A Low Complexity Adaptive Beamformer for Active Sonar Imaging

The angular resolution and contrast in active sonar images depends on the beamformer's ability to receive signals from directions of interest, while suppressing noise and interference emanating from other directions. For sonar arrays, this is achieved by applying tapering to the array channels. While classical beamformers use predefined tapering windows, adaptive beamformers estimate the optimal window by analytical evaluation of the data. The minimum variance (MV) beamformer, for instance, calculates the set of weights that minimises the variance of the beamformer's output.

Inspired from typical tapering used by the MV beamformer, we have implemented a beamformer that adaptively selects tapering from a set of predefined windows. We derive a set of “optimal” windows that yield responses near the MV beamerformer's average responses in various scenarios. The beamformer was tested using simulated data from the Kongsberg Maritime HISAS 1030 sonar. The transmitted signal was a 30 kHz band centered at 100 kHz and we used one 32 element receiving array. On a scene with speckle, highlight and shadow, the beamformer showed better lateral edge definition compared to a MV beamformer, and speckle intensity and shape comparable to DAS and MV beamformers. These effects are also verified on real data collected by the HUGIN autonomous underwater vehicle carrying a HISAS 1030 sonar.

Estimation of the optimal tapering for the the MV beamformer involves both estimation and inversion of the spatial covariance matrix for each pixel in the image. This translates to a computational complexity of up to $O(M^3)$, where M is number of channels. In comparison, the proposed method is of O(MW), where W is the number of predefined windows. Also, unlike the MV beamformer the proposed method does not suffer from signal cancellation. Hence it performs like a MV beamformer or better, but at a fraction of the computational cost.