Ultra-Wide Band Surveillance Radar

Instructor:
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Abstract:
Ultra-Wideband Surveillance Radar is an emerging technology for detecting and characterizing targets and cultural features for military and geosciences applications. To characterize objects near and under severe clutter, it is necessary to have fine range and cross range resolution. The resultant wide bandwidth classifies the systems as ultra-wideband, requiring special treatment in frequency allocation. This Tutorial is divided into four parts.

- **The Early History of Battlefield Surveillance Radar**: Examples of airborne phased array antennas and UWB radars will be summarized.
- **UWB Frequency Allocation Process**: Particular note will be taken on the benefits and difficulties in designing these ultra-wideband (UWB) systems, and operation in real world electromagnetic environments.
- **UWB Synthetic Aperture Radar (SAR)**: The benefits of polarization diversity will be quantified in detecting and characterizing both man-made and natural objects. There is a clear benefit for use of polarization in the target characterization and false alarm mitigation.
- **New Research in Multimode Ultra-Wide Band Radar**: The last two sections of the tutorial will illustrate new technologies that have promise for future multimode operation: the need to detect low minimum discernable velocity movement; and the operation of bistatic SAR in concert with a stationary GMTI illumination waveform.

Intended Audience:
Radar and Electrical Engineers interested in new and emerging technologies to measure characteristics of terrain and dense foliage for geoscience and battlefield surveillance applications. A fundamental understanding of basic radar waveforms and propagation phenomenology is desired.

Learning Outcome:
Design equations for waveform characteristics, clutter characteristics and propagation losses are covered. A fundamental SAR sensitivity Excel tool will be shown and distributed to students. The student will gain a fundamental understanding of the physical and operational limitation of this class of radar, predominantly aimed at small unmanned air vehicles.

Detailed Description:
Ultra-Wide Band Surveillance Radar is an emerging technology for detecting and characterizing targets and cultural features for military and geosciences applications. To characterize objects near and under severe clutter, it is necessary to have fine range and cross range resolution. This requires development of coherent systems that collect data over wide angles and large percentage bandwidths. The resultant wide bandwidth classifies the systems as ultra-wide band, requiring special treatment in frequency allocation. This Tutorial is divided into four parts

- **The Early History of Battlefield Surveillance Radar**: battlefield surveillance from manned and unmanned aircraft, along with early experiments in foliage penetration are covered. There were some very interesting developments in radar technology that
enabled our ability to detect fixed and moving objects under dense foliage. Examples of airborne phased array antennas and UWB radars will be summarized. These systems included electronically scanned antennas, diverse waveforms, and early requirements on waveform diversity and adaptive notching on both transmit and receiver.

- **UWB Frequency Allocation Process:** The current US regulations on UWB spectral design, along with the need for frequency avoidance will be covered. With the characterization of UWB, it is necessary to tailor the transmit pulses to avoid sensitive emergency and communications receivers. Particular note will be taken on the benefits and difficulties in designing these ultra-wideband (UWB) systems, and operation in real world electromagnetic environments.

- **UWB Synthetic Aperture Radar (SAR):** A brief description of several UWB surveillance SAR systems will be provided, along with illustrations of the SAR image and fixed object detection capability. Techniques developed for ultra-wide band and ultra-wide angle image formation will be presented. Next the benefits of polarization diversity will be quantified in detecting and characterizing both man-made and natural objects. There is a clear benefit for use of polarization in the target characterization and false alarm mitigation. Results of automatic target detection and characterization based on image characteristics within the signal to clutter and losses, and from change detection between passes will be presented.

- **New Research in Multimode Ultra-Wide Band Radar:** With the requirements for design of both SAR and moving target indication (MTI) UWB systems, new radar architectures have evolved. The last two sections of the tutorial will illustrate new technologies that have promise for future multimode operation: the need to detect low minimum discernable velocity and high resolution characterizing of moving targets; and the operation of bistatic SAR in concert with a stationary GMTI illumination waveform.

**Prior Presentations:**

This tutorial has been given at each of the IEEE and International Radar Conferences over the past 8 years. The content has been modified with recent waveform research results, and presented in 2015 in both Washington DC and Johannesburg South Africa.

**Bio-sketch:**

Dr. Mark E Davis has over 48 years of experience in radar technology and systems development. He has held senior management positions in the Defense Advanced Research Projects Agency (DARPA), Air Force Research Laboratory, and General Electric Aerospace. At DARPA, he was the program manager on both the foliage penetration (FOPEN) radar advanced development program and the GeoSAR dual frequency earth mapping radar. Dr. Davis wrote the text “Foliage Penetration Radar - Detection and Characterization of Objects Under Trees”, published by Scitech, Raleigh NC in March 2011.

His education includes a PhD in Physics from The Ohio State University, and Bachelor and Master Degrees in Electrical Engineering from Syracuse University. He is a Life Fellow of both the IEEE and the Military Sensing Symposium, and a member of the IEEE Aerospace Electronics Systems Society Board of Governors and Past-Chair of the Radar Systems Panel.