Does breast peritumoral tissue hold valuable information for texture analysis?

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TARGET AUDIENCE: Breast MR researchers: physicists and clinicians.

PURPOSE: The current methodologies of texture analysis utilising grey-level co-ocurrence matrices (**GLCM**) involve a strict segmentation process which needs to be carried out by a trained individual so that only the tumour is being analysed. Semi-automated, and fully automated segmentation software has been developed in order to reduce the time needed to perform this task, but both leave themselves open to errors caused by erroneous pixel intensities which only a human can correct based on experience. Previous work has shown that enhancement in the parenchyma may distinguish between benign and malignant lesions or predict treatment response [1]. This work assesses whether the surrounding tissue, which currently is disregarded, can add extra information to GLCM texture analysis.

METHOD: Software was modified from a previous MatLab (MathWorks, Natick, MA) programme developed in-house [2] to calculate 16 texture parameters (the 14 Haralick features [3] and including "cluster shade" and "cluster prominence"[4]) of a given region of interest (**ROI**) defined by a trained researcher, and then expand incrementally the ROI by 2px (from 2px – 10px) calculating new texture parameters for each new ROI (fig. 1). The patient cohort consisted of 100 cases (98 patients with two presenting bi-laterally), median age 48 years (31-77 years), all with biopsy confirmed breast cancers. MR scans were taken before neoadjuvant chemotherapy (**NAC**) began, using a dedicated 8-channel breast coil with a fat nulled Volume Imaging Breast Assessment (**VIBRANT**) sequence to produce sagittal images on a 3T HDx (GE Healthcare, Milwaukee, WI) scanner. GLCM texture analysis was performed on 1 minute post-contrast (Gadolinium) images for each patient as this time point resulted in the largest number of statistical differences when conventional GLCM texture analysis was performed on this cohort. Univariate analysis was performed with SPSS v.20 (Chicago, IL), using Mann-Whitney U-tests to determine differences between patient groups, with a significant results being defined as a $p < 0.05$. The four patient sub groups being examined are: partial response (>50% reduction in largest diameter) or no response (<50% reduction in largest diameter) to NAC (**PR vs. NR**); positive or negative lymph nodes (**Nodal Status**); biopsy grade 3 or all other biopsy grades (**Biopsy Grade**); and Triple Negative (ER, PR, and HER2 negative) or all other cancers (**TNEG**).

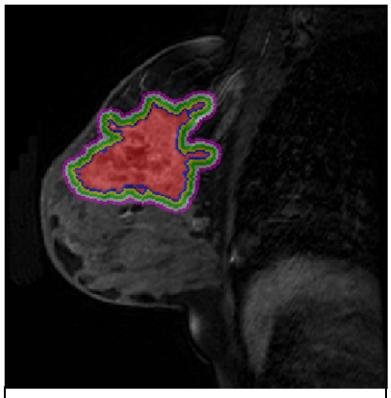

Figure 1: ROIs of different sizes simulating varying levels of lesion segmentation. Pictured are the original ROI (red) and ROIs with subsequent borders of 2px (blue), 4px (yellow), 6px (green), 8px (white), and 10px (magenta).

RESULTS: The number of statistically significant differences between patient sub-groups varied as ROI size increased. A summary of significant differences is presented in Table 1. The greatest number of differences were found when a 6/8px border was added to ROIs finding 13/16 parameters with significant differences between TNEG sub-groups. When using Bonferroni correction, 9/16 parameters were still deemed significant for a 6px border.

	Fully segmented	2px Border	4px Border	6px Border	8px Border	10px Border
PR vs. NR	2	0	0	0	0	0
Nodal Status	0	0	0	0	0	0
Biopsy Grade	5	4	1	4	2	0
TNEG	6	4	11	13	13	7

Table 1: Summary of number of texture parameters found (max=16) which present statistical differences (p<0.05) from Mann-Whitney U-Tests between patient sub-groups with varying ROI sizes. Expanded ROIs are inclusive of original fully segmented ROI.

DISCUSSION: GLCM texture analysis performed to a comparative standard when ROIs were expanded to include non-tumour tissue for every patient sub-group and surpassed previous models when determining TNEG status. The work presented here indicates that inclusion of extra tissue in texture analysis may not impinge on the performance level of classification, and would allow for a more-is-more attitude in ROI creation.

CONCLUSION: In the context of TNEG breast cancers the increased number of significantly different parameters – and their increased level of significance – would suggest that including periturmoral tissue in texture analysis can increase the confidence of a diagnosis of TNEG breast cancer in the face of borderline biopsy results.

1. Park, C., et al., *Breast magnetic resonance imaging (MRI) enhancement beyond the tumor margin: Is there an association with treatment response?* INT J RADIAT ONCOL, 2006. **2.** Ahmed, A., et al., *Texture analysis in assessment and prediction of chemotherapy response in breast cancer.* J Magn Reson Imaging, 2013. **3.** Haralick, R.M., Shanmuga.K, and I. Dinstein, *Textural Features for Image Classification.* IEEE T SYST MAN CYB, 1973. **4.** Conners, R.W., M.M. Trivedi, and C.A. Harlow, *Segmentation of a high-resolution urban scene using texture operators.* Computer Vision, Graphics, and Image Processing, 1984.