Robust Radiometric Parameter Estimation and Automatic Morphological Segmentation of Brain Internal Structures in 3D MR Images

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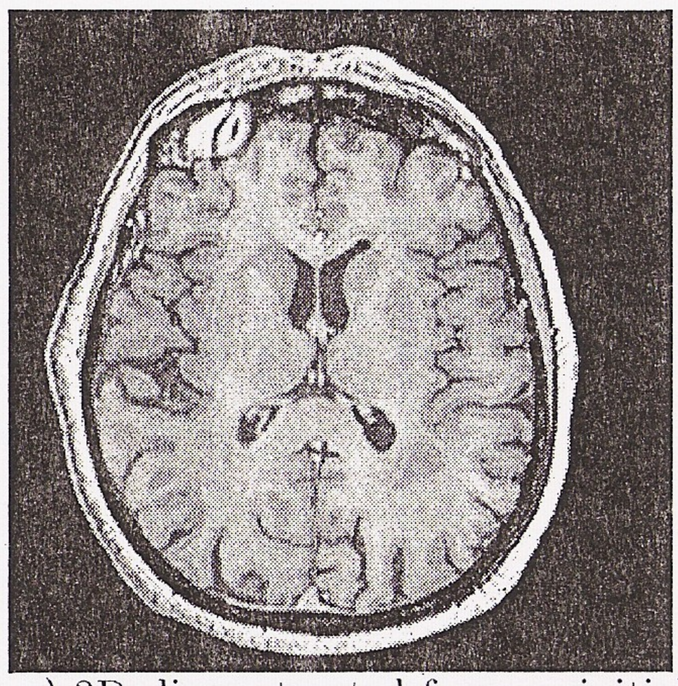
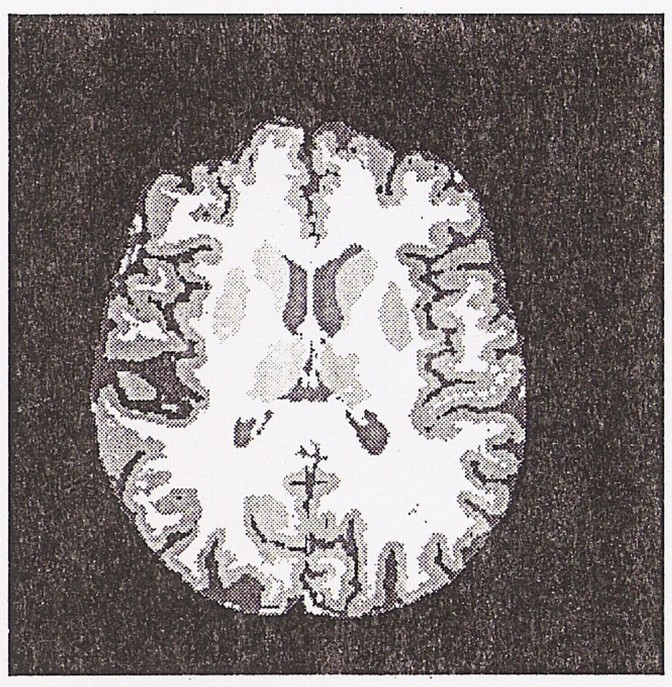
Due to the important progress in imaging technology, the quality of three-dimensional magnetic resonance images has significantly improved over the last few years, and non-invasive examination of the brain has received great attention. A major issue is segmentation of internal structures; the number of applications is steadily growing: morphometric measurements, pathology detection, surgery planning, reference for functional studies, and so forth. In this paper, we propose an original approach to perform internal structure segmentation in 3D MRI which combines reliable radiometric estimations with morphological operations.

Robust Radiometric Parameter Estimation The literature shows that the radiometric distribution of each anatomical structure can be rather well modeled by a Gaussian probability distribution. Unfortunately, although MR images now offer a good resolution, partial volumes are yet numerous and a remaining principal difficulty is to get reliable statistical parameters for those laws. Until now, this task was performed on regions of interest manually delineated by a physician; the results were not statistically consistent due to the low number of voxels taken into account and due to the bias introduced by human subjectivity. The original method we have developed aims at pointing out only the points composed of pure tissue for each structure. Starting from a rough initial classification, we analyze the evolution of gray level statistics on each side of the interface between two structures. We observe that, when sufficiently far into the interior of each structure, the statistics become stable: therefore, the points correspond to pure tissue and their membership to a certain class is ensured. Several applications may be found for this estimation: it can be used as a guide for segmentation as proposed in the next section. It can also be used for estimating partial volume effect and, more precisely, the percentage of the different tissues covering a voxel [2].

Automatic Morphological Segmentation An initial detection of main objects (cerebro-spinal fluid, gray matter and white matter) is a good starting point for a complete recognition method. This detection can be performed by gray level multi-thresholding. As the different radiometric distributions significantly overlap, a precise knowledge of statistical parameters is required. Otherwise, some structures (for instance nuclei) can disappear or, on the contrary, can be over-estimated and then merged with other structures. The use of our results on parameter estimation that we have previously obtained also ensures an optimal pre-segmentation and permits us to proceed to morphological recognition of internal structures. For this purpose, we make use of classical morphological



a) 2D slice extracted from an initial 3D MR image, by courtesy of Hôpital La Timone, Marseille, France (contrast has been enhanced for visualization).



b) Segmentation result (only for printing, differently labeled nuclei have the same gray level).

FIG. 0.1 - *Morphological segmentation*

filters [3] such as connected component labeling, conditional transforms, dilation or erosion that we have extended to 3D. The structuring elements are balls constructed with anisotropic chamfer distance transform [1], in order to comply with the voxel sizes of 3D image and to make the method independent of the acquisition system. Morphological segmentation is achieved by taking into account anatomical information and spatial relationships between structures. Results are depicted in figure 1b.

Conclusion Thanks to the precise and reliable radiometric parameter estimation method proposed in this paper, automatic and robust recognition of the following structures is performed: brain itself, cortex, nuclei (caudate, thalamus, putamen), sulci and different ventricles. Future work aims at extending this method to segmentation of extra brain internal structures.

Bibliography

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