MASTER OF SCIENCE
IN
ENGINEERING ACOUSTICS

MODIFICATION AND VERIFICATION OF DESIGN SIMULATION FOR THERMOACOUSTIC RESEARCH SOFTWARE

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This thesis attempts to improve, prepare for release, and verify the accuracy of the expert system code entitled "Design Simulation for Thermoacoustic Research" (DSTAR) created previously by LT Eric Purdy. DSTAR allows a unique new approach for the rapid design and simulation of thermoacoustic devices utilizing a Microsoft Windows™ compliant interface to construct any given thermoacoustic model at runtime. The approach to simulation involves the solution of a one-dimensional acoustic wave equation simultaneously with an energy flow equation from one end of the specified device to the other, including additional lumped elements. The resulting solution is available as both a graphical and text-based output. In order to prepare for release, significant additions to the engine code and interface were completed. Additionally, theoretical results obtained by the DSTAR system code were compared to actual measured values in order to demonstrate potential engineering design applicability.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Thermoacoustic Simulation, Numerical Model

EXPERIMENTAL STUDIES OF APPLICATIONS OF TIME–REVERSAL ACOUSTICS TO NON-COHERENT UNDERWATER COMMUNICATIONS

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The most difficult problem in shallow underwater acoustic communications is considered to be the time-varying multipath propagation because it impacts negatively on data rates. Computationally intensive and complex signal processing algorithms are required to compensate for symbol overlapping. This thesis presents results of a tank scale experiment to test Time-Reversal Acoustics (TRA) approach for high data rate binary transmissions. TRA can environmentally adapt the acoustic propagation effects of a complex medium. Our results show the suitability of the TRA approach in underwater acoustic communications. The results also show good focusing properties at an intended target location. The focal region extends over a few wavelengths, outside of which scrambling of the message occurs, offering natural encryption. Range shifts of the focal region could be achieved by frequency shifting. It was found that the time focusing is aperture–size independent, but the spatial focusing is aperture–size dependent. Overall, it was shown that the algorithm can accomplish a fast, secure, and stable communication scheme with low computational complexity.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Time Reversal Acoustics, Acoustic Communications, Acoustic Signal Processing

EXAMINATION OF TIME-REVERSAL ACOUSTIC APPLICATIONS TO SHALLOW WATER ACTIVE SONAR SYSTEMS

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The ability to employ effectively an active sonar system in the littoral regions is of great interest to the United States Navy. Time-varying multi-path propagation introduces significant problems that must be overcome in the employment of shallow water active sonar. The phenomenon of time-reversal acoustics (TRA) has provided hope for a solution to this problem by undoing much of the multipath spreading without the need to have knowledge of the environment in these littoral regions. When an active sonar return is time-reversed and retransmitted, this second signal focuses in time and space back at the original source location. This thesis investigates the phenomenon of TRA as it applies to an idealized shallow water environment. Numerical modeling was performed for a variety of source and target apertures and ranges. Results demonstrate a significant enhancement in received active sonar signal strength due to the TRA acoustic field focusing effect. Furthermore, the signal strength enhancement remains significant even when the source to target range changes between active sonar transmissions. The results presented in this thesis demonstrate that the use of TRA may provide substantial signal-to-noise ratio improvements over current active sonar systems. Further modeling and real world experiments could ultimately lead to the development of a practical active TRA sonar system.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles - Ships and Watercraft, Modeling and Simulation

KEYWORDS: Time-Reversal,Acoustics,Active Sonar