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Detection and Identification of Sulci on 3D MRI

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Introduction

Cross-subject analysis of structural and/or functional images often requires accurate localisation of cortical convolutions (sulci and gyri). This is particularly relevant to better understand the anatomical/functional relationships within the brain and to increase accuracy in neuro-surgical planning. Internal brain structures are easily identified on high resolution MRI, using the Talairach space, thanks to their low variability. Unfortunately, localisation and identification of sulci are very difficult tasks because of the high variability of cortical structures. In this work, we propose an approach for automatic localisation and identification of sulci on MR images.

Methods

Brain is automatically extracted and segmented into cerebro-spinal fluid (CSF), grey matter and white matter using morphological operators (thresolding, filtering, erosion, reconstruction, dilatation). 3D skeletonization and curve thinning are applied on CSF. Sulci are then described as 3D curves on the brain surface (fig. 1).

For each sulcus, a set of features, related to localisation, orientation, shape, geometric measurements (e.g. length) and spatial relations between sulci are computed from a training set of images where sulci are identified [1]. To recognize sulci on a new brain image, the basic idea is to perform all these measurements in the coordinate space of the new brain, after registration of the training set on this brain. Linear registration is performed using the Talaraich space and all sulci of the training set are then projected onto the surface of the new brain [2]. We get all measurements, including mean and standard deviation of these features, in the space coordinates of this brain, allowing inter-subjects comparisons.

Recognition is performed by searching a connected path on the surface of the brain with respect to the computed features, by minimising a cost function. Recognized sulci on the brain surface are propagated towards the center of the brain to obtain 3D surfaces, which are the medial parts of the convolutions (fig. 2).

Results and conclusion

Six main sulci on each hemisphere (lateral, central, pre-central, post-central, superior temporal, superior frontal sulci), have been identified on a training set of nine T1-weighted 3D MRI (SPGR sequence, 1.3 mm^3). The proposed method performs automatic detection and identification of these sulci on each hemisphere of thirteen T1-weighted MRI, with good results.

We have developed a methodology for studying the morphology of the cerebral sulci and for building a sulci atlas. We get features for morphometry allowing inter-subjects comparisons. These features are used to identify sulci on 3D MRI, which are landmarks for inter-subjects or inter-modality (functional/anatomical) registration and mapping.

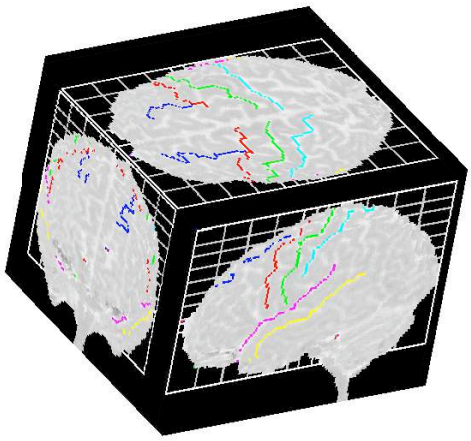

Figure 1 : Identified sulci on the surface

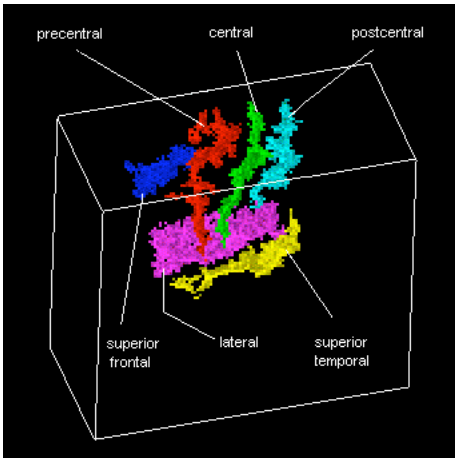

Figure 2 : 3D medial surface of sulci

References

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2/ Desvignes M., Royackkers N., Revenu M. - Sulcal variability in a computerized brain atlas. *IEEE/EMBS, Amsterdam, 1996.*