International Journal For Technological Research In Engineering
Volume 1, Issue 9, May-2014 *ISSN (Online): 2347 - 4718*

Vein Pattern Detection System Using Cost-effective Modified IR Sensitive Webcam

Navdeepsinh V. Limbad[1] (ME scholar), Prof. G. D. Parmar[2] (Asstistant Professor)
Department of Biomedical Engineering
Government Engineering College, Sec-28, Gandhinagar
Gujarat, India.

Abstract: Vein detection is one of the latest medical Imaging techniques researched today. Now a day's very few devices based on the IR technique have been implemented & researched there is strong demand to develop such devices. While the concept behind the IR imaging is simple, there are various challenges to be found throughout the design and implementation of a device concerning the illumination system, image acquisition system & the image processing algorithms at a very low price. The major problem faced by the doctors today is difficulty in accessing veins for intra-venous drug delivery & other medical situation. Blood clots, bruises, rashes, etc. occurs due to improper detection of veins. That's why a non-invasive subcutaneous vein detection system has been developed success-fully based on near IR imaging and interfaced to a laptop to make it portable. A customized webcam (CCD camera) is used for capturing the vein images and Computer Software module (MATLAB) is used for the processing. This system also has application in treatment of varicose veins, deep vein thrombosis, and vascular ailments & also in the area of finger vein pattern recognition & biometric applications.

I. INTRODUCTION

The vein detection process consists of an easy to implement device that takes a snapshot of the subject's veins under a source of infrared radiation at a specific wavelength. The system is able to detect veins but not arteries due to the specific absorption of infrared radiation in blood vessels. Almost any part of the body could be analysed in order to extract an image of the vascular pattern. In many medical practices, X-ray and ultrasonic scanning are used to form vein images. These methods can produce high quality images for blood vessels; it is an invasive technique as it requires injection of agents into the blood vessels. This is not feasible for general purpose imaging applications in the real-world. Therefore, obtaining the vein pattern images in a fast and non-invasive manner is the key challenge in a vein pattern biometric system. However, no research has specifically addressed the issue of vein pattern acquisition, and there is a lack of analysis of the factors affecting the quality of the vein pattern images. This paper is thus motivated to investigate the utilization of infrared imaging technologies in this area of application. Generally there are two types of infrared imaging: Far-Infrared (FIR) & Near Infrared (NIR). NIR gives better results for vein detection because of its certain attributes as compared to FIR [1]. Far infrared imaging means red hot image, that recognition rate often greatly influenced by humidity and temperature, but near-infrared can use the advantage of special wavelengths infrared penetrates most human tissue easily, so it can acquire more clear and reliable image quality than far-infrared imaging[4].

II. NEED FOR VEIN DETECTION

When the doctors are treating trauma patients, every second counts. Bums 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, blood withdrawal, blood donation, etc. it is necessary to know the exact position of the veins. Even trained nurses and doctors many times find it difficult to exactly locate the blood veins, on the first attempt, especially for obese people. In various medical situations, the exact location of veins needs to be identified. The other situations where vein imaging is required are [2]:

- Intravenous injections: For giving medicines and drugs to the patients, intra- venous injections are given by doctors and nurses.
- Bruises and Bums: In case of vein diseases like Deep Vein Thrombosis and Varicose Veins, bruises appear on the skin, therefore for the treatment of these diseases, detection of veins is highly essential. Accidents involving first or second degree of bums cause the scarring of the skin. Here appearance of the skin becomes deterred causing the skin to appear whiter or in certain cases darker. The determinations of veins become tough in such cases as well.
- Blood transfusions: It is a process in which blood is given to the person intravenously. Blood donation, kidney dialysis also need perfect vein detection.
- Among children: Locating veins in young children and infants may be especially difficult and having to puncture them several times with a needle is very frightful and agonizing for the child.
- Geriatrics: Many elderly 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.

III. PROBLEMS ASSOCIATED WITH PREVIOUS WORK RELATED TO VEIN IMAGING

- In many medical practices x-rays & ultrasonic scanning are used for vein imaging. In the above mentioned vein imaging modalities unnecessary radiation dose is given to the patient.
- Although the above mentioned vein imaging techniques can produces high quality images for blood vessels, they are invasive techniques as they required injection of contrast agents into the blood vessels for that unnecessary puncturing of veins is done. This is not acceptable for general purpose vein imaging.
- However, the far infrared (FIR) technique is also used for vein imaging the problems associated with this imaging modality are: 1) the images acquire using FIR have low levels of contrast, which makes it difficult to separate the veins from the background. 2) In addition it is limited for the major vein pattern imaging. 3) The FIR vein imaging is much more sensitive to the environment temperature & humidity.

IV. PRINCIPLE OF NEAR-INFRARED (NIR) IMAGING

Human eyes can only detect visible light that occupies a very narrow band (400 - 700nm) of the entire electromagnetic spectrum. However, there is much more information contained in other bands of the electromagnetic spectrum rejected by the objects of interest. For human vein patterns on the periphery, the visibility under normal visible light conditions is very low. However, this can be resolved by using Near-Infrared imaging techniques. The special attributes of Near-Infrared imaging which makes it suitable for vein detection are:

- NIR can penetrate into the biological tissue up to 3mm of depth [1]. The reduced haemoglobin in venous blood absorbs more of this infrared radiation than the surrounding tissue[6]. Therefore, by shooting the infrared radiation of specific wavelength at the desired body part, the vein image can be captured by an IR camera. In the resulting image, the veins appear darker than the surrounding tissue [1].
- Biologically, there is a “medical spectral window” which extends approximately from about 700 to 900 nm, where light in this spectral window penetrates deeply into tissues, thus allowing for non-invasive investigation [1]. Therefore, typically, the wavelength of the infrared light beam coming out from a light source is selected to be within the near infrared region with wavelength around 850nm. Using this wavelength, it also avoids undesirable interference from the IR radiation (3um - 14um) emitted by the human body and the environment [1].

The basic phenomenon governing the vein viewing devices is that Near Infrared (NIR) radiation of the wavelength region 740 nm-760nm is able to detect veins but not arteries due to the selective absorption of infrared radiation in blood vessels. The reason for using the aforementioned phenomenon is the fact that the deoxidised haemoglobin [deoxy-Hb or Hb] in the veins almost completely absorb the radiation while the oxidised haemoglobin [HbO] in the arteries become almost transparent.

V. OVERVIEW OF THE PROPOSED SCHEME

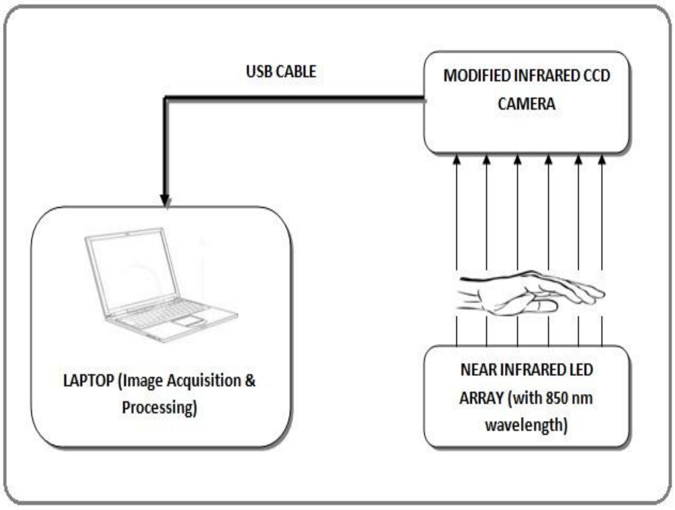

Fig. 1: Overview of the near infrared vein imaging system

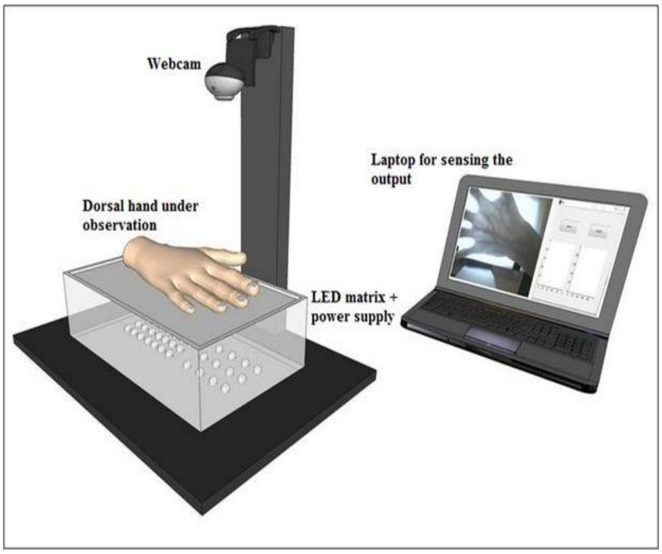

Fig. 2: Clip Art Image of Proposed Vein Imaging System

VI. IMPLEMENTATION AND PROCESSING

The model primarily consists of three parts:
1. A near Infrared LED source,
2. A modified near Infrared CCD camera to capture the Infrared image,
3. A Software Module (MATLAB) for Image Processing.

Our acquisition system is composed of a modified web camera; a NIR ring of LEDs is used for illuminating the desired body part with infrared light. The LED ring has a circuit driver and the power is provided from the laptop itself through a USB cable the camera is also interfaced through a USB cable. The software module used for processing is MATLAB instead of Computer Vision (Open CV) on windows OS for sake of simplicity and to achieve cost effective criterion of our system [2].

A. Near Infrared LED source:
NIR ring of LEDs is used for illuminating the desired body part with infrared light. The LED ring has a circuit driver and the power is provided from the laptop itself through a USB cable [9].

Fig. 3: LED Source Setup [2]

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. The experiments conducted have shown that near infrared LED array provides constant illumination and high contrast over the region of interest. Also holographic diffusers are required to scatter the light from the LED's have an undesirable effect of reducing the contrast due to high quantity of radiation emitted. To modify the distribution of intensity, various arrangements of LED array have been experimented with and the result shows that the triple concentric LED array arrangement gives by far the most effective uniform distribution of intensity. It has been proven that the near IR vein imaging technique does not depend upon the skin colour and pigmentation of the person and it does not interfere with the imaging process, except in case of people with several tattoos due to which the radiation were not able to pass through the skin.

B. A modified Near Infrared CCD Camera
CCD cameras have the capability to detect infrared radiation out past the 1000nm wavelength. The eye cannot be able to detect wavelengths larger than about 750nm.

Fig. 4: Modified CCD Web Camera (iBall Webcam)

I describe how to modify an inexpensive computer webcam into IR sensitive camera:
The fact that CCDs are sensitive to IR is a detriment to good photography. To get around this, all CCD cameras have a built in IR blocking filter. The cheaper the camera, the less effective the IR blocking filter. First unscrew the webcam casing, then look for the IR filter (tiny color film like thing).The IR blocking filter must be removed to make a good IR camera. With help of cutter or scissors carefully get off the IR filter.This will void the warranty and possibly wreck the camera. Therefore webcam is a good choice. The general purpose IR filter is a coating on the lens. This must be removed which can degrade image quality. The best acceptable filters that are part of the lens housing. These can be easily popped out without any risk. This camera worked well on a PC and my laptop running Windows's OS.

C. Steps of Webcam modification:

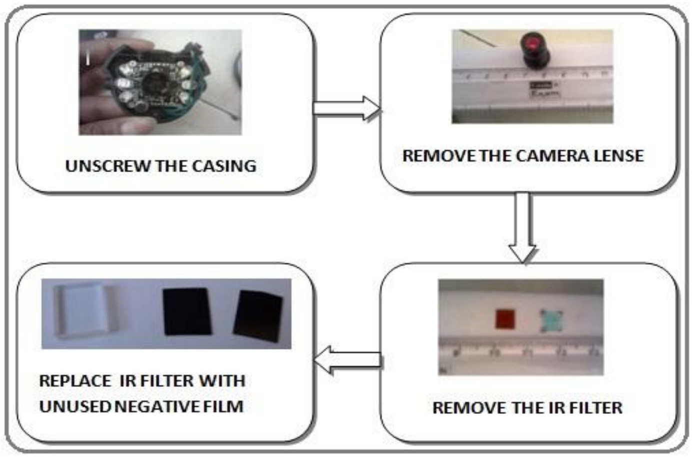

Fig. 5: Steps of iBall Webcam modification

The camera sensor response should lie in the near infra-red radiation for taking vein images. The camera should have sufficient spatial resolution so as to identify the vein details. The CCD alone is perfectly capable of detecting near infrared radiation 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 must be eliminated in order to gain access to the infrared part of the radiation spectrum. To block the unnecessary visible radiation (below 720nm) and allow the near infrared radiation to pass through the transmission filter is placed on the inner part of the lenses (replace the IR filter with a clean un-used negative film). In this way filter can effectively blocking more than 90% of the visible radiation.

D. Image Acquisition & Processing [2][5]
The algorithm of the image processing is as shown below and the details of each step are as follows:

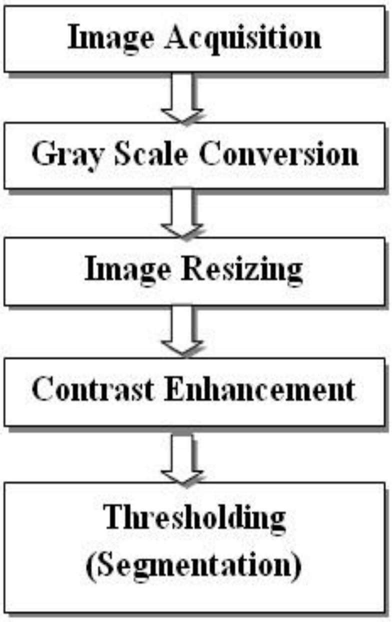

Fig. 6: Image Processing Through MATLAB

The image acquisition and processing algorithm can be described using the following steps:

- First establish the region of interest and the camera is focused on the established region. The region is illuminated using near infrared radiation (LED Array). In some particular cases the amount of radiation must be compensated with the environment lighting if natural or artificial infrared light sources are present.
- An image of the vein pattern is acquired with a CCD camera the result being a grey scale image with almost black lines representing the veins which absorbed the near infrared radiation.
- The image is acquired using MATLAB Image Acquisition Tool.

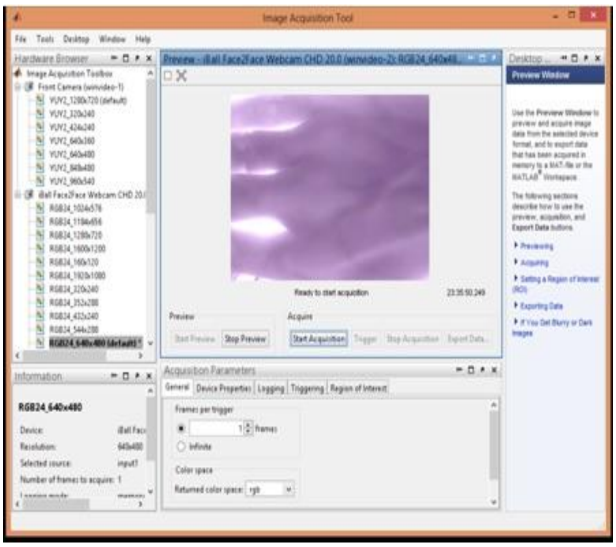

Fig. 7: MATLAB Image Acquisition Tool

Acquired Image is in RGB format it must be converted into gray scale image, which allows faster processing in the further stages as compared to coloured images.
Matlab Code: *"rgb2gray"* converts true colour image into gray image by eliminating the saturated information while retaining the luminance. After the acquisition of the gray scale image, to enhance the contrast, the user is allowed to stretch it beyond its assigned values to his/her need. With this, the slightly dark veins appear darker, hence allowing for easier distinction between the veins and its surroundings. The range of contrast for this image now ranges from -255 to +255 rather than the conventional 0 to 255 pixel intensity.
Consecutive contrast operations are used to enhance the image of the vein model then a threshold (segmentation) is applied thus creating a black and white image containing just the vein pattern. This stretched gray scale is now ready to be segmented. Using one of the simplest of segmentation, the Adaptive thresholding marks clear boundaries between "foreground" and "background" pixels determined by the threshold value opted by the user through the track-bar. This segmentation hinders the speed of processing the least and has so far resulted as the most reliable. The constant parameter is introduced to compensate for the drawbacks of the early adaptive thresholding. Upon this segmentation, the image results as a binary image demarcating quite clearly the foreground image and the background image based on the contrast enhanced image [10].

VII. PERFORMANCE ANALYSIS AND TEST RESULTS

Result: After Gray Scale Conversion

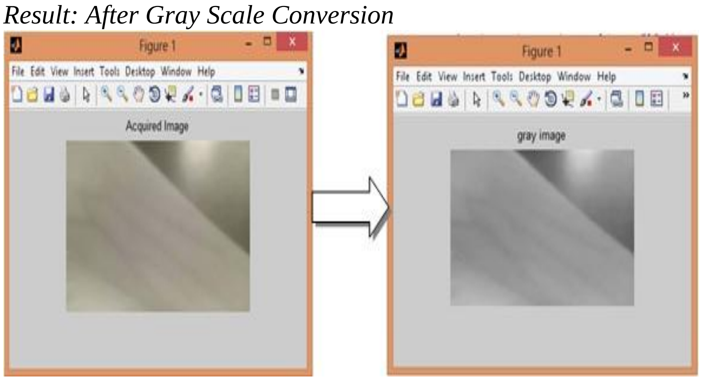

Fig. 8: Gray Scale Conversion

Result: After Contrast Enhancement

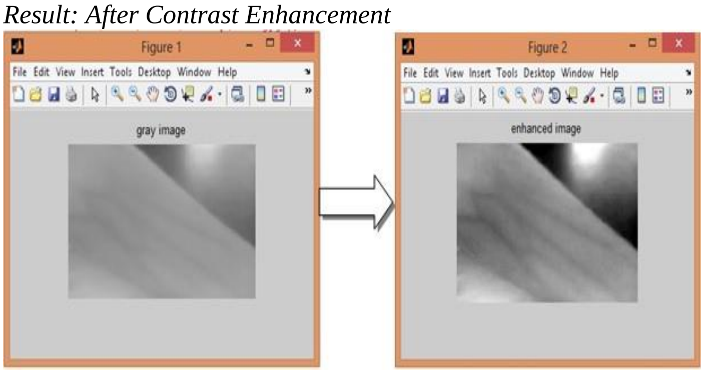

Fig. 9: Contrast Enhancement

Result: After Image Segmentation

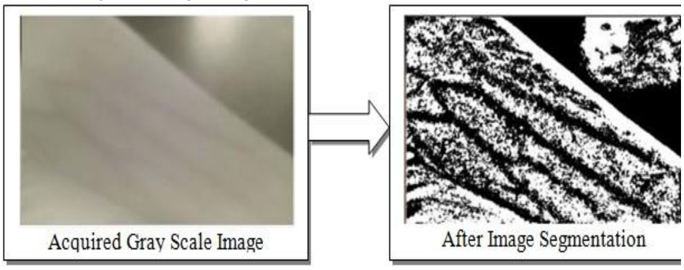

Fig. 10: Image Segmentation

VIII. CONCLUSION

This paper investigates near infrared techniques for vein imaging. Since we have made portable IR imaging due to that we have encountered a lot of motion artefacts problems. We are trying to remove the noise in grater extents. So, that the veins are more clear & error is reduced. Therefore, our main goal of obtaining a potable efficient vein imaging system at a very low cost is accomplished.

REFERENCES

[1] Wang Lingyu and Graham Leedham, “Near- and Far-Infrared Imaging for Vein Pattern Biometrics,” Proceedings of the IEEE International Conference on Video and Signal Based Surveillance (AVSS 2006).

[2] Manam Mansoor, Sravani. S. N, Sumbul Zaha Naqvi, Imran Badshah, & Mohammed Saleem “Real-time cost infrared vein imaging system” Proceedings of the IEEE International conference on Signal Processing, Image Processing, & Pattern Recognition (ICSIPR 2013).

[3] Jian Hong & Cao Qubo “The Finger Vein Image Acquisition method & vein pattern extraction study based on near infrared” 2011 - IEEE.

[4] H. D. Zeman, G. Lovhoiden, and C. Vrancken, “The Clinical Evaluation of Vein Contrast Enhancement, “Proceedings of the 26th Annual International Conference of the IEEE EMBS.

[5] Septimiu Crisan, Joan Gavril Tarnovan, and Titus Eduard Crisan, “A Low Cost Vein Detection System Using Near Infrared Radiation,” SAS 2007 - IEEE Sensors Applications Symposium.

[6] Liukui Chen, Hong Zheng, Li Li, Peng Xie & Shuo Liu “Near-infrared Dorsal Hand Vein Image Segmentation by Local Thresholding Using Gray scale Morphology” , 1-4244-1120-3/07, IEEE-2009.

[7] Koushik Kumar Nundy & Shourjya Sanyal “A Low Cost Vein Detection System using Integrable Mobile Camera Devices”, 978-1-4244-9074-5/10, 2010 Annual IEEE India Conference (INDICON).

[8] “Combining near-infrared illuminants to optimize venous imaging” Vincent Paquita,b,c, Jeffery R. Pricea, Fabrice M' eriaudeaub,c,Kenneth W. Tobina and Thomas L. Ferrellc.

[9] Sang-Kyun Im, Hyung-Man Park, Young-Woo Kim, Sang-Chan Han, Soo-Won Kim, Chul-Hee Kang and Chang-Kyung Chung, "An Biometric identification system by extracting hand vein patterns", Journal of the Korean Physical Society, 38(3): 268-272, March 2001.

[10] N. Miura, A. Nagasaka, and T. Miyatake "Feature extraction of finger vein patterns based on repeated line tracking and its application to personal identification".

[11] N. Miura, A. Nagasaka, and T. Miyatake "Extraction of finger-vein patterns using maximum curvature points in image profiles." IAPR conference on machine vision applications 9 (2005).

