Vein Detection System Using OpenCV with Patient Database System

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Abstract: Non-invasive vein detection for intravenous (IV) procedurescan be carried out using infrared (IR) raysfor the purpose of illuminating a region, and then using an infrared camera for observing it. The image is processed using different techniques on the OpenCV software platform. We further propose the creation of a centralized database system for the management of patient data, which will securely store the previously captured images of the patient's venous system for the healthcare professional's records, thereby increasing the staff productivity and patient satisfaction as well as bettering overall clinical workflow.

Index Terms: infrared camera, noninvasive vein detection, OpenCV, patient database management system

I. INTRODUCTION

In the field of biomedical instrumentation, current research being done is yielding efficient but high cost results. The utilization of IR imaging procedure and imaging in broad regions is a moderately less investigated territory which guarantees proper results at lower costs. IR imaging can be carried out under two subcategories – Near IR (700-1300nm), which easily helps us capture more and better information, and Far IR (8-14 μm), which gives us lower quality images. NIR penetrates up to 3mm deep into the human tissue. The basic principle of operation which is explored in this paper for vein detection using NIR imaging is that, the deoxy-hemoglobin present in the blood vessels of the human body absorbs more infrared radiation than the neighboring tissues. The veins containing deoxyhemoglobin seem darker on absorbing the infra-red light, so they become visible and the image of veins gets captured by the camera.

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A critical problem which is encountered by the doctors and medical practitioners is the visualization of patient's veins for injecting medication and various other purposes, especially in case of emergency situations like trauma patients, where time is of essence.Medical treatments and procedures get delayed if the location of veins is improper and unreachable due to patient's own characteristics that, in some cases, make visualization or palpation of the veins difficult. More difficulties arise in case of obese or dark toned patients as well as with children, especially new-born where finding veins might be troublesome. For patients with bruises or burns, in which cases bruises are present on the region of interest, the quick detection of veins is very critical and any delay can cause critical issues. Redundant vein puncturing carried out by the medical practitioners, can cause bruising of skin, inflammation, irritation and bleeding and therefore, the process of venipuncture represents an aggression for the patient. As such, a device is required to provide the accurate position of the vein during the processof blood withdrawal, transfusion or donation, intravenous injection etc. where, the precise region needs to be distinguished.

[1] discussed using infrared light to facilitate detection of veins in a procedure consisting of illuminating the skin with infrared light, capture the video of the reflected image of the veins and performing the processing of said image using MATLAB algorithms. [1] proposed a low-cost prototype with resources accessible at the local level that allowed obtaining venous pattern on dorsal face of the hand. An array of NIR LEDs is made to illuminate the forearm and the image of the arm is captured by camera. The captured vein image is then is passed through levels of processing using Open CV and image enhancement techniques are used to obtain a clear image of the veins. The processed image of venous pattern is available for use simultaneously, and is also uploaded to a centralized database accessible to doctors and medical practitioners of the hospital, along with the patient information, i.e., patient name, age, weight, as well as current body temperature and pulse rate. The database maintained is for future reference and use. The central and secure database is especially useful in emergency situations where the time for venous imaging is not available, instead the image present in the database is accessed and used. Hence, in this paper we have proposed an effective system of medical service that is accessible, cost effective and available in case of emergencies.

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II. LITERATURE REVIEW

Much research is being conducted in the area of healthcare, with an aim to make the practices more efficient, and increase the comfort level of patients while accessing medical services. In this section, some of the previous work in the area of venous imaging has been discussed which provided key motivation and insight in the design and methodology proposed in this paper.

The measurements taken through the capturing of the image can have an increase in inaccuracy due to physical factors such as skin tone or hair on the skin. Vincent Paquita et al. [2] performed experiments to determine the best NIR wavelengths to optimize vein contrast for removing the issues caused by these. They employed an array of NIR LEDs and experimented with different NIR illuminations to find the best combination of illuminant radiation by performing two-class linear discriminant analysis (LDA). In other research, Koushik Kumar Nundy [3] described a vein detection system using common VGA quality camera phones in order to take infra-red images., whose setup is easy having minimal cost, and the image quality is based on number and the relative positioning of the NIRLEDs, height of system, and angle of inclination of LEDs. Naoto Miura et al [4] proposed a method in which vein in hand is captured with CCD with an attached IR filter to capture images in which vein appears darker and used an attached IR filter to capture images in which vein appears darker for stable and unique biometric features with automated image processing, noise reduction and normalization, pattern extraction and pattern matching algorithms. Li Xueyan et al [5] have also proposed a system of biometric identification using palm vein in which the infrared palm images containing the palm vein information are used for biometric identification. Subhasis Chaudhuri [6] have applied image processing algorithm feature extraction based on the optical and spatial properties of objects for blood vessels having poor local contrast in retinal images. Manjiree S. Waikar et al [7] have implemented infrared vein detection using infrared LED and matching system for biometric identification using different algorithms in MATLAB. Marios Vlachos et al [8] have proposed a fully automatic method for finger vein pattern recognition using edge suppression process in which the vein patterns are extensively enhanced. Simon Juric et al [9] have described in their paper low-cost solution for vein detection using near-infrared spectroscopy in which on the vein image local dark lines are identified, and line tracking is executed by moving along the lines, pixel by pixel. Christopher A. Mela et al [10] have proposed a vein imaging system that combines the reflectance mode visible spectrum images) with transmission mode near-infrared (NIR) images in real time

III. TECHNICAL BACKGROUND

In this section we have provided a description of technical backgrounds that will help to provide a better understanding of our proposed system.

A. NIR LED

NIR LED is a Light Emitting Diode (LED) that emits radiation in the near infraredzone of the electromagnetic spectrum. In this model, an NIR LED array projects NIR radiation on to the affected body region. We can pick up the difference between the vein to be detected and the background tissues, by capturing and processing the difference in absorption and reflection of the near infraredlight in the image.

B. Raspberry Pi

Raspberry Pi is a single-board computer used for electronics education and rapid prototyping. It has grown rapidly in international communities and gained importance for use in production in schools, universities and other institutions as well. In this model, a Raspberry Pi unit has been used as the main processor for the operations-**/* required.

C. The NoIR Raspberry Pi camera

Raspberry Pi camera is an image sensor of high quality designed as an add-on device for use with Raspberry Pi. The NoIR Raspberry Pi camerais a similar sensor to the basic RPi camera, but with a modification, namely the removal of the IR cut filter, allowing IR radiation to be detected by the sensor. The v2 Pi NoIR has a Sony IMX219 8-megapixel sensor and can be used for a variety of applications where the visible spectrum is insufficient or unusable. In this model, the RPi NoIR camera is used to capture the IR-frequency image of the body region under examination.

D. CLAHE algorithm

Contrast Limited Adaptive Histogram Equalization, known popularly as CLAHE algorithm in image processing is a method used for enhancement of the visibility of minute details of an image by increasing the contrast between local regions. In this model, the algorithm is applied for helping in clearly demarcating the veins from the background tissue regions as captured in the image of the patient's affected body region.

E. HTML&CSS

HTML which stands for Hyper Text Markup Language describes the structure of web pages and web applications using standard markup language. Along with Java Scripts and Cascading Style Sheets HTML forms the basis of creating websites. HTML constructs, images and other objects embedded into web pages are the basic building blocks of web development.

F. Firebase

The Firebase Realtime Database is a cloud-hosted NoSQL database that can be used to store and sync real-time data enabling access to the stored data from any device for better coordination between users.

G. Pulse sensor

Pulse Sensor is a plug-and-play sensor used as a non-invasive heart rate detection device. It uses infrared radiation to measure the change in volume of blood vessels caused due to the heartbeat.

IV. OVERVIEW OF DESIGN AND WORKING

A. Image and patient data acquisition

The acquisition system consists of the Raspberry Pi Camera and an arrangement

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of NIR LEDs for illuminating the region of interest (here, the forearm). There is a total of twenty NIR LEDs mounted in the form of a matrix and the camera is interfaced with the Raspberry Pi unit. The image captured by the camera is then processed, a description of which is provided in the next section. A DHT11 and a pulse sensor are also incorporated which collect the body temperature and the pulse of the patient. This information along with vein image is displayed to the medical personnel on site as well as transferred to the central database accessible to authorized medical practitioners offsite.

Fig. 1. The Raspberry pi camera setup used for acquisition of vein image.

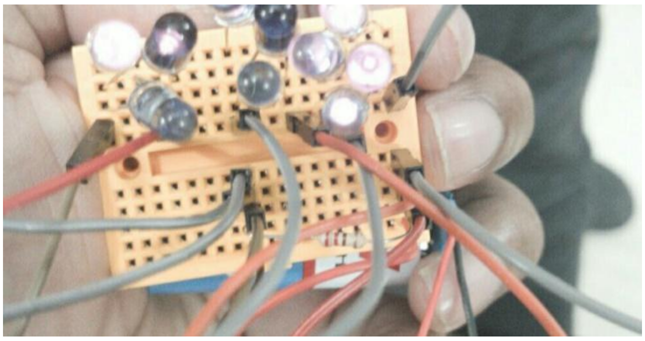

Fig. 2. The array of NIR LEDs used to obtain distinct image of veins

B. Image processing

The 24-bit image which is acquired using the Raspberry pi camera in which the veins appear darker than the background image is first converted to grayscale. In order to get a still image, the image of the vein is taken in the frame form. Out of the three colors red, blue & green, green color decreases the background brightness & increases the brightness of veins to provide a better view of the acquired image. Noise in the image needs to be reduced, and for that, first the gray scale image is blurred implementing the Gaussian blur technique. On the Gaussian blurred output, Histogram Equalization is performed in order to have an equally distributed output image along the range of the intensity of pixels.Using this technique, the contrast of the image is increased and all pixels are given equal distribution between the values of 0 to 255, as a result, veins appear darkened in comparisonwith the background. The technique of median filtering is implemented to further remove the noise. In this technique, median of neighborhood values replaces the pixel value. Based on the neighborhood pixel value of the histogram, threshold value of the pixel is found which is used to distinguish between the background image and the veins. Division of the main image into multiple sub- image is performed, where sub-image contains both the veins and background image. For the veins i.e. the foreground image all pixel values are set above the threshold value whereas for the background image the pixel value is less than the threshold value. This provides effective segmentation of the image. For further removal of the noise and dark regions of the background image, a morphological close operation is performed and along with that region growing is applied. In skeletonization, the detection of the vein’s median axis is performed. Basically, skeletonization is performed to reduce the thickness of all lines to that of a single pixel. Finally, segmentation is performed due to which veins are segmented from the background image and are coated over the original image. But to perform the pixel- based segmentation, the region of interest should be within the threshold.

Fig. 3. Vein image before image processing is performed.

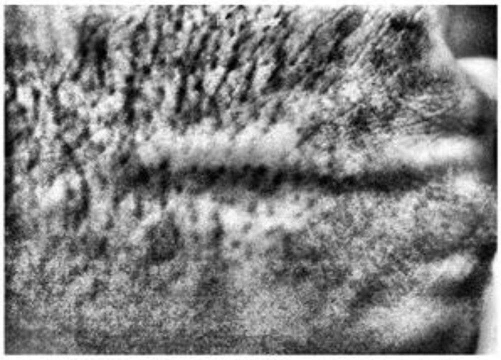

Fig. 4. Vein image after image processing

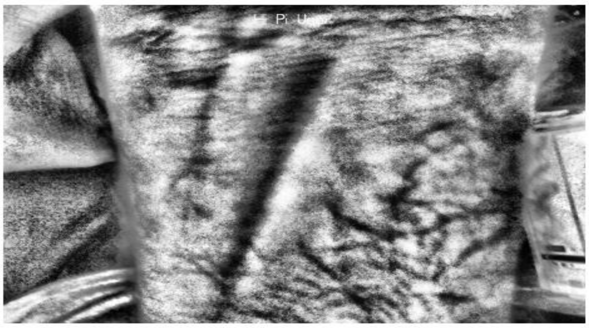

Fig. 5. Vein image after image processing

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C. Centralized database for patient information

We propose in our system, the construction and maintenance of a centralized medical records database. The data is accessible to only the registered medical practitioners and in certain cases other authorized personnel like emergency responders etc. A sign-inauthentication option is given to prevent unauthorized entry and use. Along with the captured and processed vein image, the pulse rate and body temperature of the patient are also uploaded to the database. The main use of the central database is for patients who need to undergo medical procedures requiring vein detection on a regular or frequent basis. For, these patients the previously captured image of the vein detection system can be reused to save time and resources. We have also implemented pulse rate and body temperature detection so that a complete record of the patients' current state can be maintained in the database for future reference.

V. CONCLUSION

Near Infra-Red imaging has been used to acquire the vein image as it penetrates up to deep enough into the human tissue to reach the surface blood vessels.The vein detection system can alternatively be used with real time video capturing and processing instead of image capture. The vein detection system proposed in the paper was tested on different subjectshaving varying features and skin complexions. It was found to be effectivein acquiring and processing the captured vein image of most of the subjects. Slight difficulty in detection occurred in case of subjects having darker skin tone and for subjects having more body hair. We also tested out the system with different number of NIR LEDs to get the minimum number of LEDs that can be used to get a proper vein image. The obtained image was processed using the CLAHE algorithm to create greater contrast between the vein and the surrounding tissues and enhance the veins. Additionally, DHT11 and pulse sensors were used to measure the body temperature and pulse of the patient. All the acquired data is maintained in a centralized patient database system. The system is user friendly not only for the doctors and medical professionals but also for the patients.The future work involves further processing of the vein image so as to get a clear image which can be used for further applications.

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