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Electronic Vein Finder

Vivek Sureshkumar[1], Sheba Elizabeth Kurien[2], Smilu Sunny[3], Stephy James[4], Lakshmy .S[5]

Dept. of Electronics and Communication Engg, Mar Baselios College of Engineering and Technology,

Trivandrum, India

Abstract: Electronic Vein Finder is a system which aims to help locate and distinguish vein effectively for various medical purposes. The existing technology is complex and expensive. In this paper a simple design is proposed to capture the vein images under infrared lighting and extract the vein pattern using image processing technique. The enhanced image can be projected back on to the patient's hand.

Keywords: Image processing, infrared, region of interest, vein display.

I. INTRODUCTION

Blood test, vaccination and fluid injection are common procedures that millions of people are administered with each day. The basic step for these procedures is to locate the patient's vein. But in many cases finding the vein becomes a difficult task. This is especially applicable for obese people, people with dark complexion, old people and for patients whose veins are collapsed.

Accuvein, Vein viewer and Veinlite are among the few devices existing in the market that can easily map the vein pattern but high cost make these devices unfavourable. In this paper we discuss the design of a camera and projector based system to locate the hand vein pattern based on infrared imaging technique.

II. PRINCIPLE

Near-infrared imaging (NIR) is used to distinguish veins from the rest of the body tissue. The basic principle is that NIR can penetrate upto 3 mm depth inside biological tissues [6]. Moreover, reduced haemoglobin in the venous blood absorbs more of the incident infrared radiation than the neighbouring tissues. This makes the veins appear darker than its surrounding in the IR image.

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. 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].

III.SYSTEM DESIGN

The system consists of a CMOS webcam from which the IR filter is removed so that the camera can detect the IR light. The camera transfers the captured image to the laptop by serial communication through USB port, and 24 bits correspond to a single pixel (8 bits of Y, Cb, and Cr component each). The image is captured in the maximum resolution of the camera, which is 640 x 480.

The webcam is surrounded by an array of IR LEDs to illuminate the region of interest.

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This infrared lighting system is encased by a black box to block visible light. The LEDs are given 5V power supply using a micro USB cable. This arrangement is shown in Fig. 1.

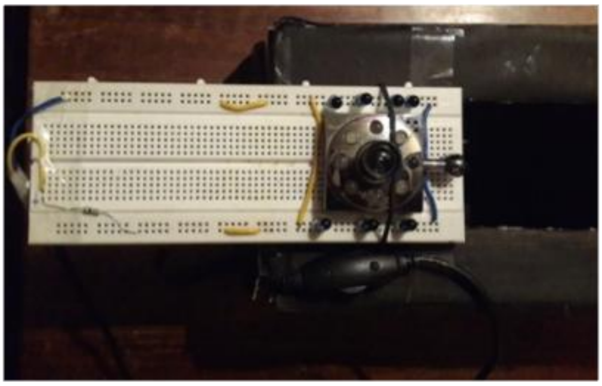

Fig.1. IR lighting and image acquisition system

A Panasonic PT-LB50U Projector is mounted vertically on a stand and the focal length is adjusted to its minimum of 1.1m [5]. The hardware setup is shown in Fig. 2.

Fig.2. Hardware Setup of Electronic Vein Finder

IV. SOFTWARE IMPLEMENTATON

The algorithm involves real time image acquisition followed by histogram equalization and morphological operations to bring out the region of interest. We tested the algorithm in MATLAB. The corresponding VHDL code for RGB to grey scale conversion and histogram equalization was written in ModelSim [4]. The flowchart of the algorithm tested in MATLAB simulation is given in Fig. 3.

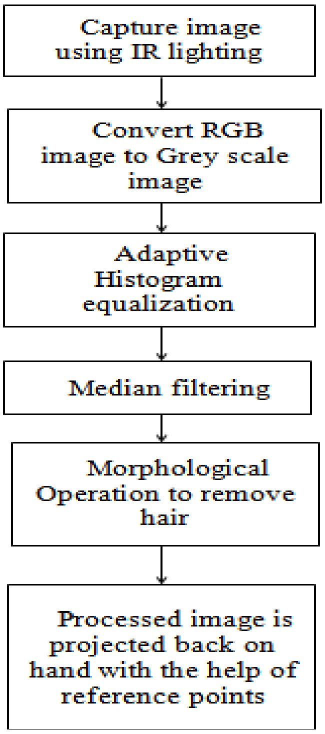

Fig.3. Flowchart of the algorithm

A. Real Time Image Acquisition

Before taking an image, a few reference points are considered so that the enhanced image that gets projected back will coincide with the region of interest [2]. The webcam captures the image in YCbCr format which is converted to RGB in MATLAB using a single line command. However for converting the image to greyscale using Modelsim we used the following method.

The binary value of the image is obtained from Matlab. The chosen image is read and its red, blue and green components are identified. The red component of the image is stored in r.txt, the blue component of the image is stored in b.txt and the green component of the image is stored in g.txt as binary values. Only 256*256 pixels of the image are used for processing.

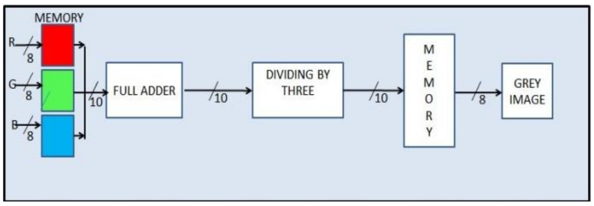

Fig.4. RGB to Gray Conversion Block in VHDL

These text files are then used as the test bench values for the RGB to Grey conversion block done in ModelSim as shown in Fig.4.

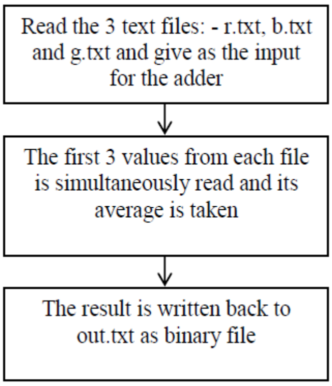

Fig.5. Algorithm in VHDL

The RGB image is converted to greyscale for the next step which involves histogram equalization.

B. Adaptive Histogram Equalization

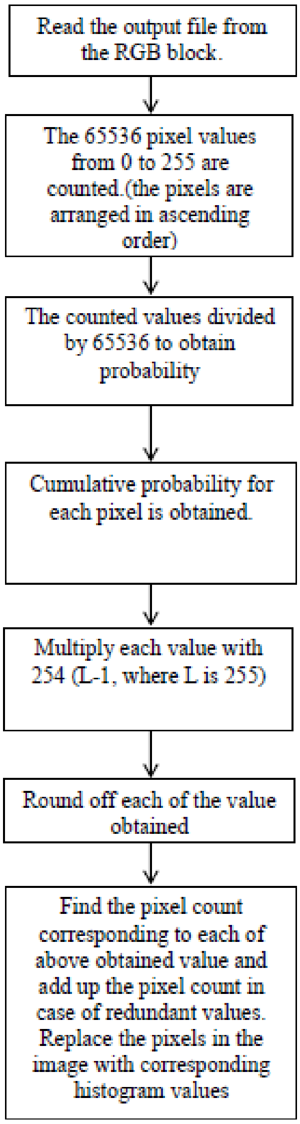

Fig.6. Algorithm of histogram equalization in VHDL

Histogram is the plot of number of pixels versus intensity value. Histogram equalization increases the contrast of an image by distributing the recurrent intensity values. Ideally, the equalized histogram has a flattened intensity distribution curve. In this algorithm, Contrast Limited Adaptive Histogram Equalization (CLAHE) is performed. CLAHE differs from ordinary histogram equalization in respect that the image is divided into several bins and each undergoes histogram equalization based on its local contrast. The bins are then merged using bilinear interpolation to eliminate artificial boundaries. In our software implementation, we used adaptive histogram equalization twice which resulted in a better contrast image.

The contrast enhanced image had random specks of black and white pixels. These are known as salt and pepper noise caused in an image due to analog to digital converter errors, bit transmission errors etc. In this algorithm, it occurs because of the bilinear interpolation step of CLAHE. Here, the additional pixels made during interpolation get filled by neighbouring pixel values. Thus in addition to enhancing the contrast, the noise present in the image also gets amplified. A median filter can be used to remove this noise.

The algorithm we used for doing Histogram Equalization in Modelsim is as shown in Fig.6

C. Morphological Operation

In the CLAHE and median filtered image veins are distinctly visible, however the arm hair is also enhanced which is undesirable. Morphological operations are performed to remove this noise. This technique involves processing the image based on defined shapes.

Bottom hat filtering is applied on the median filtered image using ‘disk’ as structuring element to isolate the hair as a separate image. Hair is further segregated from this image by thresholding and dilation. Now, hair in the original image is removed by smoothly interpolating its pixel value inwards based on the segregated hair image.
The hair removed image is then binarized and given two distinct colours which makes the veins stand out. This final image is projected back to superimpose on the region of interest with respect to the reference points.

V. RESULTS

The algorithm proposed in this paper was tested on different skin tones. It was found that it can locate the veins in all cases. The noise due to androgenic hair was successfully removed. The captured and processed images of a wrist are shown below. Fig.7. shows the image captured in the IR lighting system.

It was observed that skin complexion does not affect the quality of captured image. Fig.8. shows the contrast enhanced and filtered image. It can be seen that the veins are distinguishable but the hair acts as noise to the image. In Fig.9. hairs on the arm are removed by morphological operations and only veins stand out. The final output of our system is shown in Fig. 10.


Fig.7. Image captured in the IR lighting system.

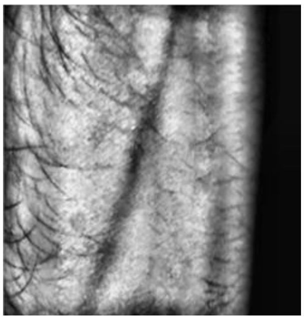
Fig.8.Contrast enhanced and filtered image

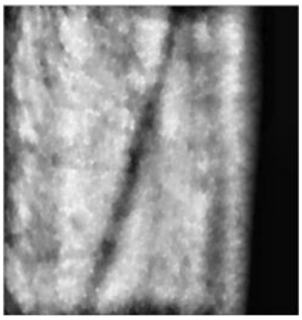
Fig.9.Hairs removed by morphological operation

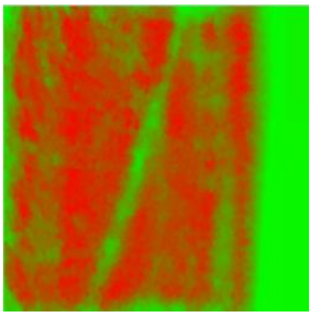
Fig.10.Final Image showing position of the vein

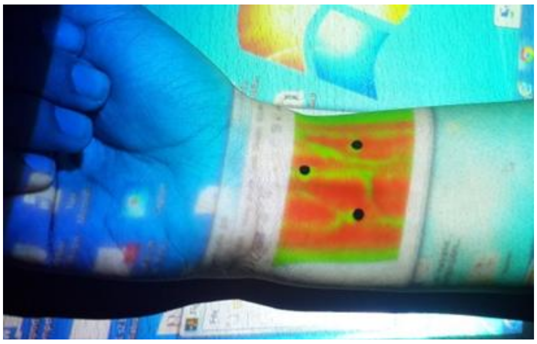
Fig.11. Projection of the superimposed image on the hand

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The vein pattern identified from a captured image can be precisely projected back on the region of interest. Fig. 11 shows the projection of a processed image which is superimposed with respect to the reference points chosen on the wrist.

The hardware setup was constructed based on many trials and errors. The specifications and dimensions thus chosen for the setup gave satisfactory results for the different cases we tested. However, it may have to be varied to work in all possible cases. In future, a portable device can be developed by interfacing an IR camera and a Pico projector to an FPGA based embedded hardware [3].

VI. CONCLUSION

A simple low-cost non-invasive vein finding system has been designed which can be made readily available to patients in high end hospitals as well as primary health care centers. The performance of its algorithm was tested in MATLAB and the results were satisfactory, with enhanced vein pattern and noise reduced to a great extent in all tested images. A clear and distinguishable vein pattern was obtained in all tested cases.

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BIOGRAPHIES

Vivek Sureshkumar, Dept. of Electronics and Communication Engineering, Mar Baselios College of Engineering and Technology, Trivandrum, India

Sheba Elizabeth Kurien, Dept. of Electronics and Communication Engineering, Mar Baselios College of Engineering and Technology, Trivandrum, India

Smilu Sunny, Dept. of Electronics and Communication Engineering, Mar Baselios College of Engineering and Technology, Trivandrum, India

Stephy James, Dept. of Electronics and Communication Engineering, Mar Baselios College of Engineering and Technology, Trivandrum, India

Lakshmy S., Assistant Professor**,** Dept. of Electronics and Communication Engineering, Mar Baselios College of Engineering and Technology, Trivandrum, India

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