09 December 2015

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN
Established in collaboration with MIT

40.530 Statistics (Graduate)

Lecturer	**: Shaowei Lin**
Pillar/Cluster	**: ESD**
Initial Offering	**: January, 2014**
Elective or Core	**: Core**
Grading Method	**: Letter grade**
Workload	**: 4-0-8 (A = classroom, B = Lab, and C = self-study)**
Subject Credits	**: 12 (equal to A + B + C above)**

Subject Description
This graduate-level course aims to acquaint students with classical concepts in Probability, Statistics and Learning that are important to many applications in the mathematical sciences and in engineering. A basic understanding of elementary probability will be assumed, and a quick review will be conducted during the first week to start everyone on the same page. The course will focus on fundamental paradigms in statistics – their motivations, their differences, and how they influence various methodologies used in learning (also known as statistical inference).

Learning Objectives
Through this course, the students will:
- Understand classical probabilistic theories,
- Appreciate important statistical paradigms, and
- Apply useful learning methodologies in real-world problems.

Measurable Outcomes
By the end of the course, the students will be able to:
- Define basic statistical concepts such as model, estimator, inference, bias and consistency,
- State differences between parametric and non-parametric models,
- State differences between frequentist and Bayesian inference,
- Estimate the CDF and statistical functionals using the empirical distribution,
- Estimate standard errors and confidence intervals using the bootstrap,
- Derive the maximum likelihood estimator for important models,
- Apply suitable tests for different problems in hypothesis testing,
- Outline typical strategies in Bayesian inference,
- Outline typical strategies in statistical decision theory,
- Derive important estimators used in linear regression,
- Define the multinomial and multivariate normal distributions,
- Estimate integrals using importance sampling and Markov Chain Monte Carlo methods, and
- Review learning methodologies described in state-of-the-art research papers.

Pre-Requisite/ Co-requisite/ Mutually Exclusive Subject(s)
Calculus, Linear Algebra, Multivariate Calculus, Elementary Probability.

Assessment Methods

Assessment Items	Percentage	Period
Final Exam	30%	Week 14
Midterm Exam	30%	Week 9
Homework	20%	Week 1-12
Project	20%	Week 13

Instructional Methods and Expectations

The class will be carried out in two (90 min) lectures per week.

Required or Recommended Text and Readings

Required

Wasserman (2004), All of Statistics: A Concise Course in Statistical Inference, Springer.

Recommended

DeGroot and Schervish (2011), Probability and Statistics, 4th edition, Pearson.

Jun Shao (2003), Mathematical Statistics, 2nd edition, Springer.

Taboga (2012), Lectures on Probability Theory and Mathematical Statistics, 2nd edition, CreateSpace.

James, Witten, Hastie and Tibshirani (2013), An Introduction to Statistical Learning, Springer.

Detailed Outline of the Subject

Probability (review)

- Probability
- Random Variables
- Expectation
- Inequalities
- Convergence

Statistics

- Models and Learning
- Statistical Functionals
- Bootstrapping
- Parametric Inference
- Hypothesis Testing
- Bayesian Inference
- Decision Theory

Learning

- Linear Regression
- Multivariate Models
- Simulation Methods

If time permits, we will also cover Graphical Models, Independence and Causality.