Chapter 5
MRI Denoising for Healthcare

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ABSTRACT

Biomedical Image processing is an important research domain which contributes to the human health care. Magnetic resonance imaging (MRI) is the most popularly used medical imaging modality for its ability to scan any organ or tissue of a body without causing health risk to patient. Because of immense potential of MRI in health care it is very popular with the researchers. Along with improvisations in MR machines, the researchers are exploring different de noising filters, implementation techniques, and platforms so as to improve the MR image quality and enhance accuracy of diagnosis. The chapter discusses all the aspects of MRI - its physics, image attributes, rician noise pdf, different denoising filters and their implementation aspects. The performance analysis being significant in evaluating image quality, different quality measures used are discussed in details. The chapter also briefs about possible opportunities of research in the said domain.

MAGNETIC RESONANCE IMAGING (MRI)

Medical Images are images of internal body organs, tissues and thus an extremely powerful means to diagnose a disease or injury. There exist many imaging modalities such as Computer Tomography, X ray, Ultrasound and Magnetic Resonance Imaging. Out of these, MRI is a technique extensively used and preferred by doctors for its ability to capture every possible body organ and tissue which otherwise could not be seen by any other imaging technique. The main advantage of MRI technique is it can acquire scans in different planes such as coronal, axial, sagittal without altering position of the object. This helps the medical practitioner to diagnose a disease or deformity with more accuracy. MR imaging has clinical advantage as it does not involve any invasion, surgery to patient. The next section elaborates significance of MRI for patient healthcare.

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MRI and Patient Healthcare

Due to the unique ability to generate images of soft tissues, MR imaging is specially used for scanning body parts such as brain, spine, and joints. Neurosurgeons use this technique to identify swelling or bleeding in patient’s brain. MRI of head can detect brain tumors as well as brain aneurysms, strokes, etc. The MR image can identify abnormality of tissue which may occur due to multiple sclerosis. Thus, the disease can be treated in its early stages and help restore patient’s health. The orthopedic doctors use MR scans to analyse proper functioning of spinal cord and knee joints. The MR scans show important information about soft tissues, bones, glands and organs inside abdomen. The MR scans also help to inspect structure of heart, aorta or any other defects/tears that are present. MRI has a unique advantage of being painless and does not use any form of radiation.

There are no known dangers to MRI scan itself. The procedure can be repeated without problems. MR scans are not performed on pregnant woman for the risk to fetus. Patients with artificial valves in heart, metallic ear implants, bullet fragments, insulin pumps cannot undergo MRI procedure.

The next sections discuss different aspects of MRI such as its physics, the evolution of MRI systems, technical specifications of MR image and noise in MR image (Catherine W. 2008; E. Mohammed et al 2012; H. Yoshioka, H. Gudbjartsson et al 2008; K. Iniewski, 2009; IMAIOS: Medical websites and e-learning for healthcare professionals www.imaios.com/en, Xiaoping Hu, 2004).

Physics of MRI

MRI technique is based on the operating principle of nuclear magnetic resonance. The human body mainly consists of hydrogen atoms in the form of water. The proton in the hydrogen atom spins at a fast rate and produces a small magnetic field. The spinning proton when placed near a large magnetic field aligns itself with the same. This principle forms basis of MRI scanner.

The MRI scanner is a tube which is surrounded by a circular large magnet. The patient to be scanned is placed on a bed which is inserted inside this circular magnet (Figure 1). This causes the hydrogen atoms within the body to spin. The magnetic vector of spinning protons is split in two components –longitudinal or Z component and transverse component which lies in the XY plane. These two components are orthogonal to each other. The atoms while spinning get aligned either in parallel or anti parallel to the large external magnetic field. To these aligned hydrogen atoms, RF signal is applied which makes them tilt from their position as shown in Figure 2.

On removal of RF pulse sequence three events occur:

1. The RF signal is retransmitted by hydrogen atoms as they return to their initial state from state of excitation. This is NMR signal which is proportional to proton density.
2. The spinning hydrogen atoms return to the initial orientation i.e. parallel or antiparallel to the external magnetic field. The time required for 63.2% of magnetization to align back to the external magnetic field is known as relaxation time constant T1. This is also called Spin-lattice relaxation or Longitudinal relaxation. (Figure 3)
3. The in phase, spinning excited protons while returning to initial state dephase resulting in signal decay (Figure 4). This is also known as transverse or spin-spin relaxation time denoted as T2 and is the time when signal decays to 36.8% of its original value.
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