

Adaptive Sampling for Marine Microorganism Monitoring

Bin Zhang, David Caron, Carl Oberg, Aristides Requicha, Beth Stauffer, Gaurav S. Sukhatme
<http://robotics.usc.edu/~itr>

Introduction: Adaptive sampling algorithms for an underwater sensor network

Goals

- Acquire the sensed data with
 - High spatial resolution
 - Few sample points
 - High energy efficiency
- Develop efficient sampling algorithms for underwater sensing

Application: Localize Thermoclines

- Microorganisms, such as Phytoplankton, can be exceedingly small (2-3 μ m)
- They have patchy distribution in the ocean on various spatial scales
- Light intensity (from above) and nutrients (from below) are important factors that limit their growth
- Thermoclines are regions that offer competitive trade-off between light and nutrients

Problem Description: How to find a maximum gradient in an efficient, scalable manner

- How does one node communicate with the others?
- How to reduce energy consumption?
- How to overcome a noisy environment?
- How to overcome a local maxima and find a global gradient?

Distributed Algorithm for Maximum Gradient Detection

Proposed Solution: Find Local Maximum and Negotiate with Neighbors for a Global Maximum

Assumptions:

- Each node executes same algorithm
- All nodes are equally important
- Only local communication is assumed

Algorithm

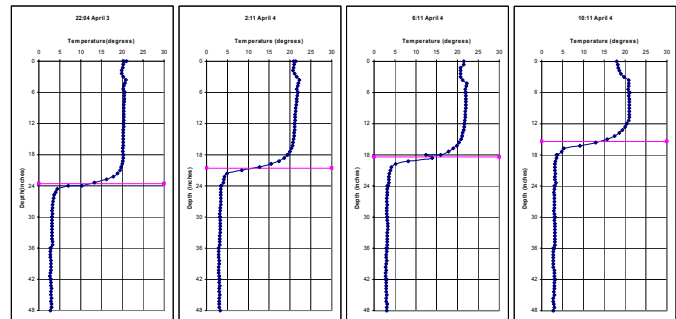
- Step1: Find Local Maximum
 - Binary Search
 - Polynomial Fitting
- Step2: Negotiate with neighbors for the global maximum gradient
- Step3: Move nodes to the place where there is maximum gradient

Simulation:

- All nodes can move independently
- Any node can only talk to its neighbors

Testbeds:

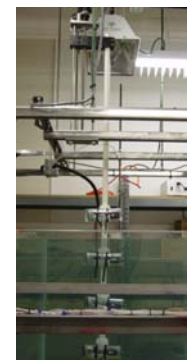
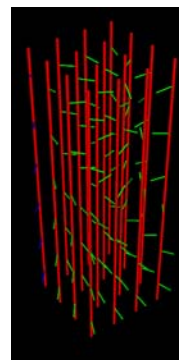
- Tethered Sensor Array
 - All sensors are fixed on a pole
 - There are wires linking each sensor to PC
- Wireless Sensor Array
 - Each node has its own CPU, Radio and Sensors
 - All nodes are fixed on a pole
 - Each node talks to its neighbors though radio



Experiment results for 24 hours on Tethered Testbed

---- the data collected by dense sampling (1 sample per inch)

---- the thermocline found through binary search



Simulator (left) Tethered Testbed (middle) and Wireless Testbed (right)