

Image Deconvolution Techniques for Extending the Area Coverage Rate of Synthetic Aperture Sonar

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Abstract: Synthetic aperture sonar (SAS) is capable of producing seafloor imageries with frequency and range-independent azimuthal resolution. However, the area coverage rate (ACR) of SAS is limited by the receiver array length in order to satisfy a well-known range-doppler ambiguity requirement. The basic criterion is that the array should not advance more than half its length per ping. When this speed limit is violated, the synthetic array becomes sparse with attendant image artifacts, i.e., elevated grating lobes.

Since the structure of the artifacts is known based on a record of the array's speed of advance, one should be able to remove these artifacts in post-processing. We consider the CLEAN and WIPE image deconvolution techniques for this application. These techniques are invented by the radio astronomy community. CLEAN is a powerful technique for "cleaning" up the images of point-like objects. WIPE is a regularized form of CLEAN that trades resolution for inversion stability. It is purported to be more stable in the presence of extended objects.

Since the structure of the undersampled SAS point response is dissimilar to those encountered in radio astronomy, it is not obvious that WIPE should perform better than CLEAN or that either technique should work at all. We used numerical simulations to test the entire class of techniques, including both CLEAN and WIPE on simulated SAS data. The results suggest that one may be able to exceed the SAS speed limit by a factor of two to three without serious degradation of image quality. Furthermore, these techniques appear to be capable of inverting for the shapes of extended objects in SAS. They are also capable of preserving the shadows behind mine-like objects. Finally, in all cases tested, CLEAN appears to perform just as well, if not better, than WIPE. We will report these results as well as the convergence characteristics and the computational speed of these techniques.