

ORIE 4580/5580: Simulation Modeling and Analysis

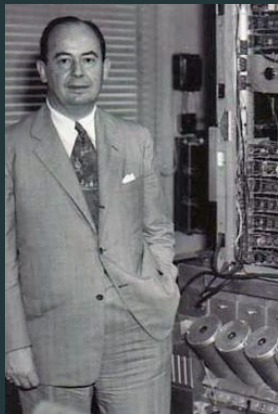
ORIE 5581: Monte Carlo Simulation

Unit 16: Wrap up

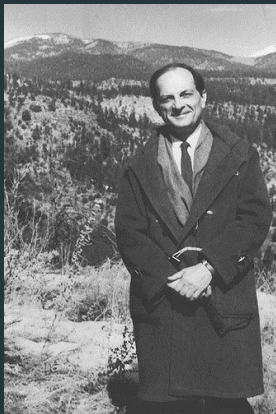
Sid Banerjee

School of ORIE, Cornell University

Monte Carlo simulation



John von Neumann



Stanislaw Ulam

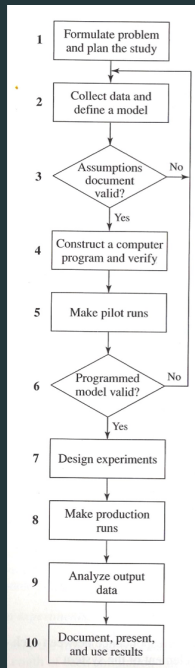


Nicholas Metropolis

why study simulation?

stochastic simulation has four major applications

- **numerical computation**: used for estimating difficult integrals for scientific computing purposes
- **algorithms for massive data**: sketching, streaming data, random-walk network algorithms, graphical models, etc.
- **risk analysis**: quantifying/hedging against random 'shocks' in daily life
- **'what-if' analysis**: understanding/optimizing complex systems in-vitro



the simulation flow-chart

simulation analysis

- analyzing simulations
 - confidence intervals (pilot runs, number of replications)
 - measures of risk (smore plots)
- random number generation
 - PRNGs: LCGs, period, seed
 - non-uniform RNG: inversion, a-r, special techniques (Box-Muller, correlated Gaussians, thinning for NHPP)
- input modeling
 - 'physics' behind distributions
 - parameter fitting: method of moments, MLE
 - goodness-of-fit: chi-square, Kolmogorov-Smirnoff
 - output sensitivity: parametric bootstrap
- variance reduction
 - antithetic variates, common random numbers
- programming tools
 - python (ipython notebooks, scipy.optimize, matplotlib, pandas)

simulation modeling

- discrete-event simulation
 - simulation clock, event lists
- queueing models
 - physics of queues (stability, flow-balance, Little's law)
 - Markovian queueing models ($a/b/c$ queues)
- Markovian simulation models
 - exponential rvs, Poisson processes; memorylessness
 - complex models: phase-type distributions, complex state-space
- output analysis
 - terminating simulations, steady-state simulations, warm-up, replication-deletion, batch means
- comparing alternative systems
 - common random numbers, union bound
 - subset selection

and beyond. . .

- optimization and simulation
 - simulation optimization for large number of parameters
 - using simulation models for control
(markov decision processes, approximate methods)
 - reinforcement learning
- markov-chain monte carlo
 - generating from complex distributions
 - example: generating spanning trees