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Detection of Suspicions of Varicose Veins in the Legs using Thermal Imaging

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***Abstract*—Varicose veins also known as venous insufficiency, are dilated veins due to an accumulation of blood that occurs in different parts of the body, the most common are in the legs, in addition to having a higher index in women for clothing style that they use. Varicose veins are classified by grades ranging from I to IV and can cause pain, itching, cramps and even ulcers if they are treated in time. Not all varicose veins can be visible superficially, many of them begin inside of the skin. According to the WHO (World Health Organization) 10% of the world population has varicose veins. That is why the detection of suspicions of varicose veins in the legs was raised in this research work, first a thermal image will be obtained using the FLIR ONE Pro thermal camera following a necessary protocol of distance and temperature range. The thermal image is processed in MATLAB to identify the segments of the histogram of the thermal image, to obtain the area of the highest temperature indicating the presence of varicose vein in the subject's leg. The segmentation of the areas with the highest temperature was obtained as a result to be overlaid on the real image, showing the real image with the varicose vein segment found in the thermal image processing.**

Keywords*—Thermal image; varicose veins; detection; image processing; image segmentation

I. Introduction

Varicose veins are inflamed veins that can be seen under the surface of the skin, majority appears in the legs because it is where it exerts more force to charge the weight of the torso, but are not the only places where varices can manifest. In addition, they can cause mild pain, blood clots, skin sores and itching [1].

According to the WHO (World Health Organization) , varicose veins are superficial, cylindrical or vascular veins and can be caused by many factors such as: sedentary lifestyle, pregnancy, exposure to heat, overweight, wear tight clothes and shoes, etc. [2]. Its main function is to prevent the return of blood to the heart continuously, so the veins of the body tend to degenerate and more if you live sedentary, the most common areas are the legs[1].

According to the WHO, varicose veins are a very common problem that almost 10% of the world population suffers, the rate is higher in women, in addition, the risk of developing varicose veins increases with age, with 35% of active people and increases between 50 to 60% when it comes to a sedentary lifestyle [3].

Varicose veins are classified by grades from I to IV [4], usually begin as an aesthetic problem showing a thin turquoise blue lines, giving the sensation of itching, heaviness and fatigue, then when going up grade, varicose veins can be appreciated in the surface of the skin with small swellings [5] and finally if they are not treated in time or the damaging factors of varicose veins continue to be applied, they can produce ulcers, internal circulation failures and inflammations of large areas in the leg [2].

The detection of suspected varicose veins in the legs early can help prevent further progress, although it is a medical condition that progresses slowly, is aggravated when they are shown superficially, in addition to feeling itching, cramping, etc.[6]; which are some symptoms of early varices. If in the event an early detection and healing process is not followed, the symptoms are ulcers, inflammation and swelling, bleeding from the veins near the skin and finally sensibility in the legs [7].

The main objective of the research work is the detection of suspicions of varicose veins while they are still not shown superficially to indicate that a healing process is required. It is detected through the segmentation of thermal images captured in the legs.

Thermography is a science of the study of temperature variation means that it can be applied where the problem can be revealed through a thermal difference. Currently, there are thermal cameras that connect to Smartphone and are used for areas such as aviation, medicine, construction, electronics, etc [8].

The thermal images show the thermal composition of a body or object depending on the temperature range to which it has been programmed, these images can be processed with image processing software because they are compatible [9]. In addition, the use of these images is useful for the detection of internal pathologies being not superficially visible, that is why it has been used for the detection of suspicions of varicose veins in the legs.

The following research work is structured as follows: In Section II, the image processing methodology for thermal image segmentation will be presented. In Section III, the

[1] https://medlineplus.gov/spanish/ency/article/000203.htm [3]

[2] https://www.aeev.net/varices.php [4]

results will be shown by a thermal image and the segmentation of the varicose vein overlaid on the real image. In Section IV, it will present the discussion of the research work. Finally, in the Section V, it will present the conclusion and a future plan of the research work.

II. Methodology

In this part, each part of the segmentation of the thermal image is developed for the detection of suspicions of varicose veins, which consist of the acquisition of the image, image processing, segmentation of the areas with higher temperature and finally the segmented image overlaid on the real image [10].

The study of the images of the thermal camera was also used in the vascular disorder [11], making a segmentation of the grayscale histogram in the MATLAB program, then the bodies of the histogram will identify the hottest areas, then convert the image to the HSV scale to know the intensity of the image and finally show it separately, the blue being the hottest zones.

The stages of the system are shown in Fig. 1 where the processes by which the thermal image will be subjected:

A. Image Acquisition

For the acquisition of an image, we use the FLIR ONE Pro, it is a camera capable of capturing thermal images, being compatible with IOS and Android mobile devices. It has a thermal sensor that will help to sectorize the temperature levels of the object being pointed. This device has two lenses as shown in Fig. 2, the upper lens captures the images and the lower lens captures the thermal images. In addition, the C to Micro USB connector converter is shown because an Android device was used to capture the thermal images [12].

Table I shows the operating characteristics of the FLIR ONE PRO [13].

The FLIR ONE Pro is a device capable of analyzing and visualizing at a distance the temperature distribution of complete surfaces, it was born as an idea for industrial areas due to the complexity of the detection of equipment failures, currently used in the field of the detection of problems not only of equipment but also of human bodies.

B. Image Processing

In this stage, the thermal image is in 3 dimensions Fig. 3(b), so, using the MATLAB program, we convert it to gray scale.

The software makes a averaged sum by taking the values of each pixel of the image of each dimension and multiplying with a normed value as shown below:

$$0.2989 * R + 0.5870 * G + 0.114 * B \quad (1)$$

Then, there is the histogram of the image Fig. 3(c), identifying the segments of the thermal image, to observe the histogram, we use the following code:

$$imhist(thermal\_image\_gray)$$

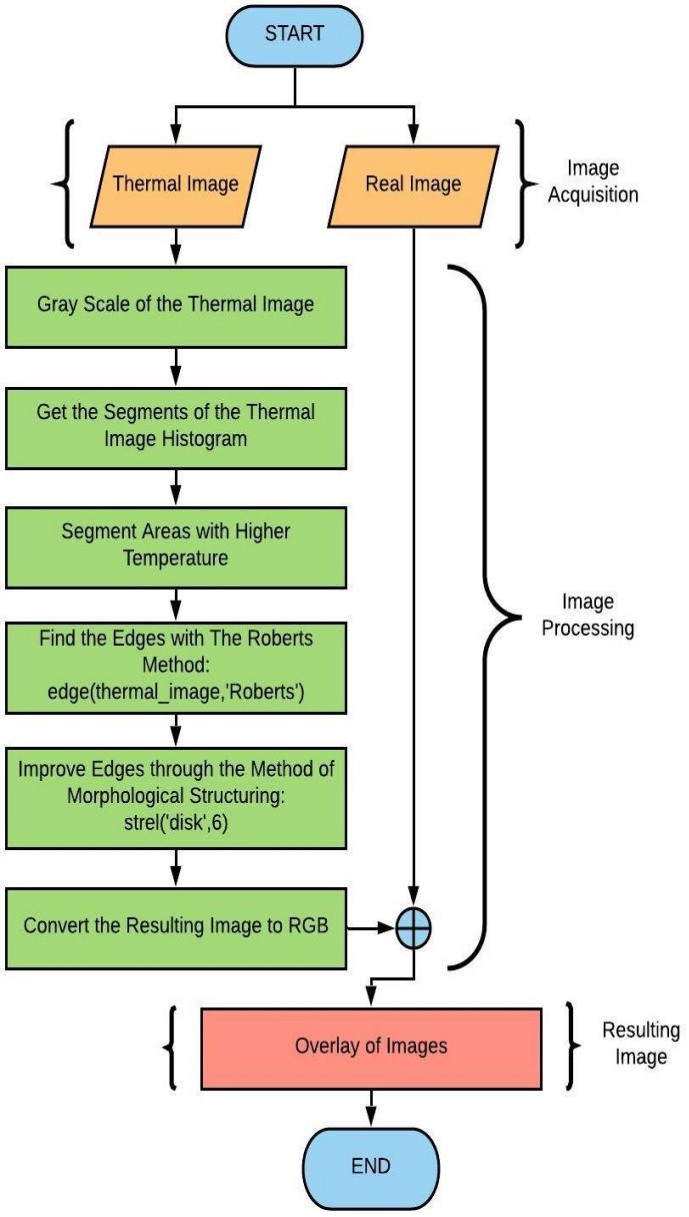

Fig. 1. Process Flow Diagram for the Detection of Suspected Varicose Veins in the Legs.

Fig. 2. FLIR ONE Pro Thermal Camera and Type C to Micro USB Connector Adapter.

TABLE I. CHARACTERISTICS OF THE FLIR ONE PRO

FLIR ONE Pro	
Temperature Range	-20 °C – 400 °C
Compatibility	IOS and Android Devices
Distance	Functional Distance l to 1.8 meters
Weight	36.5 g.
Dimensions	68 x 34 x 14 millimeters
Thermal Resolution	160 x 120
Operating Time	1 hora

Each segment obtained from the histogram is to identify the peaks that can be considered as identifiable objects in the image. After identifying the segments, they will be overlaid to obtain the hottest zone of the image Fig. 3(d).

Next, finding the edges of the hottest zone, for that case, the Roberts Method was used, this method was chosen because it can easily identify the diagonal edges, besides filling that space Fig. 3(e). Roberts' method uses a filter that focuses on each pixel through the following formula:

$$\frac{df}{dx} = f(x+1, y) - f(x, y) \quad (2)$$

$$\frac{df}{dy} = f(x, y+1) - f(x, y)$$

Where to locate the pixel (x, y) that is in gray scale within the range of 0 to 255, if the areas have a constant intensity, will turn them into 0, thus giving the edges where the varicose vein is drawn.

The next step is to improve this segmentation because when going through the Roberts Method, segmentation will always be obtained with noise. To improve the edges, we will use the Morphological Structure Method, its formula is shown below:

$$\delta_B(X) = X \oplus B = \{x | X \cap B_x \neq \emptyset\} \quad (3)$$

Where it is indicated that X will travel through the whole image, when it passes through B, it will provide information about the data of the neighbors of that pixel, converting it to the maximum value of the environment of that neighborhood defined by the element of the structure [14]. The values that are around each pixel are called neighborhood. Then when the pixel has a neighborhood of values different from it, it will take the maximum value of that neighborhood; thus, improving the edges of the varicose vein.

Finally, fill in the border of a transparent color to overlay the segmented image of the varicose veins and the real image. Fig. 3(f), the whole process is shown in Fig. 3.

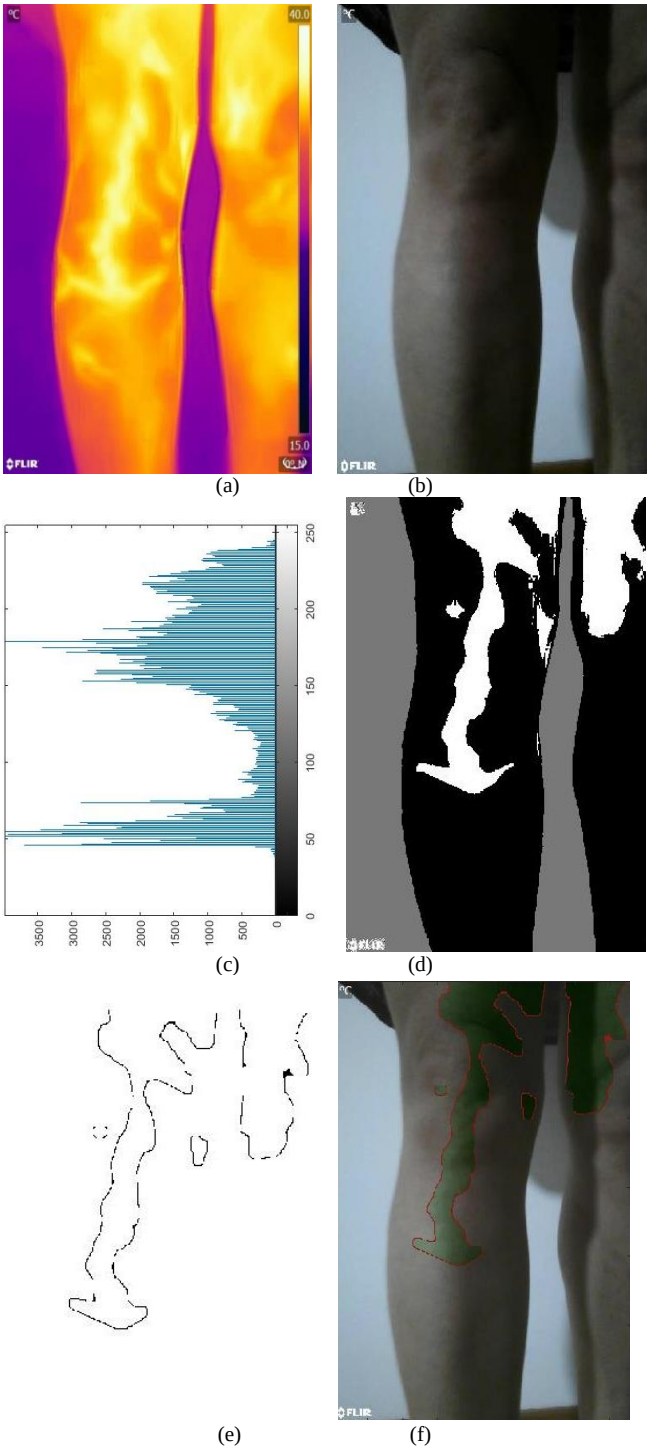

Fig. 3. Varicose Veins Segmentation. (a) Real Image of the Tibial. (b) Thermal Image of the Real Image captured by the FLIR ONE PRO. (c) Histogram of the Gray Scale Thermal Imaging. (d) Union of the Segments of the Image Histogram. (e) Identification of Edges with the Roberts Method. (f) Superpose the Segmented Varicose Vein to the Real Image.

III. Results

The thermal images were acquired based on a protocol because all the images are required to have the same characteristics and therefore the same processing. In Table II, the characteristics of the thermal images are presented:

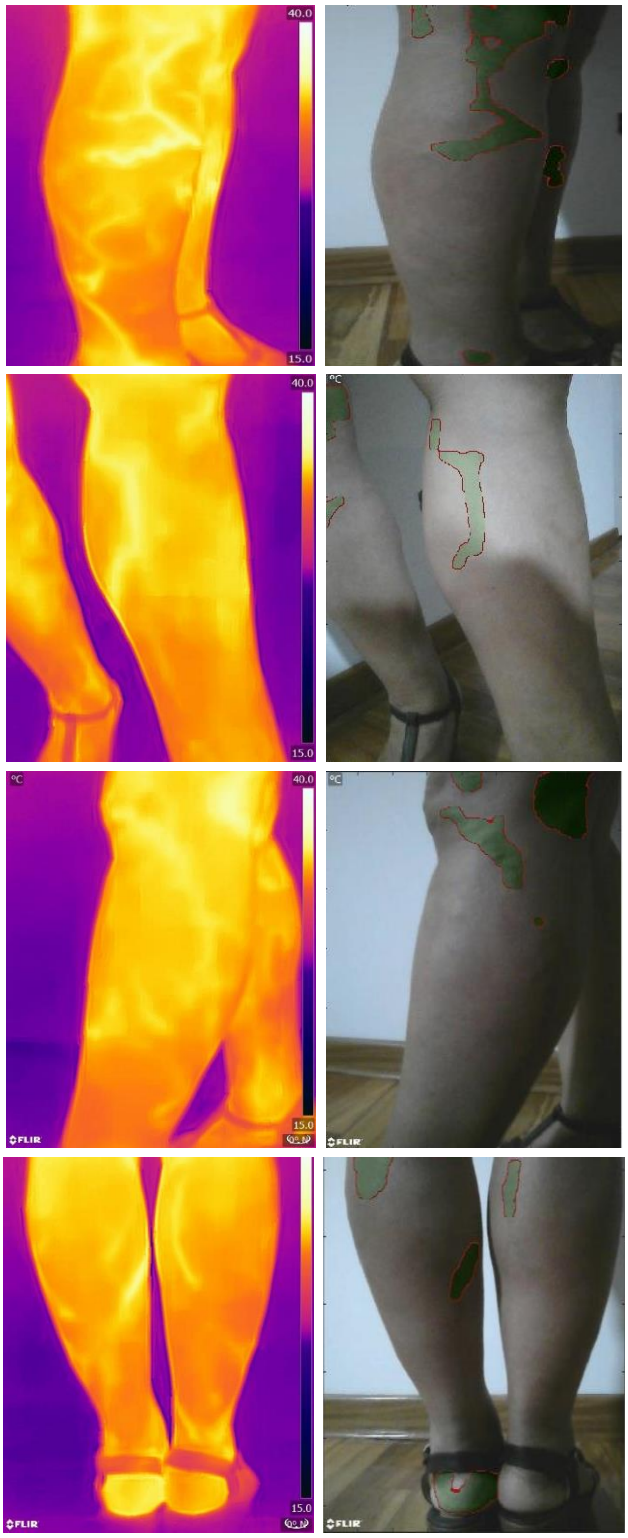

Fig. 4. Thermal Imaging and Segmentation of the Varicose Vein Overlaid on the Real Image.

Fig. 5. Characteristics of Thermal Mages

Thermal Images	
Distance	30 cm
Temperature Range	15 °C – 40 °C
Connected Device	Moto G Play
Place where the Image was captured	-Tibialis Anterior. -Tibialis. -Soleus.
Rest Time	15 to 20 minutes of rest.

Not all varicose veins are shown superficially [15], because with the thermal image a better visualization of the involved areas of varicose was obtained. In addition, the difference in temperature between zones without any problem and varicose veins is confirmed. Fig. 4 shows the thermal image and the segmentation of the varicose overlaid on the real image of the user's leg.

In the research work [16], using thermal imaging to find varicose validating the use of thermography in the diagnosis of a venous thrombosis, indicating the area where is seen more red because there is a higher temperature variation in those points. They also indicated that the varicose vein detection process took a period of 3 weeks to find out if varicose veins were seen in that area, thus ruling out recurrent muscle warmth in the legs. Also, they used an ultrasound to reconstruct an image based on temperature, which is why they show thermal images.

IV. Discussion

The research work confirms the use of thermal images for the detection of suspicion of varicose veins due to the variation of temperature in the legs. In addition, not all varicose veins are visible on the surface of the skin, the majority is always internal.

The device to which the FLIR ONE Pro will connect is not important because it will only use as an image buffer since the FLIR ONE Pro has no internal storage. Therefore, it is only required that it is a Smartphone and has a C or Micro USB input; in addition to having the APP of the FLIR ONE Pro to capture the thermal images.

For the image processing, the real image and the thermal image were required because it was necessary to superimpose the segmented area of the varicose veins to the real image at the end of the process.

The resting time was very variable due to the fact that the legs were on the floor and did not stay static because there was always movement, being indicative of abnormal warming that may arise in the leg that is why the segmentation of the histogram was followed of the image looking for the hottest areas.

V. Conclusions

It is concluded that varicose veins can be detected through thermal imaging in an efficient and fast way because only the

images need to be captured and then the software will automatically segment it, obtaining the area where the varicose vein is located in addition to the size of the varicose vein.

It is concluded that a protocol was established because it was adjusted to the size of the user's leg in addition to having the same characteristics for each image and calibrate the FLIR ONE Pro in the required temperature range.

As a future work, we want to measure the depth of the varicose veins because if the varicose vein is very deep, it is an indication that it does not need to be superficial to be serious. In addition, not only to analyze varicose veins, also another type of pathology that can be identified through the temperature difference.

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