Transmit SENSE for arbitrary reduction factors

Ulrich Katscher[1], Peter Vernickel[2]

[1]*Philips Research Laboratories, Hamburg, Germany*
[2]*TUHH Technology GmbH, Hamburg, Germany*

INTRODUCTION:

Transmit SENSE [1] allows the shortening of the duration of spatially selective RF pulses by the use multiple RF transmit coils. It is known from standard SENSE for the receive case, that the time reduction factor R does not need to equal the number of coils N_C used, but can be lower [2] or larger [3] than N_C. This study transfers the aspect of arbitrary reduction factors to Transmit SENSE. In a simulation, Transmit SENSE is used to excite a circular pattern at 3T using a transmit array with 32 independent elements.

METHODS:

A transmit array of 32 cylindrically arranged, independent rods (diameter = 30 cm, length = 30 cm) is assumed. In the framework of the software package FEKO [4], the sensitivities of these rods are calculated in the central plane perpendicular to B_0. Then, independent B_1 waveforms are derived for the different rods using Transmit SENSE [1], assuming a Cartesian trajectory in the excitation k-space. The desired excitation pattern is defined in the field of excitation (FOX) as a circle with a radius of ten pixels on a 32×32 grid. Simulations are performed for cases $2 < R < 32$ and $1 < N_C < 32$. The over- and underdetermined cases $N_C < R$ and $N_C > R$ require different algebra to solve the Transmit SENSE matrix inversion [5]. Regularization is applied using a minimum-norm condition. Finally, the reconstruction error is calculated as mean quadratic difference between the desired and reconstructed excitation pattern averaged over the FOX.

RESULTS:

The results are summarized in Fig. 1. The reconstruction error is below 10% for all cases $N_C > R$ and can go up to 30% for $N_C < R$. In principle, two features can be observed:

- For a fixed number of coils, the reconstruction error increases with increasing reduction factor.
- For a fixed reduction factor, the reconstruction error decreases with the number of coils used.

For $N_C = R$, the first feature dominates, and the reconstruction error increases.

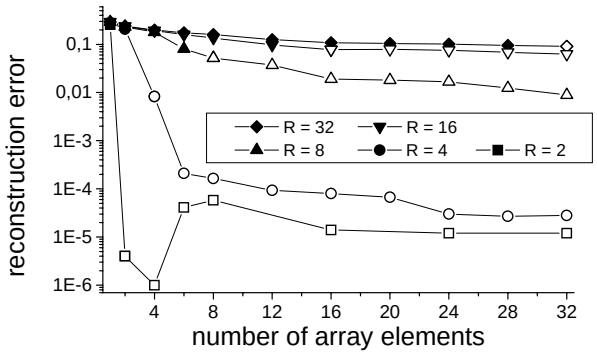

Figure 1: Reconstruction error of the simulated excitation pattern as a function of the number of array elements and the reduction factor. The filled symbols indicate experiments with $N_C < R$, the open symbols experiments with $N_C \geq R$.

DISCUSSION:

Transmit SENSE seems to be able to deal with a wide range of reduction factors and number of coils. Using the described 32-element array, the reconstruction error converges for more than about 16 elements for all reduction factors investigated. This converging suggests, that the use of more than about 16 elements with a transmit array does not improve the results, at least for the described scenario. A reduction factor might be chosen, which exceeds the number of coils, until the resulting reconstruction error is of the order of the expected system noise.

REFERENCES:

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