Co-Aerial-Ecologist

Robotic Water Sampling and Sensing in the Wild

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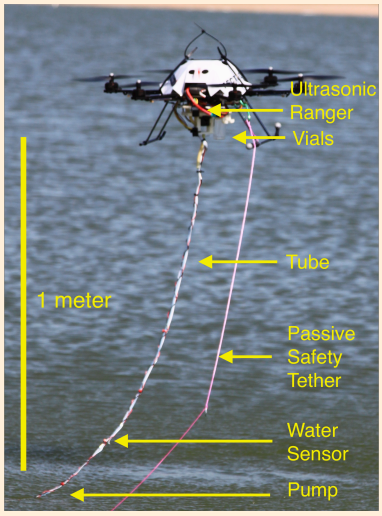
Motivation

Monitoring and predicting water quality poses a significant challenge since sources of fresh water and contaminants come in from huge areas of land and waterways. Further, the source of pollution can change quickly during and after rainfall events. Characterizing large-scale and quickly changing water systems remains a critical bottleneck that inhibits understanding of transport processes and the development of effective management plans to address water quality issues. Fixed sensors tend to lack the versatility to directly detect contaminants of interest, are expensive, and only monitor a single location. Consequently, there is still a strong reliance upon manual "grab-sampling" within hydrologic and aquatic ecology applications. At best, this reliance is expensive, inconvenient and presents safety risks to personnel involved (e.g. when samples must be taken at night). At worst, manual sampling results in datasets that cannot answer many questions of interest due to limitations of temporal and spatial resolution in the sampling strategy or the inaccessibility of sites (e.g. canyons).

Fremont lakes, NE, is one of the most popular recreation sites in the state. Since toxic algae blooms in 2004, they require active monitoring and management.



Aerial water sampler in field test.

Results

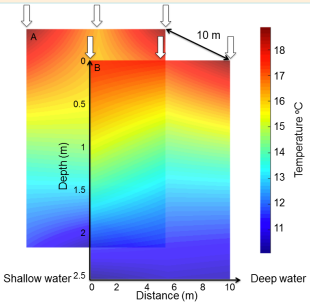
- Successfully collected **100s of samples** with scientists.
- Validated that aerial water sampling mechanism **does not bias measurements** of critical dissolved gasses (O) and ions (P, Cl).
- Developed robust altitude controller for near-water flight and characterized its' ability to collect samples in up to **15 knot winds.**
- Developed new sensing modalities for thermal structure and water conductivity gradients that are fast and non-intrusive.
- Created code instrumentation tool to connect user intervention to program parameters, so when a user intervenes, the system suggests parameters that are impacting behavior at that moment.
- Created tool to automatically generate unit tests from trace files, making regression testing faster for system developers.

Comparison to traditional sampling

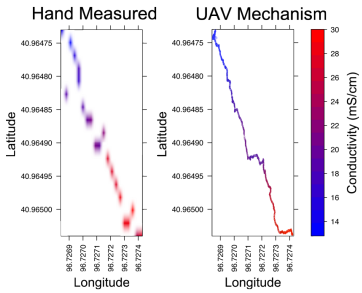
Automatic Unit Test Generation From Trace Files (ROSBags)

New Sensing Modalities

- **Thermal Structure** obtained by sampling temperature through a water column, enabling greater spatial resolution of thermal datasets without extensive static sensor arrays.
- **Water Conductivity** measured quickly in high resolution without disturbing sensitive ecosystems, helping scientists identify and understand cryptic saline water gradients.



Water Thermal Structure

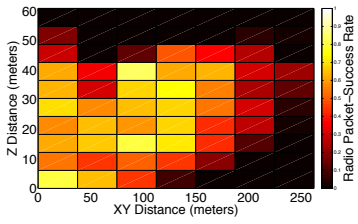


Water Conductivity

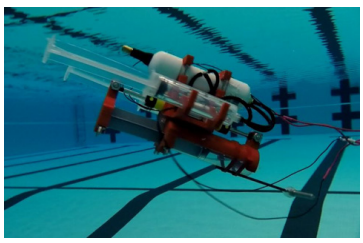
Future Work

- Sub-surface sensing/sampling
- Robust height control (winds)
- Automated test generation
- Robot debugging
- Invasive species monitoring
- Characterize radio propagation over water for UAV / underwater network.

Integration with static sensors



Further characterization of radio Propagation over water.



Sub-surface Sampling

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