A Sparse TSENSE approach for improved dynamic parallel MRI

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Introduction:

In dynamic parallel MRI improved reconstruction quality can be achieved by taking into account that signal changes occur in localized regions only [1,2,3,4]. Here, a frame-work for improved TSENSE [5] reconstructions is presented. TSENSE is based on a time-interleaved acquisition scheme and does not require a separate pre-scan for coil sensitivity estimation. Thus, robust reconstructions at high frame rates can be obtained. In this work it is shown, that by considering only dynamic regions within the field-of-view for the reconstruction process, the noise enhancement due to ill-conditioning of the inverse problem is significantly reduced.

Theory and Methods:

A simple example is described for a more intuitive comprehension. Consider a four-fold accelerated MRI experiment using four receiver coils for signal reception. In this setup (Figure 1, left), four pixels are superimposed and need to be unfolded by inverting the coil sensitivity matrix. However, by removing the static pixels fewer signal containing pixels need to be unfolded (Figure 1, right). In this specific example, two pixels can be neglected for the reconstruction process and a modified SENSE equation with reduced problem size can be written as:

$$\begin{pmatrix} I_{A,DYN} \\ I_{B,DYN} \\ I_{C,DYN} \\ I_{D,DYN} \end{pmatrix} = \begin{pmatrix} C_{A1} & C_{A2} & 0 & 0 \\ C_{B1} & C_{B2} & 0 & 0 \\ C_{C1} & C_{C2} & 0 & 0 \\ C_{D1} & C_{D2} & 0 & 0 \end{pmatrix} \cdot \begin{pmatrix} \rho_{1,DYN} \\ \rho_{2,DYN} \\ 0 \\ 0 \end{pmatrix}$$

Compared to the conventional SENSE equation, the condition for inversion of the sensitivity matrix is improved resulting in better reconstruction quality.

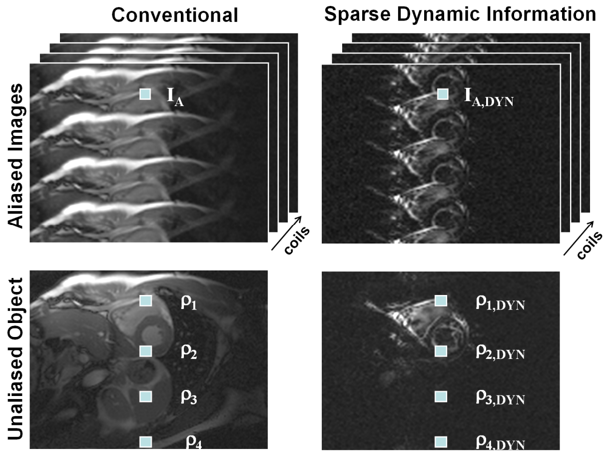

Figure 1: Relationship between aliased and true pixel intensities.

For reducing the problem size, the dynamic regions within the full FOV have to be determined. To this end, a sliding window reconstruction is performed to generate full FOV images. The static component in the resulting images is removed by subtracting a composite image that has been obtained by merging all acquired time-frames, for example. By summing over the magnitude of the resulting images, a reference image indicating the dynamic regions is generated. This reference image is used to create a mask, which is applied to the coil sensitivity maps (that have been calculated as in conventional TSENSE). After SENSE reconstruction of the dynamic information for each time frame, the final reconstruction is obtained by adding the static signals.

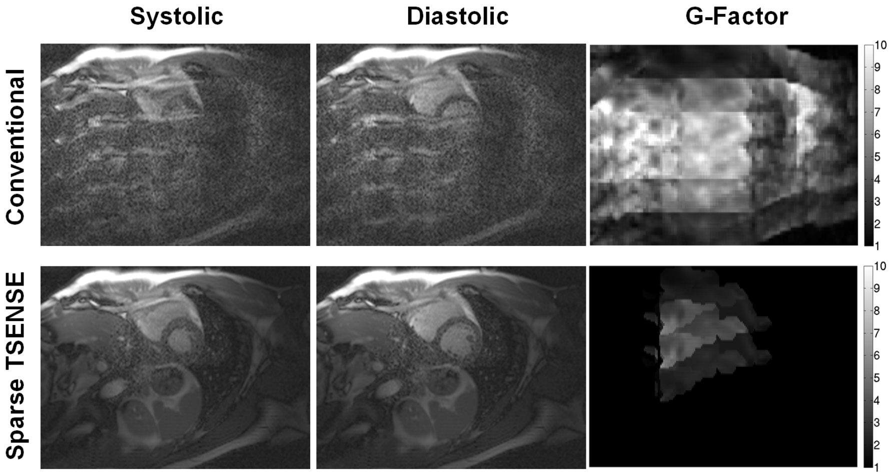

Figure 2: Segmented cardiac cine results using an acceleration factor of R = 6. The g-factor maps are scaled from 1 to 10.

Results and Discussion:

Figure 2 shows results from an in-vivo cardiac cine MRI experiment using a 32-channel array for signal reception and an acceleration factor of R=6. The sparse TSENSE approach (Figure 2, bottom) shows significantly improved image quality which is represented by reduced g-factors (Figure 2, right side). No temporal filter has been applied and no training data was required for the reconstruction process. In general, sparse TSENSE is more robust in presence of pre-foldings in the full FOV as compared to conventional TSENSE [6] since critical regions are masked out during the reconstruction process.

In conclusion, sparse TSENSE results in improved image quality as compared to conventional TSENSE by including only the dynamic information in the reconstruction process. A simple algorithm has been presented for determining the dynamic regions.

References:

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