Detection in Heterogeneous Sea Clutter using Dictionary Learning

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Maritime airborne surveillance radars operating at high grazing angles experience significant sea clutter returns with a time and range-varying Doppler spectra, thus making the detection of small targets extremely difficult. Dictionary learning (DL) is a data driven approach that can be used to estimate the background sea clutter and better distinguish targets. In this work, different batch and online-DL techniques are applied to reduce the unwanted sea clutter in maritime radar returns. While previous studies [1,2] dealt with the sparse representation of target returns, in the presented approach we now use different DL algorithms to learn a dictionary that is able to sparsely represent sea clutter contributions and subsequently remove them from the data prior to target detection.

Two different approaches are presented in this work. The first considers the application of DL in the range/Doppler domain, while the second exploits the space-time power spectrum achieved with a multichannel radar. Multichannel approaches work by exploiting the angle/Doppler domain, where targets can be separated from any unwanted clutter and/or jammers in the scene [3]. This is important as without the spatial dimension, adaptive processing could potentially suppress any stationary or slow moving targets along with the clutter. This approach is motivated by the inherent sparsity of the clutter in the angle-Doppler domain, a feature that is further exploited by DL processing. The optimal power spectrum relies on a covariance estimate that is typically averaged over a number of range bins. However, by training the dictionary to learn what the power spectrum looks like at a single range bin, the approach becomes robust to variations over range, and ideally suited for detection in heterogeneous clutter. The dictionary is learnt from target free measurements only; there is no previous assumption on clutter statistics or modelling involved. To quantify performance, both simulated X-band data and Ingara L-band data collected by the Australian Defence Science and Technology Group has been used with performance determined by a Monte Carlo simulation with synthetic targets injected into a target free scene.

References

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