed on the output of Gaussian blurred image. The output of this image is not distributed equally along the pixel intensities. Hence histogram equalization is used to distribute equally along the range of intensities. Histogram equalization on the image is performed by calculating each value in the histogram with total number of pixels in the image. It is used to enhance the contrast of the image. It distributes all the pixels equally from 0 to 255. Hence veins appear darker than the background.

$$p_i = \frac{\text{number of pixel with intensity i}}{\text{total number of pixels}}$$

i = ranges from 0 to L-1

Fig 5. Histogram Equalized image

D. Image enhancement

The goal in image enhancement to enhance the veins clearly for display. The first step is to remove the noise in equalized image using the technique of median filter. A window is moved along the image and pixel value is replaced by the median of the neighborhood values.

$$y(m,n) = \text{median}\{x(i,j), [i,j] \in p\}$$

Where ‘p’ represents a neighborhood pixel, centered around [m,n] location in the image.

Dilation is performed on the image. It helps to remove noise and enhance the image. The veins can be seen clearly. In this process the image is convolved with structuring element and it is seen that the dark region is enclosed by bright region. Hence the width of veins size is reduced to enhance the image.

Fig 6 Image Enhancement

E. Adaptive Thresholding

Thresholding is used to segment the veins from the background image. A threshold value for the pixel is set which separate the background value from foreground value. In the process of adaptive thresholding, the image is divided into sub-images. The sub-images must contain both the vein and background image. The output of thresholding gives a binary image. It segments an image by settling all pixel values above threshold value to a foreground image and all the remaining pixels to background value. Here local adaptive thresholding is

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used. In which it finds threshold value for each pixel in an image is found based on neighbourhood pixel value of the histogram.

There is noise obtained in the image. Hence morphological close operation is performed to remove noise. This helps to remove the background noise present in the image and segment the veins. It removes the dark regions in the background. It removes small objects present in the background.


Fig 7a. Segmentation


Fig 7b. After removal noise

F. Skeletonization
It is a process to reduce to all lines to a single pixel thickness. Here we detect the medial axis of vein. After detecting the medial axis of vein, region growing is applied to remove the background noise. It mainly deals with pixel-based segmentation. The seed point and threshold is selected. The region to be segmented must be within threshold. Hence the veins are segmented from the background and it is overlayed on the original image.

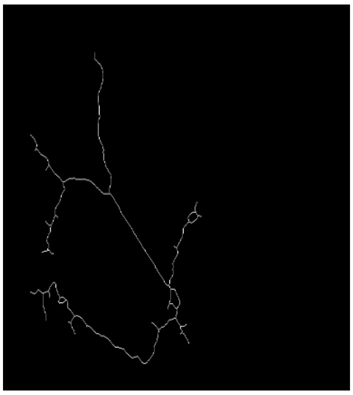
Fig 6a. Thinned veins

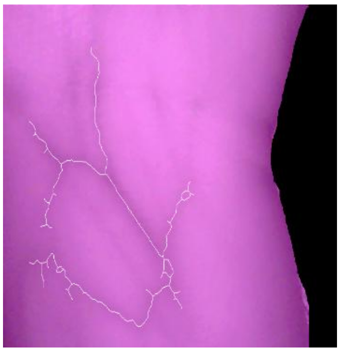
Fig 6b. Overlay of veins on the original image

IV. EXPERIMENTAL RESULTS

The Vein detection experiment was conducted on different subjects. The subjects were of different age, sex, colour complexion. The test results are tabulated as shown in Table 1

Table 1: Tabulation of results

Age		
Subjects	**Easy**	**Difficult**
Young(<30 years)	8	2
Aged(>50 years)	2	0
Children(<15 years)	1	1
Complexion		
Subjects	**Easy**	**Difficult**
Fair Skin tone	2	2
Medium Skin tone	6	0
Dark Skin tone	2	2

In the final step of processing, the image acquired we could clearly see the veins in the subjects as tabulated in the table. This method is a very user friendly method to the doctors which helps to locate the veins easily.

V. CONCLUSION

The main goal is to make a portable Non-Invasive vein detection system has been accomplished. A lot of study on subjects as shown in the table for different age and complexion. The implementation part consists of vein illumination system and the processing of vein image. Processing of image is done to obtain a clear image of vein using Histogram Equalization. To identify the veins, segmentation is done from the background. In the future work, the IR imaging part must be focused to get a clearer image and to identify the veins in all subjects clearly. The processing of image can be taken further to find the depth of the veins.

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