Beamforming Performance Enhancement by Adaptive Hyperbola Array Shape Estimation

By

Michael Kaiping Liu

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ABSTRACT

Analysis of U.S. Navy Ice Exercise 2016 (ICEX16) data, through a collaboration with MIT Lincoln Laboratory, demonstrated that towed array curvature commonly exhibited heading differences up to 100° and never maintained heading differences less than 30° between the forward compass and the aft compass. These deviations reflected a disparity from the underlying assumption that the towed array remained rigid with no deviations from a rigid, straight-line configuration.

Using lessons learned from ICEX16, a field experiment in Massachusetts Bay 2019 (FEX19) tested whether a hexagonal search pattern would sufficiently address the curvature concern, thereby, validate the underlying rigid, straight-line beamformer assumption more commonly used. Results from the experiment showed that a hexagonal search pattern maintained a heading differences of less than 4° within 79 seconds of an initiation of a 60° maneuver. This was a marked improvement when compared to ICEX16's vehicle maneuvers, which never maintained a heading difference of less than 30°.

Even with this improvement in FEX19, 39.6% of the acoustic data was collected when the towed array did not meet the straight-line assumption. Use of the hexagonal search pattern, in two instances during U.S. Navy Ice Exercise 2020 (ICEX20), showed that 45.1% and 27.1% of the collected acoustic data did not meet the towed-array straight-line assumption.

Although this realization will influence operators to minimize maneuvers that introduce significant deviations from the underlying beamforming model, field experiments often call for sharper maneuvers. This realization spurred the development of a beamformer that modeled towed array curvature using headings, effectively tangential slopes, at either end of the hydrophone portion of the towed array with a known fixed length to predict how the towed array bends.

Analysis of FEX19 showed that the adaptive hyperbola array shape estimation led to a beamformer output aligned to GPS heading data over 30% of the experimental window compared to less than 10% for the straight-line beamformer. This improvement held true even when the towed array had little or no curvature.

Thesis Supervisor: Henrik Schmidt
Title: Professor of Mechanical and Ocean Engineering

Thesis Supervisor: Bryan Moser
Title: Academic Director and Sr. Lecturer of System Design and Management