Title
SIP0: CENS Sensor Information Processing Research Overview

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## Introduction: Five signal processing problems in sensor networking are presented below

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### Problem Description: Brief descriptions of the five problems considered here

1. **Inherent unreliability of sensors often collect data with errors, faults and missing samples.** We address the data integrity and computational sensing problems in sensor networks.

2. **Measuring sunlight values under a forest canopy has basic values in biological applications.** Sensors equipped with mobility, (e.g. NIMS nodes), can selectively sample the 2-D sunlight random field.

3. **The ability to do robust meaningful research with minirhizotron images is currently limited by the amount of time that can be spent by a human expert classifying the data.**

4. **Data integrity is vulnerable to faulty and malicious behavior in sensor networks.** It is necessary to detect and handle faults and malicious data before they cause problems in an integrated sensor system.

5. **Localization of an emitting acoustic source as well as sensor nodes is needed in sensor network applications.** The AML estimation and the distributed Gauss-Newton algorithms are used to solve these problems.

### Proposed Solution: More details on the five problems considered here

**Problem 1**
- Data integrity and computational sensing are two canonical problems in sensor networks
- Generic approach for both tasks includes three phases: statistical modeling, prediction, and fusion and analysis
- Phase 1: Statistical data-driven models; unique features of computational sensor modeling
- Phase 2: Constraint manipulation
- Phase 3: Formulate data integrity as an optimization problem; minimize the discrepancies between the sensor readings and the models; model constraints and users specified constraints

**Problem 2**
- Besides its value in biology and energy harvesting, sunlight under forest canopy constitutes a good realization of 2D random field
- Sensors equipped with mobility, e.g. NIMS nodes, can selectively sample the field based on current information
- Reconstruct the field based on scattered samples – thin plate spline
- Candidates for next round sampling are generated by circle fitting
- Statistical model and local roughness based sampling point pruning
- Bending energy increase is used to gauge the approximation convergence

**Problem 3**
- The ability to do robust, meaningful research with minirhizotron images is currently limited by the amount of time that can be spent by a human expert classifying the data
- Classifying the images is a hard problem for humans; there is variability between experts. In addition, there is large within-class variability of the scale, appearance, and color of the objects in the images
- An application is being developed to aid in the classification of the images
- Algorithms are also being explored to completely automate the process, although this is a much harder task than it at first seems

**Problem 4**
- System support for analyzing a remote outdoor testbed of motes in the presence of various faults
- Reconfigurable support modules through SOS
- Provide a user-level interface for customizing the behavior of RFSN
- Reputation Based Framework for Sensor Networks
- Can handle malicious and faulty behavior.
- Can handle misbehavior in networking, sensing as well as data processing.

**Problem 5**
- Localization of acoustic source uses the Approximate-Maximum-Likelihood (AML) methodology
- In virtual array method, the AML est. direction-of-arrival (DOA) can be used to localize the source under controlled reverberant scenarios
- For localization of an impulsive acoustic source, whitening of the observed data before the AML operation is shown to be effective
- For wireless sensor node localization, the locations of the anchor nodes are assumed to be known
- Range information among neighborhood sensor nodes as well as from sensor nodes to neighborhood anchor nodes are also available
- Dist. Newton-Gauss algorithm is used to find the sensor node loc.