UDT
Undersea Defence Technology
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Research on Passive Detection Technology of Underwater Target Tone Based on Unmanned Underwater Vehicle

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Background

UUV

- Freedom from harsh conditions
- Strong Flexibility
- Low cost-effectiveness ratio
- Easy to cluster

UUV + Passive sonar system

Detection

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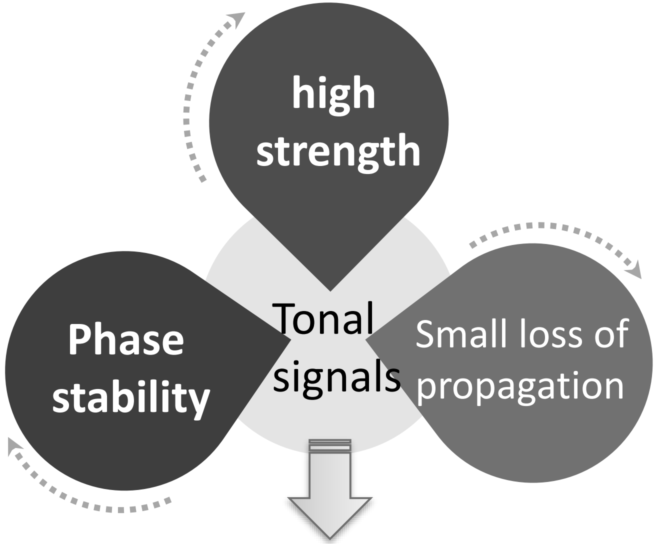
Tonal signals radiated from underwater vessels

Background



The tonal signals radiated from underwater vessels are of great significance for UUV sonar systems to detect the underwater objects.

Signal model & Problem

Signal model:

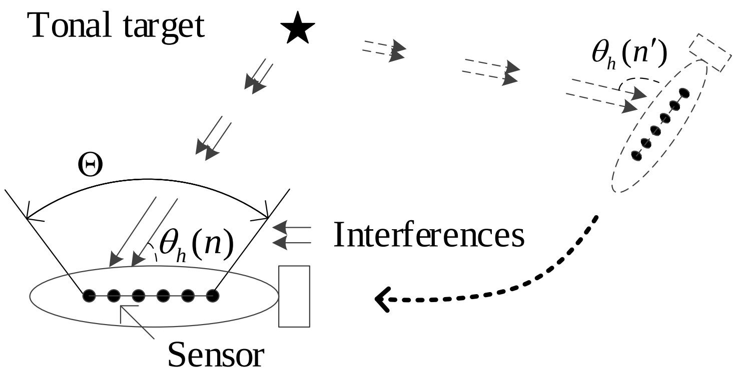


Fig. 1. UUV sonar array signal reception schematic

Beamforming technique

Tone detection

Problem:

$\theta_h(n)$ denotes the DOA of tone and is usually fast time-varying in the UUV or target motion-case

the main beam direction deviates from the DOA of tonal target.

Signal model & Problem

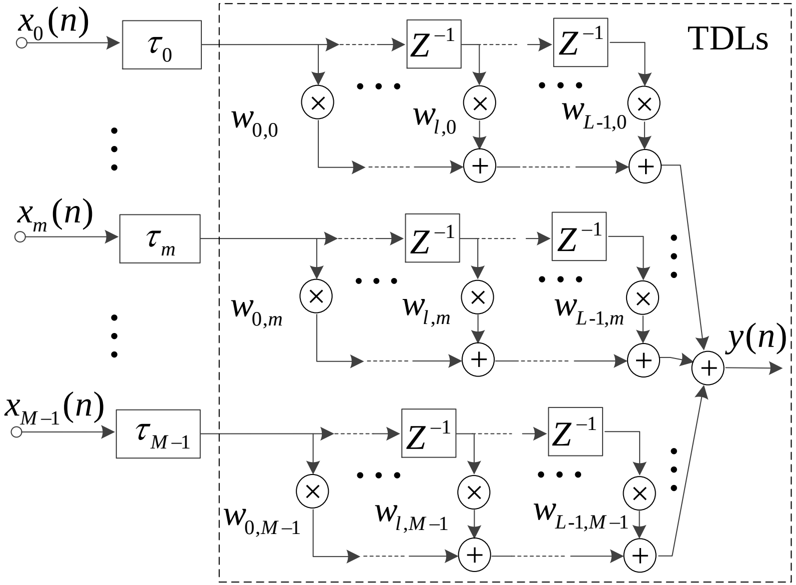


Fig. 2 . Conventional broadband beamformer

$\theta_h(n)$ cannot be effectively estimated in advance

↓

resulting in improper pre-delays τ_m to be selected

↓

A pointing deviation of the main beam will appear.

↓

Unable to detect tone

Proposed technique

Basic idea:

The main idea of this technique is to introduce the self-tuning filtering characteristics of the adaptive line enhancer (ALE) into the broadband beamforming technique

Advantages:

The technique does not need to estimate the DOA of tone in advance and can adaptively form a real-time tracking beam pointed to the DOA of tonal target.

Proposed technique

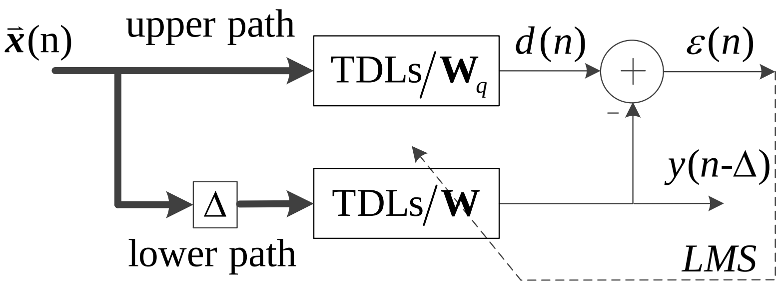


Fig. 3. The proposed self-tracking beamformer block diagram

The fixed weight vector $\mathbf{w}_q$ is chosen so as to eliminate signal of interest in $\bar{\Theta}$

(Convex optimization tools)

→ $\mathbf{w}_q$

LMS algorithm

Minimize → $\xi(\mathbf{W}) = E\left\{\left|d(\mathrm{n}) - \mathbf{W}^H\mathbf{X}(n\text{-}\Delta)\right|^2\right\}$ → $\mathbf{W}$

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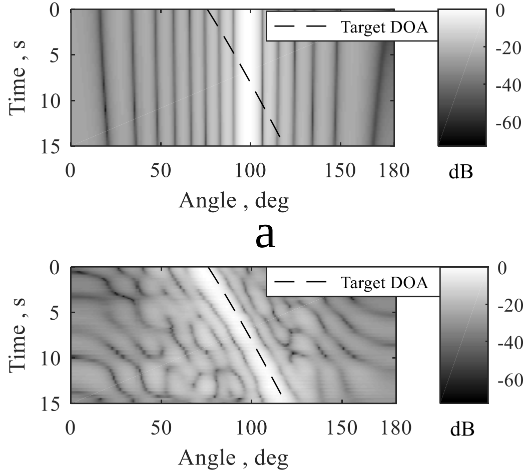
Simulations



b

Fig. 1 *Beam pattern at target frequency bin versus time*
a Conventional beamformer (pointed to100°)
b Self-tracking beamformer

Sensor number: M=20

Subregion of interest: Θ=50°~130°

Target DOA varies from 75° to 120° over 15 seconds

The main-beam of the self-tracking beamformer can adaptively track the target DOA

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Simulations

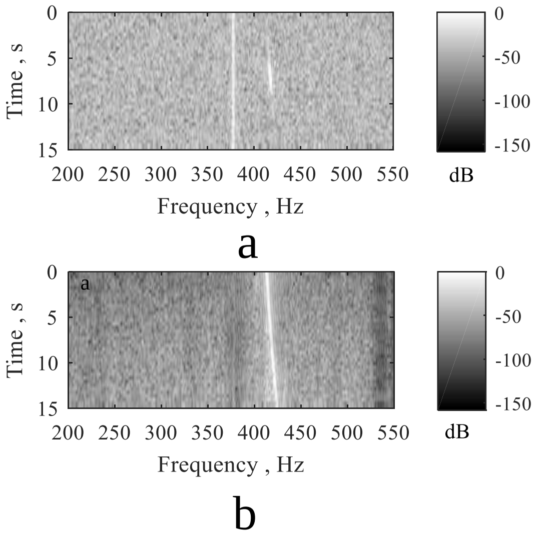

Fig. 2 *Time-frequency analysis of wideband beamformer output*
a Conventional beamformer (pointed to100°)
b Self-tracking beamformer

Tonal signal of the target can be observed over the entire time range and the interferences as well as the broadband noise are suppressed efficiently

Conclusion

The proposed technique can adaptively form a real-time tracking beam pointed to the DOA of tonal target and avoids the beam pointing deviation due to UUV-platform swinging, the rotational motion of UUV, the fast maneuvering of target or UUV, etc.