Accelerated spiral Fourier velocity encoded MRI using SPIRiT parallel imaging

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Introduction

Fourier velocity encoding (FVE) [1] is robust to partial volume effects that may cause loss of diagnostic information in phase-contrast imaging [2]. Scan time in FVE can be significantly reduced using spiral trajectories in k_x-k_y for spatial encoding [3], and/or temporal acceleration [4,5]. The use of parallel imaging may reduce spatial aliasing due to temporal undersampling in temporally-accelerated FVE [6]. We investigate the use of the iterative self-consistent parallel imaging reconstruction (SPIRiT) method [7] to accelerate the acquisition of spiral FVE.

Theory

Spiral FVE: Acquisition is performed using spiral trajectories in k_x-k_y for spatial encoding, and bipolar gradients for phase-encoding the velocity dimension (k_v).

SPIRiT: The iterative self-consistent parallel imaging reconstruction (SPIRiT) approach [7] is an autocalibrated coil-by-coil parallel imaging reconstruction method, based on self-consistency.

Methods

Spiral FVE data was acquired on a GE Signa 3T EXCITE HD system (40 mT/m, 150 T/m/s), using a 4-channel carotid coil. Scan parameters: 1.4 x 1.4 x 5 mm³ spatial resolution over a 16 cm FOV, 5 cm/s velocity resolution over a 240 cm/s FOV, 12 ms temporal resolution. Scan time was 146 seconds (256 heartbeats at 105 bpm). Parallel imaging acceleration was evaluated using 2-fold and 4-fold spatially-undersampled datasets, obtained from a fully-sampled set. Data was reconstructed using sum-of-squares or SPIRiT.

Results (quantitative)

Table: Signal-to-error ratio (in dB) for 2-fold and 4-fold accelerated results, relative to the fully-sampled reference.

<table>
<thead>
<tr>
<th></th>
<th>sum-of-squares (2x)</th>
<th>sum-of-squares (4x)</th>
<th>SPIRiT (2x)</th>
<th>SPIRiT (4x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>spatial RECA</td>
<td>5.1</td>
<td>9.8</td>
<td>10.9</td>
<td>10.3</td>
</tr>
<tr>
<td>RECA</td>
<td>12.5</td>
<td>13.7</td>
<td>10.3</td>
<td>10.3</td>
</tr>
<tr>
<td>LCB</td>
<td>-1.2</td>
<td>6.3</td>
<td>4.7</td>
<td>3.2</td>
</tr>
<tr>
<td>SPIRiT</td>
<td>7.5</td>
<td>9.8</td>
<td>9.8</td>
<td>6.6</td>
</tr>
</tbody>
</table>

Results (qualitative)

Figure: Axial magnitude images of the neck obtained using sum-of-squares (top row) and SPIRiT (bottom row), with different acceleration factors. These images correspond to m(x, y, v, t) for v = 0 and t = 0.

Discussion

Qualitatively, good results were obtained with 2-fold acceleration, in both spatial and time-velocity domains, but poor results were obtained with 4-fold acceleration. In time-velocity distributions, aliasing due to spatial undersampling typically results in increased signal at v = 0 cm/s, since the majority of the aliasing signal is associated with static material. Quantitatively, SPIRiT results are consistently better (higher signal-to-error ratio) than those obtained with sum-of-squares reconstruction.

Conclusion

We have demonstrated 2-fold acceleration of spiral FVE using SPIRiT parallel imaging. In future works, we will use SPIRiT to reduce spatial aliasing in temporally-accelerated spiral FVE [4]. This will enable the use of a less-selective UNFOLD filter, which will improve temporal resolution for high velocities.

References


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