Statistical Computing and Simulation

# Spring 2017

**Instructor:** Jack C. Yue (余清祥)

**Lecture Times:** 9:10~12:00 Tuesday

**Phone:** 2938-7695, e-mail: [csyue@nccu.edu.tw](mailto:csyue@nccu.edu.tw) (strongly recommended)

Home page: <http://csyue.nccu.edu.tw>

**Office Hours:** 10:00~12:00 Wednesday, or by appointment

**References:**

Elements of Statistical Computing (1988) by R.A. Thisted

Modern Applied Statistics with S-Plus (1999) by W.N. Venables & B.D. Ripley

Numerical Methods of Statistics (2001) by J.F. Monahan

Handbook of Computational Statistics: Concepts and Methods (2004) by J. E. Gentle, W. Härdle, and Y. Mori (Eds.)

Stochastic Simulation (1987) by B.D. Ripley

A Course in Simulation (1990) by S.M. Ross

Modern Simulation and Modeling (1998) by R.Y. Rubinstein & B. Melamed

Simulation and the Monte Carlo Method (1981) by R.Y. Rubinstein

Manuals and References at [www.r-project.org](http://www.r-project.org)

**Course Description:**

Mathematical analysis was used to be the most useful tool, and probably the only tool, in handling statistical problems. The rapid development of computers in recent years has made simulation a powerful tool as well, and it is especially convenient in dealing with problems without “good” statistical assumption. However, simulation is like mathematical experimentation, it needs careful design and planning in order to come out with satisfied results. At the first half of this course, we will introduce basic principles of computing and simulation, including generation of random numbers and random variables, and statistical tests. Advanced techniques and applications shall be covered in the second half of the semester. Topics covered in this course include: *Simulation and Monte Carlo methods*, *Matrix computation, Numerical integration and approximation, Data partition and resampling, Optimization methods, Density estimation, and Bayesian computing.* Also, the use of statistical software R/S-Plus is required in this course. The software R can be downloaded via <http://www.r-project.org>.

**Grading:**

Grades will be based on regularly assigned homework plus a project. The project will be due on the final week of spring semester (6/23/2017, Friday).

**Topics and contents**:

* **S-Plus and R**

🡪Basic introduction, Data analysis and graphics, Framing, Function and programming

* **Simulation and Monte Carlo methods**

🡪Pseudo-random number generation, Linear congruential method, Inverse method, Rejection method, and Statistical tests

* **Matrix computation**

🡪Least square methods, Gram-Schmidt method, Gaussian elimination, Singular value decomposition, Cholesky decomposition

* **Numerical integration and approximation**

🡪Trapezoidal and Simpson’s rules, General Newton-Cotes rules, Monte-Carlo integration

* **Data partition and resampling**

🡪Bias reduction, Variance estimation using Jackknife and Bootstrap (including Dependent Data and Bootstrap), MCMC (Markov Chain Monte Carlo)

* **Optimization methods**

🡪Maximum likelihood estimation, Newton-Raphson and Newton like methods, Fisher scoring methods, EM algorithm

* **Density estimation**

**🡪**Histograms and related density estimator, Spline smoothing, Kernel smoothing

* **Bayesian computing**

🡪Bayes’ Theorem, Bayesian thinking, Bayesian computation, Markov Chain Monte Carlo methods

**Class Handouts**:

Class materials, including in-class handouts, will be posted on my website http://csyue.nccu.edu.tw and no hard copies will be distributed.

* S-Plus and R users’ guides and notes
* Class files (Microsoft powerpoint or Acrobat pdf format)
* Class related papers and reports
* Homework assignments and solutions

**Note:** The homework is usually on a 2-week interval base and due on Tuesday/ Friday afternoon at 5. However, you need to hand-in your homework and final report in hard copy, and no email copies are allowed.