Environmental Impact on Underwater Surveillance Systems in Estuary Areas

Hongyuan Shi, Dov Kruger, and Jeffrey V. Nickerson

Surveillance systems normally rely on remote sensors and detectors to collect information on suspicious movements. For a port by a river or the sea, such surveillance systems should cover all space dimensions: terrestrial, aerial, and underwater. Our work focuses on the design of remote sensing and detecting systems for the underwater environment around estuary areas.

Monitoring underwater environments has several serious challenges. Even though terrestrial and aerial surveillance techniques are well developed, they are typically based on the transmission of electromagnetic and optical waves. However optical and electromagnetic waves have extremely high attenuation in water. This inhibits directly adopting terrestrial and aerial detecting technologies to underwater usage. Most existing underwater detection technologies rely upon sound waves, as sound can travel a relatively long distance in water.

Underwater detection can be performed by active and passive SONARs [1]. Based on environmental concerns, passive sound SONARs or detectors are normally selected for fixed deployment. Unlike active SONARs, which emit sounds to surrounding areas, passive SONARs only collect sound signals from surroundings. Based on signatures of the sounds generated from various sources, passive SONARs can estimate the distance from a sound source. They can also recognize possible movements and even type of subjects. Because the information processing depends entirely upon the quality of received sound signals, it is critical to ensure that the transmission path from the sound source is sufficient for the sensor to detect the signal clearly. However underwater sound propagation is highly susceptible to water conditions. Sharp gradients in salinity and temperature cause sound to refract and reflect. Thus the listening range, or coverage, of a sound detector is largely influenced by the underwater environment. This effect is particularly prominent in estuary areas where fresh water mixes with sea water, and tidal action causes significant water current changes.

We study the behavior of estuary water conditions and attempt to understand the environmental impacts on the performance of underwater sensing and detecting systems. In this poster, we concentrate on sensor coverage variations. Environmental data is extracted from the NYHOPS ocean model with periodic calibration from fixed CTD (Conductivity, Temperature and Depth) stations in the Hudson River [2]. The coverage area is computed from environmental data of a typical spring day. The detection probability is evaluated based on an average sound level from underwater targets [3]. For the same area, we further evaluate sensor coverage and detecting probability in other seasons since water conditions change vastly at different time of the year (Fig. 1). We compare the results of several cases and summarize the impact of different environmental factors. The result shows that careful planning is required for sensor placement in an estuary area.

Our future work will incorporate deception detection. We aim to design a sensor placement strategy to construct a robust and effective underwater surveillance system.

H. Shi and J. V. Nickerson are with the Center for Decision Technologies, Howe School of Technology Management, Stevens Institute of Technology, Hoboken, NJ 07030 USA (e-mail: {hshi, jnickerson}@stevens.edu).

D. Kruger is with the Center for Maritime Systems, Stevens Institute of Technology, Hoboken, NJ 07030 USA (e-mail: dkruger@stevens.edu).

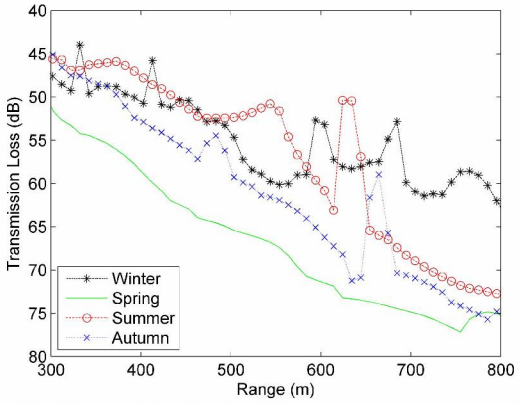

Fig. 1. Sound transmission loss in different seasons at one covered spot in the Hudson estuary area (computed from NYHOPS data using the Bellhop ray and Gaussian beam tracing program [4]).

References

[1] R. J. Urick, *Principles of underwater sound*, 3rd ed., McGraw-Hill, 1983.

[2] The New York Harbor Observing and Prediction System (NYHOPS) [Online]. Available: http://hudson.dl.stevens-tech.edu/NYHOPS/

[3] R. Stolkin, A. Sutin, S. Radhakrishnan, M. Bruno, B. Fullerton, A. Ekimov, and M. Raftery, "Feature based passive acoustic detection of a diver," presented at *the SPIE Defense and Security Symp.*, 2006.

[4] Underwater Acoustic Propagation Modeling Software V1.6 [Online]. Available: http://www.cmst.curtin.edu.au/products/actoolbox/

1-4244-1330-3/07/$25.00 ©2007 IEEE.