

THE ADVANCEMENT OF THERMAL SCIENCE AND ITS CONTRIBUITION TO MEDICINE: MATHEMATICAL METHOD PROPOSED FOR THE INTERPRETATION OF INFRARED.

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Abstract. *This paper presents such as thermography, a noninvasive method, has aided in the diagnosis of tumors in symmetrical regions of the body. The objective of this work is to standardize a technique to diagnose tumors in symmetrical regions of the human body using the conjugate gradient method proposed by Vargas (2010). The use of a standard methodology for the analysis of infrared imaging seeks to eliminate the dependence of the temperature data and the patient's body at the time of measurement.*

Keywords*: thermometry, infrared imaging, breast câncer and temperature.*

1. NOMENCLATURE

ΔT	*temperature variation*
θ	*dimensionless temperature*
W	*radiant energy flow*
T_∞	*room temperature*
T_b	*core temperature*
ε	*emissivity*
$\Delta\theta$	*affected region*
θ_{lesion}	*tumor area*
$\theta_{\substack{symmetric \\ region}}$	*normal symmetric region*
σ	*Stefan-Boltzmann Constant*
T4	*fourth power of its absolute temperature*

2. INTRODUCTION

Breast cancer affects one in every eight women in the United States and issecond in cause of cancer death, followed by the lung tumor. Randomized controlled trials and large scale have shown that periodic screening for early detection of breast cancer has reduced its mortality (KENNEDY et al., 2009; OMS, 2010; WISHART et al., 2010). Currently, self-examination and regular mammograms after age 40 are themost effective techniques for the detection of breast cancer (ACS, 2011; NCI, 2010). Mammography, the gold standard in tracking mode, reveals small and hidden malignant lesions in asymptomatic women, ie, at an early stage, producing a more favorable prognosis than the self-examination (WISHART et al., 2010; MAITRA e BANDYOPADHYAY, 2010).

All objects having a temperature above absolute zero (-273 K) emit infrared radiation in proportion to its temperature, including the human body, especially in the long infrared spectrum (BRIOSCHI *et al.*, 2007).

The infrared thermography is a complementary test still image emerging diagnostic, monitoring and prognosis in medicine. However, a field is well established and routine use in engineering. The main reason for this contrast is the lack of accurate methods for clinical use to associate the temperature readings of the skin to abnormal physiological phenomena, since the temperature of the exposed body surface is highly dependent upon environmental conditions and metabolism of the individual. Thus, one way to normalize the temperature readings for any location, ie,independent of environmental conditions and the individual's body temperature, can be very useful in clinical practice (BRIOSCHI, 2011).

Like any diagnostic method requires a minimum standards that must be followed for its realization (BRIOSCHI *et al.* 2003). Santos *et al.* (2009) noted the applicability of the use of thermography for early detectionof breast cancer, with a computer program to automate various analyzes quickly and organized. It was possible to make comparisons among temperatures but still has some limitations such as spherical model of the tumor, and still does not perform simulations of tumors adherent to the wall of the breast.

3. MEHODOLOGY STANDARDS

When considering the influence of environmental conditions and metabolism of the patient in an examination of thermometry seeks to develop a methodology for standardization of temperature readings on the body surface. Evaluation was done using the average temperature of the thermal data of the region of interest and these parameters are normalized in relation to the body core temperature according to the method proposed by Vargas *et al.*, 2009.

Through analysis of conjugate gradient was analyzed the difference in temperature standard (ΔT or asymmetry parameter) relative to the symmetric side.

3.1 Acquisition of images

The images were obtained from a camera sensor ThermaCAM T400 (FLIR Systems Inc) with 76,800 pixels which operates in the spectral range of electromagnetic waves corresponding to the long infrared (FIR) to study at -20 ° C to 350 ° C. The resolution thermal camera used is 0.05 ° C and precision temperature reported by the manufacturer is ± 1 ° C.

3.2 The exam to obtain thermographic images

For the exams, the patients stayed for 15 minutes in a room at 23 ± 0.5 ° C in the standing position, naked and barefoot for the whole body during the time of thermal balance in rubberized floor for adequate stabilization of body temperature. Was measured at room temperature and tympanic temperature average patient.

3.2.1Group of study

This study participated in the control group 104 healthy volunteers aged17-72 years. The group with diseases included 900 patients among which 35 cases had breast cancer, the focus of this work. All patients and healthy volunteers and disease signed consent of the Ethics Committee of the Hospital of UFPR.

3.3 A mathematical model for definition of dimensionless variable

The Stefan-Boltzmann Law defines the relationship between the radiated energy and temperature by stating that the amount of radiation emitted by an object is directly proportional to its area according to equation (1), where W is the flow of radiant energy emitted by a surface area, W/cm^2, and emissivity, 0.978, σ (Stefan-Boltzman Constant), 5,673.10^{-12} Watts.K.cm^{-2}, and T the absolute temperature of the skin, K. The total energy emitted by an object per unit time is directly proportional to the area of the object, the emissivity and the fourth power (T4) to its absolute temperature. This coverage allows one to make measurements of temperature from measurements of energy emitted.

To correct errors from the local temperature environment and the patient's own metabolism in medical thermography used the method published by Vargas (2009) in which makes use of normalized values of dimension less temperature, ranging between 0 and 1. Begin 0 when the temperature (θ) is equal to the environment (T_∞), and 1 when equal to a core temperature (T_b), as shown in equation (2), where T is the temperature of the skin surface, T_b core temperature and room temperature (in degrees Celsius)

$$W = \varepsilon \sigma T4 \tag{1}$$

$$\theta = \frac{T - T_\infty}{T_b - T_\infty} \tag{2}$$

By setting a nondimensional variable (θ) which combines the local temperature measured with the temperature of the body and the environment is important to normalize the temperature, independent of the units of measurement of body temperature or ambient temperature (Vargas *et al.* 2009 .)

Regions affected by breast tumor was identified as the magnitude of the lesion region subtracted from the symmetrical region, as shown in equation (3).

$$\Delta\theta = \left|\theta_{lesion} - \theta_{\substack{symmetric \\ region}}\right| \tag{3}$$

4. RESULTS

For each area $\theta(x, y)$, it was necessary to compute the value of adimension normal reference temperature. In this work we determined the values of areas of the diseases most commonly evaluated in clinical examination of thermography.

In patients with normal breast symmetry is remarkable that the great show. The Fig.1 shows a thermogram of a patient with breast cancer in an area wherethe symmetric region can be identified. The region affected by breast cancer was considered a circle 10 to 14 cm.

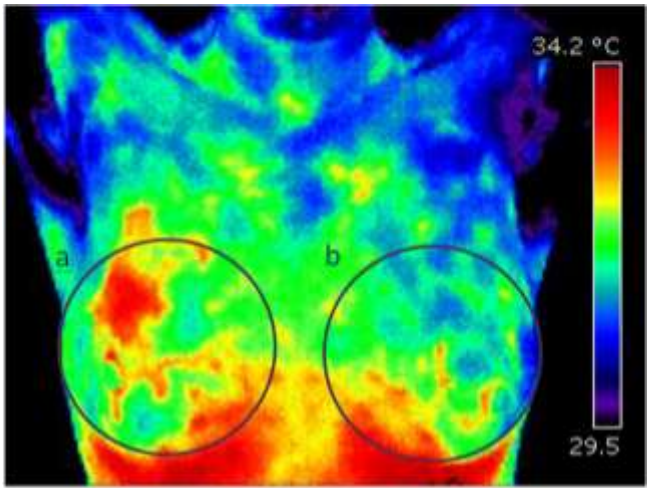

Figure 1.Thermogram of a patient with breast cancer. 1a: the affected breast, 2a:symmetric region unaffected.

The thermogram represents a case of malignant tumors of breast and the right breast $\overline{\theta}_{medium}$ entire right is 0.890 while for the left breast is 0.730, and the breast $\overline{\theta} \pm 2\sigma$ of the breast is ± 0.736. Differences above 0.014 are not considered normal.

In the group of 24 patients with malignant tumors of breast dimensionless value of temperature normalized average of 0.89 ± 0.05 and 0.79 ± 0.05 benign tumors, as shown in Figure 2.

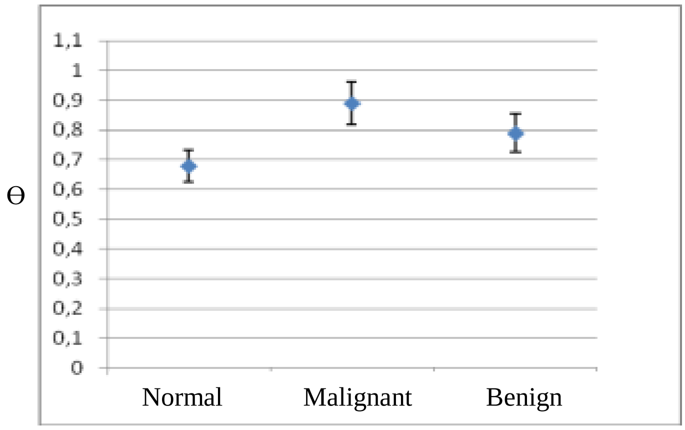

Figure 2. Dimensionless temperature normalized mean whole breast of the normal control group in the group with malignant and benign tumors.

5. CONCLUSION

The dimensionless θ method used in engineering to take into account the core temperature of the human body and the environment in place of the examination was feasible in the identification of values that have abnormalities. This method combined with conjugate gradient method was able to identify by means of infrared images of groups of groups with healthy breast tumors.

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7. REFERENCES

Brioschi, M. L.; 2011. Metodologia de normalização de análise do campo de temperaturas em imagem infravermelha humana. Dr, tese, Univesidae Federal do Paraná, Curitiba, PR, Brasil.

Vargas, J.V.C.; Brioschi, M. L.; Dias, F. G.; Parolin, M. B.; Mulinari-Brenner, F. A.; Ordonez, J. C.; Colman, D. Normalized methodology for medical infrared imaging, Infrared Physics & Technology, New York, v.52, p. 42-47, 2009.

Brioschi, M. L.; Macedo, J. F.; Macedo, R. A. C. Termometria cutânea: novos conceitos. J Vasc Br. 2:151-60, 2003.

Brioschi, M. L.; Yeng, L. T.; Teixeira, M. J. Diagnóstico avançado em dor por imagem infravermelha e outras aplicações. Prática hospitalar. 50: 93-98, 2007.

Santos, L. C. Bezerra, L. A. Rolim, T. L. Araújo, M. C.; Silva, E. D. C.; Conci, A.; Lira, P. R. M. Lima, R. C. F. Desenvolvimento de ferramenta computacional para análise paramétrica da influência da posição e do tamanho de um tumor de mama em perfis de temperatura. 9º Congreso Iberoamericano de Ingeniería Mecánica (CIBIM), 2009.

Kennedy, D. A.; Lee, T.; Seely, D. A comparative review of thermography as a breast cancer screening technique. Vol.8. pág: 8-16, 2009

OMS – Organização Mundial de Saúde, 2010.

Wishart, G. C.; Campisi, M.; Boswell, M.; Chapman, D.; Shackleton, V.; Iddles, S.; Hallett, A.; Britton, P. D. The accuracy of digital infrered imaging for brast cancer detection in womwn undergoing breast biopsy. EJSO. Vol. 36. Pág. 535 – 540, 2010.

ACS - American Cancer Society – Breast Cancer Guidelines and Statistics, 2011.

NCI – National Cancer Institute at the National Institutes of health, 2010. Disponível em http://www.cancer.gov/cancertopics/factsheet/detection/mammograms. Acesso em 01/04/2012.

Maitra, I. K.; Bandyopadhyay, S. K. Digital imaging in mammography towards detection and analysis of human breast cancer. Casct. Pag. 29 – 34, 2010.

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