Surface Ship Location Based on Active Sonar Image Data

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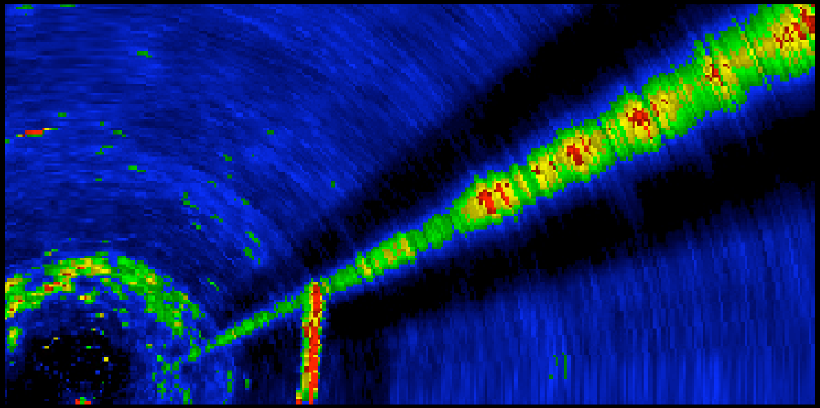
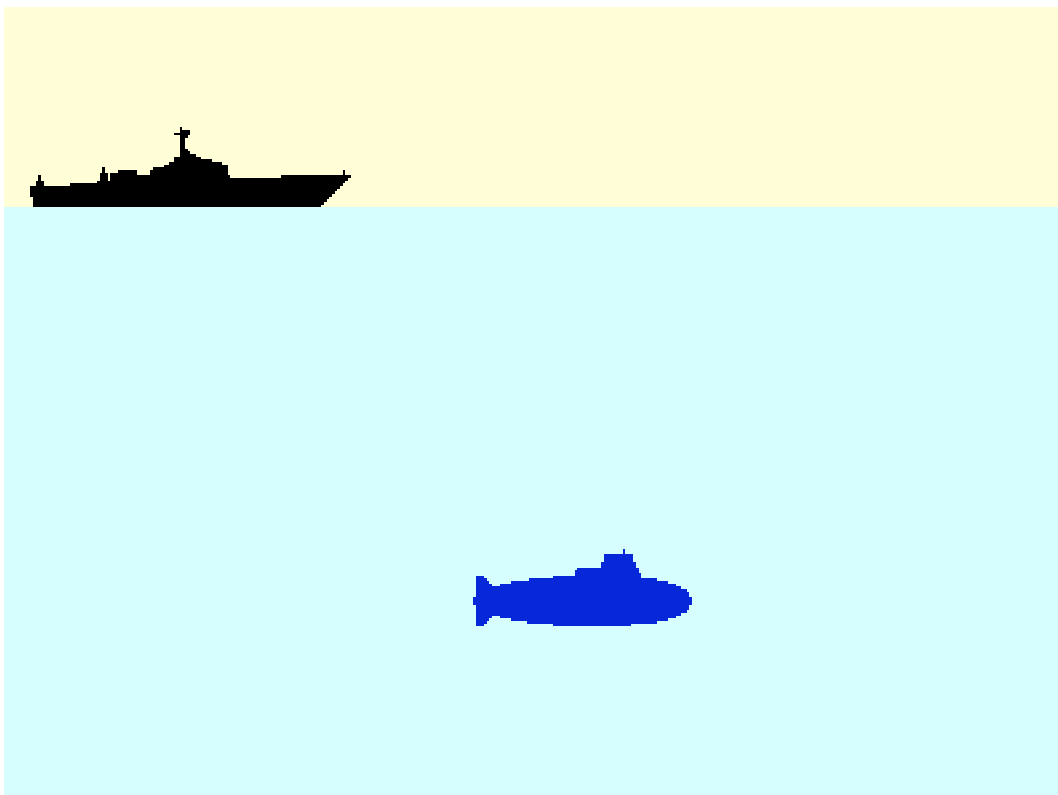


Image from Applied Research Labs, UT

What is Active Sonar?



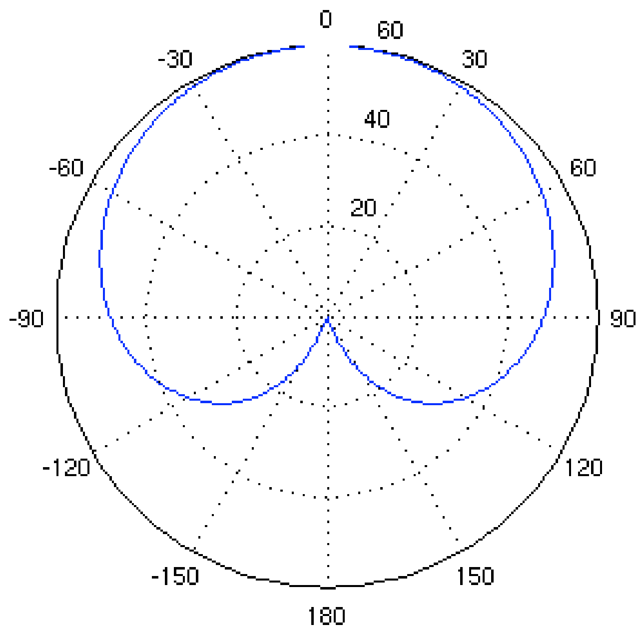
range = $\frac{\Delta t \times c}{2}$

Δt = time from transmit to receive

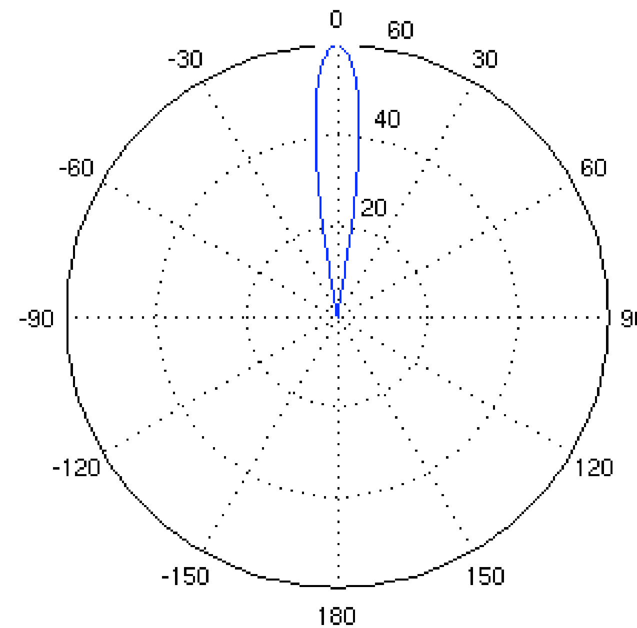
c = speed of sound in water

Image from http://www.dosits.org/science/ssea/1a.htm

What is Beamforming?



individual transducer
element response

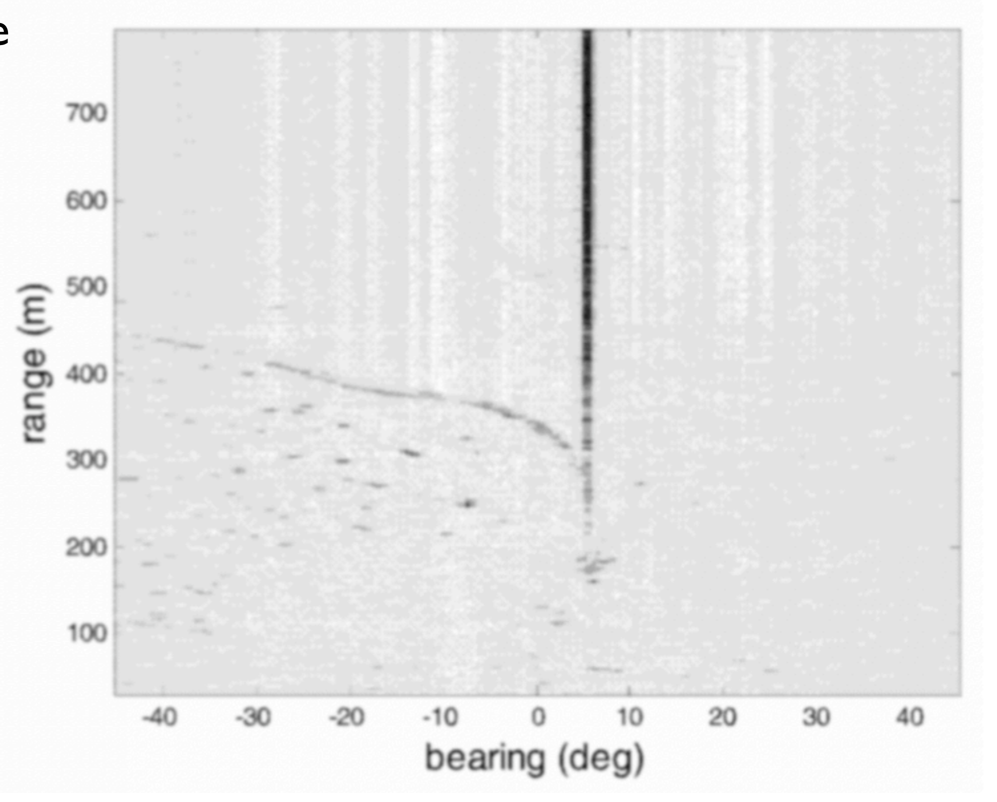


response formed from
multiple elements

Images from http://www.ece.utexas.edu/~allen/Beamforming/index.html

Paper: *Automatic Detection and Tracking of a Small Surface Watercraft using a High-Frequency Active Sonar*

- one target with noise spoke and wake
- stationary sonar
- operator-set thresholds
- integrate beams over range to find cavitation noise arrival direction
- normalize range profile with moving window to reduce target detection errors due to noise spoke



Clutter Map Processing

Geometric fading algorithm:

Suppress image features that appeared in previous frames

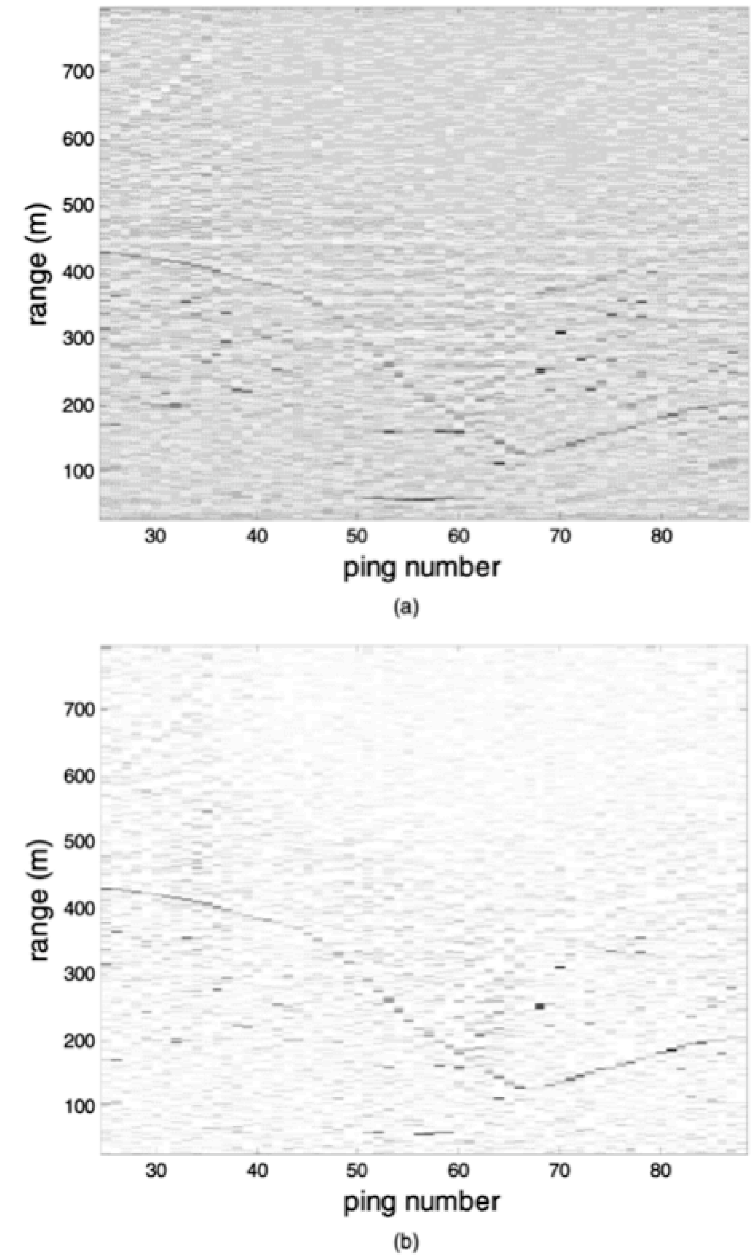


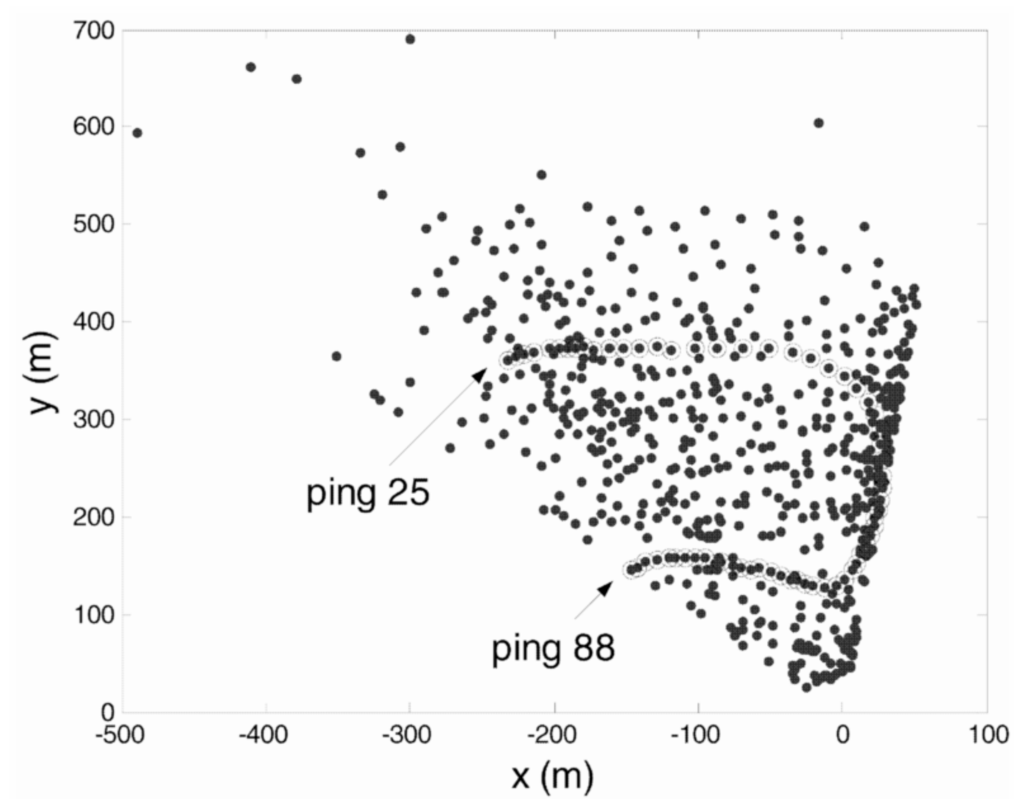
Fig. 5. Intensity plots of range profile at estimated target angle as function of ping number and range for the cases of (a) without clutter map processing, and (b) with clutter map processing.

Detection & Tracking

- require Nh consecutive noise spoke detections in angular order
- compute most likely track start from measured range values

Track Maintenance: Kalman Filtering

- target state vector: position and velocity
- compute a gate or validation region centered at predicted measurement in next ping
- discard measurments outside of the gate



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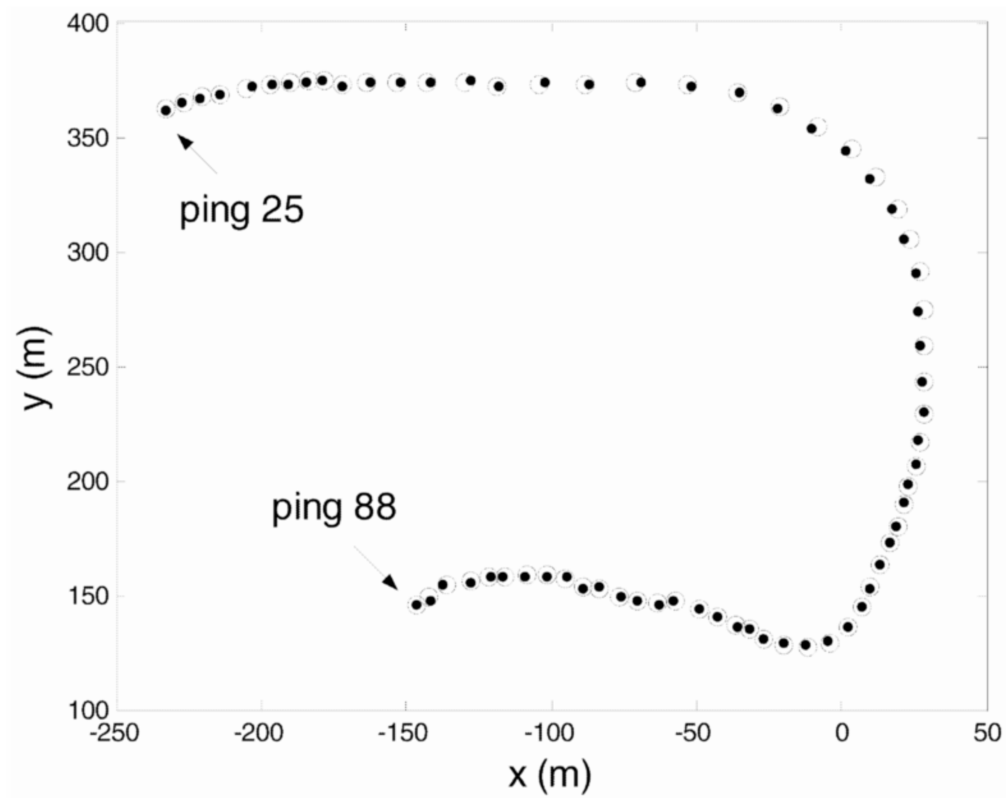

Needed improvements to previous method:

- observer motion compensation
- multiple target tracking capability

Paper: *A Recurrent Neural Network for Detecting Objects in Sequences of Sector-Scan Sonar Images*

- sonar on moving underwater platform
- assumes stationary targets on seafloor
- thresholding instead of clutter map processing
- multiple Kalman filters for multiple objects
- detection is *after* Kalman filter using multilayer perceptron

Another possible method: Particle Filtering

- probabilistic state description of targets
- has been applied to radar, multiple targets
- needs further study