

Textural Analysis of the Prostate using Co-occurrence matrices

Adrian Knowles¹, Oscar Brihuega-Moreno², Peter Gibbs², Lindsay W Turnbull²

¹Philips Medical Systems, Best, The Netherlands; ²Centre for MR Investigations, Hull Royal Infirmary, Hull, East Yorkshire United Kingdom;

Introduction

Magnetic resonance (MR) imaging is currently unable to reliably differentiate prostatic adenocarcinoma from benign prostatic hypertrophy (BPH) due to an overlap in the appearance of these two pathologies on different MR sequences¹. To improve differentiation dynamic contrast-enhanced imaging² can also be used but there still exists room for improvement in diagnostic accuracy.

Previous work carried out within our centre has attempted to classify normal, benign and malignant disease within the prostate by neural network analysis of the DCE-MRI³. The resultant neural network predicted the biopsy result with an accuracy of 89%. We have also attempted to use 2D neural networks to look at 'look' at selected regions giving a resulting accuracy of 83%⁴.

In this study we investigate the use of co-occurrence matrices⁵ in order to quantify the spatial variations in grey tone which exist. The textural descriptors derived are then used to train a back-propagation neural network⁶ which is then used for classification.

Methods

MR imaging was performed on 10 patients using a 1.5 T Signa Advantage (General Electric Medical Systems, Milwaukee) using a pelvic phased array coil for signal reception. Initial localising images were acquired in the sagittal plane to ensure correct positioning of the pelvic phased array coil. A series of axial T2 weighted Fast Spin Echo (FSE) images (TR/TE = 12750/130 ms, 20 cm field of view) with a slice thickness of 2.5cm, matrix of 256*192 were acquired from the apex to the base of the prostate (see Image 1).



Image 1

Prior to further processing the images were quantised down to 64 grey levels. Regions of interest were then acquired using an 8*8 pixel window to sample various areas of the prostate, BPH, normal peripheral zone and tumour (See Image 2). The number of regions acquired for each tissue type varied as follows; 20 regions containing peripheral zone, 35 containing BPH and 35 containing tumour.

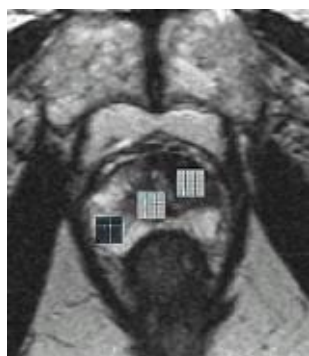


Image 2

The regions were then 'scanned' and a matrix is formed which keeps track of how often pixels that vary by z in signal intensity are separated by a fixed distance d in position. This is performed in 4 directions with the four matrices averaged at the end.

The fourteen textural descriptors as described by Haralick are then used as inputs to the neural network.

In order to minimise any bias the data was randomly segmented into 3 parts, 70% for training, 20% for testing, and a final 10% for validation purposes. A cross-validation technique⁷ was employed where the neural network architecture was trained 10 times using randomly assigned different training, testing, and validation sets to provide a final average predictive accuracy.

Results

Processing of the images was performed on a Pentium III-700 PC using custom written software to process and sample the images, and then extract the 14 textural descriptors for each region.

Calculation of the descriptors took approximately 2 seconds in total for each sampled region. Training of the neural network took 3 minutes until a minimum error had been achieved upon the test data set.

Once trained the accuracy of the network was then evaluated upon the cross validation set. This gave a resulting average accuracy of 79%.

Discussion

The calculation of co-occurrence matrices and the derivation of the statistical parameters are relatively simple but carry a heavy computational burden with regards to time if all the textural features of an entire image were to be calculated. It is more usual to sample small regions as described.

Other workers have discussed issues regarding the effects of Signal-to-Noise ratio on textural parameters⁸ and also reproducibility⁹ which may have contributed to the accuracy being somewhat lower than that obtained with 2D neural networks on the same regions-of-interest.

References

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