Texture Analysis in the Characterisation of Ovarian Lesions: Use of Synthetic Minority Oversampling

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Target Audience Ovarian MR researchers – Physicists and Clinicians

Purpose The classification of ovarian lesions is problematic due to their complex nature. MRI is the preferred technique for characterising these complex adnexal masses due to its greater soft tissue contrast resolution(1). However, the presence of overlapping features, such as solid components in benign lesions, causes diagnostic difficulty(2). Correct diagnosis is very important since benign ovarian lesions may be treated by simple cystectomy or oophorectomy, whilst malignant lesions require hysterectomy, bilateral oophorectomy, omentectomy and possibly appendectomy.

Textural analysis has previously been utilised in contrast enhanced MRI of ovarian disease(3). This study aims to build on previous work by utilising a well-established over-sampling methodology to obviate the imbalanced group size that is often encountered in clinical MRI studies.

Methods Data from 96 women with histopathologically proven ovarian cancer (n=67), borderline ovarian tumour (n=28), cystadenoma (n=14) or cystadenofibroma (n=19) who underwent pre-operative pelvic MRI using a 32 channel phase array coil on a 3 Tesla scanner was retrospectively analysed.

Texture analysis was performed on T_2 weighted images acquired with an in-plane resolution of 0.47×0.58 mm. ROIs were manually drawn on a single slice by an expert radiologist, detailing the most complex portion of the lesion. ROI data was reduced to 16 grey levels and co-occurrence matrices were computed for four directions (0°, 45°, 90°, and 135°) to enable subsequent calculation of texture parameters f_1 to f_{16} as described by Haralick *et al*(4) and Conners *et al*(5). Since no intrinsic directionality is anticipated average texture parameters were utilised in statistical analysis.

Various approaches to counteract the uneven group sizes, which can result in over emphasis on trying to correctly predict the largest group, have been proposed. Under-sampling of the majority class has the obvious drawback of not employing the entire dataset (in this instance only 14/67 ovarian cancer cases would be utilised) whilst over-sampling with replacement of the minority class has been shown not to significantly improve minority class recognition. An alternative approach, the synthetic minority over-sampling technique, as proposed by Chawla *et al*(6) was utilised in this study. This involves the creation of unique 'synthetic' examples within the multidimensional space defined by the minority class cases. All minority class groups were over-sampled using this method resulting in 67 cases in each class.

The Kruskal-Wallis test was utilised to determine significant differences between groups, and correlation analysis used to remove highly correlated parameters. Finally, a multinomial logistic regression model was developed on 50% of cases (training dataset) before application to the remaining 50% of cases (test dataset).

Results Significant differences between the four groups were consistently noted for 12 parameters (f_2, f_3, f_4, f_5, f_6, f_7, f_8, f_{10}, f_{11}, f_{14}, f_{15} and f_{16}). After correlation analysis 7 parameters were retained and inputted into the multinomial logistic regression model. The final model developed utilised only 4 textural parameters (f_2 – contrast, f_{14} – maximal correlation coefficient, f_{15} - cluster shade and f_{16} – cluster prominence) and achieved a diagnostic accuracy of 71.3% for the training dataset and 61.4% for the test dataset (chance accuracy = 25%) – see accompanying confusion matrix.

		Predicted Class			
		F	A	B	C
Actual Class	F	26	3	4	0
	A	5	20	4	4
	B	4	6	17	6
	C	0	3	12	18

Confusion matrix for test dataset (n=33 for each group). F – cystadenofibroma, A – cystadenoma, B – borderline ovarian tumour, C – ovarian cancer

Conclusions Texture analysis utilising synthetic minority over-sampling has been successfully applied in the diagnosis of ovarian malignancy. After development of a robust multinomial logistic regression model using a training dataset an overall accuracy of 61% was achieved on a previously unseen test dataset. Future work will include incorporation of other MR defined features to refine the diagnostic model.

(1) YZ Tang *et al* (2013) *European Radiology* 23:48-56. (2) SAA Sohaib *et al* (2003) *American Journal of Roentgenology* 180:1297-1304. (3) P Gibbs *et al* (2014) *Proceedings of the 22nd ISMRM Annual Meeting* 2222. (4) RM Haralick *et al* (1973) *IEEE Transactions on Systems, Man and Cybernetics* 3:610-621. (5) RW Conners and CA Harlow (1980) *IEEE Transactions on Pattern Analysis and Machine Intelligence* 2:204-222. (6) NV Chawla *et al* (2002) *Journal of Artificial Intelligence Research* 16:321-357.