Thesis

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July 6, 2016

Abstract

TODO

1 Introduction

1.1 Motivation

Rough notes

Magnetic Resonance Imaging is an imaging technique that is widely used today in clinics and medical research facilities to aid the understanding of how the human body works. It has many applications in the biomedical sciences such as the study of the human anatomy, pathology and even function.

The main aim of MRI is to allow the clinician to assess the inner workings of our bodies in a non-invasive way. This is normally accomplished in the following way: the patient sits quietly in the MRI scanner, while the clinician programs the scanner with a set of sequence parameters on how to acquire the images. The resulting data sets are made up of gray scale images which can provide different type of information or contrast depending on how the clinician tweaked the sequence parameters.

In order for the final MR images to be correct, the patient needs to sit incredibly still and all of the scanner's hardware parts need to be perfect. As this is not feasible, MR artefacts appear in the resulting images. There is a great deal of effort in the imaging research communities to come up with sophisticated algorithms to correct the imaging artefacts caused by motion or physiological changes in the body, but there is no ground truth with which to validate such algorithms.

Therefore, the main aim of our research group is to simulate the processes which are taking place throughout the whole scanning pipeline in order to provide this ground truth. In doing so, four building blocks need to be provided. Firstly, an object which mimics the behaviour of our patient is needed. Secondly, the scanner specifications such as the magnet's strength need to exist. Thirdly, the sequence parameters need to be provided and lastly the reconstruction method which outputs the final image needs to be implemented. In the following paragraphs I will give more details about these 4 main building blocks.

The sample specifications are of utmost importance when real-life MRI simulations are wanted. More specifically, a patient's organ such as his or her brain can be replaced by tissue properties such as magnetic relaxation times. Also, patient movements can be simulated using combinations of rotations and translations of the object's geometry.

Next, the scanner's specifications can be simulated more or less realistically. For example, providing the magnet's strength,

1.2 Scope and Objectives

1.3 Thesis Outline

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TODO
IMPORTANCE OF MR
WHY WE NEED SIMULATION

2 Classification of MRI simulators

TODO: Justify choice of categorization The classification of the MRI simulators used in this paper is as follows:

1. Sample
   (a) Nature of Samples
      i. 1D objects
         - Bittoun (1984)
      ii. 2D objects
      iii. 3D objects
   (b) Chemical Shift
      -
   (c) Motion
      i. No motion
         - Bittoun (1984)
      ii. Motion
2. Scanner
   (a) Magnet
      i. No inhomogeneities present
      ii. Static field inhomogeneities
      iii. Time changing inhomogeneities
   (b) Gradients
   (c) Coils
      i. Single-coil capabilities
      ii. Multi-coil capabilities
   (d) RF Pulses
      i.
3. Sequence
   (a) Provide your own sequence

   (b) Sequences are already provided

4. Signal
   (a) Bloch eq
   (b) Bloch-Torrey eq
5. Reconstruction
   (a) Parallel reconstruction capabilities
   (b) Bloch equation based reconstruction
      - Bittoun (1984)
6. Implementation
   (a) Programming Paradigm
      - Procedural
      - Object Oriented
   (b) Hardware-specific implementation
      - Can be used to drive the hardware of scanners from different manufacturers
      - Not
   (c) Graphical User Interface
      - Provides a scanner specific GUI
      - Provides an easy to use