Overview of STAP Techniques

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Overview
Adaptive Processing is becoming an integral part of modern airborne and space-based radar (SBR) systems for Air/Ground/Surface Moving Target Indication (A/G/S MTI). In particular, space-time adaptive processing (STAP) techniques combine spatial and temporal degrees of freedom to detect moving targets in strong background interference consisting of clutter and jamming. STAP uses the multiple spatial channels in a phased-array antenna and the multiple coherent pulses transmitted and received by the radar to form an adaptive weight vector that is applied to the received radar data. In order to calculate the adaptive STAP weight vector, the statistics of the interference environment are determined from the training or secondary data. The interference covariance matrix is not known a priori and must be estimated from independent and identically distributed (iid) data. However, experimental data obtained from several experiments have shown that this data is non-homogeneous, and hence violates the iid assumption. These facts are exacerbated when a bistatic, spaceborne, or a conformal radar configuration is employed. These issues and challenges will be identified and adequate solutions will be provided in this tutorial. The tutorial begins with monostatic airborne radar, where the principles of STAP are formulated. These are then extended to a bistatic configuration, where the transmitter and receiver are not co-located and move independently of each other. For SBR, the earth’s rotation around its axis adds another degree of difficulty and novel STAP techniques have been developed and will be discussed next. Recently, there has been a strong interest in deploying smaller platforms, where three-dimensional (3D) conformal arrays are used. We will extend the STAP concept to these antenna array systems such as Hyperspectral Imaging (HSI). We conclude the tutorial by extending these concepts to multiple-input multiple-output (MIMO) radar systems operating in a distributed mode. GLRT-based techniques are developed and assessed under several configurations. Concluding remarks and a bibliography are then provided.

Outline:
1. Overview
   Introduction and notation, basic detection theory, estimation considerations, CFAR issues, sample matrix-based approaches, multi-channel parametric-based techniques
2. STAP for Monostatic Air-borne Radar Systems
   Practical implementation and performance, multi-channel airborne radar measurements (MCARM) data analysis, real-Time MCARM (RTMCARM) system, knowledge aided STAP
3. Extensions to Bistatic Airborne Radar Systems
Bistatic geometry, bistatic iso-range / iso-Doppler / iso-cone contours, bistatic angle-Doppler traces and spectra, bistatic STAP techniques

4. Space-Based Radar (SBR) STAP Systems
   Radar – Earth geometry, effect of Earth’s rotation, effect of range ambiguities, performance of SBR-STAP, waveform diversity techniques for SBR

5. Conformal Array STAP
   Issues and challenges with conformal arrays, antenna modeling, conformal array STAP techniques

6. Hyperspectral Imaging (HSI)
   Overview of HIS, HSI subpixel target detection, advanced STAP techniques for HIS, experimental results

7. MIMO Radar
   Moving Target Detection (MTD) in non-homogeneous clutter environments, parametric generalized likelihood ratio test (PGLRT) for MIMO-MTD, other detectors

8. Concluding remarks

9. Bibliography

**Biography**

Dr. Braham Himed received his “Ingenieur d’Etat” degree in electrical engineering from Ecole Nationale Polytechnique of Algiers in 1984, and his M.S. and Ph.D. degrees both in electrical engineering, from Syracuse University, Syracuse, NY, in 1987 and 1990, respectively. Dr. Himed currently serves as Technical Advisor with the Air Force Research Laboratory, Sensors Directorate, RF Technology Branch, in Dayton Ohio, where he is involved with several aspects of airborne and spaceborne phased array radar systems. His research interests include detection, estimation, multichannel adaptive signal processing, time series analyses, array processing, space-time adaptive processing, MIMO radar, and waveform diversity. Dr. Himed leads the next generation over the horizon radar (NGOTHR) technology risk reduction initiative (TRRI), which is sponsored by the office of the secretary of defense (OSD). Dr. Himed is the recipient of the 2001 IEEE region 1 award for his work on bistatic radar systems, algorithm development, and phenomenology. He is also the recipient of the 2012 Warren White award for excellence in radar engineering. Dr. Himed is a Fellow of the IEEE and a member of the AES Radar Systems Panel.