A Low Cost Vein Detection System using Integrable Mobile Camera Devices

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***Abstract*— There has been a lot of discussion and research recently on mobile heath solution equipment. This paper presents such a solution in form of a vein detection system using an infrared light emitting diode [LED] illumination array and a cellphone camera.**

***Keywords*— infrared, camera, mobile health, Light Emitting Diodes, mobile phone**

I. Introduction

The vein detector is aimed at solving the efficiency based requirement of a physician or a lab technician to identify and inject at the proper point in the circulatory system the required antidote. The device is aimed as a low cost solution abling laymen to inject in their own body or to a target patient the required antidote without any prior knowledge of locating the vein. The present alternatives comes with price tags of nearly $1000 to $10,000 , are complex multi LED based and require powerful visual recorders. They are hence unaffordable by general physicians and medical practitioners who regularly administer intravenous injections. Others do not provide visual data and hence often have greater probabilities of human error. The present alternative developed by the team focuses on building a simple attachment which can be added to a camera mobile and allow vein viewing at a price tag of $10 or less, if we factor out the cost of the nearly ubiquitous mobile phone. Hence it is affordable by the general medical practitioners as well as common patients due to low price tag and easy usability.

II. Previous Work

There has been considerable work in trying to design mobile devices with biomedical and biometric capabilities. They have been used in various domains, including biometric identification, medical devices, pathological diagonisis, etc.

For example, [1] discusses a vein pattern extraction algorithm for biometric identification using low quality sensors. [2] further studies the image aquisition and pattern detection techniques for veins.

[3] discusses a technique to look past the subcutaneous fat to detect tissue patterns using thermal (IR) imaging.

A non invasive vein detection device is dicussed in [4]. However, it is much more complicated than the device discussed here, and requires costly equipment including bulky illumination setups and multiple sensors or cameras.

III. Principle

The basic phenomenon governing the vein viewing devices is that Near Infrared(NIR) radiation of the wavelngth 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 hemoglobin [deoxy-Hb or Hb] in the veins almost completely absorb the radiation while the oxidised hemoglobin [HbO] in the arteries become almost transparent.

Two basic optical coefficients are involved in this absorption process,

1.Absorption coefficient α_a,

2. Scattering coefficient α_s.

The absorption coefficient α_a determines how far light can travel before losing its intensity while still in its original path, and, the scattering coefficient α_s determines how far light can travel before losing its original phase and changing direction. The infrared radiation is absorbed in a different way in various types of tissue. In order to achieve proper desired visual penetration through the pertinent tissue, illumination should be within a very tight optical window, wavelengths 740nm to 760nm.This wavelength is consistent with the near infrared part of the electromagnetic radiation spectrum.

IV. Equipment

The model primarily consists of four parts

1. An infrared source,
2. An optical filter system,
3. A camera to view the infrared image and
4. A laser based three dimensional pointer system to give the user an idea of the optimum distance.

The infra red circuit involves six infrared diodes of a particular wavelength preferably in the wavelength range 740nm to 760nm soldered on a vero board/prefabricated printed circuit board [PCB], arranged in a concentric circle.

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Each individual infrared LED is estimated to form a light cone with a semivertical angle of $\Phi/2$. The concentric circle gives optimum diffusing potential and gives the best result for vein viewing. A central hole in the PCB containing the LED allows the camera to see the skin through it. An optical filter using butter paper is made that diffuses the incoming infra-red radiation from the diodes and spreads them on the skin uniformly to prevent uneven spread or saturated images.

Another filter made from exposed and developed film strips acts as an infrared pass filter that allows only infrared radiation to pass through the filter. It is issued to block all unwanted radiation, primarily in the visible range of the visible spectrum, that may cause fainting, undersaturation or clouding of the infra red image on the camera screen. This filter is automatically brought in front of the screen by a mechanical system when the infra red array is switched on.

Ordinary camera phones with even VGA quality pictures are potentially infra-red detectors and can take infra-red images. So switching on your mobile camera with the attached filter and infrared source will give you real time vein viewing. To optimize picture quality better resolution mobile cameras are preferred and the auto white balance of the system should ideally be turned on for optimum viewing.

The three point optical based distance marking system uses three beams of light that merge into a single illuminated area at a definite distance. This distance is preset by the manufacturer at the point of optimum vein viewing so that the user automatically focuses the system at the best viewing distance, thus obtaining optimal results.

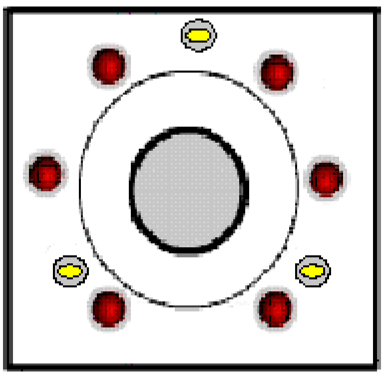

Fig. 1 Proposed model of the illumination array. Red buttons represent infrared LEDs, and Yellow represents optical laser LEDS.

V. WORKING

The model involves an external attachment to the mobile camera to allow the vein viewing. When the system is switched on an infrared pass filter as described in Section II slips in front of the camera lens allowing only infrared viewing through the camera lens. The infrared array is also switched on which results in diffused infrared illumination over the skin surface. The user, using the three point optical locater, then positions the system at the optimal viewing distance.

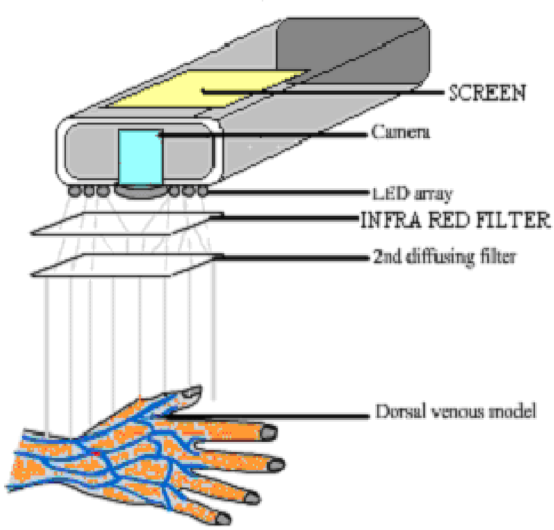

Fig. 2 Working principle of the model

Now, as this is in invisible light range the vein image will not experience interference with ambient light as the infrared filter only allows infrared light to pass. The inbuilt camera can hence see only the incoming infrared reflected light at the said wavelength. This results in a perceived notion of the presence of veins as minor undulations on the skin in the image. The photographs can be seen in real time and also recorded using normal video or image capture function .

The system, as shown in Fig. 1, would be most efficient if the entire array of NIR LEDs were to focus on the same spot, allowing greater illumination and focus. Each LED would be inclined to the vero board base at an angle of θ. On assuming that the surface is parallel to the lighting and camera contraption, this would result in an elliptical region as the effective region of influence of every individual LED as shown in Fig. 3.

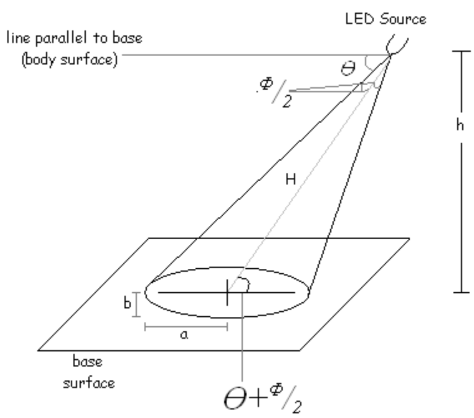

Fig. 3 Effect of 1 LED

Similarly, the use of multiple LEDs would result in an overlapping illumination pattern as in Fig. 4.

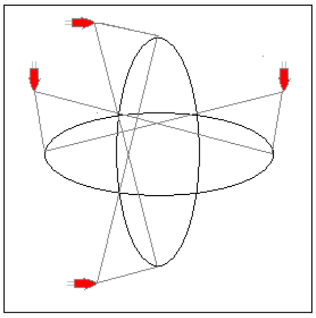

Fig. 4 Illumination pattern for 4 LED system

VI. Calculation and Optimisation

The above figures show very clearly that the IR beam illumination pattern is dependent on the number of LEDs and their positioning. For proper image quality, requisite illumination is primary, as skin penetration would result in considerable diffraction and dissipation. Thus we realise that for optimal performance, we must accordingly vary the following factors:

1. Number of LEDs ***n*** and their positioning
2. Height of system ***h*** (vertical distance of source and camera from surface)
3. Angle of inclination of LEDs $(\theta+\frac{\Phi}{2})$

The following graph plots will be needed to understand the working efficiency of the system:

1. Height vs Intensity
2. ***n*** vs Intensity
3. Field of view vs ***n***.

The field of view as we see from the figures decreases with increase in ***n***. For ***n***=6, we get a good approximation of a circular field of view of radius~***b***, where ***b*** is the minor axis of the elliptical region that is illuminated by a single LED.

Dimensions are:

1. $H=h\,cosec(\theta+\frac{\Phi}{2})$
2. $a=H\frac{\cos\theta}{\cos\Phi}$
3. $b=H\frac{\sin\frac{\theta}{2}}{\sin\frac{\Phi}{2}}$

Thus, since ***θ*** is already known as a system parameter, we can get an idea about the field of view from the variables ***Φ*** and ***H.***

Φ can be obtained from the data sheets of the NIR LEDs.

H is easily measurable for a particular system setup.

So we see that the calculation of the area of illumination is trivial. Hence, we can design a system as described above with minimal calculation or difficulty.

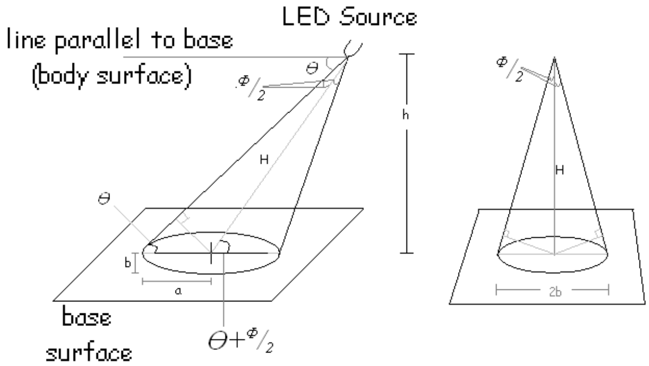

Fig. 5 Dimensional Parameters

VII. Conclusions

This system would as shown, result in minimal costing, along with high QoS, Also, if it is mass produced, then optimisation and cost reduction could be achieved. Also the system manufacture procedure is deceptively easy, causing even a electronic hobbyist to design the system with ease, given the system specifications and components.

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References

[1] Shi Zhao, Yiding Wang and Yunhong Wang - "Extracting Hand Vein Patterns from Low-Quality Images: A New Biometric Technique Using Low-Cost Devices", Fourth International Conference on Image and Graphics.

[2] Shi Zhao, Yi-Ding Wang, Yun-Hong Wang - *"Biometric identification based on low-quality hand vein pattern images"* Seventh International Conference on Machine Learning and Cybernetics, Kunming, 12-15 July 2008.

[3] J.M.Cross, C.L.Smith, *"Thermographic Imaging of the Subcutaneous Vascular Network of the Back of the Hand for Biometric Identification"*, Security Technology, Proceedings, Institute of Electrical and Electronics Engineers 29th Annual International Carnahan Conference, Sanderstead, UK, 1995.

[4] F. P. Wieringa, F. Mastik, F. J. ten Cate, H. A. M. Neuman, and A. F. W. van der Steen *"Remote Non-invasive Stereoscopic Imaging of Blood Vessels: First In-vivo Results of a New Multispectral Contrast Enhancement Technology",* Ann. Biomed. Eng. 34:1870-1878, 2006.