Compressive Sensing in MRI

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I. Introduction

Magnetic Resonance Imaging is a very powerful and safe medical diagnostic tool, but it is prohibitively expensive to use frequently. Hence, a technique that speeds up MRI acquisition would not only be helpful for patients, as it requires them to lie still for shorter periods of time, but it would also be of great benefit for doctors, as it leads to a higher patient throughput and a reduced susceptibility of the images to motion artifacts. In this work, we develop a reconstruction algorithm that handles acquisition speedup correctly.

II. Problem Statement

Speeding up MRI is done by reducing the amount of acquired data. However, signal processing theory states it is impossible to do this beyond the Nyquist limit, without losing information. However, it is possible to only lose superfluous image information, this is called compressive sensing (CS). The danger is that that a naive reconstruction technique inadvertently corrupts an image while filling in lost information.

III. Proposed Technique

An MRI image is constructed from so-called Fourier, or k-space coefficients. Due to acceleration techniques, the number of Fourier coefficients is less than the number of image pixels, resulting in an infinite number of possible images that would correspond with the acquired Fourier coefficients (an infinite number of ways to fill in the lost, superfluous information).

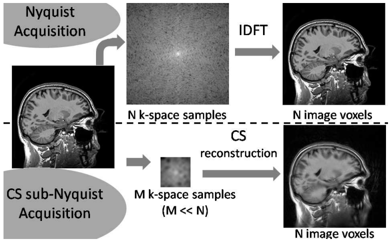

Figure 1. principle of CS MRI reconstruction

Therefore, we impose an additional constraint: the reconstructed image has to be representable with the lowest number of shearlet coefficients possible. The shearlet transform can represent natural images with few coefficients, but not noise and corruptions. It is optimal in this respect. Hence, its use will force a noise- and corruption free reconstruction. We solve this optimization problem using a split Bregman technique.

IV. Results

Figure 1 shows an example of the CS principle, along with a simulation result. This data was reconstructed from a spiral in Fourier space, sampled to only 5% of the Nyquist rate. This translates almost directly in a theoretical acquisition speedup of 20.

V. Conclusion

Our novel MRI reconstruction algorithm improves CS in MRI by using state-of-the-art shearlets. The results show that it allows for acquisition speedup combined with corruption/noise reduction.