Syllabus for Math 416/516 (Fall 2018): Simulation Methods

Hongbo Dong

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- Time/Location: Tu/Th 14.10 – 16.05, SPRK 233. (Pullman campus)
- Instructor: Hongbo Dong
  - Email: `hongbo.dong@wsu.edu`
  - Webpage: `http://www.math.wsu.edu/faculty/hdong/welcome.php`
  - Lecture notes, code, announcement on *Blackboard Learn* `https://learn.wsu.edu`
  - Office/office hours: Neill Hall 409, 9am-11am Wed., 10-11am Thur. or by appointments.
- Textbook:
  - Required text: Simulation (by Sheldon Ross, 5th eds., 2013 ISBN 978-0-12-415825-2)
  - Reference (publicly available): Julia reference manual (`http://https://julialang.org/`).

Course Description. In this course we discuss

1. efficient numerical methods for simulating discrete/continuous random variables;
2. applications to studying complex systems (e.g., queueing systems, inventory models, stock prices, etc.);
3. statistical analysis and validation techniques of simulated data;
4. variance reduction techniques;
5. Markov Chain Monte Carlo methods (Hastings-Metropolis, Gibbs sampler).

A solid background in basic probability theory/statistics and some computer programming language is required (Course Prerequisite: STAT 360; CPT S 121, CPT S 251, or MATH 300).

Computing. Efficient implementation of discussed simulation algorithms is an essential part of this course. We will use *Julia* and *Jupyter notebook* for homework, lecture notes and course project. It is recommended that students install the following (free) software on their computer/laptop:

- JuliaPro (`https://juliacomputing.com/products/juliapro.html`);
- Jupyter notebook (`http://jupyter.org/`);

Alternatively, students can run Julia code on JuliaBox (`https://www.juliabox.com/`) without installing anything. Its free version is sufficient. However, it may become inflexible for course project (required for this course).

Student Learning Outcomes and Assessment The essential student learning outcomes of this course include solid understanding of the mathematics in stochastic/probabilistic models and how to use them to efficiently simulate from probabilistic models, as well as analyzing/validating simulated data. The outcome will be evaluated primarily by homework/exams and course project. *Expectation of student effort:* Students are expected to work (assigned reading, homework, project) *at least* 6–8 hours outside of lectures.

Grading/Attendance, different requirements for 416 and 516 students. Homework will be assigned weekly and collected bi-weekely, including mathematical problems and implementation tasks. You may (and are encouraged to) discuss problems with each other. It is recommended that students upload all homework (and course project) via blackboard learn (".ipynb" files). However, you may choose to turn in hand-written solutions to mathematical problems. Final grades will be determined by homework/exam and course project in the following way:

- Homework 20 %;
- Exam 1: 25%, exam 2: 25%;
- Course project: 30%.

Some homework/exam problems will be specified as "only required for Math 516 students" or "only required for Math 416 students".

Course project. A final course project is required, and a project proposal is due in the middle of the semester for approval. A successful project can be motivated by examples (semi-realistic problems) in the textbook (our textbook contains a lot of interesting examples), implementing one or more algorithms, evaluating their efficiencies, and analysis of simulated data. For example, a final conclusion of final project could be an analysis of what factors in the model are most important, how sensitive are these factors, what conclusion can we draw to help our decision-making. If you can find some real data to validate your model that would be ideal.

A tentative schedule for the first a few weeks is given below.

Date	Day	Topics
08/21	Tu	Introduction, software demonstration
08/23	Th	Introduction to Julia (Youtube video)
08/28	Tu	Chapter 2: Probability Review
08/30	Th	Chapter 3: Random numbers, Monte Carlo Methods
09/04	Tu	Chapter 4.1-3: Inverse Trans., Poisson, Binomial RVs
09/06	Th	Sections 4.4-6: Aceeptance-rejection, composition, alias methods
09/11	Tu	Sections 5.1-2: Inverse transform, Rejection methods
09/13	Th	Sections 5.2-3: Polar methods
09/18	Tu	Section 5.4-5: Generating Poisson Processes
09/20	Th	Chapter 6 (6.1-6.2): Generating Multivariate Normal
09/25	Tu	Section 7.1-2: Single-server queueing system
09/27	Th	Exam 1 (cover Chapter 3–6)
10/02	Tu	Section 7.3-4: Multi-server queueing system
10/04	Th	Section 7.5-7: An inventory model, etc.
10/09	Tu	Section 8.1-2: Staistical analysis of sample mean and variance
10/11	Th	Section 8.3: Boostraping
10/16	Tu	Section 9.1-2: Antithetic Variables, Control Variates
10/18	Th	Section 9.2-3: Var. Reduct. by conditioning (final project proposal due)

10/23 10/25	Tu Th	Section 9.3: VR by Conditioning Section 9.4-5: Stratified Sampling
10/30 11/01	Tu Th	Section 9.6: Importance Sampling Section 9.7-8
11/06 11/08	Tu Th	(flexible) Section 11.1-2: Goodness of Fit Tests
11/13 11/15	Tu Th	Section 11.3: Two sample problem Exam 2 (cover Chapter 8-11)
Thanksgiving Vacation		
11/27 11/29	Tu Th	Section 12.1-2: Markov Chain Monte Carlo, Hastings-Metropolis Section 12.3: Gibbs Sampler
12/04 12/06	Tu Th	Section 12.4: Continuous time Markov Chains (flexible)
Final Week		Final project is due Dec. 10th (Mon.) 5pm.

WSU Reasonable Accommodation Statement (Jul., 2017.) Students with Disabilities: Reasonable accommodations are available for students with a documented disability. If you have a disability and need accommodations to fully participate in this class, please either visit or call the Access Center (Pullman) or Disability Services (in Spokane, Tri-Cities and Vancouver campuses) to schedule an appointment with an Access Advisor. All accommodations MUST be approved through the Access Center or Disability Services. For more information contact a Disability Specialist on your home campus.

Pullman or WSU Online: 509-335-3417, Washington Building 217;
`http://accesscenter.wsu.edu`, `Access.Center@wsu.edu`
Spokane: `https://spokane.wsu.edu/studentaffairs/disability-resources/`
Tri-Cities: `http://www.tricity.wsu.edu/disability/`
Vancouver: `360-546-9138`
`http://studentaffairs.vancouver.wsu.edu/student-resource-center/disability-services`

Academic Integrity. Academic integrity is the cornerstone of higher education. As such, all members of the university community share responsibility for maintaining and promoting the principles of integrity in all activities, including academic integrity and honest scholarship. Academic integrity will be strongly enforced in this course. Students who violate WSU's Academic Integrity Policy (identified in Washington Administrative Code (WAC) 504-26-010(3) and -404) will receive "F" for the course, will not have the option to withdraw from the course pending an appeal, and will be reported to the Office of Student Conduct. Cheating includes, but is not limited to, plagiarism and unauthorized collaboration as defined in the Standards of Conduct for Students, WAC 504-26- 010(3). You need to read and understand all of the definitions of cheating: `http://app.leg.wa.gov/WAC/default.aspx?cite=504-26-010`. If you have any questions about what is and is not allowed in this course, you should ask course instructors before proceeding. If you wish to appeal a faculty member's decision relating to academic integrity, please use the form available at `conduct.wsu.edu`.

WSU Safety Measures. Classroom and campus safety are of paramount importance at Washington State University, and are the shared responsibility of the entire campus population. WSU urges students to follow the "Alert, Assess, Act," protocol for all types of emergencies and the "Run, Hide, Fight" response for an active shooter incident. Remain ALERT (through direct observation or emergency notification), ASSESS your specific situation, and ACT in the most appropriate way

to assure your own safety (and the safety of others if you are able). Please sign up for emergency alerts on your account at MyWSU. For more information on this subject, campus safety, and related topics, please view the FBI's Run, Hide, Fight video and visit the WSU safety portal.