Robotic Sensor Networks for Monitoring Invasive Fish

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- Invasive fish such as the common carp pose a major threat to the ecological integrity of freshwater ecosystems around the world
- Biologists introduce radio-tagged “Judas fish” which associate with larger schools
- In summer, a robotic boat can help to track tagged fish through lake chains to identify common feeding and spawning regions.
- Large, stationary aggregations form during the winter. Wheeled rovers can traverse frozen lakes to locate these groups for removal
- We exploit the behavior of the fish to separate the problem into three phases: Coverage, Search, and Localization

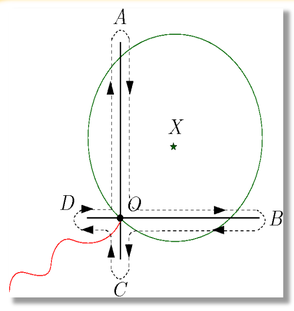
P. Tokekar, et. al. **A Robotic System for Monitoring Carp in Minnesota Lakes**. *Journal of Field Robotics*, 2010.

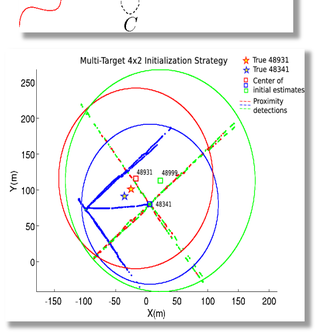
Coverage

We can formulate a search of the lake as a combination of TSPN and coverage. We present an algorithm that exploits the geometry of the neighborhoods to guarantee coverage in near-optimal time. Once a signal is heard, we can search nearby for a cluster and begin localization.

P. Tokekar, et. al. "**Coverage and Active Localization for Monitoring Invasive Fish with an Autonomous Boat** "*IEEE Robotics and Automation Magazine*. 2012. Note: To Appear.

Local Search

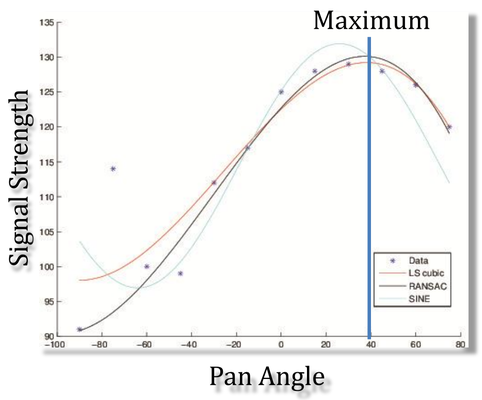




The output of coverage is an estimate of the tag based on the unknown sensing range . We improve this estimate and search for a nearby cluster by mapping the boundary of the sensing disc using a local search procedure. The local search phase ensures a consistent initial estimate of each fish’s location.

J. Vander Hook, et.al. **Local Search Strategy for Multi-Modal, Multi-Target Active Localization of Invasive Fish**. *13th International Symposium on Experimental Robotics*, 2012.

Active Localization with Bearing Measurements



Once the robot has found the cluster of fish, we can localize each of them to map out the cluster.

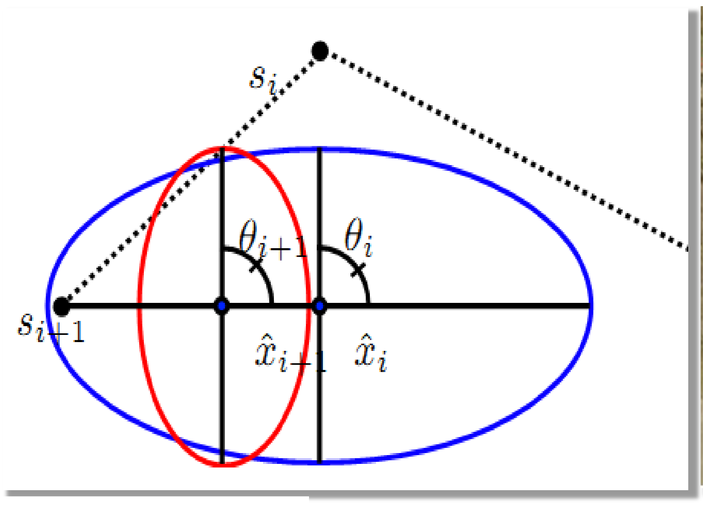
- We obtain bearing measurements using sampled signal strength by rotating the antenna
- These measurements are combined using an EKF to better localize the target
- The measurement location at each time step is given by our greedy localization algorithm
- These locations are alternatively chosen to reduce the two eigenvalues of the covariance matrix

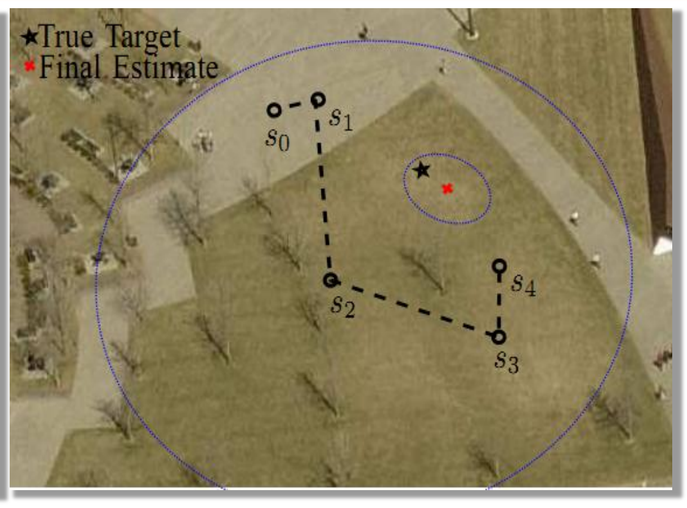
Our localization algorithm minimizes the number of measurements and travel time required to localize any individual fish. We can show that our algorithm takes near-optimal time, and can localize tags to within a few meters.

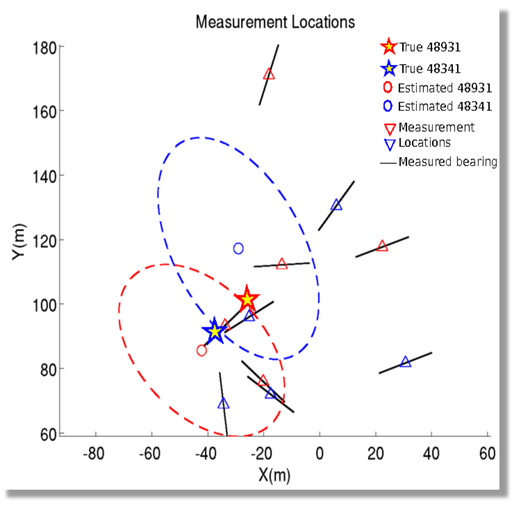
Current work focuses on multi-robot algorithms: cooperative tracking and sensor assignment.

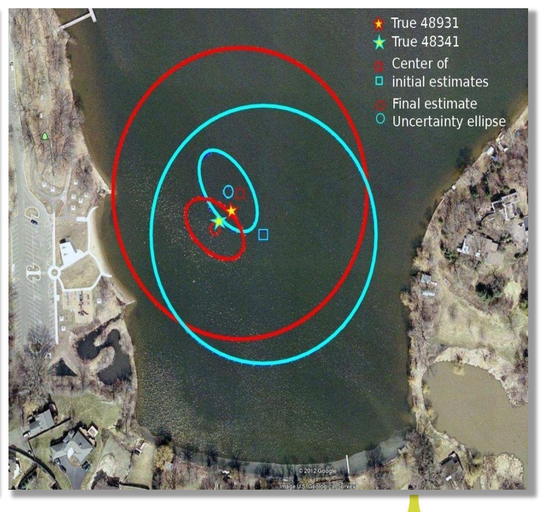
J. Vander Hook, P. Tokekar , and V. Isler. **Cautious Greedy Strategy for Bearing-based Active Localization: Experiments and Theoretical Analysis.** *ICRA*, 2012.

P. Tokekar, J. Vander Hook, and V. Isler. **Active Target Localization for Bearing Based Robotic Telemetry.** *Proc. IEEE/RSJ Int. Conf. on Intelligent Robots and Systems*, 2011.









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