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Some Topics in Simulation Optimization

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Research Streams

- Simulation Optimization
  - Discrete: model-based methods, computing budget allocation
  - Continuous: stochastic gradient estimation
- Global Optimization
  - Model Reference Adaptive Search (MRAS) [see Jiaqiao Hu]
  - connecting to stochastic approximation/gradient search [see Jiaqiao Hu]
  - particle filtering framework [see Enlu Zhou]
- Markov decision processes (MDPs)
  - Simulation-based framework, adaptive sampling
  - Population-based & model-based algorithms

Note: joint work with Steve Marcus, Hyeong Soo Chang, Jian-Qiang Hu, Chun-Hung Chen, L. Jeff Hong, Yongqiang Wang, et al.

What makes simulation optimization hard?

- Key: OBJECTIVE FUNCTION contains quantities that must be estimated from stochastic simulation output
- Ordinary optimization can concentrates on the search.
- Due to the stochastic nature of the problem, there is both search and evaluation.

- Trade-off between
  finding more candidate solutions
  vs. **obtaining a better estimate of current solutions**

  i.e., **finding $\arg\min_{\theta \in \Theta} J(\theta)$ vs. estimating $J(\theta)$**

Stochastic Gradient Estimation Approaches

approach	# simulations	key features	disadvantages
IPA	1	highly efficient, easy to implement	limited applicability
other PA	often > 1	model-specific	more difficult to apply
LR/SF	1	requires only model input distributions	possibly high variance
WD	2*(# appearances of parameter)	requires only model input distributions	possibly large # simulations
SD FD (one-sided)	2*p p+1 (dimension)	widely applicable, model-free	noiser, biased, large # simulations
SP	2	widely applicable, model-free	noiser, biased

Acronyms: infinitesimal perturbation analysis, likelihood ratio/score function, weak derivatives, symmetric/finite differences, simultaneous perturbations

Selected Relevant References

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- M.C. Fu and J.Q. Hu, *Conditional Monte Carlo: Gradient Estimation and Optimization Applications*, Kluwer Academic Publishers, 1997.
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