Comparisons of Different Contrast Resolution Effects on a Computer-Aided Detection System Intended to Cluster Microcalcifications Detected in Dense Breast Images

Fátima L.S. Nunes, Homero Schiabel, Mauricio C. Escarpinati, and Cláudio E. Góes

Clustered microcalcifications, which are frequently an important signal of possible cancer, are usually hidden in dense breast images, adding more difficulty in mammogram medical analysis. In this work we evaluate the performance of a previously developed computer-aided detection scheme, modified for application to dense breast images. The main focus of this investigation was on the effect of different contrast resolutions on the processing performance. We have processed dense breast images digitized with 8 and 12 bits to evaluate the performance of this computer-aided detection scheme with different contrast resolutions. As expected, for most of the 12-bit images, the number of detected signals was greater or at least equal to that of the 8-bit images.

SOME RESEARCH groups are working on developing computer models and techniques to aid in the detection of structures that can be associated with breast cancer, such as microcalcifications.[1-4] Because of their small size, and limitations of x-ray systems and the human eye, these microcalcifications could be missed by visual inspection of mammograms, a problem enhanced when the breast has a high density.[5] Sometimes, however, structures that cannot be perceived by the human eye can be enhanced by computer procedures. In a previous work,[6] we described a computerized procedure designed to automate detection of clustered microcalcifications in digitized conventional mammograms. In this work, we have modified the scheme to enable processing of dense breast images with higher contrast resolution (12 bits), from a digitization provided by a laser scanner. The purpose was mainly to evaluate the performance with these improvements for this type of poor contrast image, verifying how these features influence early detection rates on dense breast images.

METHODS

The previously described computer scheme detects the existence and location of microcalcification clusters in an image by applying the area-point transformation[3] to the result of segmentation and then grouping detected signals in a predefined area.[6] In the current work, the processed images were digitized by a Lumiscan scanner (Lumisys, Sunnyvale, CA), with 12 bits of contrast resolution and 0.15 mm of spatial resolution. As possible film displacements during the scanner reading procedure could yield significant differences for identifying, selecting, and recording the regions of interest (ROIs), two scans would be necessary to digitize the mammograms with 8 and 12 bits. Thus, in order to assure a pattern for late comparisons, the selected dense breasts mammograms were digitized only with 12 bits of contrast resolution and a procedure was designed to re-record the selected regions with 8 bits of contrast resolution. The ROIs were extracted from the whole images by visual inspection and each was submitted to three processing routines: segmentation, area-point transformation,[3] and microcalcification grouping. The segmentation procedure is completely parameterized. There are two parameters ("threshold value" and "standard deviation") that can be changed during a processing. The second is the value that has the larger influence on results.

RESULTS AND DISCUSSION

Fifty-two ROIs extracted from 17 dense breast mammograms were processed. Figure 1 shows graphs with the results from microcalcification and cluster detection using different SD values in the segmentation procedure. Figure 1a indicates the percentage of 12-bit digitized images for which the scheme detected more, less, or an equal amount of microcalcifications relative to the detection of the 8-bit images. Figure 1b shows detection of clusters. As expected, for the 12-bit images the number of detected signals was greater or at least equal to the 8-bit images detection. In some specific cases, however, a larger amount of pixels—related to microcalcifications—was registered for the 8-bit image compared with the 12-bit image. This can be explained by the association between the segmentation and area-point transformation[3] procedure. Our evaluation from these results indicates that, differently from our previous tests,[7] the detected signals now are probably corresponding to true-

From the Departamento de Física e Informática and the Departamento de Engenharia Elétrica, Universidade de São Paulo, Brasil.

Address reprint requests to Fátima L.S. Nunes, Departamento de Engenharia Elétrica, Universidade de São Paulo, Av. Trabalhador Sãocarlense, 400–CEP, 13566-590 São Carlos, SP, Brasil. E-mail: fatima@fc.unesp.br.

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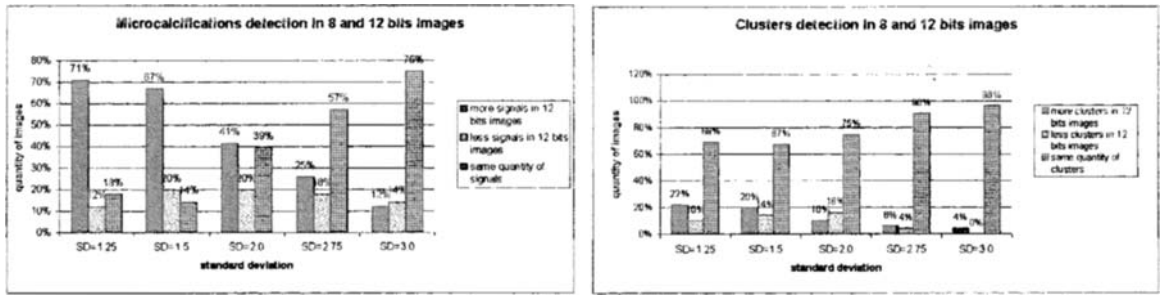

(a) (b)

Fig 1. Graphs illustrating the results from detection by the new modified processing scheme for dense breasts images: (a) microcalcification detection; (b) clusters detection.

positive results. They were obtained by changes in the routines developed for 12-bit image processing. Furthermore, even for intrinsically poor contrast dense breast images, in a large percentage of ROIs relative to the 12-bit images, more signals were detected compared with the 8-bit images. This is important to the efficiency of dense breasts image processing, since the increase in gray levels (4,096 *v* 256) in this type of image can partially compensate for the reduced contrast between microcalcifications and the typical glandular structures in the background. In fact, the larger the difference between the gray level for a given pixel and those around this first, the larger the probability of these pixels being white in the resultant binary image of the segmentation. Concerning the images with no detected signal, our analysis indicates that if any microcalcification was present, its contrast was very small compared with the background in the original image and, therefore, even with 12 bits of contrast resolution, its detection was impossible. Obviously, a specific technique designed to enhance the contrast in dense breasts images prior to the segmentation and detection procedure would be necessary to improve the scheme performance.

CONCLUSIONS

The gray level amount is a well-known factor affecting the processing results for microcalcification detection. Our tests have registered more detected microcalcifications for most ROIs corresponding to our dense breasts mammograms database when we consider the images digitized with more gray levels (4,096). The increase in detected signals was not too high compared with 8-bit detection, which is indicative that they are not corresponding to noise, but to true structures. We have also observed that 12-bit images are more sensitive to those changes than 8-bit images. Although medical evidence about the number of microcalcifications present in a single image is practically impossible to obtain, even from cytopathologic analysis, the number and positioning of clusters is often available information for comparison purposes. Considering this type of information, we could confirm that the increase in contrast resolution during the digitization procedure can improve the capability of identifying microcalcifications in dense breast images, which are well recognized as being difficult for analysis.

REFERENCES

1. Egan RL, McSweeney MB, Sewell CW, et al: Intramammary calcifications without an associated mass in benign and malignant diseases. Radiology 137:1-7, 1980

2. Nishikawa RM, Giger ML, Doi K, et al: Computer-aided detection and diagnosis of masses and clustered microcalcifications from digital mammograms, in Bowyer KW, Astley S (eds): State of the Art in Digital Mammographic Image Analysis. Singapore, World Scientific Publishing, 1994, pp 82-102

3. Chan H-P, Doi K, Galtrotra S, et al: Image feature analysis and computer-aided diagnosis in digital radiography. I. Automated detection of microcalcifications in mammography. Med Phys 14:538-548, 1987

4. Shen L, Rangayyan RM, Desautels JEL, et al Detection and classification of mammographic calcifications. Int J Pattern Recognition Artif Intelligence 7:1403-1416, 1993

5. Byrne C, Schairer C, Wolfe J, et al: Mammographic features and breast cancer risk: Effects with time, age, and menopause status. J Natl Cancer Inst 87:1622-1629, 1995

6. Nunes FLS, Schiabel H, Frere AF: Digital mammogra-

phy: Problems associated to the detection of clustered microcalcification in image processing. IASTED-International Conference on Computer Graphics and Imaging, Halifax, Canada, June 1-3, 1998

7. Nunes FLS, Schiabel H, Patrocinio AC, et al: Breast clustered microcalcifications detection: Influence of the gray scale levels on the performance of a CAD scheme. Proceedings of the International Seminar on Bioelectronic Interfaces III Workshop on Cybernetic Vision, Capinas SP, Brasil, February 23-26, 1999, pp 92-97

8. Sickles E: Breast calcifications: Mammographic evaluation. Radiology 160:289-293, 1986