Radar and Sonar Signal Processing: Similarities and Differences

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Sonar and Radar Signal Processing

GOAL: To compare and contrast signal processing developments and challenges in radar and sonar. To focus the discussion, only conventional surveillance and tracking radars and sonars will be considered (i.e. no imaging systems will be addressed).

SIMILARITIES IN RADAR AND SONAR DEVELOPMENT:

- Objectives: Target detection, localization, tracking, and classification.
- Performance metrics: Receiver operating characteristics (ROC), target location accuracy, track latency and holding time, classification accuracy.

DIFFERENCES IN RADAR AND SONAR DEVELOPMENT:

- Fact that radar propagation is 2×10^5 times faster than sonar propagation has lead to historical radar emphasis on advanced *temporal* processing versus sonar emphasis on advanced *spatial* processing.
- Fact that sonars operate at bandwidths that are 10^4 times lower than typical radars, with commensurately lower required data rates, has lead to sonar development of advanced *multiple channel* processing versus radar development of *single channel* or limited multi-channel processing.
- Complexity of sonar *multipath* propagation channel and low data rates motivates development of sonar processing which incorporates computational physical models versus simpler *direct path* models used in radar.

Sonar and Radar Signal Processing Challenges

SIMILAR CHALLENGES IN RADAR AND SONAR:

- Reducing the SNR required for target detection and track initiation.
- Operation in high traffic, non-stationary interference environments.
- Reducing the minimum detectable velocity (MDV).
- Improving target localization, tracking, and classification.

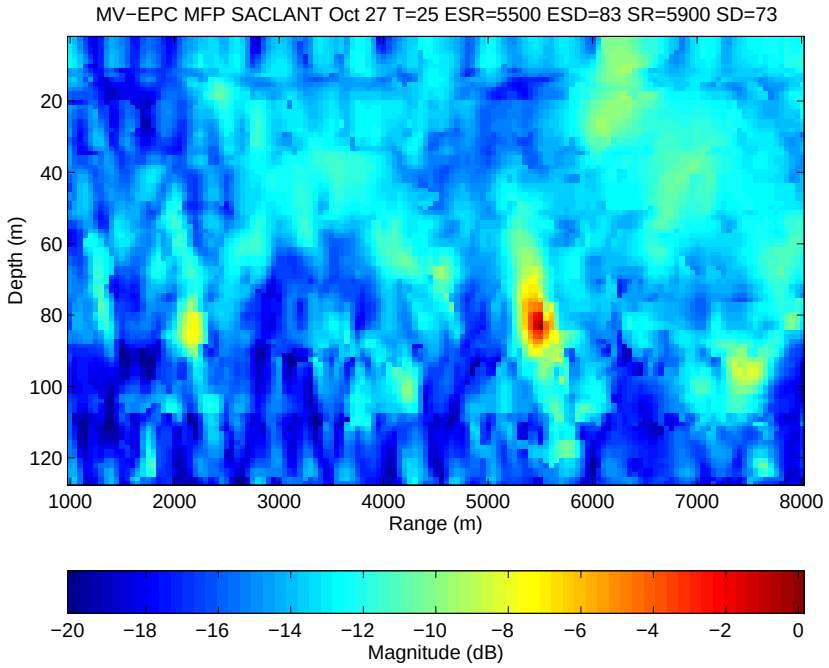
DIFFERENT CHALLENGES IN RADAR AND SONAR:

- Target detection is mainly noise and interference limited in passive sonar versus mostly clutter and reverberation limited in radar/active sonar.
- Large sensor-to-snapshot ratio and inability to isolate signal from the "noise training data" often results in more complicated adaptive detection problems in sonar versus radar where true CFAR detectors are well-known.
- MDV in passive sonar defines lowest detectable source level. MDV in radar defines how close the target can be to the clutter.
- Sonar challenge is often detecting very weak targets versus radar challenge often discriminating a target-of-interest (TOI) from many uninteresting tracks.

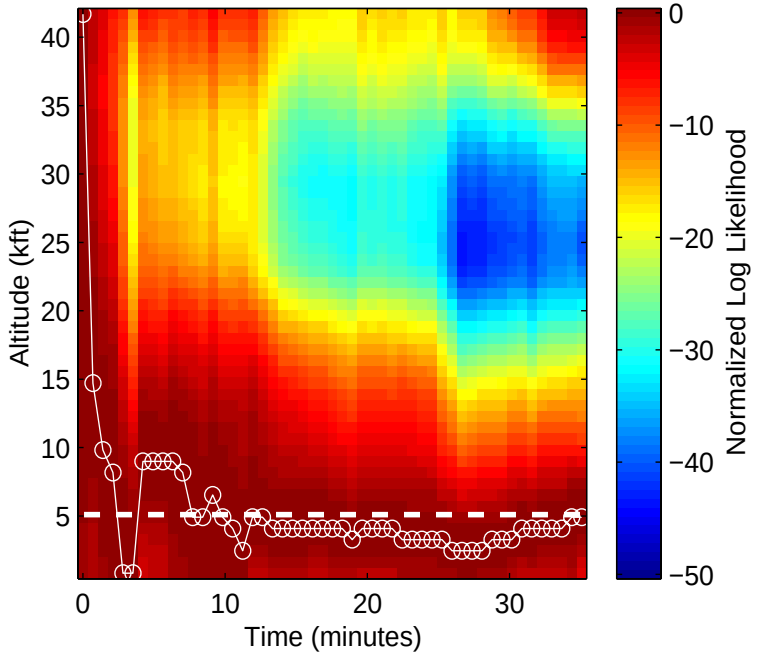
How Sonar Often Leads Radar Signal Processing

- Because of the lower data rates and computational throughput required, sonar signal processing development has often lead radar development. Examples: adaptive beamforming, and signal processing using computational models.
- One example is matched-field processing (MFP) which was originally developed for sonar but has subsequently been transitioned to radar applications.

Robust MV matched-field processing of a source at 5.9 km range and 79 m depth using SACLANT vertical line array data.



Matched-field altitude estimation of an aircraft at 2300 km range and 5.2 kft altitude using the Navy's ROTHR system



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