Vein Detection System using Infrared Light

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Abstract – The process of obtaining intravenous (IV) access, Venipuncture, is an everyday invasive procedure in medical settings and there are more than one billion venipuncture related procedures like blood draws, peripheral catheter insertions, intravenous therapies, etc. performed per year [3]. Excessive venipunctures are both time and resource consuming events causing anxiety, pain and distress in patients, or can lead to severe harmful injuries [8]. The major problem faced by the doctors today is difficulty in accessing veins for intra-venous drug delivery & other medical situations [3]. There is a need to develop vein detection devices which can clearly show veins. This project deals with the design development of non-invasive subcutaneous vein detection system and is implemented based on near infrared imaging and interfaced to a laptop to make it portable. A customized CCD camera is used for capturing the vein images and Computer Software modules (MATLAB & LabVIEW) is used for the processing [3].

Index Terms— Venipuncture, Near-Infrared imaging, vein detection system, MATLAB, LabVIEW, Webcam, Vein Detection

1 INTRODUCTION

Accessing veins in cases of elderly or obese as well as dark toned & adult patients becomes very difficult sometimes for drug delivery physicians. Although significant work has been done in this area and many devices have come up, but the major problem lies in their cost and portability. A low cost, portable & efficient infrared imaging detection system is the need of the hour.

Burns and other physical injuries make it difficult to locate veins and administer lifesaving drugs. In such cases it becomes very necessary to have a device that detects the exact location of required vein. Also in case of blood transfusion or withdrawal, etc. it is necessary to know the position of the veins. Even trained nurses and doctors many times find it difficult to exactly locate the blood veins on the first attempt itself. In some medical situations, the location of vein needs to be identified. Each second counts when the doctors are treating trauma patients. The other situations where vein imaging is required are:

(A) *Bruises and Bums:* In case of vein diseases bruises appear on the skin like Deep Vein Thrombosis and Varicose Veins, therefore for the treatment detection of veins is highly essential. Accidents involving first or second degree of bums cause the scarring of the skin. The appearance of the skin becomes deterred making the skin to appear either whiter or darker. The determinations of veins become tough in such cases.

(B) *Intravenous injections*: For giving medicines and drugs to the patients, intra- venous injections are given by doctors and nurses.

(C)*Amongst children*: Having to puncture them several times with a needle is very frightful and agonizing for the child & so locating veins in young children and infants may be difficult.

(D) *Blood transfusions*: It is a process in which blood is given to the person intravenously. Blood donation, kidney dialysis also need perfect vein detection.

(E) *Geriatrics:* Old people often require numerous blood tests or medicinal injections and an efficient means of puncture would reduce excessive bruise and enhance the patients overall comfort level.

Human eyes can only detect visible light that occupies a very narrow band (400 - 700nm) of the spectrum. However, in other bands of the electromagnetic spectrum there is much more information contained rejected by the objects of interest.

The visibility under normal visible light conditions is very low for human vein patterns on the periphery. This can be resolved by Near-Infrared (NIR) imaging techniques. The special properties of Near-Infrared imaging are:

Depth penetration of up to 3mm into biological tissue using NIR. More absorption of radiation by venous as compared to surrounding tissues. The vein image maybe captured by an IR sensitive camera, therefore, by shooting the infrared radiation of specific wavelength at the desired body part results the veins to appear darker than the surrounding tissue in the image.

A spectral window exists from 700 to 900 nm where light can penetrate deep into the tissues. The wavelength of the Infrared (IR) light beam coming out from a light source is selected to be around 850nm. It also avoids undesirable interference from the radiation (3um – 14um) of human body.

The basic phenomenon is radiation of the wavelength region 740 nm-760nm is to detect veins but not arteries because of selective absorption of infrared radiation in blood vessels. The reason is the deoxidized haemoglobin [deoxy-Hb or Hb] in the veins almost completely absorb the radiation while the oxidized haemoglobin [HbO] become almost transparent.

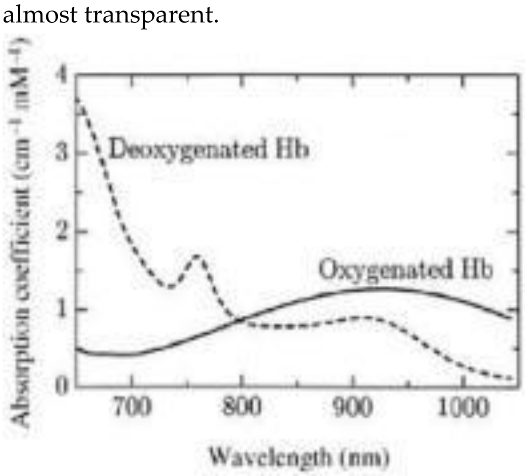

Figure 1. Absorption of light by blood

There are two types: Far-Infrared (FIR) & Near Infrared (NIR). Because of its certain attributes as compared to FIR, NIR gives better results for vein detection. Far infrared imaging means red hot image, that recognition rate often greatly influenced by humidity and temperature, NIR penetrates most human tissue easily, so it can acquire more clear and reliable image quality than FIR.

The designed vein detection takes a snapshot of the subject's veins under a source of infrared radiation. Almost any part of the body could be analyzed in this method. In many medical practices, X-ray and ultrasonic scanning can also be used to form vein images. They are all invasive techniques as they require injection of agents in blood stream. This is not feasible for general purpose imaging applications. The key challenge in a vein pattern biometric system obtaining the vein pattern images in a fast and non-invasive manner.

2 Design

NIR ring of eight LEDs were used for illuminating the desired body part with infrared light. The design of the light source should provide perfect illumination so that the vein images can be captured and there should be a contrast between the veins and the surrounding tissue. So a ring of LED is chosen as the camera lens is circular, making the centre as webcam lens. The experiments conducted had shown that near infrared LED array provided illumination but it had a ringing effect light had alternate light and dark bands. So, to correct this, each LED was diffused by using sandpaper, and rinsed by water. The result was an almost uniform intensity of illumination. Also, NIR vein imaging technique does not depend upon the skin color and pigmentation of the person and it does not interfere with the imaging process. In case of people with several tattoos due to which the radiation were not able to pass through the skin.

The camera should have sufficient spatial resolution so as to identify the vein details. The CCD is perfectly capable of detecting NIR up to a wave length of approximately 1mm but all modern cameras have an infrared cut-off filter in front of the sensor since the main purpose of the camera is to see the maximum amount of visible radiation. This filter was eliminated in order to gain access to the infrared part of the radiation spectrum for the detection system.

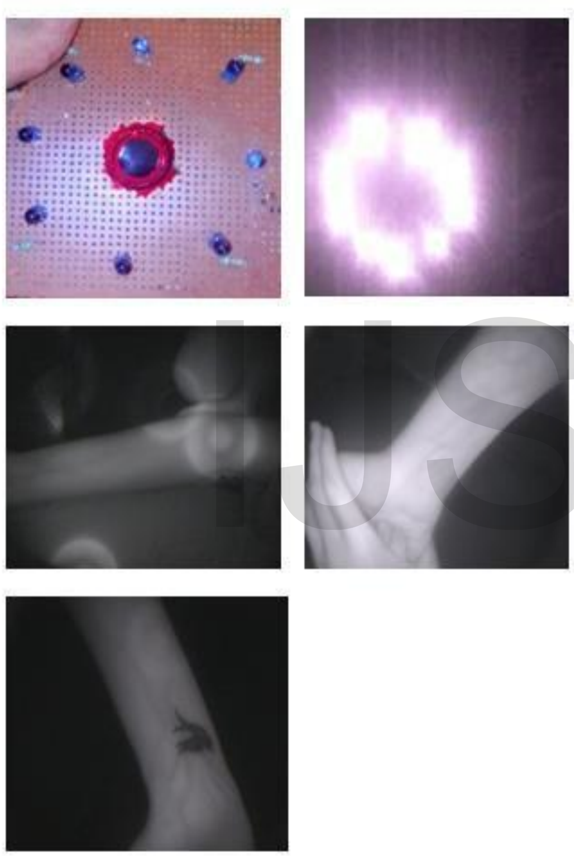

Figure 2-5 from L-R, Assembly, LED output. Ring Effecy. Diffused LED output images

The main goal of the project was to make a portable and cost effective device. Visible LEDs inbuilt in the webcam were replaced with Infrared LEDs. The added benefit was that batteries were redundant, as the LEDs were driving power from the IC board of the webcam itself. The LEDs were soldered in the same position as the previously connected visible LEDs. The LEDs were soldered into the board, they were diffused & tested. In addition, the filter was replaced with a freshly developed filter especially for this purpose. The result of this was an illumination less intense than the LED grid & enabled us to take close up images of the forearm.

Figure 6: Final Modification of camera

The designed subcutaneous vein detection device used USB-based customized webcam .The output of the webcam was fed to computer. The images obtained were of 640X480 8-bit dimensions. MATLAB was used for coding. The following figure gives the outline of the algorithm.

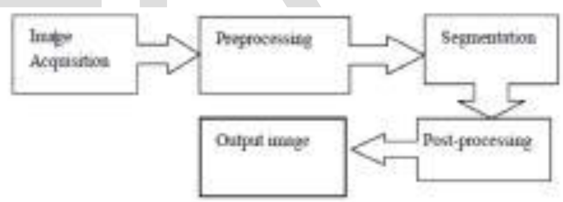

Figure 7 Software Algorithm

2.1 Image Acquisition and Preprocessing

The image of the arm was captured using an ordinary webcam that has been modified to only allow infrared light to reach the image detectors. After taking the image, preprocessing was applied to the image. The purpose of this step was to improve the imaging quality so that vein patterns can be more easily detected during the segmentation. This was done by first cropping the image to isolate the ROI, applying filters to reduce noise and enhance the contrast

2.2 Segmentation and Post-processing

Since the noise had been reduced and the contrast enhanced, segmentation permitted to separate the vein pattern from the background. The vein pattern was located and isolated from the rest of the image. This was the most crucial step in the entire recognition. If the veins are not properly detected, the errors increases.

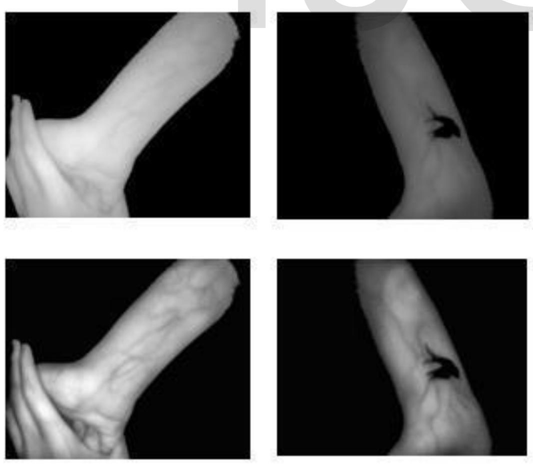

Figure 8-11:From L-R: Thresholded Images, Equalized Images

The resulted segmented grayscale images were with some unwanted information such as noise, shadows and faint veins. Therefore it was not always a true representation of the actual vein pattern.

(c)LabVIEW Implementation

For obtaining real time images LabVIEW (Laboratory Virtual Instrument Engineering Workbench) which is a system-design platform and development environment for a visual programming language from National Instruments was used.

NI Vision Acquisition Software is driver software for displaying, acquiring, monitoring images, & logging from a multitude of camera types. This software is includes all NI vision hardware and all NI vision software licenses. NI Vision Acquisition Software is sold separately for security and monitoring applications not requiring image processing or specialized hardware. The special block in LabVIEW is crucial in the working of our project. The block selects automatically the connected camera thereby removing the need for an interfacing code between camera and the software. It also gives a variety of configuration options associated with the webcam like resolution, frame rate of the webcam. Use NI-IMAQ to acquire from analog, parallel digital, NI Smart Cameras & Camera Link. Vision acquisition made it easy to perform filtering, grayscale conversion and allowing frame by frame viewing.

The preprocessing step served two main purposes. The first was noise removal & smoothing. Since the images were captured using a modified webcam, considerable noise were present in the images. Gaussian and median filters were used to remedy the effect of this noise. The second was contrast enhancement, which was necessary as the vein pattern was faint.

A Gaussian filter is a smoothing filter based on the Gaussian distribution. It is suitable because it acts as a low pass filter, attenuating high frequency noise while leaving the lower frequency features unchanged. Another source of noise in the images was hairs that show up as very thin dark lines. A way to remove these was is to use a median filter. The use of IR image capture makes the veins stand out, it is often necessary to further improve the contrast before segmenting the image.

Global threshold separates the foreground and the background pixels. Global threshold is better than other techniques because it uses bimodal histogram and calculates the inter-variance between them. Adaptive histogram splits the image into different tiles of 8x8 pixels and finds the histogram in each tile to give a better contrast.

3. Result

The following real-time video snapshots were obtained from the designed system. The videos obtained provided a very vein pattern, however they are not perfect. The snapshots obtained are obtained in a contained environment with ideal lighting conditions. Thus there's a need for external adjustment or automatic software calibration. Plus, the USB cable restricts the frame rate of the transfer but it is suitable for diurnal purposes.

Figure 12-15: Real Time Video Snapshots

4. Conclusion

This paper investigates near infrared techniques for vein imaging. The stand-alone, portable NIR vein detection system was able to visualize and detect vessels from anterior forearm. Various image algorithms were tried on still images the histogram equalization worked best on MATLAB. LABVIEW real time processing was implemented and samples obtained. Taking sample images from people of different skin complexities and muscle built, the desired image output were successfully obtained. Since we have made portable IR imaging due to that we have encountered motion artifacts issues. Therefore, our main goal of obtaining a portable efficient vein imaging system at a very low cost is accomplished.

5. Conclusion

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