MUSIC-Based Direction of Arrival Estimation for Null-Steering Reconfigurable Antennas

Elias Wilken-Resman* (1) and Jennifer T. Bernhard* (1)
(1) University of Illinois at Urbana-Champaign

The MUSIC algorithm (R.O. Schmidt, IEEE Trans. Antennas and Propag., 3, 276-280, 1986) is a popular technique for direction of arrival estimation. Commonly used with antenna arrays, it has recently been applied for use with single beam-steering reconfigurable antennas, e.g. (H. Paaso et al., CROWNCom, 166-171, 2013). The reconfigurable MUSIC algorithm is based on measurements obtained from a radiation pattern sweep. Relevant matrix quantities in the MUSIC signal model are assembled through time-domain synthesis.

The null-steering antenna used in this work is a two-dimensional Reconfigurable Null Scanning Antenna (RNSA), a patch antenna which includes varactors to change the effective lengths of four parasitic elements (S. Yong and J.T. Bernhard, IEEE Trans. Antennas and Propag., 10, 4538-4544, 2012). In HFSS simulation of this design, we adopt a control technique that maximizes null depth at each null steer angle. We obtain a set of 47 radiation patterns with nulls spaced at 2° intervals on [-46°, 46°]. Time-domain MATLAB simulations are then conducted with plane waves incident from a variety of angles. After implementing a null sweep and collecting the antenna response, we construct the reconfigurable signal model. We then obtain signal and noise subspaces and apply the MUSIC direction of arrival equation. When the number of distinct null sweep patterns exceeds the number of incident plane waves., we observe excellent direction of arrival estimation performance.

The reconfigurable MUSIC algorithm is challenged by dynamic signal sources, with signal characteristics that vary rapidly in time relative to the sweep duration. To improve performance under these conditions we must minimize the total sweep time. This can be accomplished by reducing the number of distinct radiation patterns included in the null sweep. A series of MATLAB simulations demonstrates that steering one null towards the direction of incidence results in the best performance, maintaining pattern diversity while avoiding ambiguities associated with the null-steering radiation pattern.