ARRAY FAR FIELD SYNTHESIS WITH NEAR FIELD CONTROL

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In some antenna problems it is important to reduce the field produced by an antenna array in an assigned region V in the near-field zone, to the aim of reducing the electromagnetic coupling with the environment. However, the problem is to obtain such a reduction without an excessive distortion of the far field pattern.
Given an antenna array, let $\mathbf{I}=[I_1, I_2, \ldots, I_N]$ be the generic excitation vector, $F(\mathbf{I}, \theta)$ the corresponding far-field pattern in the direction θ and $\mathbf{E}(\mathbf{I},\mathbf{r})$ the electric field produced at the point $\mathbf{r}$. We assume that a mask M for the far-field pattern is assigned (by M we mean the set of all functions $G(\theta)$ such that $M_1(\theta) \le |G(\theta)| \le M_2(\theta)$, where $M_1(\theta)$ and $M_2(\theta)$ are two non-negative functions). We want to solve the following problem: *determine an excitation vector* $\mathbf{I}$ *such that* : (a) $F(\mathbf{I}, \theta) \in M$; (b) $|\mathbf{E}(\mathbf{I},\mathbf{r})| \le E_{max}$ for $\mathbf{r} \in V$, *where* E_{max} *is a given threshold* and V *is the assigned region.*
Denoting by K the set of all vector functions $\mathbf{S}(\mathbf{r})$ satisfying condition (b), and by A the Cartesian product $M \times K$, the problem can be formulated as follows: determine a pair ($F(\mathbf{I}, \theta)$, $\mathbf{E}(\mathbf{I},\mathbf{r})$) belonging to the set A (assuming that $A = M \times K$ is non-empty). Denoting by B the set of all pairs $(F(\mathbf{I},\theta),\mathbf{E}(\mathbf{I},\mathbf{r}))$, where $\mathbf{I}$ is the generic excitation vector, a solution to the problem is any pair $(F(\theta),\mathbf{E}(\mathbf{r})) \in A \cap B$. This suggests the possibility of solving the problem by the method of alternate projections (O.M. Bucci, G. D'Elia, G. Mazzarella, and G. Panariello, " Antenna Pattern Synthesis: A New General Approach," *Proceedings of the IEEE*, Vol. 82, No. 3, Mar 1994, pp. 358-371). To this aim, we introduce the following norm $\|(G,\mathbf{S})\|$ of the generic pair $(G(\theta),\mathbf{S}(\mathbf{r}))$:

$$\|(G,\mathbf{S})\|^2 = \|G\|_1^2 + T\|\mathbf{S}\|_2^2$$

where $\|G\|_1^2 = \int_I |G(\theta)|^2 d\theta$, with I the interval containing the space directions θ, $\|\mathbf{S}\|_2^2 = \int_V |\mathbf{S}(\mathbf{r})|^2 dV$ and T is an assigned real positive number. This allows introducing a distance between two pairs, so that the following two projectors can be defined: P_A, that associates with any pair $(F,\mathbf{E})$ a pair $(F_A,\mathbf{E}_A) \in A$ closest to $(F,\mathbf{E})$; P_B, that associates with $(F,\mathbf{E})$ the pair $(F_B,\mathbf{E}_B) \in B$ closest to $(F,\mathbf{E})$. If $(F,\mathbf{E})_0$ is a starting point, then we follow the iteration scheme $(F,\mathbf{E})_n = P_B\, P_A\, (F,\mathbf{E})_{n-1}$ (n=1,2,...). The elements $(F,\mathbf{E})_n$ belong to B (that is, F is an array pattern corresponding to an excitation vector $\mathbf{I}$ and $\mathbf{E}$ is the field produced by $\mathbf{I}$), and have progressively decreasing distances from A. An element $(F,\mathbf{E})_n$ sufficiently close to A is considered as a solution to the problem.
In order to find a simple implementation of the projector P_A, we replace the above condition (b) by the stronger conditions: $|E_x(\mathbf{r})| \le E^x_{max}$, $|E_y(\mathbf{r})| \le E^y_{max}$, $|E_z(\mathbf{r})| \le E^z_{max}$, where E^x_{max}, E^y_{max} and E^z_{max} are such that: $(E^x_{max})^2 + (E^y_{max})^2 + (E^z_{max})^2 = (E_{max})^2$.
Several tests showed the effectiveness of this method.