Standardizing the MR Image Intensity Scale and Its Applications [11]

László G. Nyúl and Jayaram K. Udupa

Magnetic Resonance Imaging (MRI) has revolutionized radiological imaging of the internal structures of the human body. It has the advantage of being noninvasive with no known health hazards. A variety of MRI protocols are currently available, with and without the use of contrast agents, such as T1, T1 with a contrast agent, T2 and proton density (Pd) with spin-echo (SE) or fast spin-echo (FSE) sequences, magnetization transfer (MT), FLAIR, SPGR, and GRASS. These protocols allow the setting up of different contrasts among the different tissues within the same organ system. Ironically, this richness of acquisition schemes comes with a major difficulty. Unlike in other modalities such as x-ray computerized tomography, MR images taken for the same patient on the same scanner at different times may appear different from each other due to a variety of scanner-dependent variations, and therefore, the absolute intensity values do not have a fixed meaning. This implies that MR images cannot be displayed at preset windows; one may have to adjust the window settings per case. The lack of a standard and quantifiable interpretation of image intensities also poses problems in image segmentation and quantification.

We have devised a two-step method wherein all images (independent of patients and the specific brand of the MR scanner used) can be transformed in such a way that for the same protocol and body region, in the transformed images similar intensities will have similar tissue meaning. In the first step, the parameters of the standardizing transformation are "learned" from an image set. In the second step, for each MR study, these parameters are utilized to determine the mapping needed to deform its histogram into the standardized histogram. The method was tested quantitatively on 90 whole brain studies of Multiple Sclerosis patients for several protocols and qualitatively for several other protocols and body regions. As measured by mean squared difference and the coefficient of variation of the mean tissue intensities, standardized images have statistically significantly more consistent range and intensity meaning for tissues than those without. This consistency achieved seems to be independent of the scanners. Fixed gray level windows can be established for the standardized images and used for display without the need of per case adjustment. Image analysis and tissue segmentation methods are considerably improved in terms of their constancy of parameter settings and their degree of automation. With standardization, numerical meaning is achieved, and hence numerical diagnosis and study of diseases may become possible. The method can be easily implemented in a PACS via DICOM value of interest look up tables.

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