CNN You See Me?

An exploration of the application of machine learning to the problem of peak detection in HF Over The Horizon Radar (OTHR) data. A description of the problem space, the approach taken, and learned lessons. Can we separate the signal from the noise using Convolutional Neural Networks (CNNs), and how do we measure its performance compared to a conventional CFAR system?

HF Skywave OTHRs present some unique challenges due to the use of ionospheric propagation to look beyond line of sight. These challenges include dominant clutter due to land and sea reflections, interference from natural phenomena thousands of kilometres away, multi-path propagation, and radar-to-ground coordinate registration.

The accuracy with which the operator can assign propagation modes directly influences the accuracy of the ground location at which the target is placed. The complexity of the mapping between target peak return and ionospheric propagation path often means that the radar operator needs to view raw radar data in the form of azimuth-range-doppler (ARD) images. These images are non-intuitive and place a high cognitive load on the operator.

As part of an effort to reduce the operator workload and allow them to concentrate on tasks of higher value we have explored the use of modern machine-learned image processing methods in the early stages of peak detection.

Using a de-noising auto-encoder (DAE) trained on synthetic target peaks injected into real radar background noise, clutter, and interference we have shown that a relatively simple CNN architecture can learn to remove noise from the ARD images.

Coupled with a peak detector, this simple network can produce peak locations with a very low false alarm rate - currently at the cost of some probability of detection at higher SNRs. The output from the model also be used to enhance or augment the image currently presented to the operator.

Author

Educated as an electrical engineer before the birth of the internet, Chris has spent most of his 31-year defence career delivering software instead. In his 28 years at Lockheed Martin most of his work has been related to the development of solutions for high frequency over-the-horizon radars. In recent years Chris has been advocating for research and development that applies modern machine learning techniques to this field.

Email

christopher.r.willoughby@lmco.com