Homogeneous Distributions of RF Fields over the Human Head Volume at 7 Tesla

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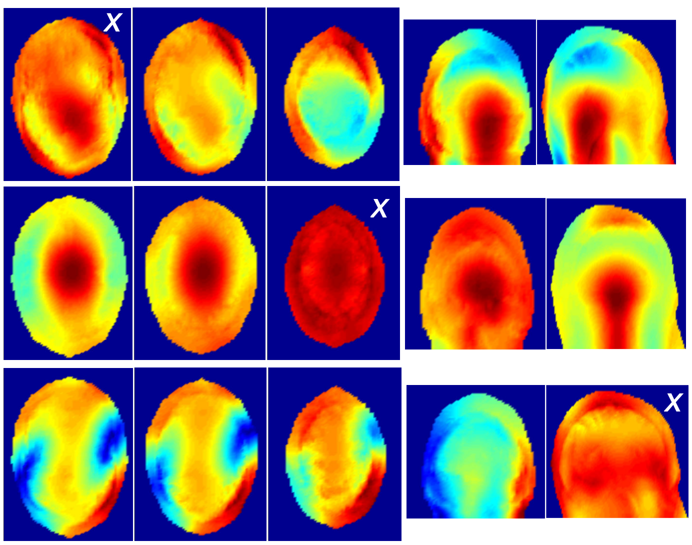
INTRODUCTION: With the increasing number of the 7 Tesla whole-body systems around the world, the need for a solution that deals with the associated RF inhomogeneities is clear. While the optimization of the circularly polarized component of the magnetic (B_1^+) field distributions [1,2,3] using multi-port excitation has provided a potential for a viable tool that can be used to solve this problem, it was only demonstrated for specific axial slice(s) [1,2]. In this work, we will study the extension into multiple axial slices as well as coronal and sagittal slices at 7 Tesla. To study the robustness of this method, we will also investigate the effects of utilizing sets of the optimization parameters on the non-optimized regions.

METHODS: A TEM head resonator was numerically modeled and tuned to approx. 298 MHz (7 Tesla). The coil consists of 16 struts which are contained in an open resonant cavity. All of these struts were driven, and numerical optimization routines were utilized to optimize 3 axial, 1 coronal, and 1 sagittal slices through multiple element driving. The optimization criterion was the same in all the slices where the goal was to obtain the best possible field distribution in all of the specified slices.

RESULTS: Figure 1 displays sets of the B_1^+ field distribution optimized in specified slice(s) (marked with an ***X***) and in other four slices associated with the optimized fifth slice at approx. 298 MHz. Table 1 corresponds to the standard deviation (STD) value of the B_1^+ field distribution under the specified optimized conditions for each slice and under the standard quadrature excitation.



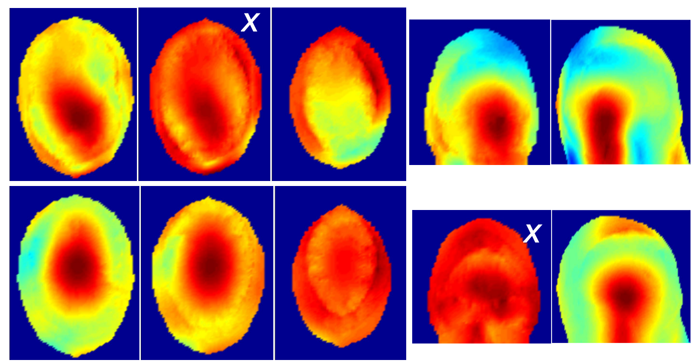


Figure 1: Each set of data corresponds to optimized $\boldsymbol{B_1^+}$ field distributions at 7 Tesla and the corresponding distribution for the other non-optimized slices using the same optimization parameters. Note that the slices for which the optimization was done are marked by an ***X.*** Each set from left to right corresponds to "Axial 1", "Axial 2", "Axial 3", "Coronal", and "Sagittal" slices.

DISSCUSION: The results demonstrate the feasibility of using this method for improving the homogeneity across the structure of the human head; it can be seen from Table 1 that the worst improvement was approx. 97% (for Axial 2 slice). While the optimization on a specified slice did not in particular provide a superior homogeneity in all the other slices, there was commonality between some slices. It can be observed that optimizing "Axial 1" assists (16.2%) in improving "Axial 2", the opposite is also correct (51%). It can also be seen that the same relationship is existent from optimizing "Axial 3" on "Axial 2" resulting in an improvement of 15.5%. The striking improvement however was obtained mutually between "Axial 3" and "Coronal" slices where the improvement reaches 52% on "Axial 3" and utilizing the optimization parameters of "Coronal".

Optimized slice	**Axial 1**	**Axial 2**	**Axial 3**	**Coronal**	**Sagittal**
Initial Conditions	0.2296	0.1589	0.1019	0.1126	0.2192
Axial 1	***0.1181***	0.1520	0.2145	0.2169	0.3380
Axial 2	0.1368	***0.0819***	0.1376	0.1441	0.3169
Axial 3	0.2699	0.1687	***0.0295***	0.0639	0.2213
Coronal	0.2931	0.2911	0.1020	***0.0607***	0.3734
Sagittal	0.2723	0.3159	0.1887	0.2214	***0.0904***

CONCLUSION: We demonstrated that multi element excitation is an effective method for the alleviation of the field inhomogeneities at 7 Tesla for multiple axial, sagittal and coronal slices. The results indicate that there often exists a commonality between the optimization parameters of different slices and therefore a robust technique could be designed for multiple slices simultaneously.

Table 1: STD values for the specified slices for both optimized and non-optimized fields. The initial conditions correspond to STD value before applying the optimization. The bold/italic numbers correspond to the STD value at every slice of interest.

REFERENCES:

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