Chapter 6
Intensity Inhomogeneity Correction in Brain MR Images Based on Filtering Method

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ABSTRACT

Brain tumor is a mass of abnormal growth of cells in the brain which disturbs the normal functioning of the brain. MRI is a powerful diagnostic tool providing excellent soft tissue contrast and high spatial resolution. However, imperfections arising in the radio frequency field and scanner-related intensity artifacts in MRI produce intensity inhomogeneity. These intensity variations pose major challenges for subsequent image processing and analysis techniques. To mitigate this effect in the intensity correction process, an enhanced homomorphic unsharp masking (EHUM) method is proposed in this chapter. The main idea of the proposed EHUM method is determination of region of interest, intensity correction based on homomorphic filtering, and linear gray scale mapping followed by cutoff frequency selection of low pass filter used in the filtering process. This method first determines the ROI to overcome the halo effect between foreground and background regions. Then the intensity correction is carried out using homomorphic filtering and linear gray scale mapping.

INTRODUCTION

Brain tumor is a life-threatening disease that arises due to abnormal growth of cells in the brain. The diagnosis and treatment of brain tumor is based on the clinical symptoms and its radiological appearance. Brain tumor segmentation is a potential investigation tool used for partitioning abnormal tissues from the normal regions. Magnetic Resonance Imaging (MRI) is a non-invasive medical imaging modality used for revealing the anatomical structure of brain tumor. The prime intention of magnetic resonance brain tumor imaging investigation is to draw out the vital clinical knowledge that would improve clini-

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cal diagnosis and treatment of disease. Due to its excellent soft tissue contrast and novel innovative acquisition sequences, Magnetic Resonance Imaging has become one of the most popular imaging modalities in health care. However, associated acquisition artifacts can significantly reduce image quality. Consequently, these imperfections can disturb the assessment of the acquired images. In the worst case, they may even lead to false decisions by the physician. Moreover, they can negatively influence an automatic processing of the data such as image segmentation or registration. If possible, the sources of artifacts have to be removed during the acquisition process. In many cases, however, this cannot be achieved due to physical or financial issues. Then, they have to be dealt with using appropriate correction methods. Some of the artifacts can even simulate pathologies that are invisible in the artifact free case. Even though many artifacts do not create false pathologies in the images, they make the diagnosis process much more complicated for the radiologist. Most mentionable artifacts in MRI are intensity non-uniformities, also denoted as signal intensity variations. Generally, these variations are very smooth, and in many cases a human observer is not able to recognize them. Figure 1 shows the sample MR images affected by intensity inhomogeneity.

Intensity inhomogeneity is a smooth intensity change referred to as intensity non-uniformity, intensity variations, bias field or gain field. Intensity variations in MR data are due to the combined effect of the imaged object, the MR pulse sequence and the imaging coils. These intensity variations pose major challenges for subsequent image processing and analysis techniques. The signal intensity variations make it impossible to predefine standard transfer functions to visualize certain tissue classes. The radiologist has to perform the adjustment manually in every single case and even for different regions within the images. This process can be very time consuming. These artifacts change the appearance of structures within the images and have a significant influence on the quality of the results of image processing techniques. Many segmentation techniques assume that objects to be segmented have homogeneous intensity characteristics. If these are altered due to imaging artifacts, many techniques will perform significantly worse or even fail. The intensity inhomogeneties in MR images make the segmentation of brain tumor a challenging task.

In the last decades, many researchers in the field of medical imaging have developed significant approaches for the correction of intensity inhomogeneities in MRI. Generally, the corrections are done focusing on two main directions, namely prospective and retrospective. Prospective methods regard inhomogeneity as an error acquired during the imaging process, and the intensity correction is based on adjustments of hardware and acquisition methods such as phantom-based calibration and multichannel transmit scanning (Clare, Alecci & Jezzard, 2001). These methods provide a good solution to intensity correction by gaining information from the scanner system. However, in many cases, they require additional scans which increase the cost and the time complexity. Moreover, these methods are often

Figure 1. Examples of intensity inhomogeneity in MR images