FULL FIELD 3-D GEOACOUSTIC INVERSION

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Shallow water acoustics

LONG-TERM GOALS

The full field 3-D geoacoustic inversion method is eventually intended for real-time estimation of range, depth, and azimuthally varying shallow water environmental properties by non-invasive, acoustic, remote sensing means via simple broadband sources such as SUS. The estimated environmental properties would then be available as input parameters to fleet acoustic propagation models used for the detection of targets, e.g., subs or mines.

OBJECTIVES

The objective of this approach is to estimate those environmental parameters to which acoustic fields are sensitive. Such environmental parameters include: number of sediment layers, sediment thicknesses, densities, and sound-speed profiles. The intention is to replace present requirements for extensive environmental sampling (which can be extremely time-consuming and expensive) with intense computational processing of array data (with limitations determined primarily by the nature of the array configuration and the computer system available for data processing).

APPROACH

The full field approach involves using measured array data for a broadband source with good signal-to-noise levels at frequencies from 50 to 500Hz. The measured fields are compared to modeled fields where the model environmental inputs are varied in a systematic way so as to converge to a set of values which optimize the correlation between data and model. The principle assumed is that high correlations will indicate input values "closer" to the "true" environmental values, i.e., those which would be measured given sufficient resources. The "true" values would result in accurate predictions for acoustic fields over the broadband of frequencies and over the selection of target ranges of interest. Unlike the focalization approach our method hopes to estimate the "true" geoacoustic parameters.

WORK COMPLETED

Work completed includes the organization and chairing (shared with R.Chapman) of a workshop devoted to the comparison of available geoacoustic inversion techniques

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applied to benchmark data sets. This workshop was well attended with over 20 presentations over 3 days. The results are being compiled into a Special Issue of the Journal of Computational Acoustics to be published in Spring/Summer of 1998.

RESULTS

Over the past 12 months we have emphasized the analysis of simulated, benchmark data for geoacoustic inversion processing. This has been highly important for the understanding of inversion limitations and potential accuracies and has resulted in major improvements in the tomographic inversion method under study. We are also finding successful ways to search the large solution spaces and to eliminate non-uniqueness difficulties in solution estimation. We have also made significant progress in understanding what bottom and geometric properties affect the relevant acoustic fields and how important are those properties; what are the optimal frequencies for processing to estimate those properties; and what are the optimal array and source configurations?

Thus, we have continued to advance the capabilities of the tomographic, high resolution MFP based inversion method (RIGS) which has been under development for this project. The RIGS method (Refined Iterative Grid Search) was applied to the workshop data with excellent results. Conclusions to date include: broadband processing is critical, the propagation model used is critical (KRAKEN was found to have significant difficulties but incorporating ORCA can overcome those), physical insight to efficiently organize parameter seaches can be very helpful, and some parameters are easily estimated with high accuracy (such as source coordinates, water depth, sediment density and attenuation).

IMPACT

If this technique proves to be successful, it could influence array technology and the selection of propagation models used by the fleet for target detection and localization. It could also affect fleet strategy for the calibration of a region's environmental parameters with resultant target searches prior to subsequent committment of fleet resources. The estimation of true geoacoustic properties will beextremely important for the detection and localization of targets such as subs as well as of buried targets such as mines.

TRANSITIONS

The Workshop97 and RIGS results are influencing a host of methods for geoacoustic inversion (see next section).

RELATED PROJECTS

Many inverse techniques are currently being pursued to determine bottom properties, and the newest involve the use of MFP for a signal measured along an array of receivers. The MFP techniques often involve simple least squares fits of model predictions to data which are subsequently combined with computationally intense, random number based methods such as simulated annealing (Chapman, Dosso, et al.). The full field 3-D geoacoustic inversion approach being developed in this work is NOT a least squares fit NOR is it random-number based. It is based on the high resolution non-linear minimum-variance (MV) processor plus a global, directed search through parameter space.

Other investigations in the area of geoacoustic inversions are being conducted by the Canadians (Chapman et al.; Heard et al., Zala and Ozard), Europeans (Hamson and Ainslie of Great Britain; Jesus of Portugal; Siderius and Gerstoft of SACLANT Centre; Simons and Snellen of The Netherlands; Stephan et al. of France; Taroudakis and Markaki of Greece; Westerlin of Sweden), and Asians (Ratilal et al. of Singapore; Zhang et al. of China).

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