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FRIDAY, NOVEMBER 14, 2014
POST 723
11:00 am

Characterization of Underwater Acoustic Sources Recorded in Reverberant Environments with Application to Scuba Signatures

Abstract

The ability to accurately characterize an underwater sound source is an important prerequisite for many applications including detection, classification, monitoring and mitigation. Unfortunately, anechoic underwater recording environments, required to make ideal recordings, are generally not available. Current methods adjust source recordings with spatially averaged estimates of reverberant levels. However, adjustments can introduce significant errors due to a high degree of energy variability in reverberant enclosures and solutions are inherently limited to incoherent approximations. This dissertation introduces an approach towards a practical, improved procedure to obtain an anechoic estimate of an unknown source recorded in a reverberant environment. Corresponding research is presented in three self-contained chapters.

An anechoic estimate of the source is obtained by equalizing the recording with the in- verse of the channel's impulse response (IR). The IR is deconvolved using a broadband logarithmic excitation signal. The length of the IR is estimated using methods borrowed from room acoustics and inversion of non-minimum phase IR is accomplished in the least-squares sense. The proposed procedure is validated by several experiments conducted in a reverberant pool environment. Results indicate that the energy of control sources can be recovered coherently and incoherently with root-mean-square error (RMSE) of approximately -70 dB (10 - 70 kHz band).

The proposed method is subsequently applied to four recorded SCUBA configurations. Results indicate that reverberation added as much as 6.8 dB of energy. Mean unadjusted sound pressure levels (0.3 - 80 kHz band) were 130 ± 5.9 dB re 1 µPa at 1 m. While the dereverberation method is applied here to SCUBA signals, it is generally applicable to other sources if the impulse response of the recording channel can be obtained separately.

This dissertation also presents an approach to separate all coloration from the deconvolved IR. This method can be used to estimate the channel's IR or the magnitude spectrum of the combined electrical equipment. The procedure is validated using synthetic results of an image-source model and the channel's IR is recovered over the full band with a RMSE of -31 dB.