Automatic Ground Clutter Rejection Processing Using Doppler-angle Domain Image Features Based Processing (DAIP)

H. Deng
The University of North Texas, USA

For airborne radar systems, the ground clutter received through antenna sidelobe poses a serious threat to effective ground moving target detection. Traditionally Space-Time Adaptive Processing (STAP) is widely used in airborne radar system for ground clutter and jammers. The joint space-time processing is necessary for ground clutter rejection because the ground clutter couples between space domain and time domain due to the platform movement. However, successful implementation of STAP requires accurate estimation of the clutter covariance matrix in real time. The "training" data used for clutter estimation is normally obtained by sampling the secondary units that are spatially adjacent to the primary detection unit with the assumption that the clutters in the primary and secondary units are statistically Independent and Identically Distributed (IID). Since the ground clutter is inhomogeneous in nature, finding sufficient IID secondary data for clutter estimation poses the most serious challenge to successfully implementing STAP algorithm. In this work, a novel Doppler-Angle domain Image feature based Processing (DAIP) technique is to be developed for effective ground clutter rejection processing without using secondary data. The airborne radar system collects the echo data in space-time domain by transmitting multiple coherent pulses and receiving data from each element of an antenna array. STAP suppresses interference by "whitening" interference signals and further integrates target signal through two-dimensional matched filtering in the time-space domain. The proposed DAIP, however, transforms the collected time-space data directly into the Doppler-angle domain; hence, both target signal and interferences are coherently integrated through the transform. The discrimination processing of target and interference signals for target detection is performed based on their different features on the Doppler-angle plane without actually filtering out interference signals.

The target signal is a concentrated point in the transform domain. Jammer signals on the Doppler-angle plane are straight lines parallel to the Doppler axis. Ground clutter on the plane is normally a tilted ridge or even multiple parallel ridges dependent on the ratio of the platform moving speed to the radar Pulse Repetition Frequency (PRF). The thermal noise is statistically uniformly spread in the Doppler-angle plane through the 2-D Fourier transform. Therefore, in the Doppler-angle domain, the structure of target signal is conspicuously different from that of ground clutter or jammer, i.e., target signal is concentrated and interferences are extended. It is further noted that moving target signal generally does not overlap with clutters on the Doppler-angle plane because of their different Doppler frequencies. Hence, based on the above observations DAIP algorithm is to be developed for automatic rejection of ground clutter. The first step of DAIP is to transform radar data collected in the space-time domain to an image in the Doppler-angle domain through two-dimensional Fourier transform. Subsequently, a clamping processing is applied to all pixels of the transformed images to remove the white noise. Following the clamping processing, the remaining non-zero pixels are either target signals or interferences (clutter or jammer). The feature extraction of the clamped image is carried out by clustering non-zero pixels into pixel blocks consisting of consecutively connected non-zero pixels through an image segmentation algorithm called region growing. With the segmentation processing, the image becomes a collection of pixel blocks that are either target or interference. Target detection for a pixel block is based on pixel concentration level, which may be measured by a metric called block size.

The processing results in the work indicate that DAIP can effectively reject ground clutter and detect ground moving targets based on distinguishing features of target and interference in the Doppler-angle domain. Without requirement of estimating clutter covariance, DAIP is particularly suitable for applications in highly inhomogeneous or unknown clutter environment.