Optimizing Test Source Polarization in Time Reversal Electromagnetic focusing

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Time Reversal (TR) is a well known simple time/spatial refocusing based on the time invariance of wave equation in lossless media, which is performed in a two phases process (M. Fink, *IEEE Trans. Ultrason. Ferroelec. Freq. Contr.*, **39**, 1992, pp. 555–566). The first (*sensing*) step consists in sensing the field radiated by a point source located in the point where one wants to refocus the field. In the second (*back-propagation*) step, the signal collected by a set of receivers (Time Reversal Mirror) is time reversed and back-propagated. By virtue of the time invariance of the wave equation which governs the propagation phenomenon, the wave will undergoes the same path focusing in the point where the original point source was located.

This simple focusing technique was applied to ultrasounds successfully in several contexts (telecommunications, imaging, lithotripsy..) and, recently, it has been transposed to electromagnetics. This transposition is not straightforward due to the vector nature of electromagnetic fields. Some interesting contributions have enlighten its feasibility giving a rigorous mathematical formalization of the problem (J. de Rosny *et al.*, *IEEE Trans. Antennas Propagat.*, **58**, **10**, 2010, pp. 3139-3148), but there are still a lot of open issues.

TR is a valuable, simple and fast synthesis technique for designing the excitations of antenna array applicators, whose geometry is fixed and able to focus the electromagnetic field in a point into lossless non-homogenous scenarios. The weak aspect of this synthesis procedure is its inability in controlling the amplitude of side lobes around the target point which is a crucial aspect in focusing applications in realistic lossy scenarios (D. A. M. Iero *et al.*, *IEEE Antennas Wireless Propag. Lett.*, **12**, 2013, pp.1029-1032). In this framework, optimizing the configuration is required to guarantee the desired focusing performances.

An aspect of the TR experiment's configuration which has not been analyzed in detail yet is the polarization of the test source used during the *sensing* phase of the process, which could have a remarkable impact on focusing performances and, hence, it is advisable to be optimized.

Selecting the test source polarization which guarantees the best TR focusing performances could be performed simply by simulating both the TR stages numerically for each possible polarization while planning the TR process. This approach would be very time consuming as it requires the solution of two direct scattering problems for each polarization. Therefore, we have developed a formulation of the TR focusing problem which allows to perform the above optimization by solving just one direct scattering problem. The proposed synthesis strategy is simple, efficient, computationally inexpensive and it has been assessed in complex scenarios proving interesting improvements in TR focusing performances. A detailed description of the entire optimization procedure will be given at the conference corroborated by numerical examples.