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Image processing can cause some malignant soft-tissue lesions to be missed in digital mammography images

L.M. Warren [a,*], M.D. Halling-Brown [b], P.T. Looney [a], D.R. Dance [a,c], M.G. Wallis [d,e], R.M. Given-Wilson [f], L. Wilkinson [f], R. McAvinchey [g], K.C. Young [a,c]

[a] National Co-ordinating Centre for the Physics of Mammography, Royal Surrey County Hospital NHS Foundation Trust, Guildford, GU2 7XX, UK
[b] Scientific Computing, Royal Surrey County Hospital NHS Foundation Trust, Guildford, GU2 7XX, UK
[c] Department of Physics, University of Surrey, Guildford, Surrey, GU2 7JP, UK
[d] Cambridge Breast Unit, Cambridge University Hospitals NHS Foundation Trust, Cambridge, CB2 0QQ, UK
[e] NIHR Cambridge Biomedical Research Centre, Cambridge, CB2 0QQ, UK
[f] Department of Radiology, St George's University Hospitals NHS Foundation Trust, Tooting, London, SW17 0QT, UK
[g] Jarvis Breast Screening and Diagnostic Centre, Guildford, GU1 1LJ, UK

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AIM: To investigate the effect of image processing on cancer detection in mammography.

METHODS AND MATERIALS: An observer study was performed using 349 digital mammography images of women with normal breasts, calcification clusters, or soft-tissue lesions including 191 subtle cancers. Images underwent two types of processing: FlavourA (standard) and FlavourB (added enhancement). Six observers located features in the breast they suspected to be cancerous (4,188 observations). Data were analysed using jackknife alternative free-response receiver operating characteristic (JAFROC) analysis. Characteristics of the cancers detected with each image processing type were investigated.

RESULTS: For calcifications, the JAFROC figure of merit (FOM) was equal to 0.86 for both types of image processing. For soft-tissue lesions, the JAFROC FOM were better for FlavourA (0.81) than FlavourB (0.78); this difference was significant (p=0.001). Using FlavourA a greater number of cancers of all grades and sizes were detected than with FlavourB. FlavourA improved soft-tissue lesion detection in denser breasts (p=0.04 when volumetric density was over 7.5%)

CONCLUSIONS: The detection of malignant soft-tissue lesions (which were primarily invasive) was significantly better with FlavourA than FlavourB image processing. This is despite FlavourB having a higher contrast appearance often preferred by radiologists. It is important that clinical choice of image processing is based on objective measures.

* Guarantor and correspondent: L. M. Warren, National Co-ordinating Centre for the Physics of Mammography, Royal Surrey County Hospital NHS Foundation Trust, Guildford, GU2 7XX, UK. Tel.: +44 (0)1483 408310; fax: +44 (0)1483 406742.

E-mail address: lucy.warren@nhs.net (L.M. Warren).

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Introduction

The optimal way to process mammography images to improve the detection of breast cancer is uncertain. Image-processing techniques include greyscale transform, unsharp masking, multiscale image enhancement, and peripheral enhancement.[1] The greyscale transform aims to ensure that the parts of the image with the highest diagnostic information content are displayed with optimal contrast, whereas other parts that are less relevant have a lower contrast. Unsharp masking aims to sharpen images by using a blurred mask of the original image. It is most often used to enhance high frequencies in an image. Multi-scale image enhancement allows for features at different frequencies to be enhanced differently. Peripheral enhancement compensates for the reduction in tissue thickness at the edge of the breast.

There have been a few studies[2–7] investigating the effect of image processing on cancer detection. Some found that change in image processing caused a significant difference in cancer detection,[2–4,7] whereas others found no significant difference.[5,6] The aim of the present study was to investigate the effect on cancer detection of two types of clinically used Siemens image-processing techniques (Siemens Healthcare, Erlangen, Germany). This is the first study to investigate these two types of image processing. The image processing techniques were provided by the manufacturer. It was not possible and it was not the objective to optimise the image processing, which would have required a much wider investigation with control of image processing parameters; however, it is a clinically relevant situation, because currently clinicians must decide which type of image processing they would prefer. A further aim was to investigate if this decision would have an effect on cancer detection.

The design of this study is similar to the studies by Zanca *et al.*[4] and Warren *et al.*[6,7] Novel aspects of this work include the use of quadrant-zooming and two-views in a free-response observer study. This is more clinically realistic than using one view as is typically performed in such free-response studies. Additionally, all the cancers used were real with a range of appearances, rather than simulated as used in previous studies.[4,6,7] Finally, the study has the advantage of having access to a large database of mammography images and their clinical information. It has therefore been possible to investigate characteristics of cancers seen in the two types of image processing, in terms of grade, invasive status, size, and radiological appearance.

Materials and methods

The methodology comprises four parts: (1) case selection for the observer study, (2) image processing, (3) study protocol, and (4) statistical analysis. The study protocol was approved by the national research ethics committee as part of the OPTIMAM research programme.[8]

Case selection for observer study

The cases used in the present study were selected from a database of unprocessed mammography images collected locally.[9] At the time of the study, the database contained unprocessed mammography images collected from 1,624 women attending a UK NHS breast screening programme (NHSBSP) centre, imaged between March 2011 and June 2014 on Hologic Selenia and Hologic Dimensions systems (Hologic, Bedford, MA, USA). A database of Siemens images was not available.

The cancers had been collected sequentially from the beginning of the study period, and all women were aged between 47–73 years. Processed versions of the images in the database were annotated by expert radiologists who did not participate in the study. They drew a rectangular region of interest (ROI) tightly around each lesion. They then described the radiological appearance of the lesion (mass, distortion, asymmetry, calcification), whether the lesion was malignant or benign, and the conspicuity of the lesion on a three-point scale (very subtle, subtle, or obvious). Conspicuity was defined as how visible the lesion was in the image, in the radiologists' judgement.

In the present study, the cancer cases included only women with subtle or very subtle signs of breast cancer on the mammograms. The number of cancers with a subtle or very subtle appearance required in the study was based on the results of a pilot study, using power calculations performed using jackknife alternative free-response receiver operating characteristic (JAFROC) software (JAFROC, version 4.0, D.P. Chakraborty; http://www.devchakraborty.com/). It was found that 83 cases containing subtle calcification clusters and 86 soft-tissue lesions were required for 80% power and an effect size of 0.01. The effect sizes used in the power calculations were based on effect sizes found in the pilot study. Twenty-two of the 169 (83+86) abnormal cases contained multiple cancers; therefore, there were 92 calcification clusters and 99 soft-tissue lesions in the 169 abnormal images. In addition to the cases with cancer, 35 women were randomly selected from those with biopsy-proven benign lesions and 145 women were randomly selected from those with normal images.

When the study began, the women whose images were "normal" had not yet returned for their next 3-yearly breast screening examination. Subsequently, 110 of these women attended their next screening examination and all were again read as normal, the remaining 35 women did not re-attend 3 years later at the same centre; however, they have not presented with interval cancers.

The examination consisted of two views of each breast, a craniocaudial (CC) view and a mediolateral oblique view (MLO). In this study, all four breast images were used. The volumetric breast density measured with Volpara (Volpara Solutions, Wellington, New Zealand) varied from 3% to 46% (average of 10%). There was no significant difference between the average breast density measured on the images used in the study, and the average breast density measured on all images in the database (p=0.29).

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