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HF Signal Isolation

Abstract:
High Frequency (HF) signals are transmitted throughout the world by radio broadcast stations, amateur or hobbyist radio operators, rebel or insurgent forces, and nation-state military personnel. HF transmissions propagate over long distances via ground wave and/or skywave propagation modes. Transmit distances range from tens to hundreds or thousands of kilometers, providing an inexpensive and easily deployed methodology to communicate over long range.

HF receivers are subject to a multitude of interference and noise sources including local man-made (cultural) sources (e.g. engines, lights, etc.), sferics (e.g. lightning) and co-channel HF transmitted signals. Additionally, continuous ionospheric changes due in part to traveling ionospheric disturbances directly affect the propagation channel including changes to critical frequencies, propagation path variation of beamsplit X- and O-mode skywaves, and variable signal power losses due to ionospheric absorption.

In the IARPA HFGEO Phase 1A program we addressed the challenge of detecting, spatially locating (in angle and polarization), and isolating HF signals with advanced signal processing algorithms in support of signal localization in heavily cluttered environments. IARPA conducted multiple data collections in which HF communications and radar signals were transmitted from controlled test sites and received by an array of Electromagnetic Vector Sensors (EMVS). We developed a number of EMVS adaptive beamforming techniques such as the Generalized Linear Combiner- Robust Capon Beamformer (GLC-RCB) to address challenges associated with processing electrically small EMVS arrays.

Our beamforming methods generated low-variance angles of arrival and polarization estimates and high signal isolation gains when compared with conventional methods. Additionally, we developed techniques to exploit the full diversity of the EMVS-provided signal space (temporal, spatial, spectral, polarimetric) for increased signal isolation and detection performance. Our algorithms were integrated into a semi-automated end-to-end software testbed.

We will present signal detection, isolation, and angles of arrival and polarization estimation performance analysis and results for various algorithms applied to HFGeo datasets and discuss the impact of ionospheric modeling on extending signal processing localization advances into a full HF source geolocation system.