Time delay estimation of noisy signals using spatial amplitude distribution analysis

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Datasonics has developed and tested a two-way acoustic telemetry link with software/firmware for command, control, and recovery of data from an (RDI) acoustic Doppler current profiler (ADCP) instrument. In operation, the acoustic link is quasitransparent to the system operator. Standard ADCP user command protocol allows PC-generated commands to be buffered and transmitted from a surface acoustic modem to a subsurface modem, which is connected by RS-232 interface cable to the ADCP. The acoustic down link command signals are reformatted in the subsurface modem and passed on to the ADCP. Data are transmitted over the up-link in 4096-byte packets at a data rate of 1200 bits/s. The self-contained subsurface acoustic telemetry modem (ATM) is housed in an aluminum pressure housing 5 in. o.d.$\times$33 in. long. Connectors are provided for RS-422 I/O to the ADCP and for external power input for long-term *in situ* deployments. A choice of directional or omni directional acoustic transducers is available. The system was tested in the Piscatagua River in Portsmouth, NH and will be installed in Tampa Bay as part of NOAA's PORTS program, which offers shipping traffic access to current profiler data in near real time. The operating software protocol will be discussed and results from both the New Hampshire tests and Tampa Bay operations will be presented.

3:20

1pUW5. Time delay estimation of noisy signals using spatial amplitude distribution analysis. Andre M. Rog (Naval Biodynamics Lab., P.O. Box 29407, New Orleans, LA 70189), Marc W. Losh, Terry E. Riemer, and Russell E. Trahan, Jr. (Univ. of New Orleans, New Orleans, LA)

The estimation of time delay in signals in the presence of noise has been an historically stubborn problem. A discrete method, known as spatial amplitude distribution (SAD) analysis, is shown here to be an effective procedure for dealing with time delay estimation issues. This technique employs a window that is shifted along the data point set containing the signal (if any) and noise. The amplitudes of this windowed signal segment and the original reference signal are paired point for point, forming a two-dimensional distribution. As the window is shifted along the noisy signal a set of distributions is produced that may be analyzed independently of time. SAD map simulations involving both sinusoidal and Gaussian noise signals contaminated with Gaussian noise of varying SNR produced results indicating substantially improved performance over conventional cross-correlation techniques.

3:35

1pUW6. A comparison between ray theory and normal mode theory to very high frequencies. E. White and M. F. Werby (NRL, Theor. Acoust. Codes 223 and 221, Stennis Space Center, MS 39529)

A new normal mode method capable of predictions to very high frequencies is developed. The objective is to compare predictions of ray theory with the more exact normal mode theory to determine how well and at what point ray theory agrees with normal mode theory. The approach is to compare transmission loss curves computed by both methods. Discussion of the discrepancies are made and comments will be made on how improvements can be implemented. In strong ducting problems it is shown that there is a strong association between the lower order modes and the ray trace results.

3:50

1pUW7. A fast perturbation approach for calculating pulses in a waveguide with applications. M. F. Werby and M. K. Broadhead (NRL, Theor. Acoust. Code 221, Stennis Space Center, MS 39529)

A fast normal mode code based on a full perturbation method and a fast Fourier transform method has been developed. This enabled one to perform broadband pulse calculations to high frequencies. Further the pulse returns can be decomposed into their constituent modes. Studies are preformed on pulse returns for realistic shallow water waveguides for signals out to 25 km, the various dispersion effects are illustrated, and model arrivals are separated with increasing distance from the source. Particular emphasis is placed on strong channeling.

4:05

1pUW8. The influence of a bubbly layer on near-surface acoustic propagation and surface loss modeling. Raymond J. Christian (Naval Undersea Warfare Ctr., Detachment New London, New London, CT 06320)

The impact of refraction, attenuation, and scattering due to a near-surface bubbly layer on acoustic propagation modeling can be significant in appropriately sensitive surface duct and shallow water environments. Hall [J. Acoust. Soc. Am. **86**, 1103–1117 (1989)] presents a semi-empirical acoustic model to determine the propagation affects of the bubbly layer on one-way horizontal transmission in a surface duct. Expressions for the depth-dependent complex sound speed and attenuation are used to extend the Hall model to the general near-surface acoustic interaction problem. The rough surface scattering at the air–sea interface and the propagation through the subsurface bubbly layer are treated independently in a simplified approach toward examining the impact of bubbles on modeled surface duct and shallow water transmission loss. The dependence of the "effective" surface loss on grazing angle and wind speed are analyzed in the frequency band of approximately 0.5–5 kHz.

4:20

1pUW9. Does ray chaos in range-dependent environments disappear when higher-order approximations are made? Martin A. Mazur (Appl. Res. Lab., P.O. Box 30, State College, PA 16804)

Recent work has shown that when range dependence, in either the index of refraction or the boundary conditions, is introduced into the infinite frequency (ray) approximation to the wave equation, ray chaos results. This is because the resulting conservative system of ordinary differential equations is nonlinear and nonintegrable. Attempts have been made to reconcile chaotic ray behavior with the fact that chaotic solutions of the full linear wave equation cannot exist. When the terms neglected in making the eikonal approximation are kept, the resulting system of equations is generally no longer conservative, and hence chaos is not a *necessary* result of the higher-order approximation. [Work supported by ONR.]

4:35

1pUW10. Long-range probing of the ocean by a parametric source. Konstantin A. Naugol'nykh (N. N. Andreev Acoust. Inst., Acad. of Sci. of RF, Moscow, Russia)

Experimental investigations of the performance of a parametric transmitting array (PA) in the deep and shallow ocean are presented in the present paper. The array to produce the two primary waves consisted of two parts, each 2$\times$3 m in size, with a total acoustic power of up to 24 kW. The two primary frequencies were in the band 1.9 to 3.9 kHz, the difference frequency in the band up to about 1 kHz. Three sets of experiments were made: (1) an investigation of the formation of the PA field in the homogeneous deep ocean; (2) PA performance in shallow water; and (3) directivity pattern measurements in the inhomogeneous deep ocean. The possible application of parametric arrays for long distance ocean probing is discussed.

1p SAT. PM