

## Enhanced Vein Detection from Video Sequences

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### Abstract

Nowadays, infusion of a needle is everyday common practice for the medical practitioner. A numerous fault occurs at the time of needle infusion into the blood vessel which is covered inside the human skin even though it is a simple and common practice in medical practicing. This research proposes a computer-aided new technique using the vision-based imaging and Contrast Limited Adaptive Histogram Equalization (CLAHE) to detect and visualize the vein beneath a human's skin from video sequences which will be a really cost effective solution. IR night vision camera is being used to acquire the videos of an arm to compute the effect electromagnetic effect from NIR illumination which is absorbed by the hemoglobin of the blood vessel tissues. More precisely, its application can lead the process not only for error-free infusion of a needle to the patients but also localization of abdominal bleeding, stroke-inducing clots in the vein are the name of few.

**Keywords:** Vein Detection, IR Night Vision, CLAHE, Infusion of Needle, Video

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### 1. Introduction

Nowadays, the implantation of needle is one of the usual assignments for phlebotomy or the clinician for gathering blood, transfusion of blood and infusion of the ampule fluid or liquid into the human body, and to do that it must require finding the vein vessel to keep away from unnecessary torment because of skin tapping of the patient [1]. It is crucial part both for the patients and the clinicians to avoid panic atmosphere and reducing the duration for the process inside an ER room. From various medicinal imaginary technique Near Infrared (NIR) has ended up being an extraordinary instrument in remedial diagnostics, and in addition in Optical Clarity Tomography furnished for 3D imaging with high assurance keeping pace with low-control microscopy, in measuring circulatory system, blood volume, O<sub>2</sub> use, re-oxygenation rates and muscle recovery time in muscle [2], [3], in the noninvasive assessment of cerebrum work and other restorative applications. NIR imaginary technique can also be an extraordinary area for helping phlebotomy to perform needle implantation on patients. A standard focal point camera can't see at the NIR spectrum ranges since it requires a camera which is able to capture the light beyond the view of humans [4], [5] and the range of NIR illumination is around 740 nanometers to 940 nanometers and is capable to infiltrate 5mm subterranean into the skin tissue [6], [7].




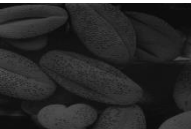
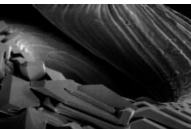

The vein patterns are the core characters while the skin giving the protection to the veins from bricklaying, propagation, and scratches and localizing the vein is the technique for dissecting the pattern using beneath of the skin. Additionally, the reflectance of the human skin is noticeable in the NIR illumination period [8]. The recent study shows that, every year approximately half billion needle implantation on human body occurs and there are approximately 3 to 5% failure rate to get actual vein in the first attempt [9].

Another expensive line of product is Vein Viewer gives flexibility to the clinician by projection on the arm of the patient while the working principle still on the basis of NIR illumination [6]. However, CMOS based camera and XBee sender and receiver pair with IR illuminator will work for the better visibility of the veins. Moreover, in [10], the interesting concepts for vein shape detection between different devices through the sensor and in [11], [12], modification of camera RGB camera by removing the IR filter from the camera sensor can be applied to visualize vein clearly. Moreover, uncovered human eyes visible spectrum between 380nm (violet) and 720nm (red) while the underlying tissues absorbs the

light by the deoxygenated blood hemoglobin [13]. In contrast, the vein cannot be seen clearly on the skin because of its diverted skin tone between the wavelength 830nm and 850nm [6], [14].

Furthermore, the enhancement of the frame or image is also an important part for the visualizing the vein clearly. In [15], it is illustrated that the limitation of the adaptive histogram equalization enhancement technique and overcome the limitation by replacing with new CLAHE enhancement technique. Moreover, the Bi-Histogram Equalization (BBHE) enhancement technique work with the two subimages which can be obtained from the decomposing the input image considering the average to preserve the average brightness of the input image. Moreover, Recursive Mean Separate Histogram Equalization (RMSHE) create recursion level to equalize by forming subimages [16], [17]. On the contrary, in [18], Recursive Sub Image Histogram Equalization (RSIHE) generated better enhancement results for grayscale images as compared to some of conventional histogram equalization techniques such as BBHE and RMSHE and RSIHE recursively separates a histogram based on its center value instead of average as in RMSHE. Table 1 shows the entropy difference among BBHE, RMSHE, RSIHE and CLAHE where CLAHE has an exceptional entropy value for every type of image, more precisely for the vein image.

Table 1. The comparison among different image enhancement technique

Input Image	Initial				Entropy			
	BBHE	RMSHE	RSIHE	CLAHE	BBHE	After Enhancement RMSHE	RSIHE	CLAHE
	5.0047	5.0047	5.0047	5.0047	0.00	4.6156	4.654	6.8157
	6.7304	6.7304	6.7304	6.7304	0.036885	6.3938	6.4204	7.5525
	6.0083	6.0083	6.0083	6.0083	0.00	5.6203	5.7614	6.9236
	5.6542	5.6542	5.6542	5.6542	0.019986	5.3209	5.3872	7.3662
	6.7557	6.7557	6.7557	6.7557	0.00	6.535	6.4734	7.5985
	7.7316	7.7316	7.7316	7.7316	0.91763	7.5759	7.5932	7.7798

**2. Proposed Method**

The proposed method can be summarize like the following:

a) Video sequence and the Acquisition of Frame

The video sequence of the human arm is taken from driverless IR night vision camera with 24bit 640x480 resolution and 850nm IR illuminator and blocking the IR cut filter for day or

night time IR illumination. The acquisition of frame is the initial step in our application and set up with the precise light condition.

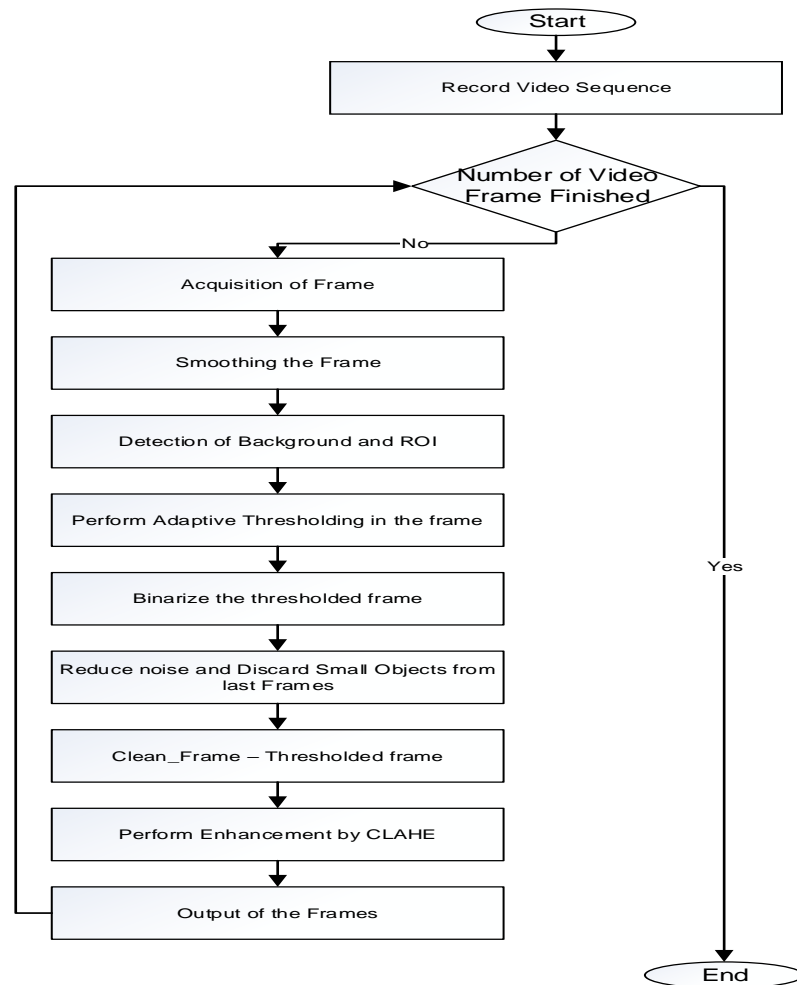


Figure 1. Block diagram of vein detection methodology

#### b) Pre Enhancement

The pre-enhancement is enabling the procedure to find more unpretentious components of the edge which will have or basically to include some select features of energy for an image. This is an uncommonly subjective locale of that image. The decision based on the computation be used depends upon the possibility of the acquired frame. The frame that is acquired from video sequence containing may require for smoothing in this step and this Pre-enhancement incorporates with the removal of salt and pepper type noise.

#### c) Frame background and ROI

In Region of Interest (ROI) in the frame is determined by forwarding the process to identify the general information by image thresholding system and intensity change can be selected of ROI with respect to the background frame information.

##### Thresholding and removal of noise

Thresholding is done by changing over of grayscale frame into its binary form and adaptive thresholding is used to create a frame of each fragmented digits in order to get darkest vein by changing elements of the matrix of values  $>.95$  will be 256 and values  $<0.5$  will be 0. This binary information is treated as a reference frame can have unwanted noise or any other small object in the frames. Additionally, by the background subtraction procedure the image element

received from thresholding step from most recent discarded noise frame element it will produce a matrix with darkest elements.

d) Post Enhancement

In this step the output image will be enhanced using CLAHE to receive a brightest visualization of the vein by ensuring higher contrast ratio.

### 3. Research Method

#### 3.1. Contrast Limited Adaptive Histogram Equalization (CLAHE)

Images with low-Contrast ratio, CLAHE was originally applied to that type of images [19] which is different from normal Adaptive Histogram Enhancement technique. The Main advantage of CLAHE is its clipping limit which is introduced to overcome the noise intensification problem [20], [21] by clipping its histogram at a predefined input before calculating the Cumulative Distribution Function (CDF) and the main parameters of CLAHE are Block Size (BS) and its Clipping Limit (CL) which are mainly used to enhance low-contrast image [15]. The methods to enhance the input image using CLAHE entails of the subsequent stages:

*Stage-1:* The collective number of sub image is equivalent to  $P \times Q$ , and  $8 \times 8$  is a decent incentive to save the picture chromatic information by separating the intensity of real image into non-covering logical locales.

*Stage-2:* By inspecting the nearness of dark levels in the exhibited picture, ascertaining the histogram of each logical locales.

*Stage-3:* The calculation of the contrast limited histogram for the logical locales using CL value:

$$Q_{avg} = \frac{Q_r X \times Q_r Y}{Q_{gray}} \quad (1)$$

Where the mediocre value of pixel is  $Q_{avg}$ , the integer of gray level in the logical locales is  $Q_{gray}$ , the integer of pixel in the X-axis and Y-axis of the logical locales are  $Q_r X$  and  $Q_r Y$  respectively. The concrete CL illustrated as

$$Q_{CL} = Q_{clip} \times Q_{avg} \quad (2)$$

Where  $Q_{CL}$  is indicating concrete CL and the values of the  $Q_{clip}$  is the normalized CL in the series of  $[0, 1]$ . The pixels will treated as clipped if the integer of pixels is larger than  $Q_{CL}$ . The integer of the sum of total clipped pixels demarcated as  $Q_{\Sigma clip}$ , then the mediocre of the outstanding pixels to each gray level is disseminated as

$$Q_{avggray} = Q_{\Sigma clip} \times Q_{gray} \quad (3)$$

The clipping rule for histogram is given by following

$$\begin{aligned} & \text{If } H_{region}(i) > Q_{CL} \text{ then} \\ & Q_{region\_clip}(i) = Q_{CL} \end{aligned} \quad (4)$$

$$\begin{aligned} & \text{Else If } (H_{region}(i) + Q_{avggray}) > Q_{CL} \text{ then} \\ & Q_{region\_clip}(i) = Q_{CL} \end{aligned} \quad (5)$$

$$\begin{aligned} & \text{Else} \\ & H_{region\_clip}(i) = H_{region}(i) + Q_{CL} \end{aligned} \quad (6)$$

Where  $H_{region}(i)$  is original histogram and  $H_{region\_clip}(i)$  is clipped histogram of each locales at  $i$ -th gray level.

*Stage 4:* Redistributing the outstanding pixels until the outstanding pixels have been all disseminated by:

$$Stage = \frac{Q_{gray}}{Q_{remain}} \quad (7)$$

Where  $Q_{remain}$  is the outstanding clipped pixels.  $Stage$  is positive number at least 1. The program begins to seek from the base to the most extreme of the graylevel with the above stages. On the off chance that the size of pixels in the graylevel is not as much as  $Q_{CL}$ , the program will convey one pixel to the graylevel. In the event that the pixels are not all appropriated when the inquiry ends, the program will ascertain the new advance as indicated by Equation (7) and begin new pursuit round until the point that the rest of the pixels is altogether distributed.

**Stage 5:** Improving intensity in apiece locales by Rayleigh transformation. Clipping in histogram is transformed to collective probability,  $P_{input}(i)$ , to generate transfer role. The forward transformation by is:

$$Y(i) = Y_{min} + \sqrt{2\alpha^2 \ln\left(\frac{1}{1 - P_{input}(i)}\right)} \quad (8)$$

Where  $Y_{min}$  is the lower bound of the pixel information, and  $\alpha$  is a Rayleigh distribution parameter for scaling to each input images. Here, the significance in Rayleigh distribution for  $\alpha$  is fixed to 0.04. The output possibility concreteness of apiece intensity value can be articulated as:

$$p(y(i)) = \left(\frac{y(i) - y_{min}}{\alpha^2}\right) \times \exp\left(-\frac{(y(i) - y_{min})^2}{2\alpha^2}\right) \quad (9)$$

for  $y(i) \geq y_{min}$

Depending on the value of  $\alpha$ , will effect in more significant contrast enhancement in the appearance, in the meantime increasing  $\alpha$  value also amplified the noise levels.

**Stage 6:** The output from Equation 9 is re-scaled by linear contrast stretching and can be written as,

$$y(i) = \left(\frac{x(i) - x_{min}}{x_{max} - x_{min}}\right) \quad (10)$$

Where  $x(i)$  input is value from the transformation process,  $x_{max}$  and  $x_{min}$  denote the maximum and minimum significance of the transfer process.

**Stage 7:** Ascertaining the new graylevel substitution of pixels inside a sub-matrix with logical locale by utilizing a bi-straight introduction between four distinct mappings to wipe out the limitation.

For the experiment purpose, we have used a 2megapixel driverless IR USB camera, a 850nm NIR illuminator and where we covered up the IR-cut filter to ignore outside light and Matlab 2017a.



Figure 2. (a) 2mp Driverless IR Night vision Camera (b) Video Frame Acquisition using MATLAB

One of frames from the acquired video is taken using NIR imaging techniques and the output for vein detection and enhancement has been illustrated in the Figure 4, where particularly used a still image for our experiment and it can be seen reference image is blurred (Figure 4(a)) and followed by the detection of background and the selection of ROI by image thresholding techniques in the image (Figure 4(b)) which is require to adopt the best information from the image. Furthermore contrast enhancement technique CLAHE helped to provide clear veins for visualization can be seen as the acquired image (Figure 4(c)).

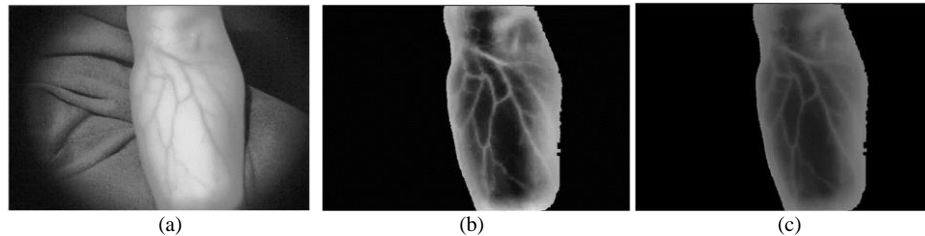


Figure 3. Simulation result for a single image (a) Acquired Image (b) Threshold image with binarizing and subtracting (c) Post-Enhanced image using CLAHE, displayed consecutively

Moreover, the histogram analysis using different type of enhancement technique is showing an extremely satisfied output and CLAHE exceeds our expectation.

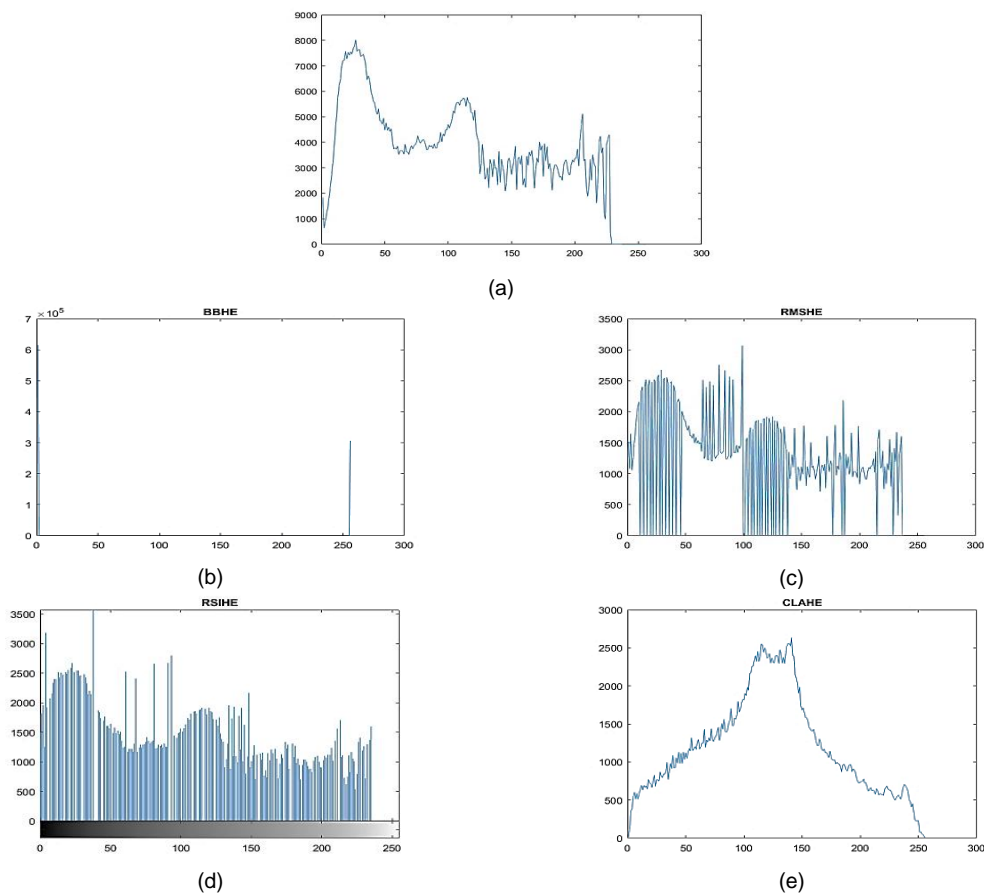


Figure 4. (a) Histogram of Input Vein image, (b) Histogram of Enhanced Vein image using BBHE, (c) Histogram of Enhanced Vein image using RMSHE, (d) Histogram of Enhanced Vein image using RSIHE, and (e) Histogram of Enhanced Vein image using CLAHE

The Mean-Squared Error (MSE) is calculated from the reference input frame and enhanced frame of the input. The formulation for MSE for X and Y array,

$$MSE = \frac{1}{ROW \times COL} \sum_{j=0}^{ROW-1} \sum_{k=0}^{COL-1} [X(j, k) - Y(j, k)]^2$$

The Peak Signal-to-Noise Ratio (PSNR), can be formulate as the following:

$$PSNR = 10 \log_{10} \left[ \frac{L^2}{MSE} \right]$$

Where L is the range of values of a pixel and for our vein detection sytem we have used grayscale 8bit image, so, the value for  $L = 2^8 - 1 = 255$ . So, for the Vein image, Table 2, is representing the value for MSE and PSNR for BBHE, RMSHE, RSIHE, and CLAHE.

Table 2. MSE and PSNR for the Vein Image using different image enhancement technique

	BBHE	RMSHE	RSIHE	CLAHE
MSE	238.6895	70.2982	17.3980	2693.8455
PSNR	24.3525	29.6614	35.7258	13.8271

Now, after consideration of the above table, it can be clearly seen that from MSE ratio of the input and CLAHE enhanced output is surprisingly exceptional with respect to other technique and the PSNR is also so lower than the other technique which is so helpful for representation of clearer vein.

#### 4. Results and Analysis

At this time, by continuous processing for each of the frames of the video sequence, the vein representation for the each frame is clearly being illustrated as shown in the output figure \*\*. Therefore, the clinician can easily identify the vein for any kind of needle infusion to the vein more efficiently, errorlessly and painlessly.

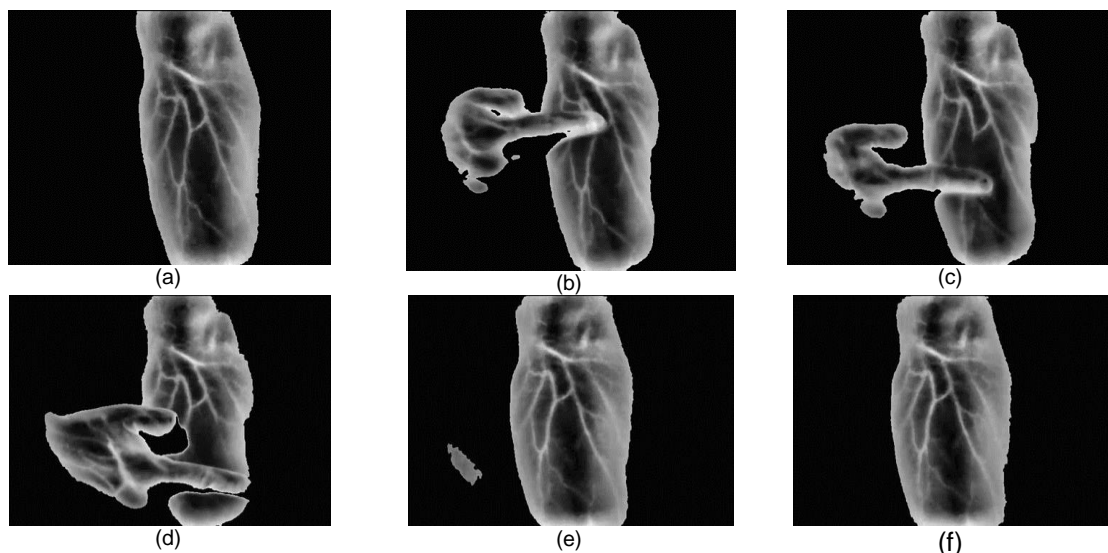


Figure 5. The resultant frames from video sequence (a) Frame 20, (b) Frame 60, (c) Frame 100, (d) Frame 450, (e) Frame 750, and (f) Frame 773, displayed consecutively

Finally, after doing all the steps on each of the frame, it indicates a solution to our objective to provide a pain and errorless needle infusion in human body using the computational power to determine clearer vein.

## 5. Conclusion

Using the proposed vision-based vein detection technique the vein from the human arm is successfully implemented which gives an alternative solution to the current clinician to perform needle infusion by visualizing the vein become more efficient as it was a complex task to see vein clearly. This work will followed by real-time vein detection system not only in the big computing devices but also most widely used handheld devices like Smartphone. The camera application for the smartphone will be treated as the more viable replaceable solution because of the cost of manufacturing for new hardware will be cut off.

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