Adaptive Sampling for Marine Microorganism Monitoring

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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 (2-3μm)
- 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

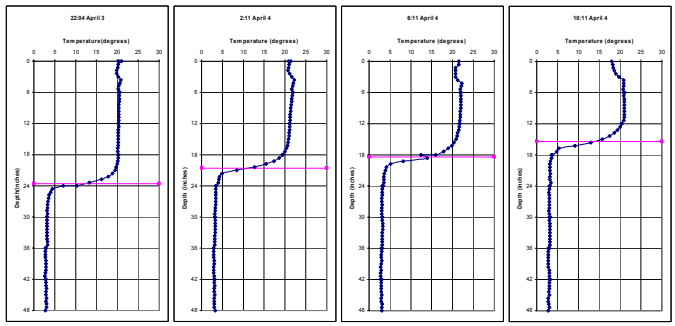
Problem Description: How to find a maximum gradient in an efficient, scalable manner

- 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

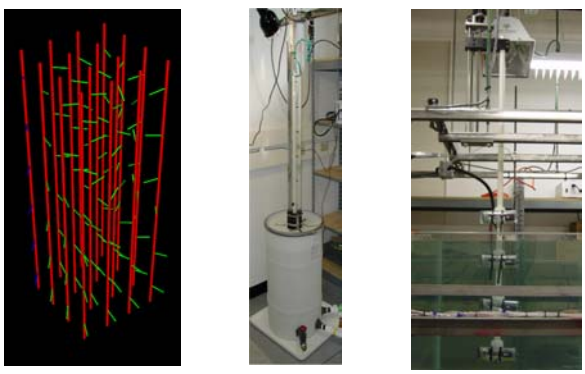
- Assumptions:
  - Each node executes same algorithm
  - All nodes are equally important
  - Only local communication is assumed
- Algorithm
  - Step1: Find Local Maximum
    - Binary Search
    - Polynomial Fitting
  - Step2: Negotiate with neighbors for the global maximum gradient
  - Step3: Move nodes 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)