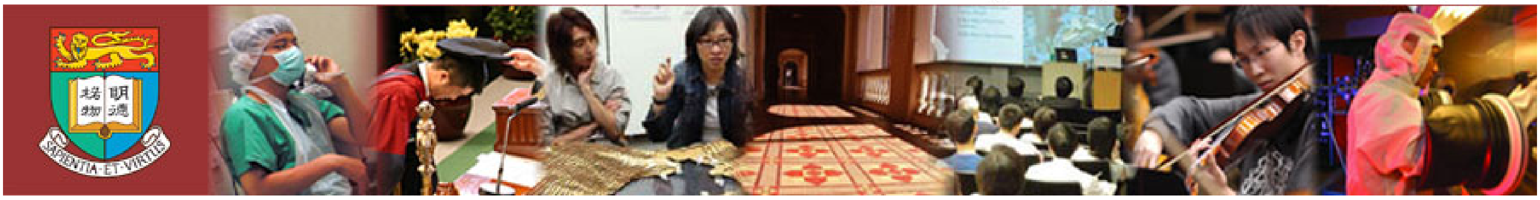

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Compensation for mutual coupling in transmit SENSE

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Introduction:

Transmit SENSE [1] has brought a promising future for decreasing RF excitation duration. In transmit SENSE, the desired B_1 field profile is generated using a coil array, and the excitation pattern of each coil can be achieved by matrix inverse. However, the mutual coupling between coils has not been considered. When multiple coils are excited, they will interfere with each other, thus the excitation pattern will be complicated. In this work, the mutual coupling between array elements is taken into account by introducing a coupling coefficient matrix into the central equation of transmit SENSE. The effectiveness of this method is verified by simulation.

Theory and method:

In parallel excitation, if we calculate the excitation pattern of every coil without considering their mutual coupling, the combined excitation pattern generated by the array may not equal to what we expected. In this study an improved transmit SENSE technique is introduced which can compensate for mutual coupling.

For an R-element array, the central equation of transmit SENSE [1] is:

$P_{des} = S^T P$, (1) where P_{des} is the desired pattern, S, P are R dimension vectors, representing sensitivity and excitation pattern of every coil.

From Ref. [2] and [3] we can deduce that every coil's individual excitation pattern $p_n(x)$ should be:

$p_n(x) = {M_{n+}}/{M_0} = i\gamma\int_0^\tau B_{1n}(t)e^{ix\cdot k(t)}dt$, (2) where $n = 1,2,\cdots,R$, M_{n+}, M_0 represent excited magnetization of every coil and equilibrium value. $B_{1n}(t)$ is the B_1 field of the nth coil, γ is the gyromagnetic ratio, $k(t)$ is k-space trajectory.

Then, we take mutual coupling into account, deduced from Ref. [2] the total magnetization excited by the coil array will be:

$M_+ = i\gamma M_0\sum_{m=1}^{R} s_m\int_0^\tau\sum_{n=1}^{R} c_{m,n}B_{1n}(t)e^{ix\cdot k(t)}dt$, (3) where s_m is the sensitivity of the mth coil, $c_{m,n}$ is the mutual coupling coefficient between coil m and coil n. Thus, the desired pattern excited by multi-coil will be:

$P_{des} = {M_+}/{M_0} = i\gamma\sum_{m=1}^{R} s_m\int_0^\tau\sum_{n=1}^{R} c_{m,n}B_{1n}(t)e^{ix\cdot k(t)}dt$, (4) so, from Eq. (2) and (4) we can rewrite the central Eq. (1) as:

$P_{des} = S^T CP$, (5) where C is $R\times R$ mutual coupling coefficient matrix; or

$p_{des}(x) = \sum_{n=1}^{R} s_n^*(x)p_n(x)$, (6) where $s_n^*(x)$ represents the nth element in row vector $S^T C$. Eq. (6) is similar to the central equation of transmit SENSE, so we can solve the inverse problem to get $p_n(x)$ using the same calculation method in transmit SENSE.

Simulation result:

To show the effectiveness of our method, a simple example of transmit SENSE is simulated. The desired excitation pattern is shown in Fig.1a and the sensitivity maps of the two-element coil are shown in Fig.1b and Fig.1c. The desired pattern is excited using the two element coils with a regular Cartesian k-space trajectory at reduction factor $R = 2$.

First, we calculate each $B_{1n}(t)$ using Eq. (1) without considering the coupling, like in original transmit SENSE. When mutual coupling exists, the B_1 profile generated by these calculate values of $B_{1n}(t)$ will be different from the desired profile. The resulted excitation patterns with different coupling coefficient $c_{1,2} = 0.05, 0.1, 0.2$ are shown in Fig.2a, b, and c, respectively. One can see that in presence of mutual inductance, the resulted excitation patterns by original transmit SENSE are degraded by residual aliasing artifacts.

Secondly, we calculate each $B_{1n}(t)$ using Eq. (6), which takes the mutual coupling into account. Fig.3a and b show that the excitation pattern of each individual coil has aliasing artifact. By superposition, these aliasing artifacts cancel each other, as shown in Fig.3c. Compared with Fig.2, it is shown that the improved method described in this work yields more accurate result than original transmit SENSE.

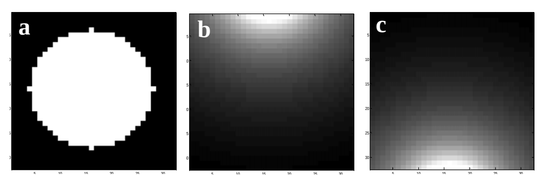

Fig.1. a: Desired pattern; b,c: assumed transmit coil sensitivity for two coils.

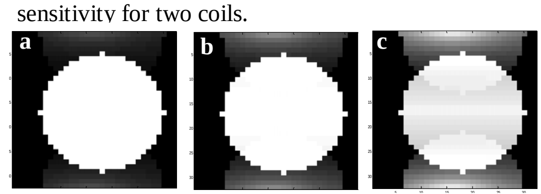

Fig.2. Mutual coupling causes aliasing artifact in combined excitation pattern, the coefficients of figure a, b, c are 0.05, 0.1, and 0.2 respectively.

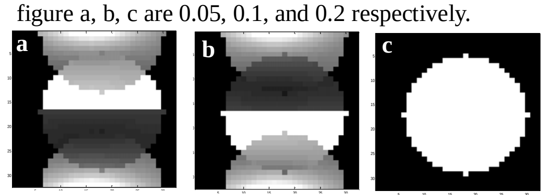

Fig.3. Simulation results using Cartesian trajectory. a,b: the excitation patterns of two coils; c: the aliasing cancel each other by superposition.

Conclusion:

In this work, the coupling coefficient matrix has been introduced into the central equation of transmit SENSE to compensate for mutual coupling between array elements. The modified equation can be solved using the same procedure as in original transmit SENSE. The effectiveness of this method has been demonstrated by simulations.

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References:

[1] U. Katscher, et al., *Magn Reson Med*, 49: 144-150, 2003 [2] J. Pauly, et al., *J. Magn Reson*, 81: 43-56, 1989 [3] C.J.Hardy, et al., *J. Magn Reson*, 82: 647-654, 1989