# Contrast-enhanced T1-CUBE brain imaging with compressed sensing

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## Introduction

Compressed sensing (CS) is a promising technique for accelerating MRI acquisition (1). CS requires a compressible image that is acquired with k-space undersampling, and a reconstruction that minimizes the L1-norm of the reconstructed image in the space in which it is compressible (e.g., a wavelet space). T1-weighted 3D FSE CUBE (2) is promising for post-contrast brain exams at 3T because of flat image contrast that is preferred when looking for subtle or small enhancing lesions (3). The relatively low gray-white contrast should enhance image compressibility, making this technique a good candidate for CS acceleration. In this work, the suitability of CS to accelerate T1-weighted post-contrast CUBE scans was evaluated.

## Method

Post-gadolinium T1-weighted 3D FSE CUBE brain scans were performed on two clinical subjects using a 3T Signa MR750 MR scanner (GE Healthcare, Waukesha, WI) with an eight-channel brain coil under an IRB-approved protocol. Data were acquired using conventional data-driven autocalibrated parallel imaging (4) with acceleration factor two. In addition to performing conventional parallel imaging reconstructions, the k-space data were further undersampled in the ky-kz plane using a Gaussian random pattern to simulate incoherent acquisition for CS. Three additional undersampling factors were tested: 1.5, 2 and 2.5, resulting in four sets of images with net accelerations 1.90, 2.74, 3.55 and 4.25. The simulated CS data sets were processed with MATLAB (The Mathworks, Natick, MA) using an L1-norm minimization to first restore conventional parallel imaging two-fold undersampling for each coil k-space data set, followed by the normal parallel imaging reconstruction (5).

Acquisition parameters for the 3D T1 CUBE scans were: sagittal plane, TE/TR = 17/600 ms, 83 kHz readout bandwidth, 24 x 24 cm field of view, 1 mm slice, 0.53 partial ky fraction, 256x256, 180 slices, fat saturation, 4 minute scan time. An elliptical ky-kz mask was used to reduce scan time. A 32x32 circular autocalibration region was acquired for parallel imaging. The CS reconstruction used 10 conjugate gradient iterations with a total variation (TV) sparsifying transform. Images were reviewed by two board-certified neuroradiologists. The following parameters were qualitatively assessed on scales of 1-5 (1=non-diagnostic, 2=marginal, 3=acceptable, 4 =good, 5=excellent): A=sharpness/spatial resolution, B=ringing-like artifacts, C=blockiness or disturbing noise texture, D=overall image quality.

## Results

Typical k-space sampling patterns with only conventional parallel imaging undersampling and with additional incoherent undersampling for CS are shown in Fig. 1. A typical sagittal slice for one subject reconstructed with the four different accelerations is shown in Fig. 2. The average scores for the two subjects for both reviewers are shown in Table 1. An additional CS acceleration 1.5 (net acceleration 2.74) resulted in image quality that was deemed acceptable by both reviewers for both patients. Even additional acceleration 2.5 (net acceleration 4.25) resulted in image quality that was deemed marginal but still diagnostic.

## Conclusions

The inherent compressibility of images limits the acceleration that can be expected with compressed sensing. T1-weighted 3D FSE CUBE has relatively low soft tissue contrast and thus provides a flat background for post-contrast vessel signal. The resulting relatively high compressibility makes this technique suitable for acceleration with compressed sensing. A CS acceleration of 1.5 in addition to two-fold acceleration with conventional parallel imaging (net acceleration 2.74) with an 8-channel coil resulted in acceptable image quality with two patients and indicates that the technique warrants further investigation.

## References

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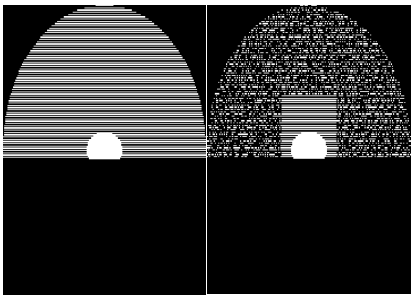

**Figure 1**. k-space sampling pattern (ky-kz plane) for parallel imaging (left) and with additional incoherent undersampling for CS (right).

| Additional (net) acceleration | A | B | C | D |
|---|---|---|---|---|
| 1.0 (1.90) | 4 | 3 | 3 | 4 |
| 1.5 (2.74) | 4 | 3 | 4 | 4 |
| 2.0 (3.55) | 3 | 3 | 3.5 | 3.5 |
| 2.5 (4.25) | 3 | 2 | 4 | 2.5 |

**Table 1**. Average of the two reviewers scores for both subjects.

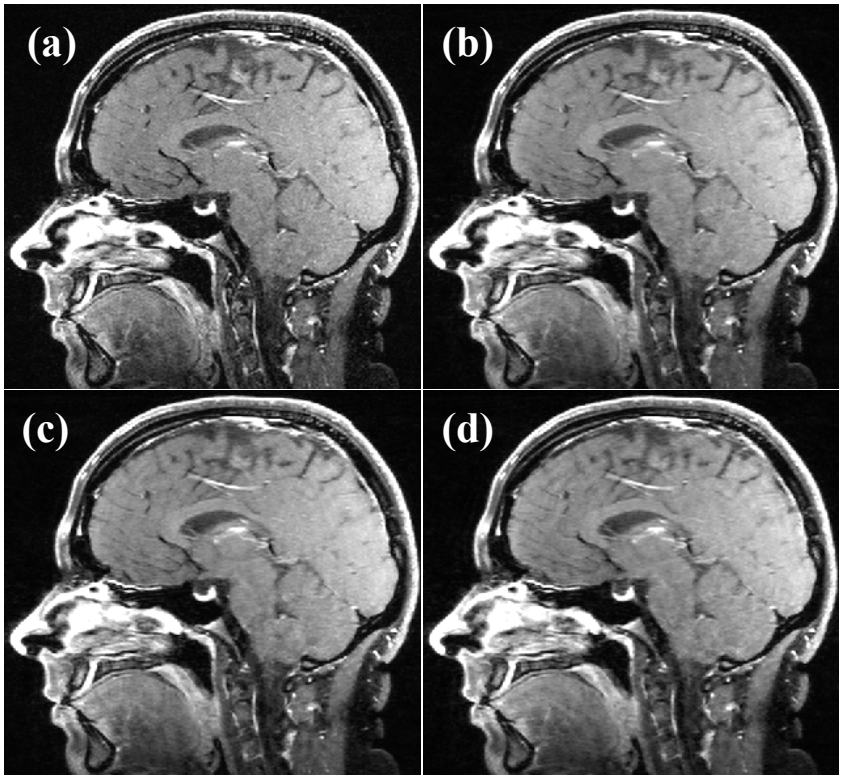


**Figure 2**. Sagittal slice for one patient with additional acceleration 1 (a), 1.5 (b), 2 (c) and 2.5 (d).