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EVALUATION OF BINARIZATION ALGORITHMS IN PREPROCESSING OF DIGITAL MAMMOGRAPHIES

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Abstract. ***Digital mammograms are a useful tool for breast cancer detection. The quality of digital mammogram image can have a negative effect on the computer-aided diagnosis system. We investigate the use of automatic image thresholding methods for microcalcification detection in mammographic images. Experimental results on the BI-RADS 4 images dataset confirm the proposed approach.***

Keywords: digital mammogram; breast cancer detection; automatic image thresholding

1. INTRODUCTION

Digital mammography is a largely used detection tool in breast cancer. Globally, statistics say that breast cancer is the most common type of cancer for women [1-2]. Screening techniques help doctors to early identify the cancer or other diseases [3-4]. The efficiency of the anti-cancer treatment depends on when the mammography has been conducted. The result of mammography is an X-ray breast photograph, which is called mammogram. Mammograms are used efficiently to diagnose breast cancer, but unfortunately not all cancer types are recognizable using this technique [5]. The diagnosis is further improved using a biopsy. The biopsy operation depends on the mammogram result. The increasing storage capacity has offered the possibility to store mammograms in digital format. Given the large number of cases, the manual workload of a radiologist trying to find similar cases can be reduced with the help of Computer Aided Detection (CAD) systems. The percent of breast cancer detection with the help of mammography is around 70-90%. The results can be further improved with the help of CAD system. Also the radiologists are proposed many CAD systems; the main drawback is the number of false-positives detected.

There are two-types of mammogram abnormalities: masses and calcifications. The calcification is a small quantity of mineral, shown as a white spot on mammogram. Masses represent a difficulty problem for CAD systems, because this is a zone which look abnormal and can contain fat cells or healthy tissues. By comparison with calcification, the area occupied by masses in a mammogram is larger and contributes to the performance of a CAD system.

Mammogram images are classified in three categories: normal, benign and malignant. In many developing countries the number of false positives for a CAD system is higher because of the equipment quality. Image processing algorithms can help CAD systems to attend classification rate advertised. In [6] the authors build a new Collection of Preprocessed Digital Mammograms (CPDM) images acquired from Mammography Clinic of Hospital de Alta Especialidad Juan Graham Casasus. The images are preprocessed in five stages in order to enhance the quality of the acquired image. The authors use a binarization technique to reduce the image area.

In this paper we evaluate several automatic image thresholding algorithms for calcification detection and reducing area of images. We investigate several binarization algorithms for the detection of calcifications in digital mammogram images.

The content of the present paper is as follows. In section II the classification of breast tissue using BI-RADS scale is presented. In sections III and IV the automatic image thresholding algorithms and experimental results on BI-RADS 4 images dataset are presented. Finally, in the last section the conclusions are drawn.

2. BI-RADS CLASSIFICATION SCALE OF MAMMOGRAMS

The radiologist interprets the mammogram based on several identification elements:

- abnormality area
- contour shape
- density of tissue
- number of abnormalities
- existence/absence of calcification zones.

The most important feature for diagnosis of cancer type is given by contour shape feature. The most used classification by radiologists is BI-RADS classification (Breast Imaging Reporting Data System) [7]. The BIRADS classification has been proposed by The American College of Radiology.

The BI-RADS assessment categories are from 0 to 6. We use BI-RADS scale from 1 to 6 for classification of the mammograms images. The BI-RADS categories based on analysis of digital mammogram images are the following:

1) BI-RADS 0
   a) The mammogram results are incomplete
   b) Further investigations are necessary
2) BI-RADS 1
   a) there is no presence of suspicious abnormalities

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b) the result is negative

3) BI-RADS 2

a) rounded macrocalcifications (fibroadenoma, cyst), vascular calcification

b) regions with fat densities

4) BI-RADS 3 (probably benign)

a) presence of solid nodules on the mammogram

b) cluster regions with tiny calcifications

c) the risk of breast cancer is lower than 1%

5) BI-RADS 4

a) There are three sub-categories for suspicion of malignancy: low (BI-RADS 4A), moderate (BI-RADS 4B) and high (BI-RADS 4C)

b) the mammogram can be malignant given the apparition of abnormalities

c) presence of microcalcifications

d) the PPV (positive predictive value) is around 20-40%

e) the biopsy operation is recommended

6) BI-RADS 5

a) high risk of real malign cancer (95% probability)

b) cancer morphological features: cluster of microcalcification, malignant microcalcifications, dense areas with irregular shape

7) BI-RADS-6

a) The diagnosis of malign cancer is confirmed

3. THE ANALYSES AND THE SEGMENTATION OF MEDICAL IMAGES

For the analyses of digital mammogram images, we investigated several automatic image thresholding methods:

- the entropy maximizing method (EM) [8];
- Minimum Histogram (MH) [8];
- Otsu method (OM) [9];
- Iterative Selection Thresholding Method (ISTM) [10].

Digital mammogram images contain breast tissue regions in foreground and a background. In order to characterize the abnormalities in the digital mammographic image we crop a region of interest (ROI) from the original image. The image cropped is further analyzed using the above binarization methods. The details of the algorithm are presented in Figure 1. The binarization threshold is computed firstly using the EM method. If the binarization threshold is not good, then a new threshold is computed using the following method. The user decides which binary image is suitable for analysis. Finally, the best threshold is chosen and the ROI image and threshold are saved.

4. EXPERIMENTAL RESULTS

The experimental results for the proposed method have been carried out on a dataset of digital mammogram images from the BI-RADS 4 category. The dataset contains 36 images. The proposed method has been implemented in Matlab program [11] using functions provided by Image Processing Toolbox (IPT). In Table 1 and Figure 2 are presented the experimental values obtained.

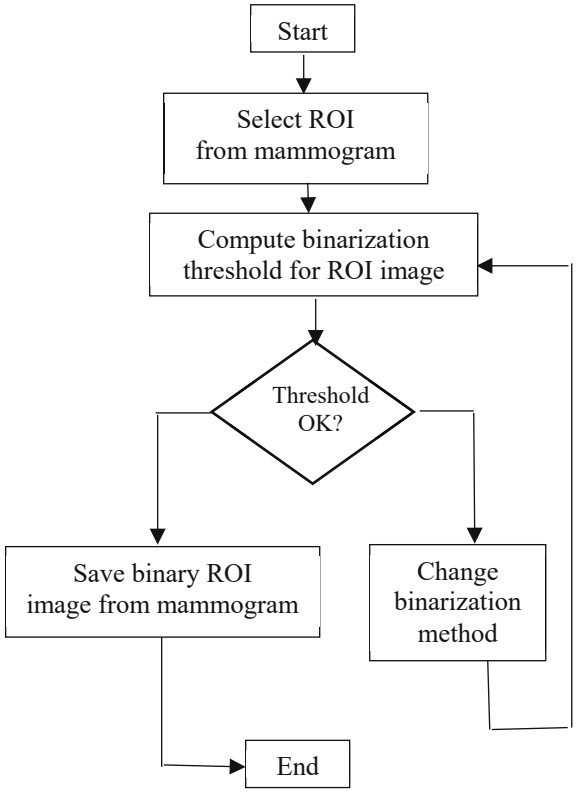

Figure 1. Proposed algorithm for the preprocessing of digital mammogram images

Table 1. Experimental results

Image	Algorithm	Threshold	Microcalcification
a	EM	30	Yes
a	MH	13	Yes
a	OM	22	Yes
a	ISTM	20	Yes
g	EM	184	No
g	MH	191	Yes
g	OM	172	Yes

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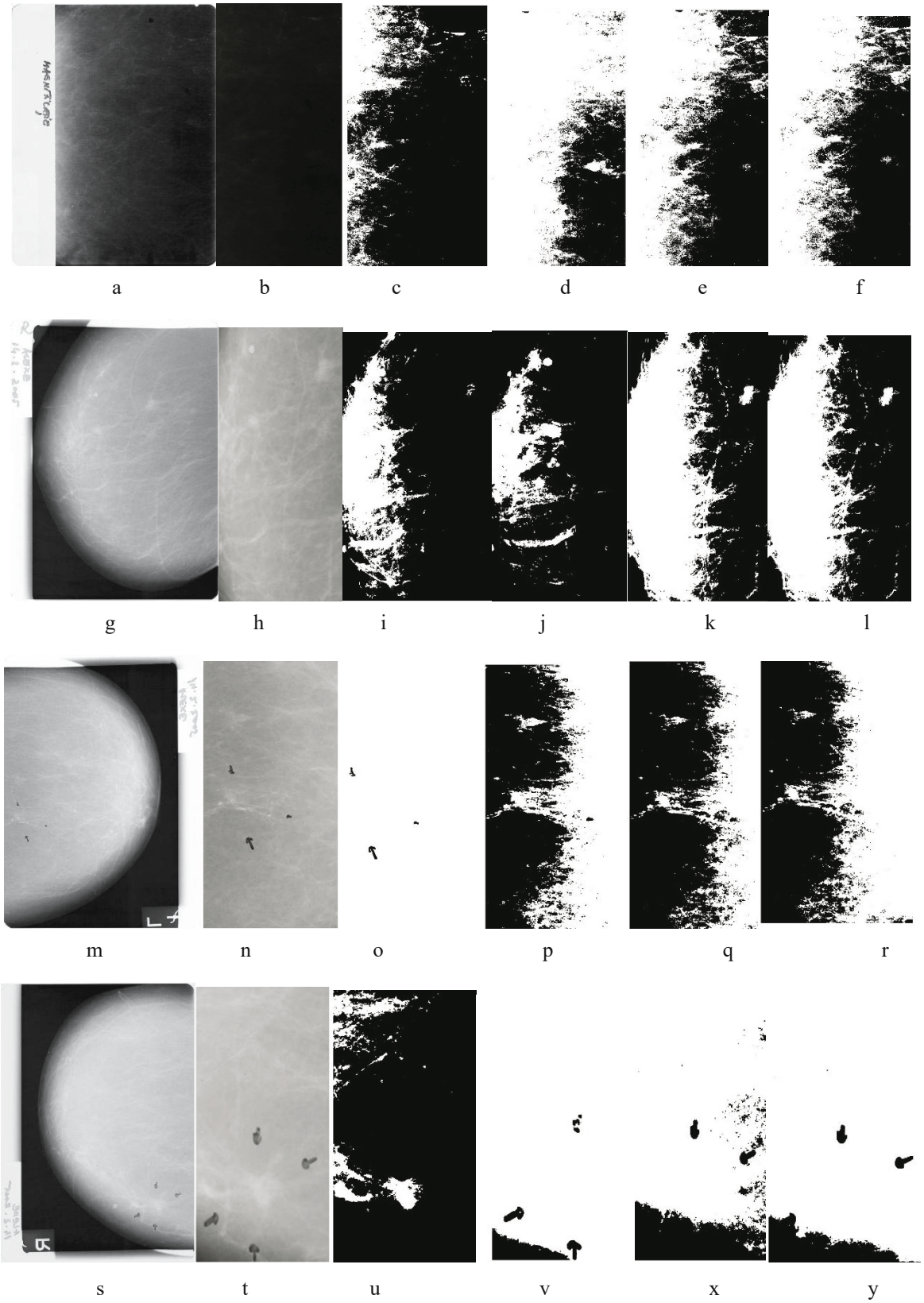

Figure 2. From left column to right: Original mammogram (first column), cropped mammogram image (second column), binarized mammogram (last four columns)

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Table 1. Experimental results (cont.)

Image	Algorithm	Threshold	Microcalcification
g	ISTM	172	Yes
m	EM	97	No
m	MH	166	Yes
m	OM	169	Yes
m	ISTM	169	Yes
s	EM	200	Yes
s	MH	128	No

From the experimental results from Figure 2 and all images from dataset has been observed that the best automatic thresholding algorithm is Otsu method followed by MH, EM and ISTM methods. The Otsu algorithm highlights the microcalcification in all images. Using digital image processing techniques [12], the monochrome image can be embedded in original image using reversible watermarking technique in order to reduce storage space [13].

5. CONCLUSIONS

In this paper an evaluation of various automatic image thresholding methods on digital mammographic images has been performed. From the experimental results we observe that the best thresholding algorithms for the microcalcification detection is Otsu method.

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