Estimation of breast density using radio wave radar imaging techniques

Poster No.:	C-1623
Congress:	ECR 2018
Type:	Scientific Exhibit
Authors:	A. Iriarte[1], G. de vargas[2], C. Bore[1], P. Bannister[1], L. Tsui[1], D. Gibbins[1]; [1]Bristol/UK, [2]Madrid/ES
Keywords:	Cancer, Diagnostic procedure, Image manipulation / Reconstruction, Oncology, Breast
DOI:	10.1594/ecr2018/C-1623

Aims and objectives

This work demonstrates the potential of the MARIA® (Micrima Ltd, Bristol UK) [1][2] - a non-ionising, non-compressing whole-breast scanning system utilising radio-waves - to automatically determine the density of breast tissue. Density can be used as a risk indicator since dense breasts are thought to be more likely to develop cancer [3]. This information can also be used to estimate patient-specific dielectric properties, which can improve the performance of breast radio-wave imaging.

Dielectric properties determine the propagation and absorption of radio-waves through a medium. The MARIA® system produces a 3D image of the internal structure of the breast based on the dielectric properties of the tissues. In the breast, the fatty content is of low dielectric constant, whereas protein and water in glandular tissues exhibit much higher values [4][5]. So the overall density of a breast varies with its bulk dielectric properties and will have a direct effect on the overall characteristics of the 3D image.

It is the goal of this work to extract metrics from the 3D image of a breast that will allow either a "lucent" (BIRAD density scores a/b) or "dense" (BIRAD density scores c/d) classification of the breast.

Methods and materials

Clinical:

Patients attending symptomatic clinics at three sites were identified by clinicians as having a palpable lump. Following informed consent, eligible patients underwent a MARIA® scan. The bilateral reconstructed 3D images were used in this study. The density classification process was accessed by comparison with BIRAD density scores estimated from mammograms.

Equipment:

MARIA® is a CE-marked radio-frequency (RF) medical imaging system [1][2] comprising a patient bed, a Scanning and Data Processing (SDP) unit which is located under the bed and a touch-screen console featuring a software user interface that controls both acquisition and review - see Fig.1. The SDP unit contains a hemispherical array of 60 RF antenna [6] which encircle the breast. The breast lies pendant in the array through a hole in the bed and one of a set of conformal ceramic inserts, placed into the array are provided to fit a range of breast sizes without the need for compression (Fig. 1). By serially energising each antenna, scattering parameters are collected from the signals received at all remaining antennas. As signals propagate across the breast, their magnitudes and phases are modified according to the dielectric properties of the tissue traversed.

Description of the procedure:

Patients were scanned before any surgical or biopsy intervention. Data collected were BIRADS score, age, menopausal status, and breast size. The subject was required to lie prone with the breast inserted into the ceramic cup. A coupling fluid [7], similar to hand moisturiser, is applied between the breast and insert to maintain good RF contact. The scan consisted of checks for goodness of fit of the breast (lack of air gap) and then at least two scans of about 30 seconds each. The total scan time with patient present was typically less than 5 minutes.

Evaluation method:

A flow diagram of the evaluation process can be seen in Fig. 2. A 3D image of the patient is created from the scattering parameters (Fig. 3) using a modified version of the classical delay-and-sum (DAS) beamforming algorithm [8]. A median filter is applied to reduce image noise and a histogram of pixel intensity is produced (Fig. 4). The area under histogram for the highest 35% of pixel magnitudes is calculated and used as a metric in a linear classification procedure. Breasts are classified as being either "lucent" or "dense".

The position of the threshold is obtained from a training set of cases with known density characteristics, for example, BIRAD scores estimated from mammograms.

Images for this section:

Fig. 1: MARIA® radio frequency breast imaging system showing patient bed and Scanning and Data Processing cabinet (SDP).

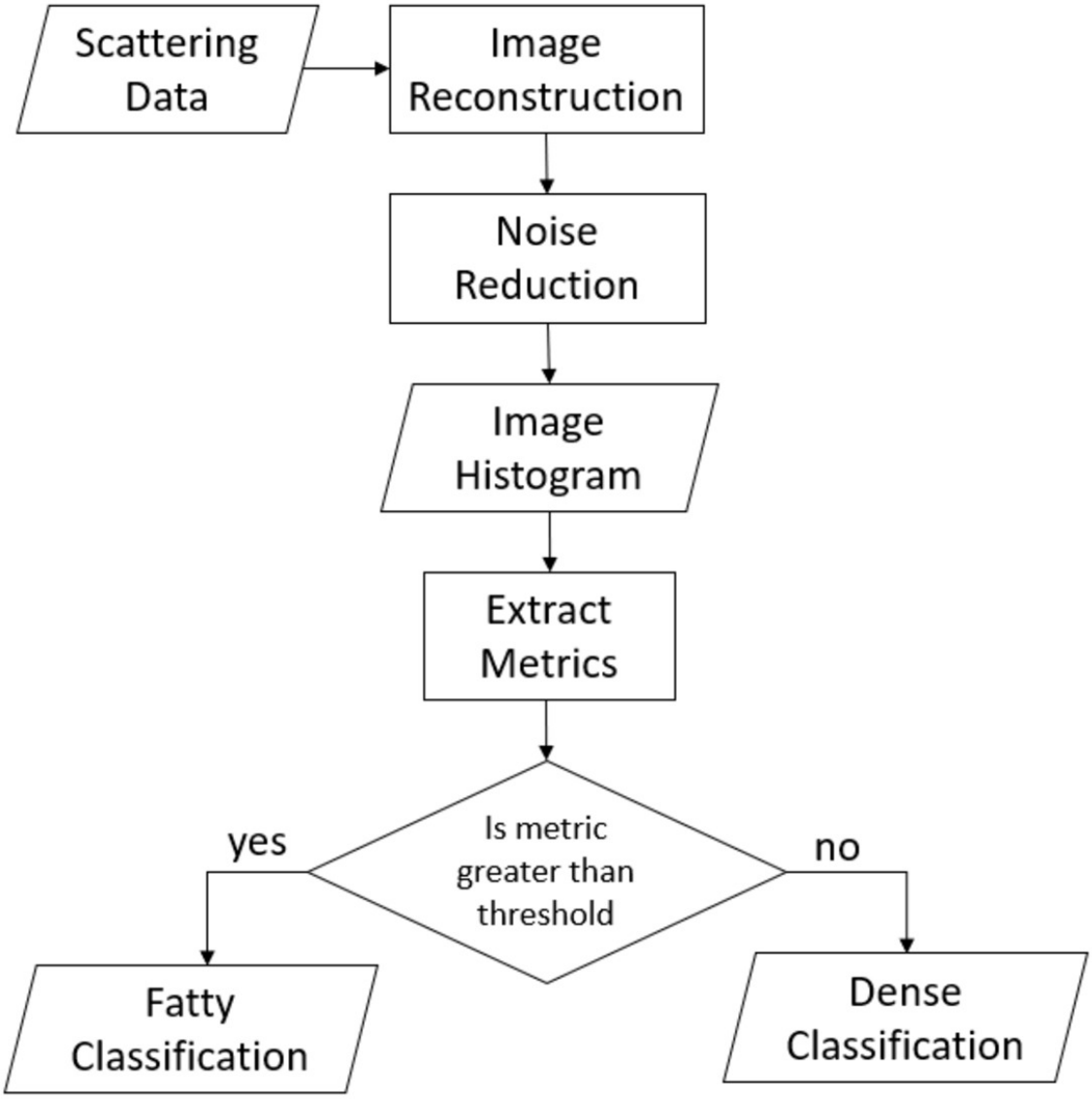

Fig. 2: Flow chart detailing the histogram based density classification process.

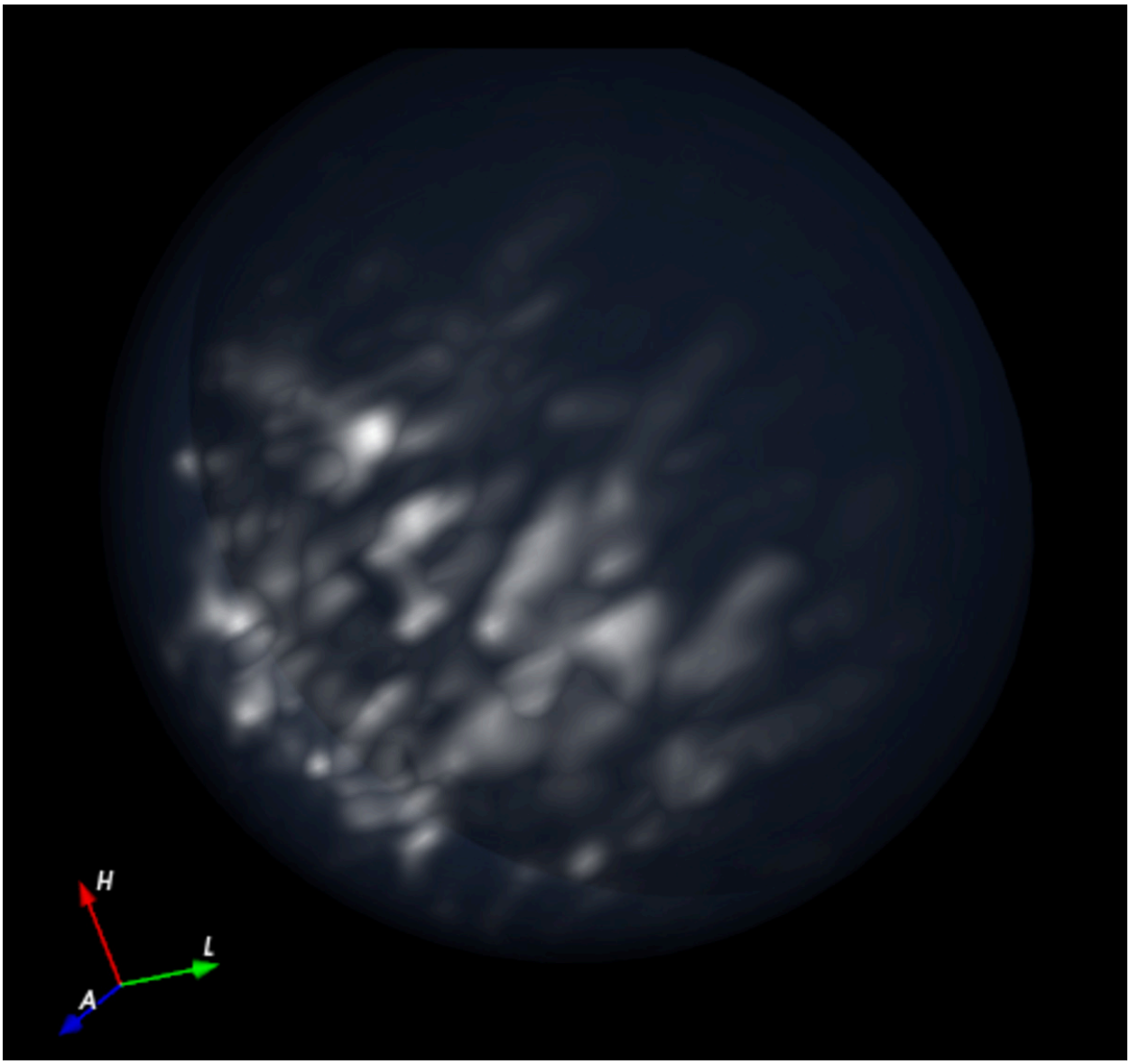

Fig. 3: Example 3D image of a breast produce by the MARIA® microwave imaging system.

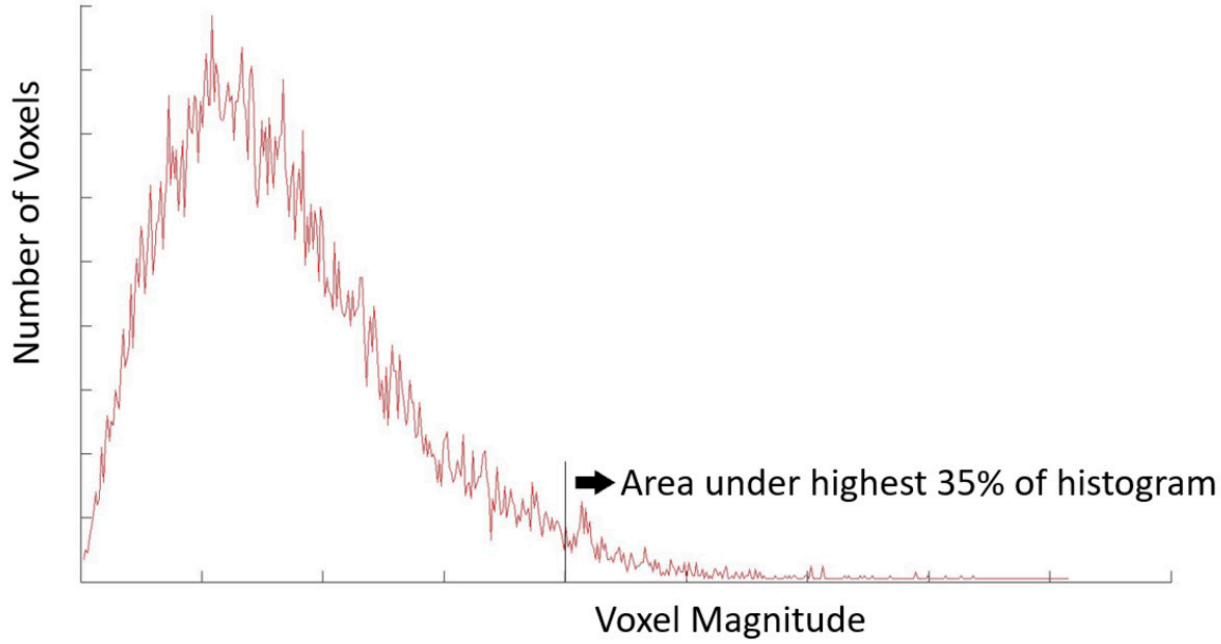

Fig. 4: Example histogram showing the distribution of pixel intensities from a typical MARIA® image.

Results

The methodology has been tested using clinical bilateral data from 57 patients with known tissue properties (25 with lucent tissue and 32 with dense tissue), leading to a population of 114 breast scans, 64/50 symptomatic/non-symptomatic. Symptomatic here includes breasts with an inclusion e.g. cyst, cancer. It was found important to account for breast size, results demonstrated here are all from a single measurement cup size of approximate volume of 460 ml.

Fig. 5 shows the classifier applied to the non-symptomatic cases. In total 76% of cases were classified correctly. Except for a single outlier in each case BIRAD groups a and d were otherwise classified correctly. As expected, groups b and c were not as easy to classify though this might be a result of error in clinical BIRAD density estimation. When evaluating both symptomatic and non-symptomatic breasts 70% of the cases were correctly classified.

Images for this section:

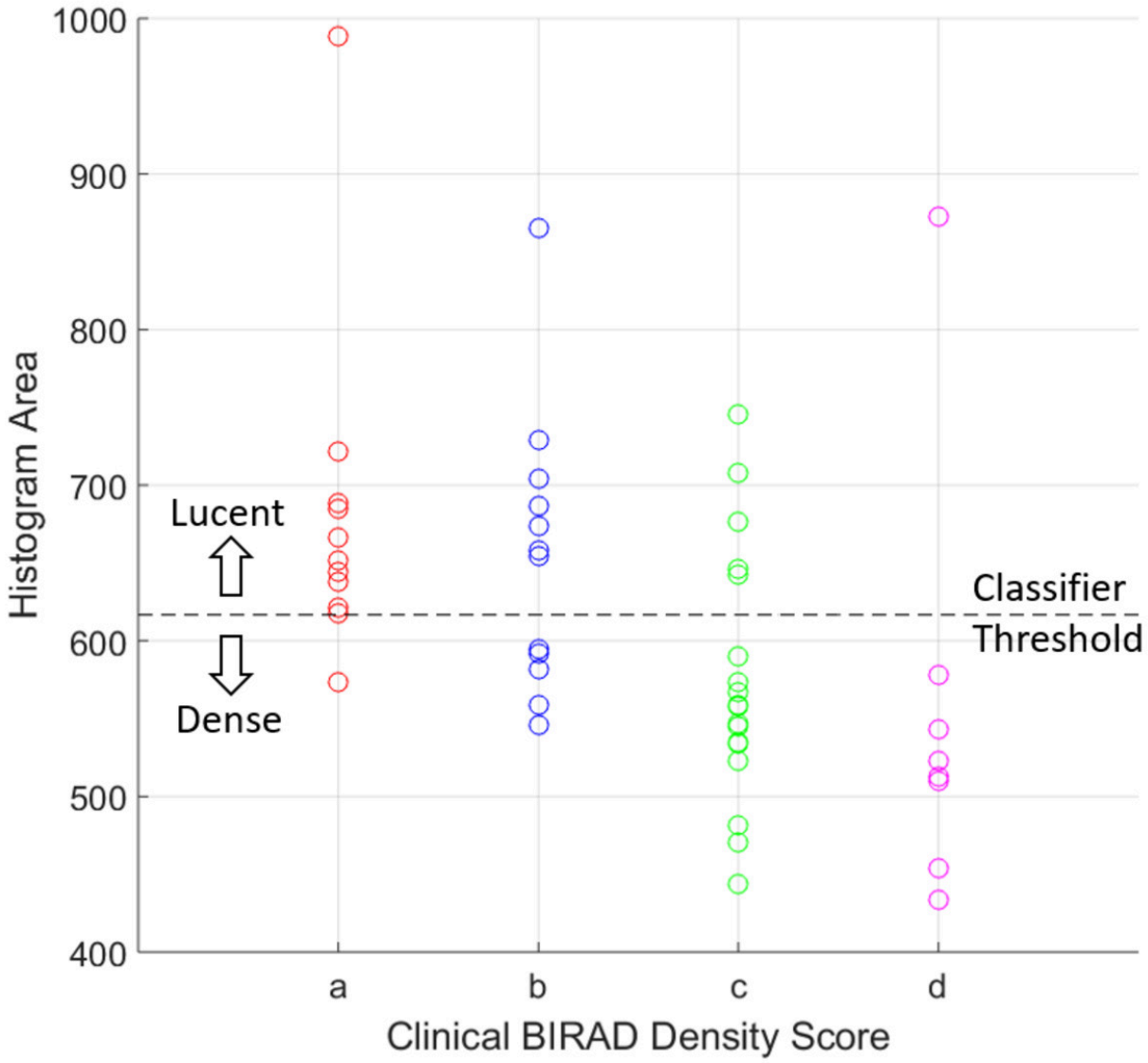

Fig. 5: Histogram Area versus BIRAD density scores for non-symptomatic cases. The threshold of the classifier is shown (dashed line) cases above are classified as lucent cases below are classified as dense.

Conclusion

The results presented are a proof-of-concept demonstrating how radio-wave imaging can be used to discriminate breast density. It has been shown that on a limited data set of 50 non-symptomatic breasts the method is able to discriminate between lucent and dense breasts with an accuracy of 76%. Future work includes improving the methodology in the presence of lesions and study the influence of other factors (e.g. age, pre/post-menopausal) in the classification process.

Personal information

Dr Ana Iriarte, Micrima Limited, One Glass Wharf, Bristol, BS2 0EL

info@micrima.com

Gemma de Vargas, San Pablo CEU University, Madrid, Spain

info@micrima.com

Prof Chris Bore, Micrima Limited, One Glass Wharf, Bristol, BS2 0EL

Chris@micrima.com

Dr Peter Bannister, Micrima Limited, One Glass Wharf, Bristol, BS2 0EL

PRB@robots.ox.ac.uk

Dr Louis Tsui, Micrima Limited, One Glass Wharf, Bristol, BS2 0EL

louis@micrima.com

Dr David Gibbins Micrima Limited, One Glass Wharf, Bristol, BS2 0EL
David@micrima.com

References

1. Preece AW, Craddock I, Shere M, Jones, L, Winton HL, "MARIA M4: clincial evaluation of a prototype ultrawideband radar scanner for breast cancer detection." Journal of Medical Imaging, 3(3), 033502 (2016).

2. Leendertz JA, Preece AW, Nilavalan R, Craddock IJ, Benjamin R, "A liquid phantom medium for microwave breast imaging," 6th Int. Congress of the European Bioelectromagnetics Association (EBEA), Budapest, Hungary (2003).

3. Boyd NF, Martin LJ, Yaffe MJ, Minkin S, "Mammographic density and breast cancer risk: current understanding and future prospects," Breast Cancer Research, 13, 223 (2011).

4. Lazebnik M, Popovic D, McCartney L, et al. "A large-scale study of the ultrawideband microwave dielectric properties of normal, benign and malignant breast tissues obtained from cancer surgeries," Physics in Medicine and Biology, 52, 6093-115, (2007).

5. Gabriel S, Lau RW, Gabriel C, "The dielectric properties of biological tissues 2. Measurements in the frequency range 10 Hz to 20 GHz," Physics in Medicine and Biology, 41(11), 2251-69, (1996).

6. Gibbins D, Klemm M, Craddock IJ, Leendertz JA, Preece A, Benjamin R, "A comparison of a wide-slot and a stacked patch antenna for the purpose of breast cancer detection," IEEE Transactions on Antennas and Propagation, 58(3), 665-674, (2010).

7. Klemm M, Gibbins D, Leendertz JA, Horseman T, Preece A, Benjamin R, Craddock IJ, "Development and testing of a 60-element UWB conformal array for breast cancer imaging," 5th European Conference on Antennas and Propagation (EUCAP'11), pp. 3077-3079 (2011).

8. Klemm M, Craddock IJ, Leendertz JA, Preece A, Benjamin R, "Radar-based breast cancer detection using a hemispherical antenna array-experimental results," IEEE Transactions on Antennas and Propagation, 57(6), 1692-1704 (2009).