QUANTITATIVE THERMOGRAPHY IN BREAST CANCER DETECTION – A SURVEY OF CURRENT RESEARCH

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ABSTRACT

Aim of our study is to find new methods of breast thermogram analysis and its classification with respect to breast cancer presence. Semi-automated system based on these methods should be able to perform thermogram pre-selection into groups of positive and negative patients. A survey of current research is presented in this paper.

1 INTRODUCTION

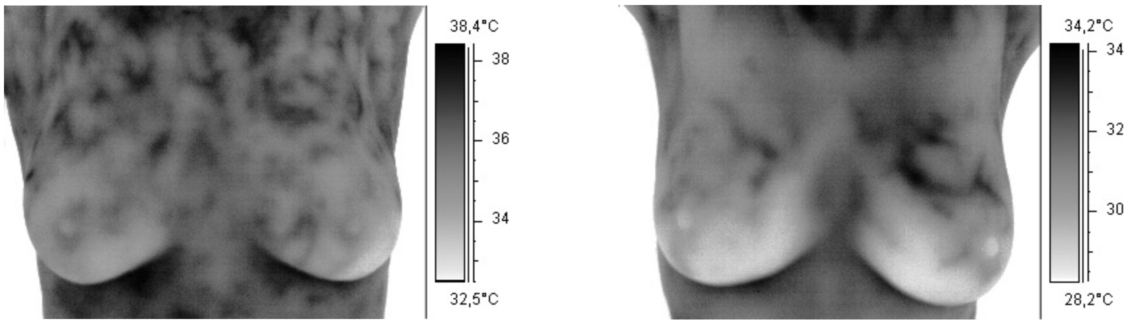
The breast cancer is the second most often cancerous cause of death among women and the second most frequent type of cancer at all. Nevertheless it is proved that early stages of breast cancer are well treatable. That is why the early detection is so important. Our research effort should help to define thermal infrared imaging as a diagnostic tool in early breast cancer detection, which can be used as a complementary modality to traditional X-ray mammography and ultrasonography. There have been performed many studies concerning with thermography in breast cancer detection in 1960s and 1970s. Classification used to be performed intuitively. It resulted in high false positive ratio, but it was proved that increased metabolic activity and vascular neogenesis in breast cancer neighbourhood causes changes in breast surface temperature relief [1]. Thermography is non-invasive and has ability to detect physiological changes caused by early cancer growth. Our approach to thermography application consists in quantitative computer performed analysis and classification of digital thermograms of breasts. This paper summarizes our existing research results.

2 METHODS

The principal task of our research is to define thermo-pathological features and find the feasible image analysing methods to extract them. Differences in vascular pattern and in hot (cold) spots appearance between left and right breast are the most significant thermo-pathological features. It represents symmetry evaluation of pairs of pictures from our point of view (fig. 1).

2.1 EXAMINATION

Each examination consists of three images. Patient sits on a chair and after twenty minutes long equilibration within air-conditioned room one frontal and two slightly lateral pictures are taken. The analysis is performed in the frontal picture. Each thermogram is attended with finding from X-ray mammography or ultrasound. Digital infrared camera FLIR PM575 is used for thermogram acquisition.



a) **b)**

Fig. 1: *Examples of real thermograms; a) thermogram of healthy women; b) thermogram of patient with positive finding in left breast*

2.2 IMAGE PRE-PROCESSING

There are several image pre-processing methods we use. One of the very useful ones is enhancement of edges performed with derivative convolution mask before application of some methods. Second pre-analysing adjustment consists in re-sampling of region of interest (ROI - covering the left and right breast) to polar coordinates. The reason is that most of used analysis methods evaluate symmetry of ROI and some of them need to have the same number of pixels in compared areas. Re-sampling can also coverts symmetry evaluation problem to similarity evaluation (fig. 2).

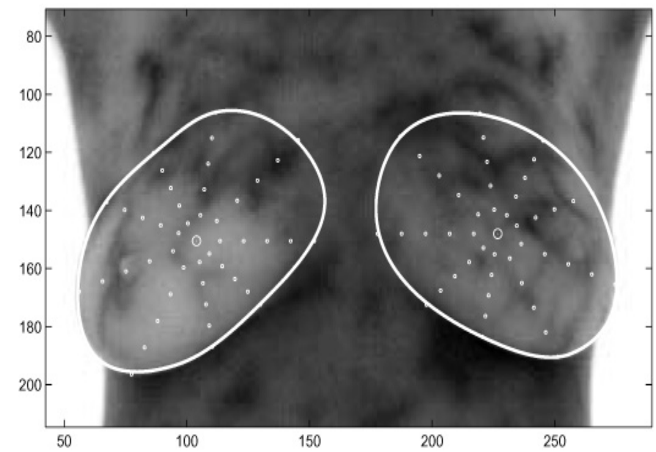


Fig. 2: *Re-sampling to polar coordinates*

2.3 FEATURE EXTRACTION

There are two possible techniques of feature extraction - non-topological (statistical) and topology-based methods. We don't use any pure topological method, but most of used methods combine both approaches. The basic statistical methods, including *histogram* analysis have been tested. The higher hybrid methods we use are based on temperature *co-occurrence matrix*, *Fourier spectrum* analysis, and moment and cluster analysis. Interpretation of the particular features was performed.

2.4 CLASSIFICATION

We have 12 features extracted and selected from the above-mentioned methods. The next step is to classify images into positive and negative classes according these features. It is possible to use each of them individually (see tab. 1, fig. 3), but the aim of classification is combining them to achieve better results.

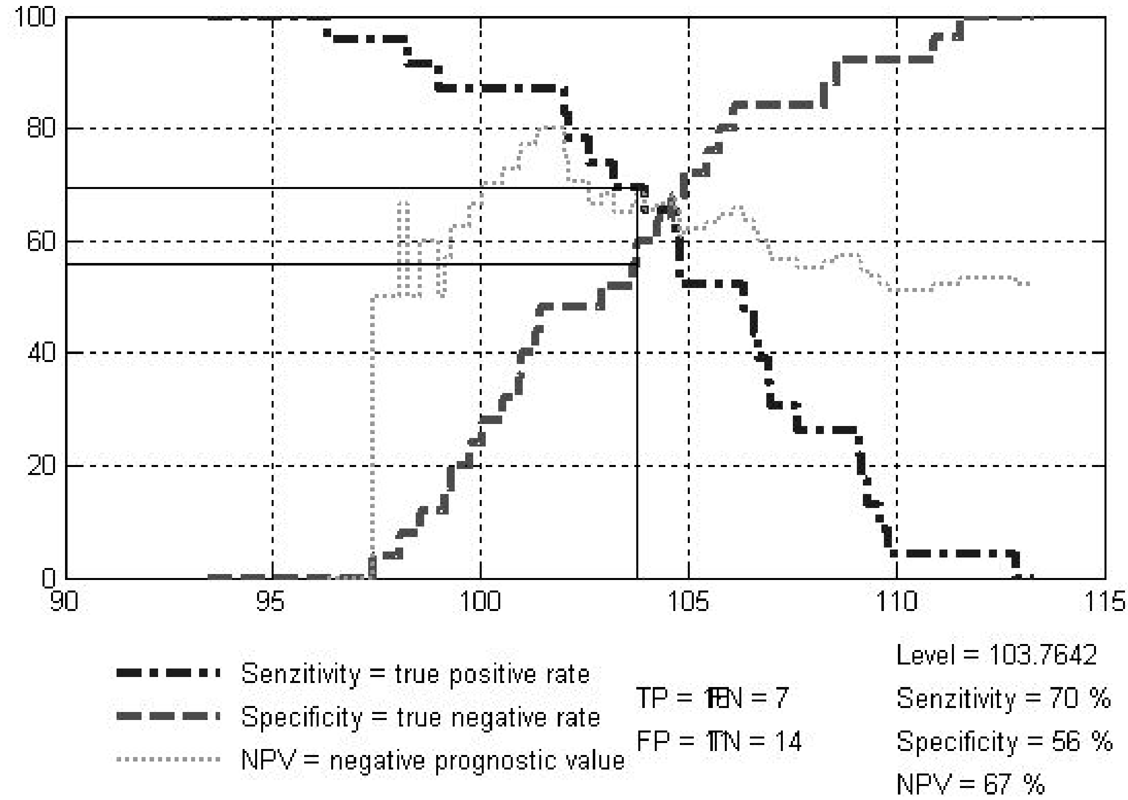


Fig. 3: *Example of statistical parameters of single feature classification computed for various threshold levels (Moment analysis - Larger of moments m_{00} for the left and the right side)*

The features combination was performed by two methods based on average and weighted relative rank, and by so-called optimal weights and reduced optimal weights method inspired by neural networks. Combining the 16 good features we have obtained a set of new combined-features. We can perform the same analysis as with the individual features.

Method	Intersection	Spec90	Senz90
Cross co–occurrence matrix – Homogeneity	67 %	32 %	15 %
Fourier analysis - The distance of maximum of modulus difference	65 %	22 %	0 %
Derivations - Difference of averages	65 %	41 %	26 %
Difference of index 90	64 %	22 %	30 %
Cross co–occurrence matrix - Contrast 1	64 %	32 %	15 %
Sharpen - Difference of averages	61 %	12 %	30 %
Ratio of averages	61 %	12 %	30 %
Polar coordinates - Effective value	61 %	41 %	15 %
Cross co–occurrence matrix - 2nd order axis moment	61 %	41 %	15 %
Laplace - Difference of averages	61 %	19 %	30 %
Difference of averages	61 %	12 %	23 %
Polar coordinates – Maximum value	60 %	24 %	26 %

Tab. 1: *Statistical evaluation of the "Top 12" applied methods*

Modality	Sensitivity	Specificity
X-Ray Mammography	80-90 %	65-85 %
Ultrasonography	70-80 %	60 %
MRI systems	80 %	70 %

Tab. 2: *Statistical parameters of commonly used diagnostic techniques*

3 RESULTS

Mentioned methods of feature extraction and classification were tested on thermogram set, which consists of 140 thermograms. We have 30 thermograms of patients with confirmed breast cancer and 110 thermograms of healthy women in time of this abstract submission. All methods were implemented in easy-to-use MATLAB environment.

The best feature found is *homogeneity* of *cross co-occurrence matrix* with intersection of specificity and sensitivity at 67 %. Combining features together further enhanced the results obtained by individual features - the best of them, *optimal weights*, reached intersection of specificity and sensitivity 79 %, and has 53 % specificity for 90 % sensitivity [2].

4 CONCLUSIONS

The thermogram classification results are comparable with commonly used diagnostic techniques (tab.2). X-Ray mammography, on which is based screening programme in Czech Republic, have a bit better results, but the results are strongly dependent on the radiologist and further, it employs dangerous radiation, which may caused new cancer genesis. Ultrasonography has low spatial resolution, which may be problem in early stage cancer detection. Examination on MRI system is very expansive. For thermography speaks, except the results, its non-invasiveness, low expenses and applicability to young women where mammography fails because of high density of breast tissue.

Our future research will be oriented to obtain significant number of patients and deep analysis of correlation between the mammography, ultrasonography and thermography findings. The main task remains in development of new analysing and classification methods.

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