Low-cost Noninvasive infrared thermal imaging system in the detection of Body injury

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Abstract— **Breast cancer is the most common cancer in women worldwide. The timely detection allows a survival of more than 5 years in most patients. This paper presents a Low-cost Noninvasive infrared thermal imaging system in that can be used to validate a potential damage not visible or in close future included in primary care for the detection of breast cancer. Thermography is one of the most recent noninvasive alternatives indicated to identify possible lesions that could indicate the early detection of breast abnormalities. In this work, a low-cost device is implemented using the measurement of infrared radiation by means of a thermal camera (thermography). The data obtained allowed to appreciate both qualitatively and quantitatively the presentation of anomalies.**

Keywords— Biomarker, Breast thermography, contactless, early detection

I. Introduction

Breast cancer is the most common cancer in women. It is estimated that worldwide more than half a million women died in 2011 due to breast cancer [1]. Breast cancer is a malignant tumor that originates in the cells of the breast, understood as a malignant tumor a group of cells that grow in a disordered and independent way, which tends to invade surrounding tissues, as well as distant organs (Metastasis) The timely detection, allows a survival of more than 5 years in the majority of patients [2]. Globally it is the second most frequent neoplasm in the population and the most frequent among the women with an estimated 1.67 million new cases diagnosed annually, representing 25% of the cases of cancer in women. The trend of mortality is rising due to a higher incidence of disease, population aging and poor response capacity of health systems in underdeveloped countries [3,4].

Thermography is one of the most recent noninvasive alternatives indicated to identify possible lesions that could indicate the early detection of breast abnormalities, has a great potential to detect early breast cancer, up to ten years before other techniques, able to differentiate lesions Benign of the malignant [5, 6, 7, 8, 9, 10].

Thermography is a technique that allows to calculate and determine temperatures at a distance, with accuracy and without need of physical contact with the object to be studied, in image each pixel corresponds with a measurement value of the radiation; with a temperature value. This image can be defined as radiometric. It is based on detecting the temperature of bodies and applies to many areas such as civil and military industry, agronomists, medicine and psychology. Its origin dates back to the early nineteenth century when attempting to apply to the measurement of heat transfer, this technique is capable of producing a visible image resulting from invisible infrared light (for the human eye) emitted by objects [11,12].

The most common methods for this purpose are [4]:

- Statistical Methods: Techniques that describe the textures of the regions in the image through the higher-order statistical moments based on the histogram of intensities.
- Structural Methods: These are techniques that describe the textures of the composition of well-defined texture elements, such as regularly spaced parallel lines, or concatenations of known geometric shapes.
- Model-Based Methods: They are characterized by the construction of an empirical model of each pixel of the image based on a weighted sum of the intensities of the pixels in the vicinity of the first. They are used as descriptors of the characteristics of the texture.
- Transform-Based Methods: Based on Wavelets transforms, Gabor transform, Fourier transform, Principal components extraction, Curvelet, etc., to obtain such characteristics. In general, all these techniques attempt to automatically find features that describe the possible asymmetries between the regions of interest (ROI) of the breast.

Infrared radiation (IR) is a region of the electromagnetic spectrum whose wavelength ranges from 0.78 µm to 1000 µm, limits the red color in the visible area of the spectrum and with microwaves. Physics allows the measurement of infrared radiation to be converted into temperature measurement by measuring the radiation emitted in the infrared portion of the electromagnetic spectrum from the surface of the object, converting these measurements into electrical signals. This allows us to measure the radiant energy emitted by objects and, consequently, to determine the temperature of the surface at a distance, in real time and without contact [13,14].

Thermal radiation is a type of radiation that is transmitted in the form of heat. This radiation extends from the wavelengths corresponding to Ultraviolet (UV) to Infrared (IR). Any material that is above absolute zero (0 Kelvin) emits thermal radiation continuously and with an intensity determined by the temperature of the subject matter [13,14]. E range of interest is 1 µm - 15 µm (SWIR, MWIR, LWIR) [15].

Infrared thermography is a technique that allows, at a distance and without any contact, to measure and visualize surface temperatures with precision. Physics allows converting infrared radiation measurements into temperature measurements, this is achieved by measuring the radiation emitted in the infrared portion of the electromagnetic spectrum from the surface of the object, converting these measurements into electrical signals. Human eyes are not sensitive to the infrared radiation emitted by an object, but thermographic or thermovision cameras are capable of measuring energy with infrared sensors, trained to "see" at these wavelengths.

It is based on the hypothesis that the increase in temperature is due to a transitory regulation by the hypothalamic regulatory center, which functions adequately as a protector and the increase in temperature is considered an organic response to possible damage

II. METHODOLOGY

Records were made in a controlled environment at constant temperature. To test the correct calibration of the sensor we opted to do tissue damage to the arm and measured the variation.

The images obtained were under follows conditions. Temperature controlled: 24 ° C with 10 young man (18-25 years), matrix data: 30x30 (2.6cm x 2.6cm), calibration time: 2 min. Scan time: 8 minutes acclimatization time: 20 minutes. Total time 30 minutes.

Implementation of this system consists of hardware and software represented by the following flow chart:

a) Embedded system: is a low cost electronic system designed to perform functions in real time, as the case may be. The system used is this Arduino implementation consisting of a microprocessor and a development environment (IDE), where each system is programmed (14 digital input / output pins, 6 analog inputs, USB connection). The growth of the use of these systems is exponential given its size, cost and reliability of data transfer (https://www.arduino.cc/).

b) Infrared sensor: it is an opto electronic device capable of measuring the infrared electromagnetic radiation of the bodies in their field of vision, as mentioned above, all bodies emit a certain amount of radiation, the one used for this purpose is the MLX90614 of Low noise, 17-bit ADC and powerful DSP unit, achieving high accuracy and resolution of the thermometer (https://www.melexis.com/en/product/MLX90614/). this type of sensor allowed us to achieve the objective of the reconstruction of a thermal image pixel by pixel taking 900 measurements with the help of a structure and servos that allowed the scanning or mapping of the image degree by pixel degree by pixel to be analyzed.

c) Servo Motor is an electric motor that controlling its speed and a specific position (Angle) will help us to scan the surface and obtain the signal sought.

d) Graphic interface. Communication with the embedded system and graphical interface were programmed under the MatLab platform (https://www.mathworks.com/).

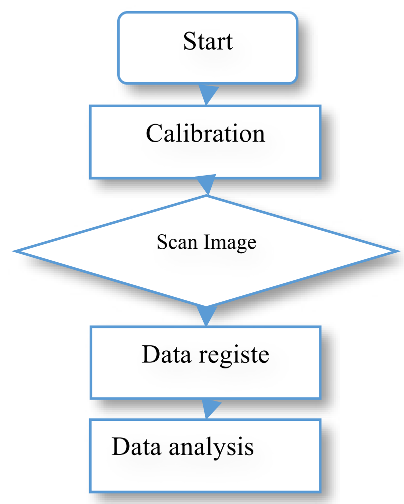


Figure 1 General flow diagram of the process

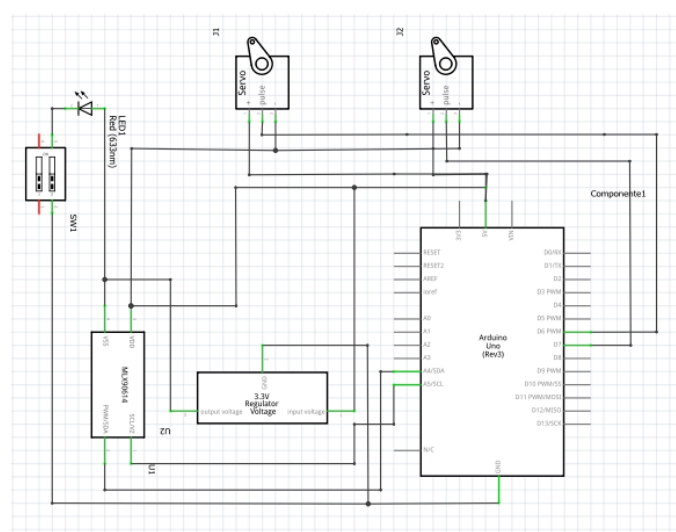


Figure 2 General circuit configuration

System was designed and implemented based on servomotors to control the movement of the sensor with the embedded system, the relevant libraries were adapted to the interface to show image reconstruction pixel by pixel with the temperature values

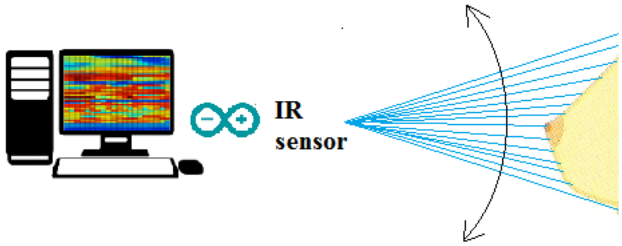
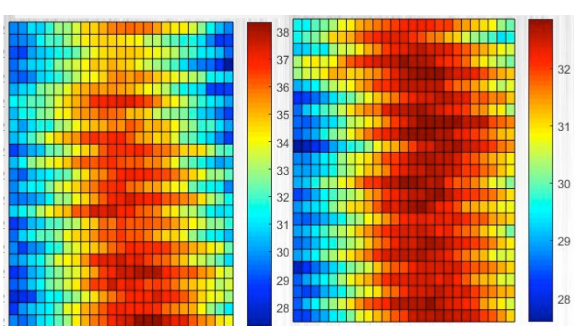


Figure 3 Block diagram

The MLX90614 is factory calibrated over a wide range of temperatures: -40 to 85 ° C for room temperature and -70 to 382 ° C for object temperature. The standard accuracy is 0.5 ° C which makes it very useful in the realization of the project. The size of the matrix in this case was 30x30. The system was calibrated in a temperature-controlled area with tests of 20 minutes duration at a constant distance.

III. RESULTS

Figure 4 & Figure 5 shows the results of a scanning infrared device was used to obtain skin temperature patterns of 10 asymptomatic man to which are generated for the purpose of investigation a slight tissue damage with the tearing of a fingernail. The camera output was digitized "on-line" and stored on digital device (data base computer). Temperature patterns were then extracted using a high-speed general purpose computer. The thermal images were obtained under carefully controlled conditions of temperature and air flow. The room temperature was 24 ° C plus or minus 0. 2 C and the patients were equilibrated 20 minutes. The resulting thermal data may be used in different issues as damage tissue or the basis for the study of absolute temperature thermography in the detection of breast cancer.



A) Basal B) Tissue Damage

Figure 4 Comparative image

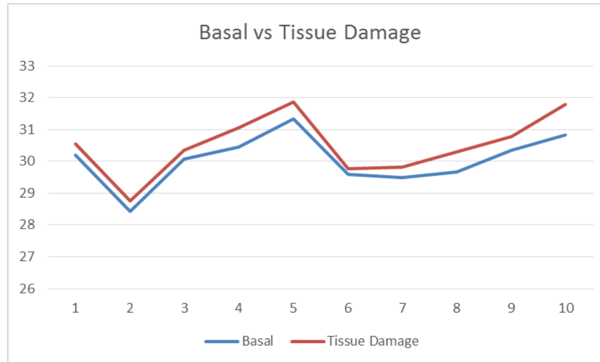


Figure 5 Comparative image data

TABLE 1 BASAL TEMPERTURE VERSUS TISSUE DAMAGE TEMPERATURE

Basal	Tissue damage	+/-
30.00	30.57	0.47

IV. CONCLUSION

In any disease, there is a present and perhaps non-perceptible temperature change, in this role that thermography provides it's most practical benefit to the general public and to the medical profession. In fact, in breast cancer thermography has the ability to identify patients at the highest risk and actually increase the effective usage of mammographic imaging procedures.

Thermography, with its non-radiation, non-contact and low-cost basis has been clearly demonstrated to be a valuable and safe early biomarker, and an excellent case management tool for the ongoing monitoring and treatment of disease when used under carefully controlled clinical protocols.

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