Title
Model Based Multiscale Sensing (MAS 5)

Authors
Cathy Kong
William Kaiser
Greg Pottie

Publication Date
2006

Model Based Multiscale Sensing

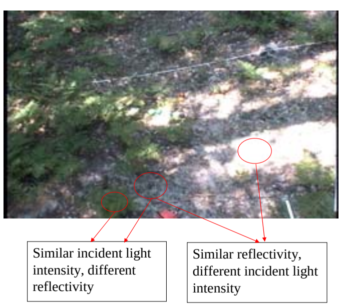
Xiangming Kong, William J. Kaiser and Gregory J. Pottie

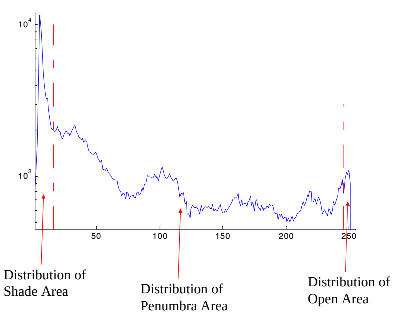
Motivation

- 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

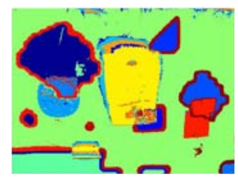
- Information Levels
  - Context: weather condition and environment
  - High level information: camera provides global measurement with low accuracy and high spatial resolution
  - Low level information: PAR sensor provides local measurement (low spatial resolution) with high accuracy





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

Original Image



Partitioned Patches in Pseudocolor

- 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