Monte Carlo Simulation

Science and Engineering Applications

NPRE 498MC

(to be reassigned as NE 456/CSE 41*)

Call Number: 05928 LECD Section: M
Hours:12:00-12:50 MWF
Location: 110H Talbot Laboratory

Course objectives: *To provide depth coverage of Monte Carlo Simulation with emphasis on the variance reduction and error estimation methodologies. This course provides motivation and sets directions of further study by emphasizing the potential applications of Monte Carlo simulation methods in the science and engineering fields in general, and particle transport in particular in the field of nuclear and plasma engineering.*

Catalog Description: The objectives of this work is not just to provide coverage of the fundamental aspects of the Monte Carlo Method for readers who are using existing Monte Carlo codes, but also to delve deeper into its sophisticated applications concerning variance reduction and error estimation, enabling them to become the developers and writers of their own future codes. A unique feature of the present work is to supplement the theoretical coverage with coding and procedure programming templates for the readers to build on their own coding. It is not meant to train the users of existing Monte Carlo codes, which is best covered in other forums.

The Monte Carlo Simulation Method or the Method of Statistical Sampling was developed as part of the Manhattan Project and the subsequent Super project for the design of thermonuclear devices. Initially used for particle and radiation interactions simulations, it was instrumental in the development of digital computers, as we know them today. This became a major spin off of the effort to carry out these simulations. With the advent of current computer architectures and platforms, its realm of application has recently drastically enlarged in most fields of Science and Engineering. Even though the readers may have been introduced to Monte Carlo in topics using numerical simulations, by covering the basic subject matter, some find that they need more time to delve deeper into the basic theoretical concepts as well as the practical methodologies of Monte Carlo. This work thus supplements and augments such coverage for those desiring it, by considering the Monte Carlo Method as the primary subject matter, and not as a subset of another more important topic. Consequently it concentrates on the theoretical and the practical programming fundamentals, and move beyond analog simulations to the realm of variance reduction methods. These include, among others, importance sampling, correlated sampling, and antithetic variates. It also gives adequate coverage on the methodologies for error estimation, primary and secondary estimators, bias avoidance, as well as both probabilistic and possibilistic sampling. It also provides the opportunity for actual hands-on programming simulations.

For those students in Nuclear, Plasma and Radiological Engineering interested in particle transport simulations, fault tree analysis in probabilistic risk assessment, and other related fields such as heat transfer, plasma physics, material science, who desire emphasis and deep coverage of the Monte Carlo methodology as the primary subject per se, this course provides motivation and sets direction of further and deeper study by emphasizing the basic and fundamental Monte Carlo theories and methodologies.

Prerequisites: Adequate mathematical background: calculus (Math 280 or equivalent), Junior,-Senior or graduate standing, and computer programming ability (CSS 101 or equivalent), or consent of instructor

Credit: 3 hours for undergraduates, or 3/4 unit, or 1 unit with project for graduate students.

Format: Lectures and programming exercises on different computer platforms

Semester: Spring semester

Information: Prof. M. Ragheb
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Laboratory Work: Instructor supervision of computing assignments. Software instruction: exercises in writing programs for direct simulations and variance reduction methods, and error estimation. Simulation problems of particular interest to students.