Compressed SENSE in MRI of Multiple Sclerosis: Halving scan time without quality loss


Purpose
Recently, Compressed SENSE (CS), a technique to accelerate MR imaging, was introduced into clinical practice. It uses sparsity constraints to undersample the k-space and therefore requires less readout measurements. We investigated, whether sensitivity for pathologies is preserved when using CS. To this end, we compared the performance of CS accelerated Double inversion recovery (DIR) sequences in MR scans of patients with Multiple Sclerosis (MS) with conventionally acquired DIR sequences.

Methods
Subjects: 109 consecutive scans in patients with MS
MR Protocol:
- 3D DIR Compressed SENSE*: (CS factor: 8.5)
- 3D FLAIR
- 3D T1
- 3D T2
*: These sequences shared the same parameters (apart from CS), resolution and FOV.
Acquisition time conventional DIR: 6:30 min
Acquisition time conventional CS DIR: 3:12 min

Background:
3 Tesla (Philips Achieva dStream)
Subjects:
109 consecutive scans in patients with MS
MR Protocol:
- 3D T2
- 3D T1
- 3D FLAIR
- 3D DIR (conventional) SENSE*
- 3D DIR Compressed SENSE* (CS factor: 8.5)

Data analysis:
- Co-Registration of all images from a single patient
- Direct visualization of focal intensity differences via subtraction maps.
- Those differences were counted and rated by 2 neuroradiologists.
- The intensity differences were classified into:
  - Definite lesions: Lesions that were rated as typically inflammatory by both readers.
  - Possible lesions: Hyperintensities that could be caused by inflammation but either did not show clear correlates in other sequences or missed the 3mm size threshold (as defined in the McDonald-Criteria).
  - Hyperintensities that clearly reflect technical artifacts.

Results
In total only very few focal intensity differences were counted:
- Definite lesions: No differences. In total, both sequences appeared indistinguishable for the readers.
- Possible lesions: 2 only visible in conventional DIR, 1 only visible in CS DIR (see Figure 2)
- Definite artifacts: 5 in subcortical location in the conventional DIR, none in the CS DIR. 22 in cortical/subcortical location in the conventional DIR, 1 in the CS DIR. The conventional DIR performed significantly worse for both locations (p<0.001 for sulcal artifacts). (see Figure 3)

Discussion
In our study, not a single definite lesion would have been overlooked when using the CS instead of the conventional DIR.

Moreover, the CS DIR proved to be less prone to artifacts. These artifacts appeared to be due to venous structures (small pial veins and perivascular spaces), which are known to cause artifacts in DIR sequences. By using random readouts which are more robust to quickly changing flow dynamics within the veins, CS may help to cancel out those venous flow artifacts.

Implementing CS for our whole MS protocol helped to reduce scan times from 23:12 min to 16:40 min even with re-investing part of the saved time into a higher resolution of the FLAIR and T2 sequences.

In summary, CS can contribute to saving acquisition time considerably without risking diagnostic accuracy.

Examples of focal intensity differences

Figure 1: Typical example for the comparison of conventional DIR (left) and CS DIR (right). Note the high grade of similarity between both sequences.

Figure 2: Example of a possible lesion

Figure 3: Example of a definite artifact