Technology Focus: Data Acquisition

Aligning a Receiving Antenna Array To Reduce Interference

This arraying algorithm has potential utility in radio astronomy and radio communication.

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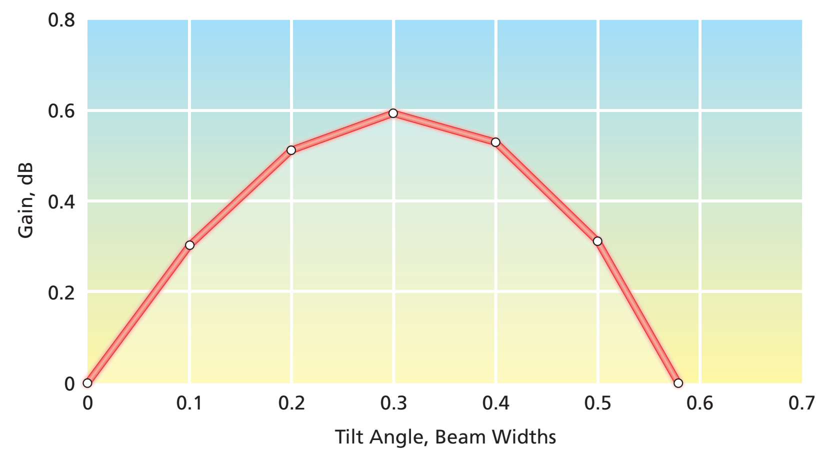
A digital signal-processing algorithm has been devised as a means of aligning (as defined below) the outputs of multiple receiving radio antennas in a large array for the purpose of receiving a desired weak signal transmitted by a single distant source in the presence of an interfering signal that (1) originates at another source lying within the antenna beam and (2) occupies a frequency band significantly wider than that of the desired signal. In the original intended application of the algorithm, the desired weak signal is a spacecraft telemetry signal, the antennas are spacecraft-tracking antennas in NASA's Deep Space Network, and the source of the wide-band interfering signal is typically a radio galaxy or a planet that lies along or near the line of sight to the spacecraft. The algorithm could also afford the ability to discriminate between desired narrow-band and nearby undesired wide-band sources in related applications that include satellite and terrestrial radio communications and radio astronomy.

The development of the present algorithm involved modification of a prior algorithm called "SUMPLE" and a predecessor called "SIMPLE." SUMPLE was described in "Algorithm for Aligning an Array of Receiving Radio Antennas" (NPO-40574), *NASA Tech Briefs* Vol. 30, No. 4 (April 2006), page 54. To recapitulate: As used here, "aligning" signifies adjusting the delays and phases of the outputs from the various antennas so that their relatively weak replicas of the desired signal can be added coherently to increase the signal-to-noise ratio (SNR) for improved reception, as though one had a single larger antenna. Prior to the development of SUMPLE, it was common practice to effect alignment by means of a process that involves correlation of signals in pairs. SIMPLE is an example of an algorithm that effects such a process. SUMPLE also involves correlations, but the correlations are not performed in pairs. Instead, in a partly iterative process, each signal is appropriately weighted and then correlated with a composite signal equal to the sum of the other signals.



Tilting the Beam of an antenna array in a refinement of the present signal-processing algorithm can afford a small gain in SNR of the desired signal. Plotted here are results of a simulation in which the desired and interfering signals were both 5 dB above noise and were coming from the same direction.

For the purpose of the present algorithm, it is assumed that the receiver at each antenna is of a multi-channel type, so that its outputs can be processed to obtain a cross-correlation spectrum of the incoming signals. It is further assumed that the channels are configured to afford both sufficient resolution and sufficient bandwidth to accommodate the telemetry or other desired narrow-band signal by use of several of its inner channels while simultaneously accommodating the wide-band interfering signal, devoid of significant contribution from the desired narrow-band signal, by use of its remaining (outer) channels. Under this assumption, pertinent correlation characteristics of the interfering signal can be calculated by use of data from the outer channels only, then subtracted from the corresponding characteristics of the total signal in the inner channels, yielding desired-signal correlations without the interferer. The calculations include least-squares fits of phase-versus-frequency models for both the desired and the interfering signals, using all the channels. The fitting process enables estimation of residual delays for the desired and interfering signals when there is sufficient signal-to-noise ratio.

The algorithm as summarized thus far guarantees only that the array is aligned to form a pencil beam that points toward the source of the desired signal. The algorithm does not eliminate or reduce the effects of the interfering signal on the overall system noise. The algorithm does, however, provide an option for further refinement through adjustment of correlation weights so as to tilt and/or reshape the beam (see figure). Depending on the angular distribution of the interferer relative to the desired source and on relative strengths of the desired signal, the interfering signal, and noise, it may be possible to increase the SNR of the desired signal through such reshaping or tilting.

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