Identifying Lesions in Paediatric Epilepsy using Morphometric and Textural Analysis of MRI

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Introduction:

Pediatric epilepsy has devastating consequences on children's quality of life. Fortunately, many of them can be successfully treated by removing the lesion responsible for epilepsy. Lesions that are responsible for pediatric epilepsy include focal cortical dysplasia (FCD) and tumours. In contrast to tumours, which are readily identifiable on MRI, FCD can be subtle and may not be detectable on routine MRI. Therefore, there is a need for more advanced and objective tool for analyzing the MRI data in FCD. Image processing offers the potential to detect subtle structural changes, which may not be identifiable on visual inspection of MRI.

Methods:

In this research, we utilized textural features along with FCD morphometric features on MRI, to improve lesion identification and detection. Fifty-four children with focal intractable epilepsy and have undergone epilepsy surgery were included in the study. Thirty-one children have subtle lesion on MRI that was suspected to be FCD (MRI-positive) and 23 children have MRI-negative focal epilepsy. Healthy controls consisted of 13 children. For morphometric features, we extracted cortical thickening and blurring at the gray-white matter interface.

The shorter distance between the white matter surface and pial surface was used to calculate cortical thickness. For gray-white matter junction blurring, we employed gradient magnitude to measure rate of change at each voxel of the interface. To detect the interface, at each voxel the neighbouring 8 voxels were examined. If at least 30% were contained in the gray matter and at least 30% were contained in the white matter, the voxel was considered to fall on the interface [1]. Textural features were assessed using Gray-Level Co-occurrence Matrices (GLCM). Symmetric GLCMs were computed with the following parameters: a distance of 3 voxels, and an intensity range of 32 gray levels such that 13 co-occurrence matrices were produced per voxel. From each generated matrix 12 textural descriptor features were computed. For each feature, the average of the 13 was taken to be the value mapped back to the initial position. Subsequently, we applied a 2-Step Naive Bayes classifier to train on morphometric, followed by textural features [1]. The following were used to measure the performance of the algorithm: 1. *subjectwise sensitivity* (the number of epilepsy subjects in which a lesion is correctly identified divided by the total number of epilepsy subjects), 2. *subjectwise specificity* (the number of controls in which no lesion is identified divided by the total number of control subjects), 3. *lesional sensitivity* (the sum of all cortical segments labeled lesional by the classifier divided by the total segments labelled lesional for all subjects), and 4. *lesional specificity* (the sum of all segments labeled non-lesional by the classifier divided by the total segments labeled non-lesional).

Table 1: Evaluating 2-Step Naive Bayes performances using T1, T2, and FLAIR on MRI-Positive and MRI-Negative cases

	MRI-Positive			MRI-Negative		
	T1	T2	FLAIR	T1	T2	FLAIR
Number of Incorrectly Rejected Cases of FCD	0/31	1/31	6/31	2/23	1/23	0/23
Subjectwise Specificity (%)	100	100	100	100	100	100
Subjectwise Sensitivity (%)	94	90	71	48	30	39
Lesional Specificity (%)	75	80	89	94	95	92
Lesional Sensitivity (%)	63	60	42	31	22	28

Results:

The results are presented in table 1. For MRI-positive cases, T1 has the highest subjectwise sensitivity relative to T2 and FLAIR (94% vs. 90% vs. 71% respectively), and also the highest lesional sensitivity (63% vs. 60% vs. 42% respectively), but the lowest lesional specificity. Combination of all three sequences improved the performance of the algorithm, with 97% subjectwise sensitivity. For MRI-negative cases, T1 has the highest subjectwise sensitivity relative to T2 and FLAIR (48% vs. 30% vs. 39% respectively), and also the highest lesional sensitivity (31% vs. 22% vs. 28% respectively). However, T2 has the highest lesional specificity relative to T1 and FLAIR (95% vs. 94% vs. 92% respectively). Combination of all three sequences improved the performance of the algorithm, with 70% subjectwise sensitivity. The 2-Step Naïve Bayes classifier correctly rejected 100% of the healthy subjects for all three sequences.

Conclusions:

In summary, computational techniques using a 2-Step Bayesian classifier trained on morphometric and textural features can assist with detecting a lesion on MRI in children with epilepsy. By demonstrating the potential location of the abnormality, the neuroradiologists can perform a second review of these areas on MRI and correlate the changes with the epileptogenic zone as identified on video EEG and other functional imaging.

References: [1] Antel, Samson B., et al. "Automated detection of focal cortical dysplasia lesions using computational models of their MRI characteristics and texture analysis." Neuroimage 19.4 (2003): 1748-1759.