

## Combining Multi-Centre Conventional and Diffusion MR Texture for the Characterisation of Childhood Brain Tumours

S. Tantisatirapong<sup>1</sup>, N. P. Davies<sup>1,2</sup>, D. Rodriguez<sup>3</sup>, L. Abernethy<sup>4</sup>, D. P. Auer<sup>3,5</sup>, C. A. Clark<sup>6,7</sup>, R. Grundy<sup>3,5</sup>, T. Jaspan<sup>5</sup>, D. Hargrave<sup>7</sup>, L. MacPherson<sup>2</sup>, M. O. Leach<sup>8</sup>, G. S. Payne<sup>8</sup>, B. L. Pizer<sup>4</sup>, S. Bailey<sup>9</sup>, A. C. Peet<sup>1,10</sup>, and T. N. Arvanitis<sup>10,11</sup>

<sup>1</sup>University of Birmingham, Edgbaston, Birmingham, United Kingdom, <sup>2</sup>University Hospitals Birmingham NHS Foundation Trust, Birmingham, United Kingdom,

<sup>3</sup>University of Nottingham, Nottingham, United Kingdom, <sup>4</sup>Alder Hey Children's NHS Foundation Trust, Liverpool, United Kingdom, <sup>5</sup>University Hospital Nottingham, Nottingham, United Kingdom, <sup>6</sup>University College London, London, United Kingdom, <sup>7</sup>Great Ormond Street Hospital, London, United Kingdom, <sup>8</sup>The Institute of Cancer Research and Royal Marsden Hospital, Sutton, United Kingdom, <sup>9</sup>Northern Institute for Cancer Research, Newcastle University, Newcastle upon Tyne, United Kingdom, <sup>10</sup>Birmingham Children's Hospital NHS Foundation Trust, Birmingham, United Kingdom, <sup>11</sup>Institute of Digital Healthcare, WMG, University of Warwick, Coventry, United Kingdom

### Background

Conventional magnetic resonance imaging (MRI) is an important tool in the diagnosis and management of childhood brain tumours. It has been commonly used to provide structural information of tumours; however it has shown a limited capacity to identify specific tumour types. Apparent Diffusion Coefficient (ADC) maps, derived from Diffusion Weighted Imaging (DWI), provide complementary information about tissue microstructure and show variation between different histological types of brain tumours. Texture analysis (TA) can provide quantitative measures of features useful for tumour characterisation that are difficult to assess visually. Previous single-centre studies have shown that low-order TA based on histogram analysis of ADC maps can discriminate between childhood posterior fossa tumour types [1]. However, integrating 1<sup>st</sup>, 2<sup>nd</sup> and higher order statistical TA of ADC maps in combination with conventional MRI has not been done and is hypothesized to provide more accurate and robust classification of childhood brain tumours in a multi-centre setting. In this paper, we present a supervised machine learning approach to achieve tumour classification based on textural features from individual image types of T2-weighted (T2), T1-weighted post contrast (T1-post) and ADC maps, as well their combination, applied to a multi-centre dataset of the most common paediatric brain tumours types in arbitrary locations in the brain; medulloblastomas (MB), pilocytic astrocytomas (PA), and ependymomas (EP).

### Material and Methods

A pre-treatment MR image dataset of paediatric brain tumours was considered, with the number of MB, PA, and EP patients being 23, 29, and 19 respectively. The acquisition of T2, T1-post and DWI was conducted in five centres using 1.5T and 3T Siemens, 1.5T GE, 1.5T and 3T Philips scanners. The processing pipeline followed the approach presented in [2] and the feature selection method followed the method suggested by [3]. A multinomial logistic regression technique [4] was customized as part of a classifier and validated by a leave-one-out cross validation. The texture based classification was performed on each single MR image type; T2, T1-post and ADC. Classification based on TA of multiple image types was investigated by examining the predicted class for each individual image type of T2, T1-post and ADC and assigning a weight (overall accuracy of each image type) to each predicted class. The outcome of this approach is a class having the highest vote from combining with the weighted predicted class. We called this approach as superposition of weighted outcome.

### Results and Discussion

In the single MR image type analysis, ADC based TA can better discriminate the three tumour types compared to T2 and T1-post based TA (see Figure 1). The superposition of the weighted outcome approach shows better overall classification compared with ADC based TA. Four cases (see Figure 2), which were misclassified by ADC based TA, were correctly predicted by this approach. Atypical characteristics of tumours e.g. solid PA without typical cystic component and EP with large cystic region, were included in the study and resulted in classification difficulties. In addition, the variation of tumour types (desmoplastic-nodular MB and anaplastic EP) and variation of cell properties in infratentorial and supratentorial regions contribute to the complexity of the classifier.

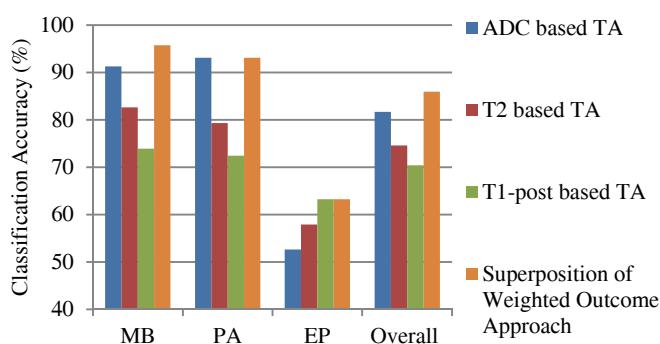


Figure 1. The comparison of classification accuracy obtained from single image type based TA and multimodal MR image analysis

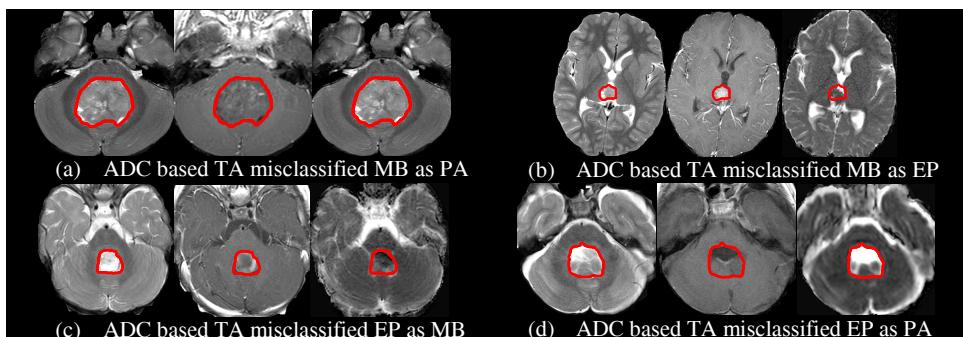


Figure 2. Four cases were misclassified by ADC based TA but correctly predicted by the superposition of weighted outcome. First, second and third image of (a), (b), (c) and (d) is T2, T1-post and ADC image. The tumour boundary is delineated by the red line.

### Conclusion

In single image type based TA, ADC provided better differentiation among the three brain tumour types from a multi-scanner multi-centre cohort. However, the characterisation of childhood brain tumours may be improved by analysing multimodal MR images using TA. Using the superposition of the weighted outcome approach improves the overall classification accuracy from 82% to 86%, with increased gains for EP, which are notoriously difficult to diagnose using MRI.

### Acknowledgments

We would like to acknowledge the financial support from NSTDA (Thailand), CSO, NIHR, CRUK, EPSRC (UK) and Department of Health (England, UK).

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