Title
SIP3: Iterative Sampling of the Sunlight Field

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Iterative Sampling of the Sunlight Field

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Overview of the problem

Sunlight field under forest canopy

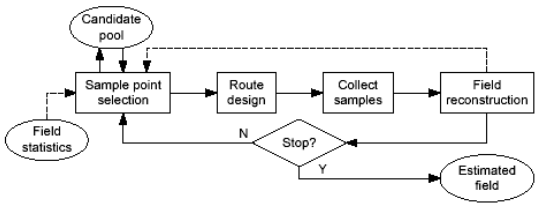
- It influences plant growth in a forest ecological system; is important for energy harvesting applications.
- Provides a good realization of two dimensional random field.
- Reconstruct mean phenomena
  - Reconstruction of instantaneous field is formidable but not necessary in many application
  - Obtain field average over short time interval
- Determine confidence level based on fidelity improvements.
- Optimally allocate limited resource.

Statistical model assisted iterative sampling

- Exploit different level of information
  - Extract statistical model from global information
  - Allocate sampling point based on local derivative information and the statistical model
- Iteratively sample and reconstruct mean field until fidelity requirement is achieved
  - Node mobility enables the iterative sampling approach
  - Determine new sampling location from previous reconstructed field
  - Reconstruct field after each round of sampling process

Overview of the algorithm

Block diagram of the iterative algorithm



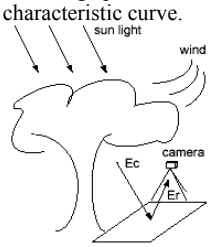
Descriptions of Functional blocks

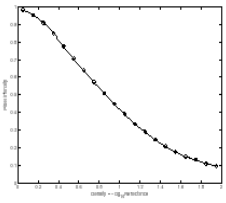
- Field statistics: build statistical model by exploring field data
- Candidate pool: generate candidates for new sampling points
- Field reconstruction: thin plate spline interpolates scattered data
- Sample point selection: Select sample points based on statistical model and bending energy
- Route design: given a set of sampling point, construct a minimum cost route to cover all of them.
- Collect samples: conduct data measurements.

Experiment and simulation results

Multi-scale experiment setup

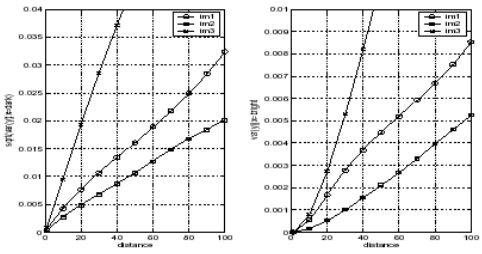
- A homogeneous screen is placed to create a reflection Er proportional to incident light Ec.
- Camera captures the reflection on its CCD
- The image pixel intensity is transformed to Er using camera's characteristic curve.





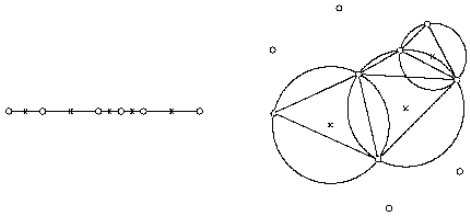
- Global scale field data.

- Statistical model based on the variogram.



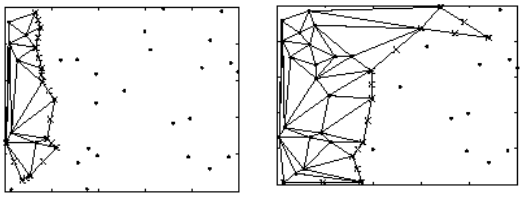
Candidate pool: circle fitting

- Minimum distance from a candidate to existing samples is maximized;
- Distribution follows that of the existing samples;
- Total number of candidates are bounded;
- Efficient algorithm exists – Front-advancing algorithm



- The inscribed triangles form a plane graph
- Use Euler's formula to bound the number of sampling points.

Front advancing algorithm



Sample point selection

- Cost function
  - C1: uncertainty based on source statistical model;
  - C2: local variation based on field derivatives.
- Convergence to the true field: $\|e\| < C*\sqrt{I(f-s)}*h$
- Use bending energy I(s) as the criterion to gauge the gain provided by new new sampling points.