

**Stat 561: Advanced Theory of Statistical Inference, Section 1,  
Spring Semester 2018**

**Time and Place:** MWF 10:10 am – 11:00 pm, 219 Thomas.

**Instructor information:**

1. Name: Bing Li
2. Office: Thomas 410
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4. Office hours: MW 4:00 pm - 5:00 pm.

**Texts and references:**

1. *Mathematical Statistics: A Decision Theoretic Approach*, Thomas Ferguson.
2. *Probability and Measure*. Second Edition. Patrick Billingsley. 1986 John Wiley & Sons.
3. *Theory of Point Estimation*. Second Edition. Lehmann and Casella. Springer.
4. *Testing Statistical Hypothesis*. Second Edition. Lehmann. Springer.
5. *Statistical Decision Theory and Bayesian Analysis*. James Berger. Springer.
6. *Bayesian Inference*. Anthony O'Hagan. Cambridge University Press.

**Examinations:** There will be a midterm and a final exam. They will be closed book and in class. You may bring a page of prepared notes for each exam.

**Assignments:** Homework will be assigned and graded every two weeks.

**Evaluation:** Midterm 30 %. Final 45%. Homework 25%.

**Course Coverage:**

**1 Bayesian Inference**

- 1.1 Basic concepts: Prior; Likelihood; Posterior; Bayesian sufficiency.
- 1.2 Calculation of posterior: Conjugate families; Conditional conjugacy; improper priors; invariance of priors.
- 1.3 Bayesian decision theory: risk; posterior expected loss; Bayes risk; Bayes rule; Generalized Bayes rule.
- 1.4 Bayesian inference: Bayes rules for estimation, hypothesis test, and classification. Bayes rules and unbiasedness.
- 1.5 Stein's phenomenon: Stein's lemma, inadmissibility of MLE, James-Stein estimator.

- 1.6 Empirical Bayes Analysis: large number of parameters; factorization assumption; estimation of hyperparameters. James-Stein estimator as empirical Bayes estimator.
- 1.7 Classification.

## 2 Finite-sample theory of hypotheses test

- 2.1 Simple vs simple test: Two types of errors; The Neyman-Pearson Lemma.
- 2.2 One sided test: Size and power; Monotone likelihood ratio; UMP test.
- 2.3 Two sided test: One parameter exponential family; Generalized Neyman-Pearson Lemma; Uniform maximization of power under two constraints; Uniform most powerful test (UMPU) when the null set is an interval; UMPU test when the null set is a point; UMP test when alternative set is an interval.
- 2.4 Test of one parameter in the presence of several: Exponential families with several parameters; Similar test; Uniformly most powerful similar test (UMPS); Sufficiency, bounded completeness, and Neyman structure; UMPU test with nuisance parameters; One sided and two sided cases; Testing linear functions for of natural parameters.
- 2.5 Constructing UMPU test in the presence of nuisance parameters: invariant family under a group of transformations; ancillary; Constructing UMPU test using Basu's theorem.
- 2.6 Converting an optimal test to an optimal confidence set.

## 3 Asymptotic theory of hypothesis test

- 3.1 von Mises expansion of statistical functionals
- 3.2 Asymptotically linear and quadratic statistics
- 3.3 Asymptotic quadratic form (AQF) tests
- 3.4 Important AQF tests: Wilk's test; Rao's test; Wald's test; Neyman-Rao's test; Lagrangian Multiplier test
- 3.5 Asymptotic null distribution of AQF tests.

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<http://equity.psu.edu/ods/guidelines/documentation-guidelines>

If the documentation supports the need for academic adjustments, ODS will provide a letter identifying appropriate academic adjustments. Please share this letter and discuss the adjustments with your instructor as early in the course as possible. You must contact ODS and request academic adjustment letters at the beginning of each semester