Reconstruction of 3D T2-weighted brain volumes from 2D high-resolution sequences

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Target and audience: scientists and clinicians with interest in high-resolution brain imaging.

Background and Purpose: histological studies have shown that cortical grey matter (GM) is not uniform, but presents a more complex structure made of different layers[1]. According to recent studies, MRI, is able to detect such stratified structure in specific portion of the cortex trough IR sequences, however a quantitative analysis of these finding has never been performed because of resolution's constraints. In clinical practice, T2-weighted images are usually acquired with an high in-plane resolution, but with really depth thickness to avoid low signal-to-noise ratio (SNR) and too long acquisition times. Our purpose is to build a 3D T2-weighted isotropic volume to study the cortical layers, thus allowing a quantitative study of these structures.

Data and Methods: *MRI data*: data from a 8 years old male healthy subject were acquired on a 3T Philips Achieva scanner equipped with a 32 channels head coil. MRI protocol included three 2D T2-weighted turbo spin echo (TSE) sequences on the same axial plane (TR= 4.1 s, TE= 82 ms, flip angle = 90°, gap = 0.3 mm, FOV= 210 x 210 x 148.5 mm^3, voxel_size= 0.219 x 0.219 x 3.3 mm^3) shifted of 1 mm along the z-axis.

Reconstruction: we processed data using the "*baby Brain ToolKit*" (BTK) [4]. A denoising step was firstly performed on the images using an algorithm based on a weighted graph representing non-local similarity of the input volume. Then, we co-registered the different volumes on a slice by slice approach. Finally, the Super-Resolution algorithm, whose purpose is to remove the effect of the blurring convolution and to increase the voxel grid density, was applied to obtain the final 3D volume with a voxel resolution of 0.2x0.2x0.2 mm^3.

Results: A particular of the pre-central cortex in the reconstructed volume is reported for each plane in fig. 1. Cortical stratification is visible in all planes, as shown by the images and by the intensity profiles.

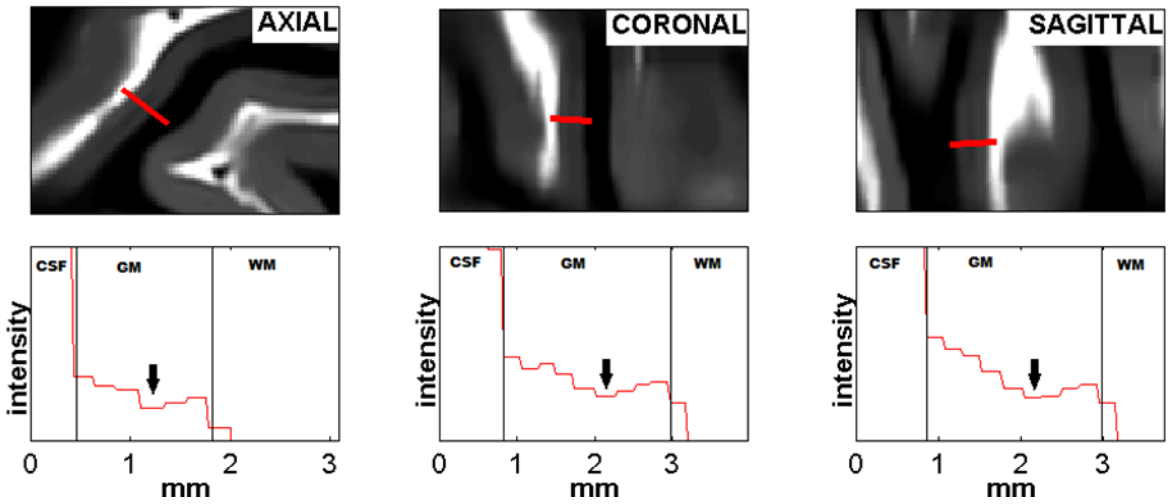

fig. 1 - Intensity profiles (lower row)of the cortex taken from the same cortical area on axial , coronal and sagittal planes. Gray Matter (GM), CerebrSpinal Fluid (CSF) and White Matter (WM) are indicated on the profiles. Arrows show the presence of a low-signal intra-cortical region corresponding to the hypo-intense layer visible on the reconstructed morphological images (upper row)

Discussion and Conclusions: The suggested pipeline allowed to build a 3D high-resolution T2-weighted volume reconstructed from a series of high-resolution 2D T2-weighted images. Results show that with this reconstructed volume it is possible to detect small structures, such as cortical layers, allowing future quantitative measures.

References: [1] Kim et Al. "*Triple-Layer Appearance of Brodmann Area 4 at Thin-Section Double IR MR Imaging*", Radiology (2009); 250 (2): 515-522; [2] Daniel Barazany et Al.. "*Visualization of Cortical Lamination Patterns with IR-MRI*", Cerebral Cortex (2012) 22 (9): 2016-2023 [3] Emmanuel et Al. "*Imaging Cortical Anatomy by High Resolution MR at 3T: Detenction of the Stripe of Gennari in Visual Area 17*", Magnetic Resonance in Medicine, (2002) 48: 735-738 [4] F. Rousseau et Al. "*BTK: An Open-Source Toolkit for Fetal Brain MR Image Processing*", Computer Methods and Programs in Biomedicine (2013), 109: 65-73.