ABSTRACT

A study of space-time (STAP) and space-frequency adaptive processing (SFAP) techniques for interference suppression in digital spread spectrum receivers is performed. STAP and SFAP algorithms combine spatial and temporal filters to suppress radio frequency interference (RFI) extending the nulling capability of a conventional adaptive array beyond its sensor-limited spatial degrees of freedom. The STAP/SFAP configured array's ability to null multiple RFI without previous knowledge of the interference characteristics or location while simultaneously receiving desired signals makes these techniques well suited for spread spectrum receivers operating in ill-defined interference environments. In the study, analytic models of STAP, SFAP, and the received noise, interference, and desired signals are used to estimate performance for narrowband, wideband, and mixed-bandwidth interference scenarios using various processor configurations.

For STAP, a detailed analysis on the effect of interference power and bandwidth on the multi-tap STAP is performed. The eigenvalue distribution of the array covariance matrix is used to characterize the interference effects on performance and consumption of the available space-time degrees of freedom. Additionally, the STAP configuration is studied to understand the effect of varying the time/tap reference within the STAP steering vector with the finding that the location can significantly affect the system's phase performance.

For SFAP, the effect of interference power and bandwidth is also studied using the eigenvalue distribution of the array covariance matrix. As SFAP is implemented in the frequency domain with the weights for each bin determined independently, the total eigenvalue distribution over all bins is accounted for. Windowing of the input time domain samples is included as a means to limit the degrees of freedom consumed. Varying the time reference location in SFAP is also studied along with window correction of the output samples to determine potential benefits and implementation impacts. Additionally, a detailed study on normalization of the frequency domain weights is presented with the finding that normalization affects processor flexibility in the nulling of individual frequency bins overwhelmed by unsuppressed interference.

The study concludes with a comparison of two computationally equivalent STAP and SFAP processors.