

Brain Segmentation and Structural Multiparametric Analysis for Cortical Malformations Detection in Focal Epilepsy

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Synopsis

With the advent of high resolution MRI, malformations of cortical development (MCD) are increasingly detected and recognized as the underlying cause of seizure in patients with intractable focal epilepsy. Processing tools including brain extraction, tissue classification and structural multiparametric analysis (SMA) are developed to enhance MCD detection on conventional MRI. The SMA application on five T1w-MRI patients point out MCD lesions that are undistinguishable from normal gray matter.

Introduction

The success of epilepsy surgery strongly depends on accurate identification of the seizure focus which is always challenged by the diffuse and multifocal nature of MCD lesions such as periventricular nodular heterotopia, polymicrogyria, focal cortical dysplasia... [1]. Therefore, the development of new imaging tools is required to localize more specifically and accurately these subtle lesions. If functional MR techniques including MR spectroscopy and diffusion are very sensitive to alterations of neuronal integrity and connectivity, respectively, their spatial resolution as well as their clinical use is still limited. Therefore, the prospect for improved MRI in epilepsy includes the development of processing techniques as clinical tools such as morphometry or curvilinear reconstruction. Detection of MCD lesions on conventional MRI is improved by developing a structural multiparametric analysis (SMA) in a Windows environment platform including algorithms for brain extraction and automatic tissue segmentation.

Material and Methods

MRIs of 5 patients (3 w, 2 m, age = 44 ± 9 y) with intractable focal epilepsy and 20 control subjects (age = 33 ± 9 y) are acquired on a 1.5 T Magnetom Vision (Siemens, Germany) system using a T1 MPR sequence (TR= 9.7 s, TE = 4 s, matrix size = 200 x 256, FOV = 250 mm, thickness = 2 mm). T1-weighted MRIs are examined by a neuroradiologist and analyzed by using brain extraction, tissue classification and SMA methods. The brain extraction method is based on simple deformable model (sphere) by application of set of locally adaptative model forces. Each vertex of the sphere is attempting to fit the real brain surface by computing the moving distance value which is constrained by surface vertex spacing and surface smoothness [2]. The automatic tissue segmentation uses the expectation maximization algorithm to model local histograms with a four Gaussian mixture. Four classes are determined by the value intensity of gray matter (GM), white matter (WM), cerebrospinal fluid (CSF) and a mix of GM and CSF based on reference global histogram. The decision criterion is based on each mean value of local classes [3]. The SMA enables the calculation of three features to model, first the cortical thickening, second, the blurring of GM/WM transition, and third, the relative intensity signal of the image. This process results in a "Ratio" image calculated from the thickness, gradient and intensity features [4]. Then, Ratio maps are spatially normalized and statistically analyzed using SPM99 (Statistical Parametric Mapping).

Results

Visual analysis of the Ratio maps demonstrates the presence of lesions in all patients. If lesions are visible on T1w-MRI, they are not distinguished from normal GM. Figure 1 shows a typical example of a patient with insular MCD. The SPM99 statistical analysis performed by comparing each patient with the control database points out significantly ($p < 0.05$) the lesions in 4 over 5 patients.

Conclusion

Brain extraction and tissue classification methods developed in this study provide similar results as those obtained by other tools such as BET or MRICro. These methods are fast but remain limited by the image quality. SMA will be tested on further patients to demonstrate its robustness in lesion detection and be used as a diagnostic tool. These methods are actually implemented in an industrial software platform for brain imaging including other tools like registration and normalisation.

References

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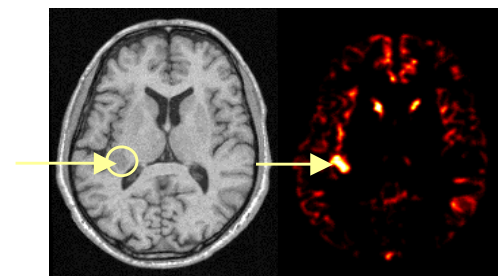


Fig.1: T1w-MRI and Ratio map of MCD lesion