Next-Generation Over-the-Horizon HF Radar (NGOTHR) Moving Target Indicator (MTI) and Clutter Mitigation Development

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Over-the-horizon radar (OTHR) systems serve as a critical technology in national defense and homeland security applications by performing wide-area surveillance at long range that is well beyond the limit of the horizon of conventional line-of-sight (LOS) radars. The current U.S. OTHR systems, such as the ROTHR, are proven to be effective for various defense and homeland security missions. Research over the last 20 years indicates that a next generation (NexGen) OTHR has potential to mitigate noise and spread-Doppler clutter sensitivity problems by exploiting two-dimensional transmit and receive configurations, advanced digital components, and advanced signal processing techniques. Target geo-location accuracy, including the altitude information, is another needed capability in OTHR systems.

The proposed work will focus on two important issues, namely, spread-Doppler clutter mitigation and the target geo-location accuracy. In the area of spread-Doppler clutter mitigation, the primary goal is to effectively employ multiple-input multiple-output (MIMO) radar configurations. Spread-Doppler clutter is a major source of impeded system performance, as it obscures the presence of the target in the range-Doppler domain, making detection of weak target returns in an OTHR difficult and most challenging. In particular, the return signals propagated through a fairly stable E layer ionosphere, which yields relatively narrow Doppler-frequency spectrum of the clutter and target return, are frequently overlaid by smeared clutter Doppler-frequency spectra as the result of poor quality returns propagated via a perturbed F layer. Because different ionosphere layers have different altitudes, it is possible to spatially mitigate the poor quality returns at both the transmitter and the receiver terminals of the radar system. The proposed work aims at developing joint sparse array and waveform design techniques in the context of MIMO OTHR so as to enhance maneuvering target detection and tracking in the presence of strong clutter and multipath.

Novel time-frequency analysis techniques which are tailored for separation of weak targets from strong clutter will be developed to allow improved geo-location, particularly, the estimation of altitude information of maneuvering targets. High-resolution time-frequency analysis is effective in identifying the Doppler frequencies due to target acceleration in a micro-multipath propagation environment. We will consider some emerging time-frequency representation methods to achieve high time-frequency resolution with no or insignificant cross-terms. These techniques will be examined for the estimation of multi-component polynomial phase signals in the context of target altitude estimation.