Software for Early Cancer Detection Using Microwave Breast Images

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***Abstract* - Microwave detection of the abnormally developing tissue structure is a new noninvasive technique, using human body emission radiometry. The research is discussing practical aspects of implementing this type of early breast cancer detection. A special software have been implemented in order to map the measured values and to constitute a microwave image data base. The patient anamnesis is stored together with the images at each stage of the medical diagnosis and survey.**

I. Introduction

Breast cancer incidence continues to grow nowadays, due to iatrogenic factors, genetic, stress or environmental conditions. its early detection is important in order to reduce the mortality and the therapy side effects. Constant survey of the atypical structures growing rate or neoplasm evolution is a must, considering the fact that breast cancer is the most osteophil malignancy [1]. Non-invasive new techniques are therefore welcomed.

The present implementation is using thermo graphic information, in the microwave range, taking into consideration the fact that the accelerated rate of tissue growth is usually the sign of a possible malignity [2].

II. Measurement and Experimental Results

This approach develops the basic principles of microwave thermography [3]÷[8], the measuring technique for biologic structures radiation, using microwave receivers for very low emission in the domain 1-10 GHz.

Our previous works have already studied diverse aspects of the microwave thermography [9]÷[12] and medical image processing [13]÷[16] for cancer detection.

The research was directed towards the breast tissue due to its electromagnetic and biologic homogeneity, relative uniformity and almost regular spatial geometry.

This paper mainly presents the software designed for the breast thermo graphic map implementation.

A radiometer, realized on a Dicke' similar schema, was used in the practical approach, in order to detect tumor tissues abnormally developing inside the breast structures.

The measuring technique resides in applying a skin-contact dielectric antenna and in measuring the electromagnetic radiation level in seconds over a specified time interval. The measured value constitutes an inner temperature indicia showing up the breast structure.

The precautions that have to be taken by measures are mainly connected to assuring a quiet/calm electromagnetic environment, without electromagnetic disturbances.

Fig. 1. Shielded room against the spurious microwave signals

The measurements were done in a large dimension shielded room. Both the patient and the installed devices were placed inside.

The systematical measurements were cyclically, alternatively made, applying the antenna of the transducer in the same symmetrical positions on the right and, respectively, on left breast. The values corresponding to temperatures were represented on a diagram as a thermo graphic map.

III. Software for the Medical Data Base

In order to constitute a systematic data base, with personal history and anamnesis, each patient is questioned, data regarding particular information are registered and each exam is accompanied by the relevant microwave images mapped by the system. The graphic representation of the measurement results in different points are displayed by the help of the software application named BCT_Analysis (Breast Cancer Thermography Analysis) that we have designed.

The application BCT_Analysis (Breast Cancer Thermography Analysis) permits the temperature map display for the studied area, but also, the patient anamnesis and registration, hierarchically structuring a data base with the most important disease history indices and relevant images to

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be further compared, during the diagnosis and the treatment survey.

This software represents temperature level curves, thermo graphic images obtained this way being similar with thermograms obtained by infrared images. The difference between these two kinds of thermo-images resides in the depth where we obtain the measurements from.

While the infrared thermography is sensitive to surface temperature (resulted both as effects to inner temperature and from temperatures very close to the surface), the microwaves are giving information on the tissues situated at a few centimeters under the skin.

Even if the image resolution, obtained by microwave thermography is relatively small, the advantages on other means of detection and diagnosis are pertinent.

The resolution in temperature is compatible with that of infrared thermography (0.1 Celsius degrees).

Our previous works considered the results obtained this way and compared them with the results given by a second parallel non-invasive method [10], the two methods reinforcing each other and influencing the expert's opinion in order to make a more confident decision.

This technique difficulties are mainly connected to the use of some components with very low thermal noise, relative to the environment, and the impossibility of antenna sensor cooling which is "on skin-contact." The resolution is also connected to the fact that the difference between the ambient/environment temperature (25°C) and the measured body temperature average (37°C) is relatively small.

The temperature measurement may be accomplished in two ways: by a fix positioning of a fix number of measuring points, or by variable positioning of the measuring points.

In this second case, a correlation is made to the real position of the human body that is examined; therefore a reference system is settled. A raster image was introduced in the process of acquisition, to be superposed to the photo image.

Usually the image normally has a certain degree of symmetry (estimated/computed) as rare parsons have entirely symmetric shapes. Taking into account this degree of person's symmetry will raise the accurate estimation of the process of right/left temperature comparison.

The software, registering the patient anamnesis together with the microwave image acquisition, is realizing a flexible, "user friendly" patient data base.

The application is using an implicit scale, for the temperature values between 32ºC and 35ºC, as in the following images.

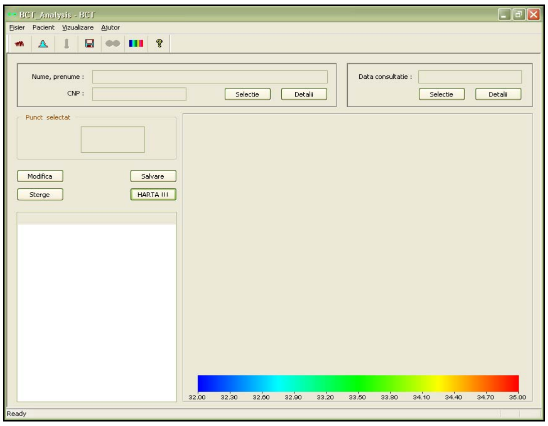

Fig. 2. BCT_Analysis Application – Main menu

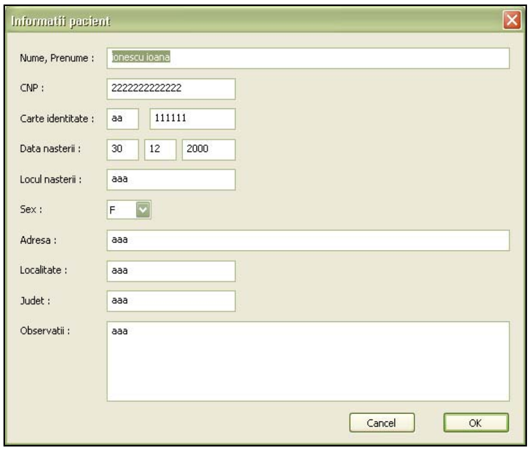

Fig. 3. Dialog window – patient information

In order to acquire the breasts temperature images in the microwave domain, a scale of colors is used in the phase of thermo-graphic map achievement.

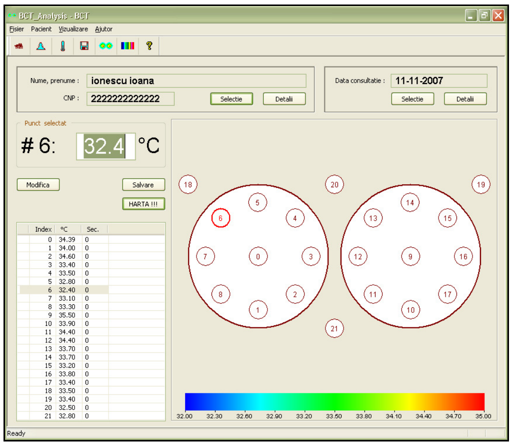

Fig. 4. Application window

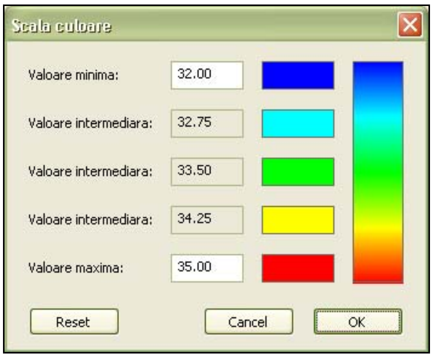

Fig. 5. Color range

We are further focusing on the technique of color display in accordance with the real tissue temperature, radiating more heat reported to the normal situation. The image is initially presenting as Fig. 6. shows.

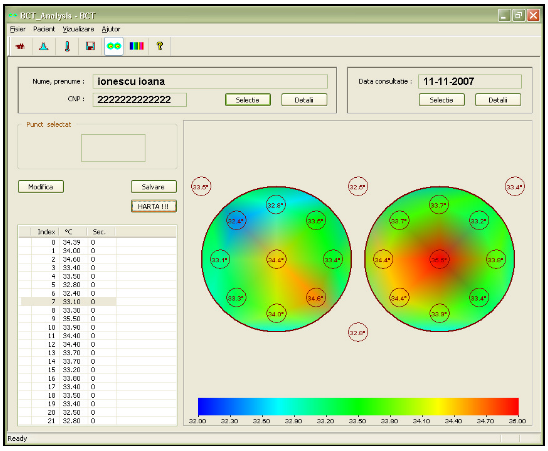

Fig. 6. Breast microwave - temperature map

The functionality and the performances of the model have been demonstrated by comparing the system diagnosis with other usually indicated invasive breast cancer tests (biopsy, scintigraphy, in diagnosis, or tumor markers analysis - when monitoring the treatment response, a. s. o.).

Temperature measurement is done by placing the transducer antenna on the explored surface. The measured value is registered into the computer.

In a first attempt a simple relation is computed for the temperature gradient G(T) measured in Celsius degrees: it is considered as the ratio of the temperature difference between the measuring points, reported to distance Δx between them:

$$G(T^0C) = \Delta T / \Delta x$$

For 8 points situated on a circumference and a central one a schema is briefly represented in Fig. 7.

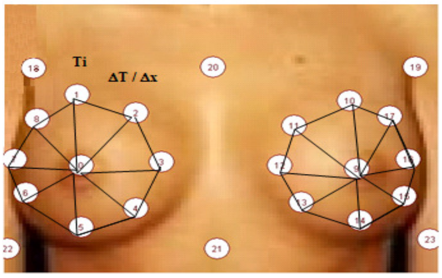

Fig. 7. Schematic representation of the measurement points

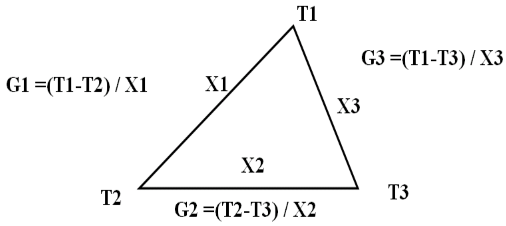

Fig. 8. Temperature gradient determination

A more complex gradient computing, using fuzzy methods was also implemented, subject of a new [17] paper submitted to IPMU 2008 (to appear). This method is taking into account the influences of the other temperature measurement points weighting their influence on a certain computing point.

Using the maximum and the minimum values in the intermediary points instead of the normal summation of the temperature values, better images as Fig. 9. and Fig. 10, are obtained.

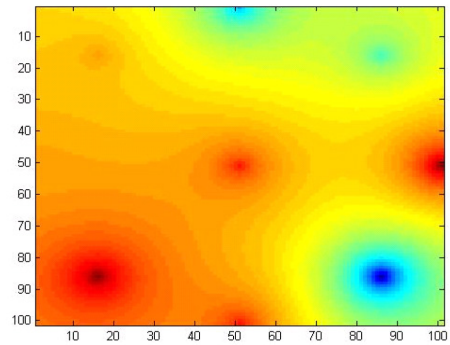

Fig. 9. Frame of microwave temperature-map image

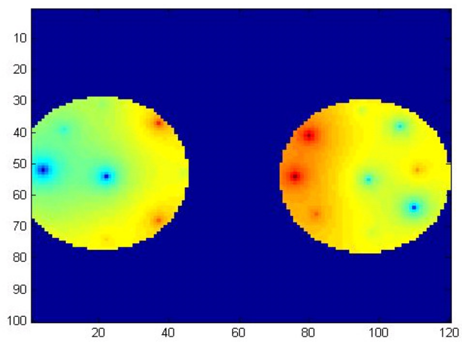

Fig. 10. Microwave breast cancer images

The measurements have been done into the shielded room, specially designed, taking into account the fact that there is a polluting magnetic environment, due to the daily activities and numerous interferences with the communication emitters in the microwave domain (mainly the mobile phones).

In order to permit the formalization of the parameters and to constitute a dedicated rule-base, a semi-supervised automatic decision system is initially used to help both patients and physicians.

IV. Conclusion

In addition to the usual classic methods, a completely noninvasive technique was carried out in the experiments done on human subjects (men and women). The obtained results were confirmed by examinations and clinic diagnosis through the help of ultrasound and infrared thermo-graphic imagistic procedures.

By the software that was implemented in this research, an accurate temperature map for microwave imaging early breast cancer detection was realized: the influence of the wormer points on the other neighbor positions is taken into consideration and an appropriate map of abnormal activity of the cells is plotted.

To situate the microwave emissions of the malignant tissue, the body microwave signals are measured with a special radiometer, the patient being placed in a shielded room.

The microwave range raise some problems of real spatial malignant tissue positioning, limited by the real breast shape partial symmetry that will be further quantized and used in our estimations.

The research is continuing due to the very complex aspects implied and the different new technical challenges and to the fact that non-invasive methods in breast cancer diagnosis are presenting incontestable advantages.

Acknowledgment

This research is an interdisciplinary attempt in order to improve the early breast cancer diagnosis efficiency. The project is conducted under the scientific management of Bioengineering Faculty, Medicine and Pharmacy University, “Gr. T. Popa”, Iaşi, in an Excellence Research Contract, CANCERDET [18].

The study will continue with a systematic survey of the patients in the oncologic clinic to insure the formalization of parameters and a rule-base of a semi-automatic decision system.

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