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A soft-segmentation visualization scheme for magnetic resonance images

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Abstract

Prevalent visualization tools exploit gray value distribution in images through modified histogram equalization and matching technique, referred to as the window width/window level-based method, to improve visibility and enhance diagnostic value. The window width/window level tool is extensively used in magnetic resonance (MR) images to highlight tissue boundaries during image interpretation. However, the identification of different regions and distinct boundaries between them based on gray-level distribution and displayed intensity levels is extremely difficult because of the large dynamic range of tissue intensities inherent in MR images. We propose a soft-segmentation visualization scheme to generate pixel partitions from the histogram of MR image data using a connectionist approach and then generate selective visual depictions of pixel partitions using pseudo color based on an appropriate fuzzy membership function. By applying the display scheme in clinical examples in this study, we could demonstrate additional overlapping regions between distinct tissue types in healthy and diseased areas (in the brain) that could help improve the tissue characterization ability of MR images.

Keywords: Visualization; Soft segmentation; Connectionist; Neurofuzzy; MRI; Window width; Tissue; Boundary

1. Introduction

Interpreting 2D magnetic resonance (MR) images is an important area in the diagnosis of a disease condition. An image visualization tool that could shorten the time required for making a diagnosis, improve diagnostic accuracy and improve throughput of doctors is much needed. Identifying different types of tissues in MR images and boundaries is the most challenging problem for interpretation and diagnosis. Difficulties in identifying tissue types based on gray scale intensity in 2D MR images are due to partial volume averaging, tissue inhomogeneity and the nature of tissue types besides factors related to imaging parameters [1,2]. We propose an interactive segmentation-based visualization tool that aims to circumvent these difficulties and to define a boundary region between distinct tissue types, which can be clinically useful with the help of anatomical knowledge and experience. The tool exploits a network-based clustering scheme and fuzzy logic to generate alternate and selective segmentation of 2D MR images for detailed analysis.

The main aim of MR image enhancement techniques is to improve visual information for human interpretation. These techniques are applied to spatial domains or histograms [3]. All the MR diagnostic consoles and offline workstations are equipped with 2D window width/window level and other image enhancement schemes [4–7]. This interactive scheme can generate multiple interpretations of 2D MR images by changing window widths and window levels or by automatically finding the optimum value [8–13].

In addition, several stand-alone commercially developed tools are also used for offline analysis and visualization. Some of these are 3DVIEWNIX [14], Analyze AVW [15–17], ApX, AVS/Express, IDL, IRIS Explorer, Khoros, MEDx, PV-WAVE, ROSS, Slicer Dicer, VoxelView, VTK [18] and BRAINS2 toolbox [19]. These software tools on offline workstations can be used in visualizing and processing biomedical images. The images can be viewed in different modes such as single slice, interactive, multimodal, multidimensional and multiplanar reformation, among others. These tools can also perform magnification, multicolor maps and

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