

Adaptive Acoustic Transmission Loss Prediction Systems

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Objectives:

Prediction of acoustic transmission loss (TL) is a complex problem dependent on a variety of physical parameters associated with geometric, atmospheric, and ground related environmental conditions. Prediction of the acoustic TL using a numeric parabolic equation (PE) method is often accepted as an accurate technique, but the computation times can be prohibitively excessive. The amount of time required to use the PE model can take several minutes or even hours to predict acoustic TL for a single environmental condition, with modern day computer processing power as shown in Figure 1. In order to overcome these extreme computational requirements, different neural network paradigms and signal processing algorithms have been explored to achieve fast and accurate acoustic TL prediction. Using these algorithms TL prediction can be accomplished in only a fraction of a second.

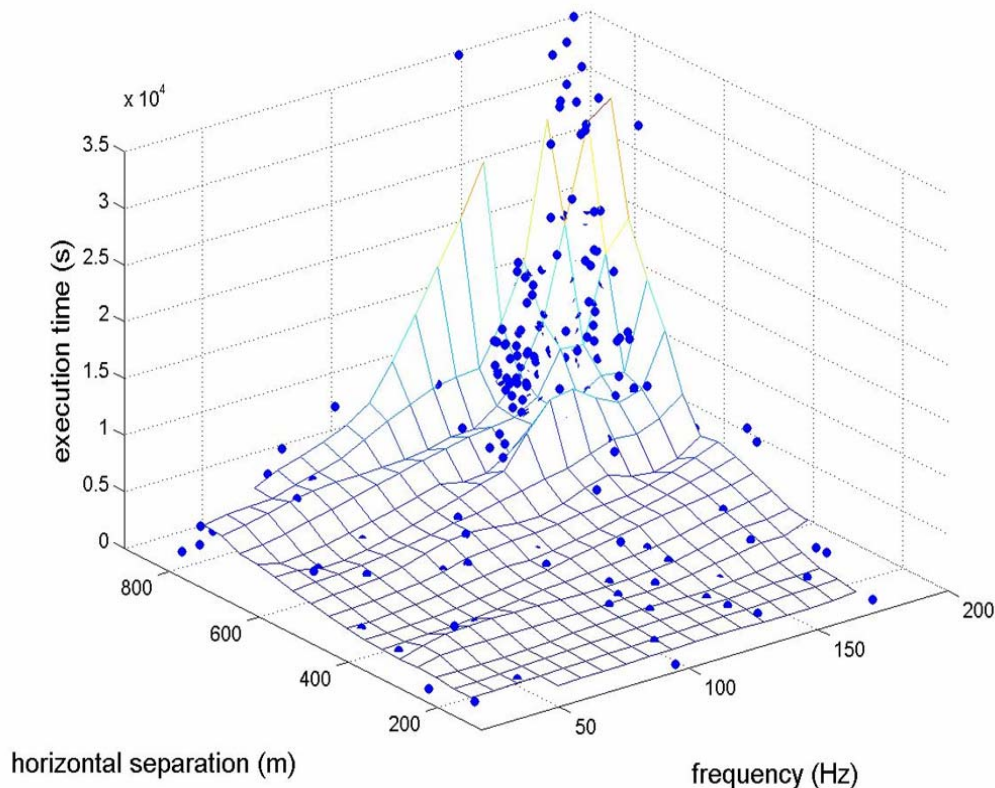


Figure 1: Execution time required for PE model transmission loss

A difficult problem in using fast methods to predict acoustic TL occurs in the stable atmospheric regime. Stable atmospheric regimes are usually present during calm cold nights, while the atmosphere is usually unstable during the day. The sound pressure level in the stable atmospheric regime, behaves in an unpredictable fashion as can be seen in Figure 2. Difficulty also occurs when the source elevation is large enough to cause interference between waves from the source and ground reflections, also seen in Figure 2.

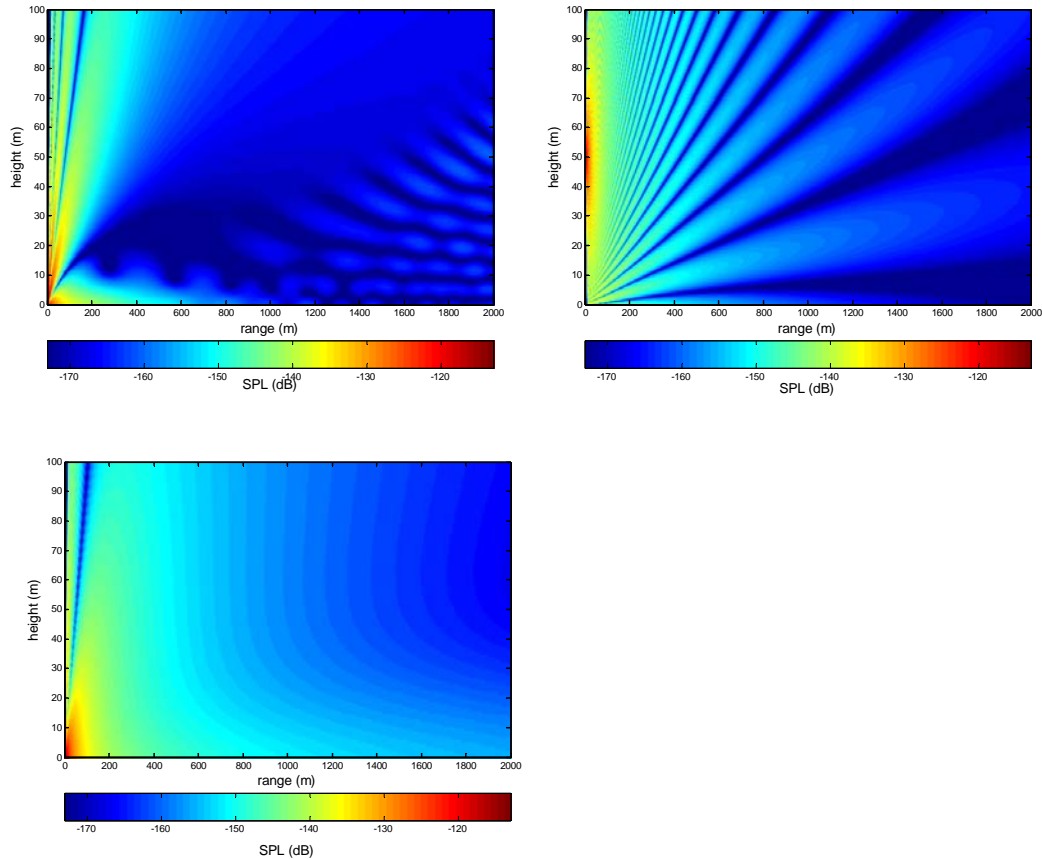


Figure 2: TL fields for different environmental situations. Notice the large change in types of nonlinearities that need to be captured by the neural network. Upper Left: Stable Atmosphere, Upper Right: Ground Interference, Bottom Left: Unstable Atmosphere. SPL signifies sound pressure level, equivalent to TL.

Two neural network-based TL prediction systems have already been developed: the Environmentally Adaptive (EA), and Operationally Adaptive (OA) systems. The EA system (see the listed paper [1] below) was developed to overcome the nonlinearities caused by the differences between the stable and unstable atmospheric regimes. Results of this system can be seen in Figure 3, which shows that the EA system reduced RMS error by 0.42dB over a benchmark single neural network TL predictor. After the EA system was developed, the range of environmental conditions over which accurate TL prediction is desired was expanded. This introduced new nonlinearities which created a more difficult problem. In response, the OA system (see the listed paper [2] below) was developed that combats the nonlinearities introduced by ground interference (interference

between direct and indirect ground reflected acoustic waves). Results of this system can be seen in Figure 3, which shows the RMS performance of the OA and benchmark prediction system. Notice the increased error in both the OA and benchmark single network systems over the previous OA and benchmark systems for the non-extended range. This overall increase in error reflects the increased complexity of the problem introduced by these extended ranges. Despite the increased complexity, the OA system reduced the RMS error by 1.32dB over the benchmark single neural network system. As a final note, our current research involves developing wavelet-based neural networks to combat the increasingly difficult nonlinearities associated with increasing frequency, horizontal separation and source elevation.

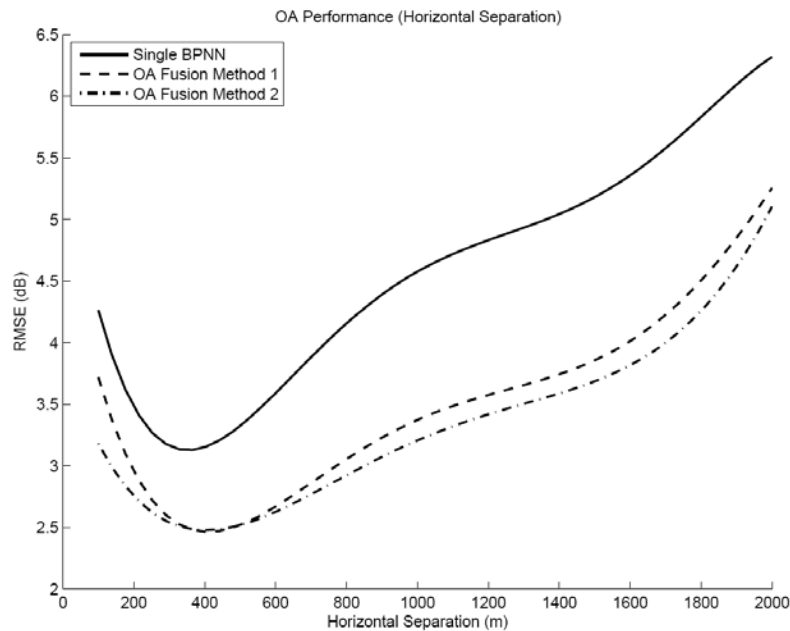
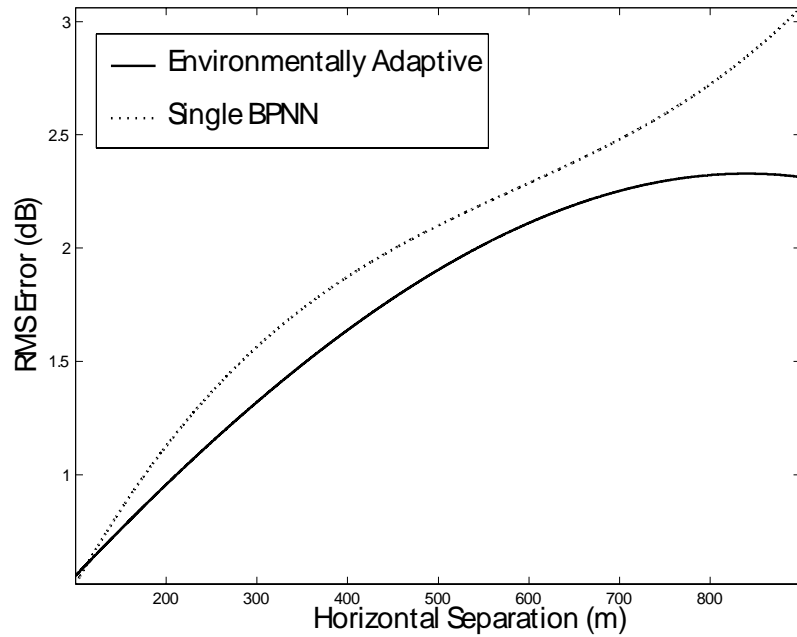


Figure 3: Performance of the EA and OA TL prediction systems. Notice the extended range for the graph of the OA system performance on the bottom, along with the increased overall error of both the OA and Single BPNN on the extended range of data.

Publications:

- [1] G. Wichern, M. R. Azimi-Sadjadi, and M. Mungiole “Environmentally Adaptive Acoustic Transmission Loss Prediction in Turbulent and Non-turbulent Atmosphere”, Invited Paper, Special Issue, *Neural Network Journal*, Vol. 20, pp. 484-497, May 2007.
- [2] M. McCarron, M. R. Azimi-Sadjadi, G. Wichern, and M. Mungiole, “ An Operationally Adaptive System for Rapid Acoustic Transmission Loss Prediction”, Proc. of IEEE International Joint Conference on Neural Networks, Orlando, FL August 2007.