BREAST CANCER DIAGNOSTICS USING INFRARED CAMERA

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ABSTRACT

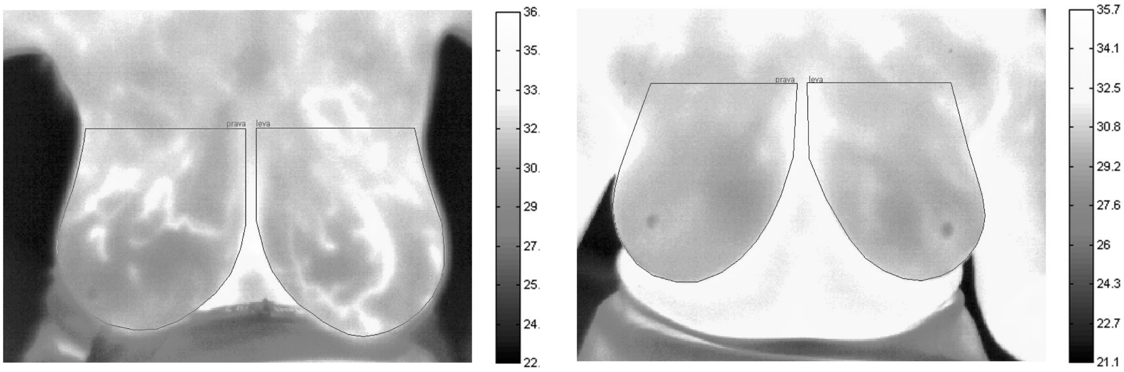
This is a research effort that helps to define thermal infrared imaging as a diagnostic tool in breast cancer detection, which can be used as a complementary modality to traditional mammography. Our approach consists in the non-topological and the hybrid methods of thermal image classification.

1 INTRODUCTION

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 neighborhood causes changes in breast surface temperature relief [1]. This technique is coming back in several last years. The main reason is development of new generation of infrared cameras, which produce digital images. Another significant reason is high computing output of personal computers, which brings new possibilities to digital image processing. Aim of our study is to find new image processing methods, which allow objectively and precisely describe essential thermopathological features. Automated system based on these methods should be able to perform pre-selection into groups of positive and negative thermograms.

2 THERMOGRAMS

We have 12 thermograms of patients with positive finding from RTG or ultrasound mammography and 10 thermograms of healthy women as a control group, now. We use our digital thermocamera FLIR PM575 for data acquisition. 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. We consider the whole breast as a region of interest.



a) b)

Figure 1: Example of real thermograms; a) positive termogram with strong veining on the left breast; b) negative thermogram with both breasts symmetrical without any hot spots or veins.

3 METHODS

Differences in vascular pattern and in hot spots appearance between left and right breast are the most significant thermopathological features. From our point of view it represents symmetry evaluation of pairs of pictures. There are two main techniques. The first is non-topological approach and it is based on using statistical methods, such as histogram of temperatures or some derived properties. The topology-based methods are the second approach. These methods use mathematical description of the basic entities occurred in the thermogram. Of course there are combined (hybrid) methods, which are a hopeful way, too. We are just focused on the hybrid methods.

3.1 SPATIAL CO-OCCURRENCE MATRIX (COM)

This hybrid method uses spatial co-occurrence matrix P(m,n) of temperatures m and n. It is defined (1) for image I, as the number of pairs of pixels having temperature m and n, respectively, and which are in a fixed spatial relationship, as a fixed distance apart or a fixed distance and a fixed angle (fig. 2) [2].

$$P(m,n) = \{((i,j),(k,l)) \in S | I(i,j) = m \quad and \quad I(k,l) = n\} \tag{1}$$

The co-occurrence matrix can be normalized by dividing each entry by sum of all entries in the matrix. These probability matrices can be used for textural feature extraction, with the advantage that they are not affected by changes in the temperature histogram of a thermogram, only by changes in the topological relationships of temperatures within the image. We can consider the veining of breasts to be some kind of macrotexture and use this method for its classification.

Figure 1 shows an example of thermogram of patient with positive breast cancer diagnosis. There is evident increased number of veins in her left breast (compare with the

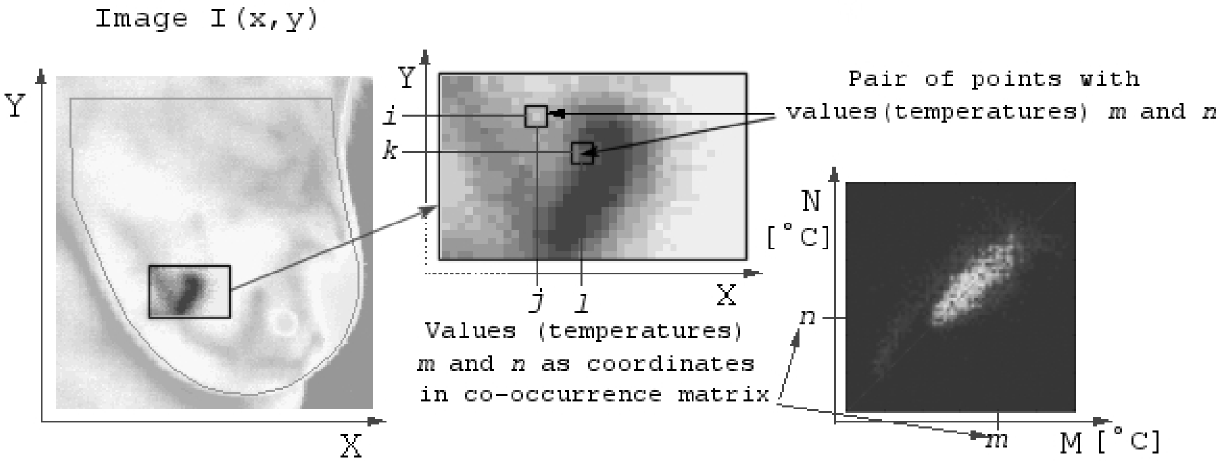
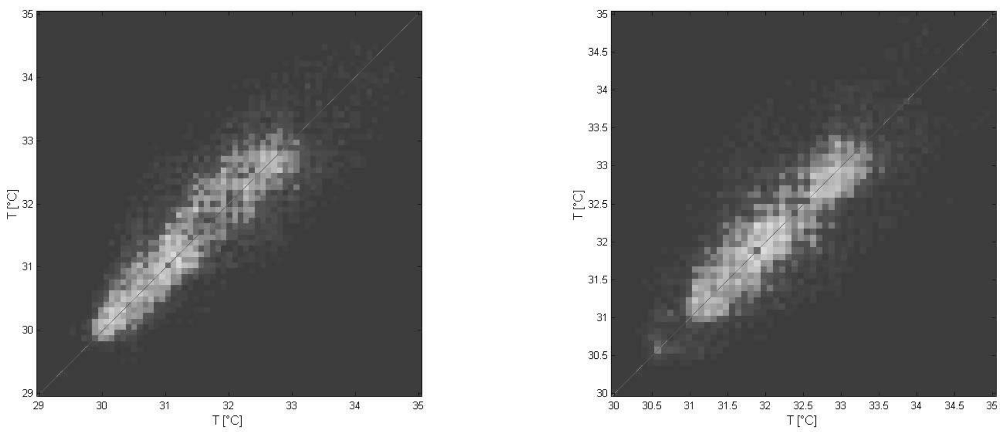


Figure 2: Illustration of acquirement of spatial co-occurrence matrix



a) b)

Figure 3: Example of spatial co-occurrence matrices for thermogram from fig.1; a) right breast; b) left breast

right one). Figure 3 shows picture of co-occurrence matrices computed for whole breasts on thermogram from fig. 1.

It is evident, that for the area with a strong texture will be "the cloud" distributed more to width and for homogeneous area most of the points will be situated on diagonal of matrix. But it is just subjective view. COM is conditional probability matrix and so we can use commonly used statistics include energy (2), entropy (3), contrast (4) and homogeneity (5).

$$E = \sum_{n}\sum_{m} P(m,n)^2 \tag{2}$$

$$H = \sum_{n}\sum_{m} P(m,n)\ln(P(m,n)) \tag{3}$$

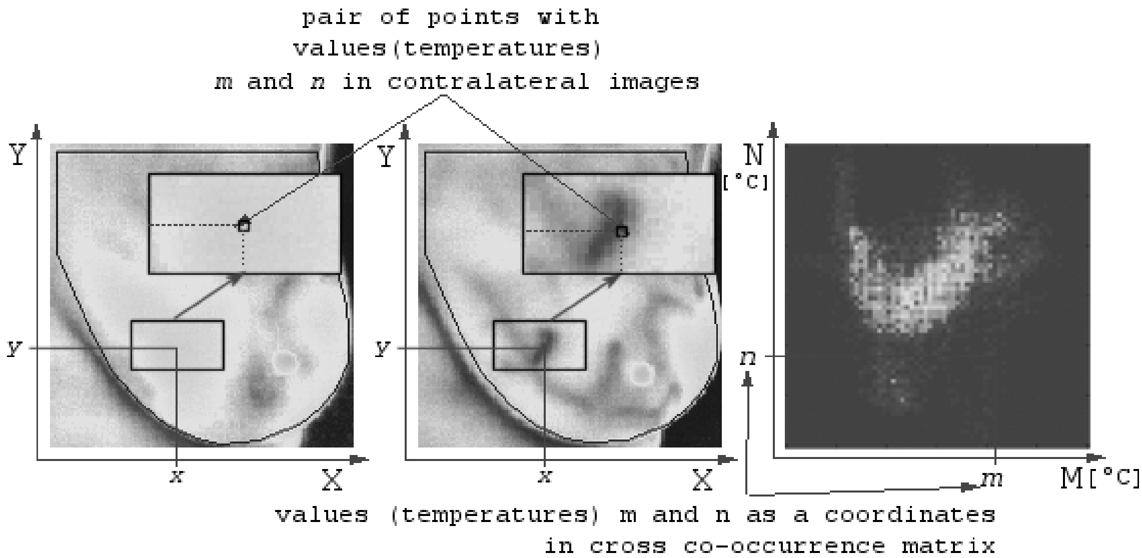


Figure 4: Illustration of acquirement of cross co-occurrence matrix

$$C = \sum_n \sum_m (m-n)^2 P(m,n) \tag{4}$$

$$G = \sum_n \sum_m \frac{P(m,n)}{1+|m-n|} \tag{5}$$

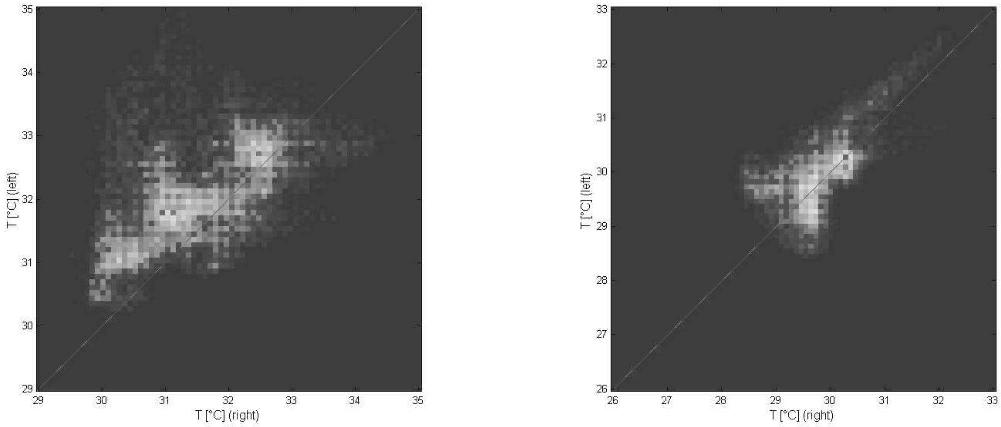
Another ways of classification are axial moment characteristics calculation (6) or mathematical description of the “cloud” shape.

$$M_k = \sum_n \sum_m (m-n)^k P(m,n) \tag{6}$$

3.2 CROSS CO-OCCURRENCE MATRIX (X-COM)

Great advantage of mentioned method is possibility to set up “roughness” and orientation of a sought texture. It can be done by change of the point distance and/or the angle. Cross co-occurrence matrix can be used to compare collateral sides. It is modification of spatial COM, where use of corresponding points on either side substitute the fixed distanced points(fig. 4). There is a problem with fitting of the either sides, but we can use center of gravity to make it center of axis system.

Figure 5 shows matrix computed for thermogram from figure 1. We can see that the areas with similar pattern on both sides are transformed to the matrix diagonal and its neighborhood. On the other hand, areas with significant differences increased distant elements. Except the features used for COM classification we set up new parameter called symmetry (7) and we modify the parameter contrast (8).



a) b)

Figure 5: Example of cross co-occurrence matrices for thermogram from fig.1; a) positive thermogram; b) negative thermogram

$$S = \sum_{n} \sum_{m>n} 1 - |P(m,n) - P(n,m)| \tag{7}$$

$$C' = \sum_{n} \sum_{m>n} |m-n||P(m,n) - P(n,m)| \tag{8}$$

4 CONCLUSION

We have tested mentioned hybrid methods on our set of thermograms. We obtained high number of parameters and we accomplished classification of thermograms for each parameter separately. Values of sensitivity and specificity we acquired exceeded 80% for some of parameters. But with respect to limited number of patients in our study these results are not very reliable. Our current research is oriented to obtain significant number of patients and negative women and reduce the number of parameters used for classification.

REFERENCES

[1] Drastich, A.: Záření v lékařství III. Infradiometrické detekční a zobrazovací systémy. Skripta FEI VUT v Brně, 1980

[2] Tzay Y. Young, King-Sun Fu.: Handbook of pattern recognition and image processing. Academic Press, 1986