Abstract

The thesis on "Studies on Brain MR Image Segmentation and Visualization" consists of three different improved, modified fuzzy c-means based frameworks for brain magnetic resonance (MR) image segmentation. These frameworks segment the dominating regions of human brain namely, cerebro spinal fluid (CSF), gray matter (GM) and white matter (WM). The necessity of this task is very crucial in medical image analysis field as it is the fundamental requirement to diagnosis of any deformities in human brain by using MR images. In MR imaging, the scanned images are drastically affected by noise and intensity inhomogeneity (IIH), because of the uneven distribution of radio frequency, generation of Eddy current and unconscious movement of patient. Further, noise and IIH make the MR images blur, mostly at the boundaries of different tissue regions and increase the difficulties to get correct segmentation results.

The fuzzy c-means (FCM) clustering algorithm is most studied algorithm to segment the images, but has limitation for high noisy images. The conventional FCM algorithm does not consider the spatial information of the images and therefore its performance decreases for the images that are highly affected by noise.

The developed three improved enhanced FCM-based frameworks address this issue and successfully segment high noisy volumetric brain MR images. The first method is based on the

complemented fuzzy membership functions. It utilizes a class-level uncertainty parameter for each voxel and incorporates complemented global and spatially constraint local fuzzy membership functions in the fuzzy objective function. It also incorporates total uncertainties in the 3D image domain by means of Shannon entropy. The complemented local fuzzy membership function estimates the degree of non-association for a voxel at the particular region, constraint by the local region-level intensity distribution. This framework allows the algorithm to utilize the spatial intensity distribution both in locally and globally within the image domain and produce more accurate cluster prototypes.

The second method is based on interval type-2 based FCM framework. In this work, a multi-objective framework is developed for segmentation of 3D brain MR image volumes using relative entropy-based type-1 and interval type-2 fuzzy c-means (FCM) algorithms. The first objective function uses a relative entropy-based type-1 FCM algorithm utilizing spatial information and locally biased class-level possibility parameter to yield local as well as global membership functions (MFs). In doing so, it utilizes the intensity dispersion within a cubic neighborhood of the center voxel under consideration. The total uncertainty is measured by using relative entropy and it is defined by local and global MFs. Whereas, the second objective function uses this global MFs and introduces an interval type-2 fuzzy MFs, weighted by the above possibility parameters. Specifically, it utilizes the local MFs as the secondary MFs in the interval type-2 fuzzy sets for better realization of correlation between the neighboring voxels. The framework calculates the final cluster centers as the arithmetic mean of those yielded by the two objective functions. Finally, it generates the final MFs by combining the global and interval type-2 based fuzzy MFs using two weighting parameters to resolve the trade-off between them.

The third method is based on fuzzy entropy-based FCM framework. The fuzzy entropy has been utilized by incorporating the local membership functions to mitigate the underlying uncertainty for voxel classification. In the objective function, the global membership functions and the local membership functions, weighted by class-specific possibility parameters are incorporated. It also incorporates the fuzzy entropy to define total uncertainty.

The performances of the contributed algorithms have been investigated both in qualitatively as well as quantitatively using several volumes of brain MR images. The outcomes of the experiments indicate the supremacy of the developed frameworks over recently developed standard state-of-the-art algorithms.