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## Posters

### Title

Multitier Multiscale Sensing: a new paradigm for actuated sensing

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# Multitier Multiscale Sensing: A new paradigm for actuated sensing

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ASCENT – www.ascent.ucla.edu

## Introduction: What is dynamic spatiotemporal phenomena and how is it sampled?

### Environmental phenomena

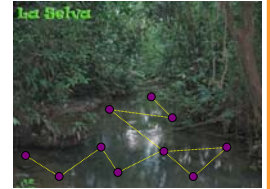
#### Characteristics

- High spatial and temporal variation
- Requires a high spatial sampling rate to achieve desired fidelity
- Requires actuated sensing (mobile robot)
- Examples of dynamic environmental phenomena include solar light radiation, CO<sub>2</sub> flux, humidity, algal blooms, nitrate, ammonium



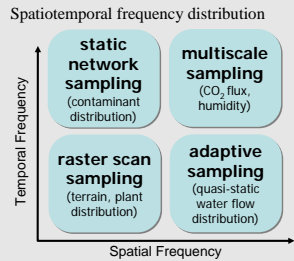
### Existing methods

- Static sensor sampling – static network of sensors
- Deterministic actuated sensor sampling (raster scan) – mobile robot carrying sensor(s) performs uniform scan of complete environment
- Adaptive sampling – multistep approach that varies sampling density at each step
- Combination of static sensors and actuated sensors – static network of sensors used to trigger sampling by mobile robot carrying sensor(s)



## Problem Description: Efficiently sample dynamic spatiotemporal phenomena to achieve high fidelity reconstruction

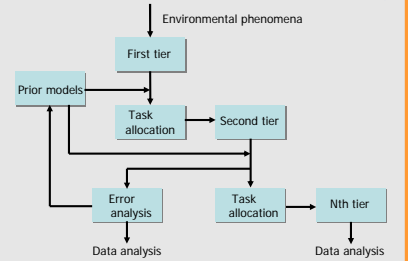
### Qualitative classification



### Limitations of existing methods

- Static sensor sampling – Requires an impractically large number of sensors to be distributed across the area of interest. Potential source of disturbance to the environmental phenomena being investigated
- Deterministic actuated sensor sampling – Significant sampling latency
- Adaptive sampling – Latency involved in extracting high variability regions is large
- Combination of static sensors and actuated sensors – Reduced sampling latency as compared with raster scan and adaptive sampling. Events occurring outside range of static sensor may be missed. Performance of technique depends on the number of static sensors

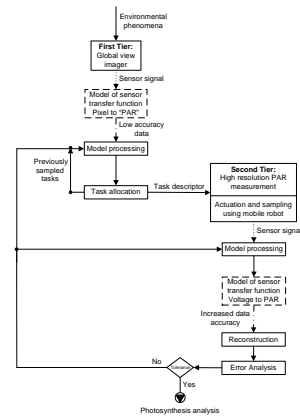
### Multitier Multiscale Sampling



## Proposed Solution: Multitier multiscale system combining resources with diverse sensing and mobility capabilities

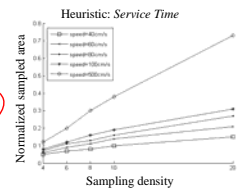
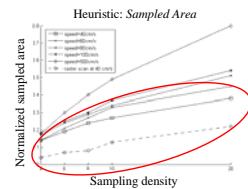
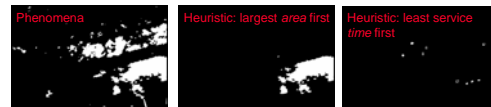
### Case study: Solar light radiation

#### Two-tier multiscale architecture

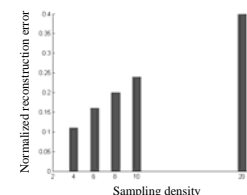
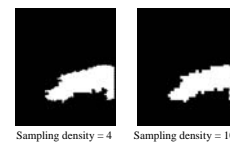


#### Task prioritization

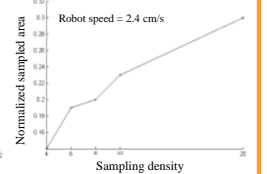
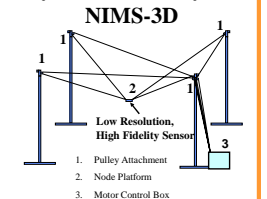
- Highest priority task is assigned to the closest robot
- Commitment policy



#### Reconstruction error

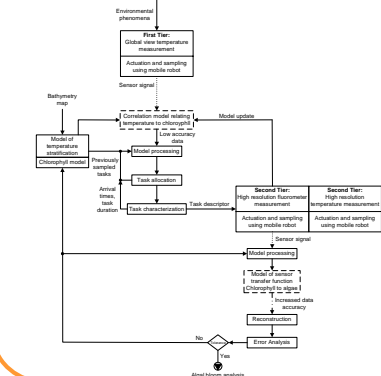


#### Physical Robotic System NIMS-3D



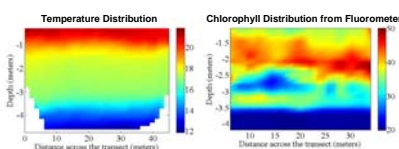
### Case study: Algal blooms

#### Two-tier multimodal multiscale architecture



#### Temperature and chlorophyll

- Algae populations rely on the availability of light and chemical nutrients for growth
- Nutrients are usually more abundant in deep waters because of decompositional processes
- The temperature gradient across different strata prevents mixing of water across the gradient. The algae are locked in the middle layer of uniform temperature with a thermal gradient above and below it



### Multimode experimental systems and physical robotic system: NIMS-Aquatic

- Apply actuated sensing to create
  - Surface temperature map
  - Bathymetry map
- Exploit model to predict spatiotemporal temperature distribution
- Exploit model to infer where algae density will be highest
- Sample accordingly
  - Sampling region will be large, i.e. > 50x50 m<sup>2</sup>
  - Sampling density will be relatively sparse compared to area of interest
  - Sampling occurs at depth using a fluorometer

