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Portable Device as Vein and Artery Viewer in vivo and in situ

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Abstract. The location of blood vessels is a difficult technic, especially, when drawing blood and administer drugs in or other fluids. The use of the catheter for this use is not a new activity, it is a clinical assignment that must be improved daily, nevertheless the wounds cause can weaken vein, trauma, and difficult to use for the short term. The implementation of a lighting system with IR LEDs type geometrical matrix. The LEDs' characteristics are wavenumber 850 nm and 3 W power, those are adequate and efficient for detecting and irradiate blood vessels in patients undergoing venipuncture procedures. The lighting system has an infrared filter with conjunction with a CCD camera that is connected electronic tablet. The proposed device has an application software that allows us to visualize and acquire in real-time the area in the skin, recognizing the veins and arteries for the puncture will be performed on the patient's forearms. The application in the area of breastfeeding is proposed to help avoid reduce errors or punctures of the venipuncture procedure to patients. The device has been tested with patients and health personnel, allowing to improve patient care and obtaining certainty that the procedure is performed properly.

Keywords: Vein and artery viewer, blood vessels.

1 Introduction

The arteries have a tubular, thick-walled shape formed by different layers located throughout the body [1]. Arteries such as the aorta and the pulmonary are connected to the heart.

Its main function is to carry oxygenated blood to the whole organism from the heart. The veins are also tubular, but their walls are thinner than those of the arteries and they are found throughout the entire body (the main sites are the cava and the pulmonary vein) [2].

The function of the veins is to transport blood rich in carbon dioxide (C02). In the case of capillaries, the walls are much thinner than veins and arteries, and as such allows them to reach our entire body in large quantities. The capillaries allow a union between veins and arteries. Its function is vital since through them the exchange of nutrients with the cells takes place, the latter being oxygen, carbon dioxide, and waste [3].

Venous and arterial vascular accesses are very common in almost all hospital services. For example, in Hemodialysis [4, 5], Intensive Care, and the Operating Room [6]. To achieve a successful venous puncture it is necessary to carry out the venipuncture procedure includes several steps, among them the following: a) Inform the patient of the procedure to be subjected, reassure the patient by eliminating the tension and stress that can cause phlebotomy, b) Posture should be sitting because a passage of body water occurs from inside blood vessels to interstitial spaces, leading to an increase in test values for lipids, enzymes and proteins, c) preparation of the material which includes the collection tubes of objects used to clean the skin, syringes, etc. and d) Application of the tourniquet that consisting of an elastic band placed on the arm or wrist that increases the venous pressure, that should not exceed 1 minute [1].

Even today, the most widespread method of finding veins is the tourniquet and finding an improvement for viewing and venous palpation to reduce the chances of "clicking" in an area of error [7]. However, many patients struggle with venous access, along with the fact that many report discomforts and a lot of tension, and what they want is for the intervention to end as soon as possible [8]. The difficulty of achieving intravenous access is in many cases a challenge for health personnel fear of many patient experiences in the presence of a needle has become a problem for the administration. Medications, fluids, blood, or their derived products, parental feeding, and hemodynamic controls in severe patients are more common than previously thought. Also, the problem is accentuated in new-born’s and patients in hemodynamic areas [9].

We are aware of different studies and publications about the prevalence of difficulties with vascular pathways inserted in admitted patients: for all cases around 45 % are peripheral; 5.5 % with a central venous catheter; 4.0 % with central peripheral insertion catheter; and 2.5 % with total parental nutrition catheter [4, 5].

This allows us to extrapolate their clinical, nursing, clinical care, and humanization management interest, as well as the special interest of the criteria related to technical applications of insertion, maintenance, permanent care, and the prevention of adverse phenomena among which infections are cited. Local and systemic with them related. Infectious problems associated with vascular accesses, concerning their location, are of two types: local (infection at the exit of the catheter, thrombophlebitis), and general (catheter-associated bacteremia and possible distant complications such as arthritis, endocarditis, etc.) [8-10].

In spare situations, it would be very useful to have a tool that allows the vein to be detected in the shortest possible time regardless of the pathology and condition of the patient and the operator [6].

For example, in the case of a patient in severe shock, there may be collapsed veins, which make it harder to find a vein for venipuncture and this puts the patient's life in danger if not assisted immediately.

The existence of a technique that succeeds in easy vascular detection could reduce the stress caused. Besides, this will significantly reduce the number of failed attempts at each puncture. At present there are several non-invasive methods for vein detection, among which are: (a) use of ultrasound images, this uses the eco-Doppler technique as a working principle for the location of the vascular network [7].

The visualization of the images is done through a screen and not on the patient's arm like in other techniques. (b) Surface patches of thermal liquid crystal created by lighting with the application of a thermochromic liquid crystal sheet sensitive to temperatures within the range of 32 to 38 degrees Celsius [8]. Once the sheet is placed, the patient must squeeze a grip placed on his hand to produce greater blood flow. The areas of the superficial vasculature will be observed on the sheet because they have a higher temperature than the surrounding tissue.

The operator can then insert the needle through the sheet in the differentiated place indicated by the vasculature. (c) Illumination with visible light: in this procedure venous intervention is carried out by placing an array of high power visible light-emitting LEDs on the surface of the patient's skin, so that the high-intensity light generates a contrast between the veins and the surrounding tissue, thus facilitating detection of their location [9]. (d) Use of near-infrared, which allows us to see a contrast between the blood vessels and the rest of the skin, in addition to eliminating some unwanted features of the skin surface and the environment. This method uses the area of the electromagnetic spectrum that extends from 760 nm to 1500 nm, called near-infrared spectrum [10, 11, 14, 15].

Biologically there is a spectral band from 700 nm to approximately 900 nm in which the incident light, with wavelength within that range, can penetrate deeply into the tissues. An attribute of the use of infrared is that the level of spectral absorption of deoxygenated hemoglobin has a maximum point in the region of the near-infrared spectrum; that is, we perceive objects with a certain color because they reflect a certain wavelength, corresponding to their color. Within the electromagnetic spectrum, only a very small portion is visible to the human eye. This portion is called the visible spectrum and includes those radiations with wavelengths between 380 and 780 nm. The infrared accounts for the part of the spectrum between 780 nm and 1 mm approximately [11-12, 15, 16].

The aim of this paper is the development presentation of a device that allows us to find blood vessels in people with difficult venous access. This procedure works with infrared light and it is for patients who are under treatment and frequently require venous interventions. It is a technical-scientific procedure that is easy to operate. This technology is available to virtually everyone and can be used by anyone seeking a positive impact on the success of medical procedures.

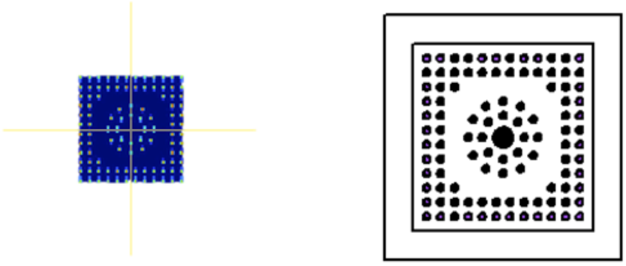

Fig. 1. Arrangement of 104 IR-LEDs**.**

2 Device Design

This device includes a commercial CCD: Logitech C270-720P [13, 14, 17], which one contains a filter that allows the infrared light visualization in addition to other filters integrated with the arrangement to exclude other wavelengths from the surroundings of the camera, namely those emitted by the IR-LEDs [15] and in this way help avoid alteration of uniformity in lighting. Its transmission percentage is significant from 700 nm to block visible light.

Commercial infrared LEDs were used, whose emission range falls within 750 nm to 810 nm. Different prototypes of infrared LED lamps were made by placing the camera in the center and thus to obtain a better image. The process is based on the design of commercial infrared cameras, especially those that are circular. Different designs of the lamp were tested to improve lighting [15-17]. Due to the greater effectiveness of the transmission principle, two lighting sources were built.

The first consists of a matrix of 40 emitting LEDs located under the forearm or fold of the elbow (ulnar fascia) and the second were used to achieve a surface uniformly illuminated and consisting of two arrays of five diodes located around and at the same height as the lens of the camera. To achieve the best configuration of the irradiation distribution of LEDs with Rhinos software simulation processes were carried out to allow us to see in advance how the behavior of the proposed configuration might be before its implementation was made in place[16].

For example, Figure 1 shows the map of the distribution that was finally built, because it was the one-sample case that showed better performance. In this figure, we can see an arrangement of 104 LEDs, distributed in three square arrangements (two of them with 44 and 36 LEDs separated of 10 mm each and the third arrangement of 4 LEDs with a separation of 60 mm between them) and two circular arrangements (one 12 LEDs separated by 25 mm and the other with 8 LEDs separated by 15 mm) with 90 grades aperture according to the company specification sheet.

Simulation of the array of IR LEDs was also performed to find the distribution of lighting generated by these LEDs at 11 cm distance from the CCD in the center of the lamp with an infrared filter to measure their irradiance and distribution homogeneous in the area to be analyzed. The results obtained from the simulation are shown in Figure 2.

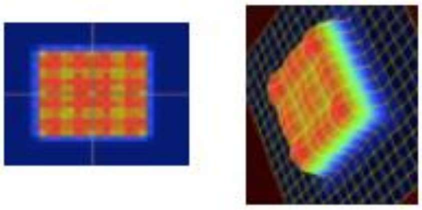

Fig. 2. The lighting distribution spectrum for the LEDs array implemented in this work.

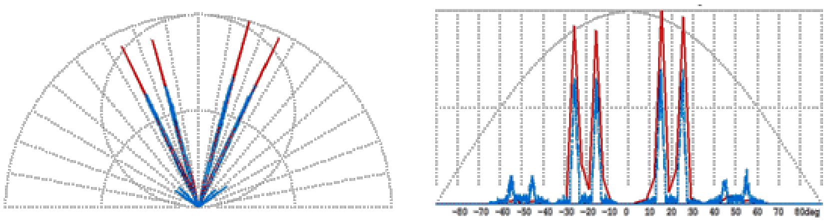

Fig. 3. Radiation is emitted by the array of 104 IR-LEDs.

Fig. 4. IR LED Panel.

The polar graph shows the distribution of the radiation emitted by the arrangement of 104 LEDs, see Figure 3.

In Figure 4, the real image of the implemented LED array is shown, which allows us to maintain a uniformly illuminated surface, since it radiates frontally with the implemented LED array.

This method of lighting, in backlight, allows to obtain a digital image of the veins through the chamber, and the product of infrared radiation that penetrates the surface of the skin, part of the radiation is reflected and another is absorbed, by what the contrast represents the absorption part of the vascular network.

Image acquisition is done with the connection to a Nexus 7 Tablet using OTG adapter cable, an application (App) was made to connect the external USB camera

Fig. 5. Health staff using the prototype.

and capture images or video. Image processing is carried out by employing algorithms implemented in Matlab.

The study of the different effects of illumination uniformity and irradiance of arrays of LED sources have been studied from different areas for their versatility of applications. In particular, the implementation of LED radiation in the area of medical bioengineering has been experienced in areas of phototherapy, plant growth, and visualization of blood vessels [17, 18].

Generally, the wavelengths used in the biomedicine area are in the range of the visible light spectrum. Low-emission green laser sources have been used to improve the visualization of arteries and veins in patients [19-21]. This denotes the importance of having a method that facilitates this procedure, reduces complications in affected patients, and easy the work of the operator.

3 Results

Healthy men and women were evaluated in a range between 20-40 years, which have different skin color and complexion. Personnel from the health sector were needed to perform the first steps of the venipuncture process. The measurements were made on the right forearm by placing the lamp at an approximate height of 11 cm from the patient. The health sector staff easily visualized and identified the vein on the screen, which can be saved and sent by email to the doctor or for your medical history if requested. Figure 5 shows a team, which is using the prototype developed in a male patient.

In Figure 6, it is shown images of veins taken on patients when the IR lamp is projected on the area of interest.

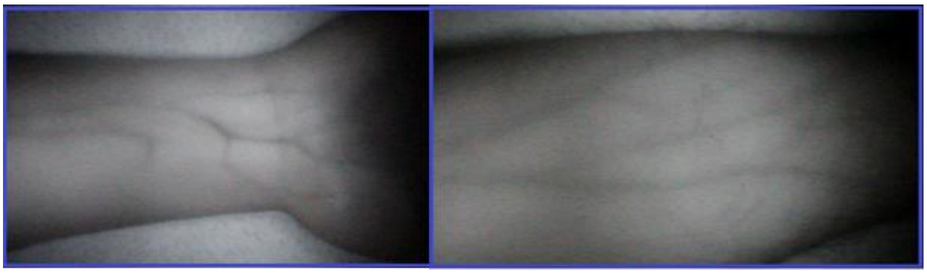

Fig. 6. Answer to the IR lamp on blood vessels recorded with the use of the implemented device.

4 Discussion

The importance of introducing a non-invasive technique that optimizes the blood collection method and reduces the number of failed venipunctures enormously benefits the neonatal and pediatric population. These patients are not the only ones with problems in the detection of veins. In particular, the patients with overweight, dark skin, diabetics, and difficult venous access can be considered due to several factors that make visualization of their veins difficult. Elderly patients may have hardened or fragile veins, they also tend to become tortuous because of poorly active circulation.

In patients with a dehydration condition, problems are also detected for the detection of veins because vasoconstriction occurs as a result of reduced blood volume. In diabetic or hypertensive patients there are lesions at the level of the smooth muscle. Vasoconstriction and hypercoagulation occur causing greater rigidity in the vessels and making canalization difficult. The lighting intensity of the LED panel is increased or decreased according to the type of skin and gender. This was done by varying its supply voltage.

The implemented device is now being validated in the medical area. More assessments are needed in newborns (0-4 months). The identification of veins on the fingers and use these results as biometric identifiers is another application of this device. The use of this blood vessel viewer on not clean hands is an advantage that this system offers.

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