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MODELS AND OPTIMIZATION TECHNIQUES FOR DISCRETE BEAMFORMING

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Abstract. Beamforming summarizes techniques to adapt the radiation pattern of an antenna array. If each element of such an array can be adjusted according to a finite set of control parameters only then adapting the radiation pattern is called discrete beamforming and, depending on an appropriate goal, leads to a difficult discrete or mixed-integer optimization problem. In this talk we will present basic beamforming approaches and concentrate on discrete receive beamforming.

Keywords: discrete beamforming; antenna array; radiation pattern; mixed-integer optimization.

Beamforming is used in wireless communications, radar, sonar and other applications. The radiation pattern of an antenna shows the strength of the radio waves as a function of direction. Beamforming techniques can be applied to antenna arrays, i.e., the antenna consists of several antenna elements. Here, we assume uniform linear antenna arrays with omnidirectional antenna elements. Usually the distance between two elements is chosen as $\lambda/2$, where λ is the signal's wavelength. With these assumptions the "main beam" of the radiation pattern of a linear antenna array points to the direction of the array's perpendicular. If the signal at every antenna element is phase-shifted and amplified, the shape of the radiation pattern changes. This technique is called beamforming. Depending on the mode of operation we distinguish between transmit and receive beamforming. We will focus on the latter. To guarantee a high communication quality one often aims at steering the main beam of an antenna to the direction of the desired signal and to place "nulls" in the direction of undesired signals.

There are many different techniques and scenarios and in most cases beamforming is done in a continuous manner (see for example [1, 2] for an overview). A reasonable approach is the maximization of the signal-to-interference-plus-noise ratio (SINR). By means of the so called Capon method an analytical solution for this problem can be provided. The idea is to minimize the interference and noise while setting the received power to a constant value.

However, in practical cases the exact adjustment of these optimal beamforming weights (phases and amplitudes) can be associated with energy losses or is not possible at all since phase shifters and amplifiers might not work continuously. Therefore, we consider the task of maximizing the SINR of a linear antenna array with discrete amplitudes and discrete phases for receive beamforming in the presence of interfering signals. This discrete optimization problem can be successfully tackled according to [3]. More in detail, the Capon method is adapted to the discrete case by deriving a parametric discrete optimization problem with a convex objective function. Its solution can be obtained efficiently by a branch-and-bound algorithm since the analytical solutions of the relaxed subproblems are available. Solving the parametric optimization problem for a limited number of parameters yields an approximate solution of the discrete SINR maximization problem. Simulations demonstrate that the presented approach is reasonable with respect to both the necessary computational expense and the quality of the obtained beamformer in terms of SINR.

REFERENCES

1. H. L. Van Trees, *Optimum Array Processing*, Wiley, 2002.
2. A. B. Gershman, N. D. Sidiropoulos, S. Shahbazpanahi, M. Bengtsson, and B. Ottersten, "Convex optimization-based beamforming," *IEEE Signal Processing Magazine*, vol. 27, no. 3, pp. 62-75, May 2010.
3. J. Israel and A. Fischer, "An approach to discrete beamforming," in *Proc. 9th Int. ITG Conf. Systems, Communications and Coding (SCC 2013)*, Munich, Germany, 2013.