Title
Model Based Multiscale Sensing (MAS 5)

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Model Based Multiscale Sensing

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Motivation

- **Multiscale Sensing**: Combining hierarchy of sensor data sources with varying deployment density and sensing modes
- **Problem**: Achieve the high fidelity of exhaustive sensing by engaging multiple levels of sparse sensing
- **Application**: Determine spatiotemporal characteristics of sunlight field under forest canopy
- **Motivation for Model Based Approach**:
  - Direct fusing of measurements at multiple levels enhances performance, but improvement benefit is limited
  - Models directly extract phenomena behavior
  - Communication and computation rate requirements constrained to most important data
  - New information can be directly incorporated by updating models

Multi-level Information Processing

- **Info Levels**
  - Context: weather condition and environment
  - High level information: camera provides global measurement with low accuracy and high spatial resolution
  - Low level information: PAR sensor provides local measurement (low spatial resolution) with high accuracy

- **Image Processing**
  - Segment the field image into feature clusters
  - Partition the field based on pixel features and connectivity

- **Three-phase Information Processing**
  - **Model learning phase**
    - Apply dense sampling in different small areas to learn the possible incident light distributions and reflectivity distributions
    - Build a set of incident light distribution and reflectivity models
      - Decompose sunlight into 3 components
      - Direct beam, sky diffused light and leaf diffused light
      - Obtain distribution model of sky diffused light and leaf diffused light from measured data
      - Obtain distribution models of direct beam from measured and simulated field
    - Combine the two to build a set of reflected light distribution models
  - **Model selection phase**
    - Compare the reflected light distribution model measured by the camera with the set of models
    - Select a few models from the model set that are closest to the measured model
    - Use static PAR sensor measurement to pick one most probable model
  - **Model validation and updating phase**
    - Verify the PAR sensor measurement matches the selected incident light distribution model
    - Update the model set if the measured incident light distribution model is substantially different from any available model in the model set
    - Bound the minimum number of PAR sensors to fulfill the model selection and validation task

- **Interactive Information Processing**
  - Simulate the field with parameters based on prior knowledge and global condition
  - Refine the simulation parameter with information from static sensor measurements
  - Update models by assimilating new simulation results, static sensor measurements and reconstructed field

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