Environmental Macroscope Observatories

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Components of the Macroscope

- Application objectives
  - Field variable sampling, event detection, sensing fidelity
- Macroscope sensor systems
  - Static and actuated
- Deployment design
  - Transducers, locations, orientations, sampling protocols
- Adaptation and reconfiguration
  - Autonomous or externally supported
- Verification
  - Audit methods, detailed calibration, physical sampling,
- Demonstrate with example
- Summarize with Macroscope research questions
Environmental Macroscopes

CENS Team
Tom Harmon - UC Merced
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Macroscope Objective

• Example: San Joaquin Valley
  – Irrigation leads to salt contamination
• Fundamental, international problem
  – Must solve salt “circuit” problem
  – Salt contamination nonuniform
• Requires Macroscope solution
  – Properly located
  – Select river “plane”
  – Measure
    • Spatially and angular resolved velocity
    • Concentration of salt contaminant
  – Compute mass flux
Macroscope Components: Static Sensors

- Javelin
  - Subsurface soil characteristics
  - Groundwater - river interaction
- Sonar depth profiling
  - River subsurface structure
  - Human actuated
- Deployed in advance
  - Guides actuated sensor placement
Macroscope Components:
Actuated Sensors

- Sensor Node
  - Conductivity
  - Nitrate
  - Ammonium
  - pH
  - Temperature
  - Depth
  - Attitude (pitch/roll/yaw)
  - Compass Heading
  - 3 Axis Velocity
Macroscope Research

• Scaling the Macroscope
  – Near term opportunity (2007)
  – Convergence of science, technology, public policy
  – Entire San Joaquin River map

• Macroscope design problem
  – Given user measurement objectives determine:
    • Sensor selection, sensor operating protocols

• Macroscope deployment design
  – Given application-specific phenomena model:
    • Develop methods for sampling at multiple scales and multiple rates to determine optimal deployment to best benefit objectives
Macroscope Research

- Macroscope run time systems
  - Adapting to dynamic phenomena:
    - Develop static and actuated sensor networks that autonomously reconfigure to adapt to time evolution or discrete events

- Physical sampling problem
  - Recognize limitation of sensor systems
    - Add ability to Macroscope to sample material water, atmosphere

- Verification problem
  - For an operating Macroscope system develop:
    - Audit methods that determine optimal locations for verification of system design selections
    - Audit methods that introduce diverse sensors and physical sampling
    - Audit methods that use sparse resources to verify over wide regions
• Multitasking Macroscope Observatory
  – Recognize that Macroscope supports many users
    • Contrast with astronomical observatory
    • Macroscope inherently is subject to unexpected events
  – Recognize that meeting schedules may be mission-critical for multiple users with competing requirements.
    • Consider example of water resource management where flow, salt, and pesticide detection must occur
    • Consider sudden flooding conditions
• Immediate next steps
  – Public health, economic, and environmental impact questions are in the near future
Comparison of Macroscope with Prior Methods

- High resolution profile of flow and contaminants
  - Flow verified to be accurate - two flow conditions
    - Each agree within less than 1% tolerance of downstream government gauging measurement
  - Enables first high resolution direct measurements of mass flow of contaminants
  - Now possible to track input/output of contaminant sources

- Prior methods
  - Manual:
    - 15m stream
    - 350 sample points and one variable
    - Two weeks
  - Macroscope
    - 50m stream
    - 6,000 sample points with 8 simultaneous variables
    - 100 min
    - Over 1000x improvement
Water Velocity Magnitude

![Graph showing water velocity magnitude with depth and width axes.]
pH

Depth (mm)

Width (m/10)

[Graph showing pH distribution with color scale from 7.4 to 8.0]
Nitrate

Depth (mm)

Width (m/10)

mg/l-N

Nitrate concentration distribution map.