Course Syllabus

STAT 512:
Statistical inference
Autumn 2022

Instructor: Yen-Chi Chen
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Office hour: (Virtual) Monday 3-4 pm (https://washington.zoom.us/j/95773222677)

Teaching Assistant 1: Yikun Zhang
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Office hour: (Hybrid) Tuesday 9:30-10:30 am (PDL B-226; https://washington.zoom.us/meeting/register/tJwsfu2gpzMtEtW-vfcNT6sI4SRuJpZ_FHju password: stat512)

Teaching Assistant 2: Zhen Miao
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Office hour: (Virtual) Wednesday 4-5 pm (https://washington.zoom.us/j/99384780380)

Course Website:
On Canvas: https://canvas.uw.edu/courses/1584499

Class Schedule: There will be two sessions a week:

- (Lecture) MWF 10:30-11:20 am at HST T747 you may participate virtually via zoom
- (Quiz session) W 12:30-1:20 pm at HSEB 145

Course Textbook:

- **Useful readings:**

Course Overview: STAT 512-513 will cover much of the “classical” theory of statistical inference (but not all; for example the theory of linear models is mainly treated in BIOSTAT/STAT 533/570.) We will begin with a brief review of univariate probability (CB Chapters 1, 2, and 3), then move to bivariate and multivariate distributions, especially the multinomial and multivariate normal distributions (CB Ch. 4-5). This should occupy the first 7-8 weeks (approximately.) The remainder of 512 and 513 will cover CB Ch. 5-8, 10, and possibly part of 9: topics include properties of random samples, limit theorems and asymptotic distributions, propagation of error (= delta method = first-order Taylor expansion), sufficient statistics, estimation theory including maximum likelihood estimation, unbiased estimation, nonparametric estimation, and large sample properties of estimators, elementary decision theory, hypothesis testing including likelihood ratio and chi-square tests, and Bayesian inference. (Linear models and regression, the topics of the final two chapters of CB, are covered in 533/570.)

Prerequisites: Multivariable calculus (limits, infinite series, partial derivatives, and multiple integrals). Linear algebra (vectors, matrices, determinants, inverses, Cauchy-Schwartz inequality, orthogonal and positive definite matrices, eigenvalues). Some familiarity with elementary probability theory, e.g., probability distributions, expected values, random variables, conditional probability (Math/Stat 394-5).

Grades:

- Homework assignments (30%)
- Midterm exam (30%)
- Final exam (40%)
Format of HWs: There will be 8 homework assignments (each worth 5%). It will be out Thursday and be due at the end of the next Wednesday 23:59:59 Seattle Time. You need to submit your answers in the format of PDF file that is typed by \LaTeX or R-markdown and upload them to the Canvas. Homework turned in late will be penalized by $0.8^x$, where $x$ is the days of late submission, rounding to the smallest integer greater or equal to $x$ when $x \leq 3$. Namely, if you are late for 10 minutes, the total score will be multiplied by 0.8. If you are late for one day and 20 minutes, the total score will be multiplied by $0.8^2 = 0.64$. Late for more than 3 days will receive 0 points.

Schedule

- Midterm exam: in the week of Nov. 2nd (tentative).

Course contents:

- **Topic 1:** Introduction to probability and statistics (week 1; 3 lectures + 1 quiz).
  - sample space and probability measures, random variables, common distributions, conditionals, independence, Bayes theorem
- **Topic 2:** Transforming continuous random variables (week 2: 2 lectures).
  - one function of one random variable, one function of two or more random variables, exponential distribution and memoryless properties
- **Topic 3:** Expectation and basic convergence theories (week 2-3: 4 lectures + 2 quizzes).
  - expectation, moment generating functions, convergence theory, weak law of large numbers, central limit theorem, concentration inequality, Hoeffding’s inequality
- **Topic 4:** Conditional expectation and conditional distribution (week 4: 3 lectures + 1 quiz).
  - conditional distribution for mixed random variables, conditional expectation, law of total expectation, law of total variance, inverse probability weighting
- **Topic 5:** Correlation, prediction, and regression (week 5: 3 lectures + 1 quiz).
  - correlation, mean-square error prediction, linear prediction, best linear predictor, multivariate linear predictor, classification
- **Topic 6:** Estimators (week 6: 3 lectures + 1 quiz).
  - maximal likelihood estimator, method of moments, empirical risk minimization, Bayes estimator (posterior mean and maximum a posteriori)
- **Topic 7:** Multinomial distribution (week 7: 2 lectures + 1 quiz).
  - multinomial distribution, conditionals in multinomials, exponential family, Bernoulli representation of multinomials
- **Topic 8:** Linear models and the multivariate normal distribution (week 7-8: 4 lectures + 1 quiz).
  - review of matrix, the Jacobian method, polar coordinate, random vector and covariance matrix, multivariate normal distributions, chi-square distributions, non-central chi-square distributions
- **Topic 9:** Order statistics (week 9: 2 lectures).
  - order statistics, Beta-binomial relation, spacings in uniform random variables
- **Topic 10:** Asymptotic theories and statistical functionals (week 9-10: 4 lectures + 2 quizzes).
  - statistical functions, consistency, empirical distribution function, plug-in estimate, the delta method, variance-stabilizing transformations, asymptotic theory of sample covariance matrix, asymptotic theory of quantiles, asymptotic efficiency

Accommodation. Washington state law requires that UW develop a policy for accommodation of student absences or significant hardship due to reasons of faith or conscience, or for organized religious activities. The UWs policy, including more information about how to request an accommodation, is available at Religious Accommodations Policy (https://registrar.washington.edu/staffandfaculty/religious-accommodations-policy/). Accommodations must be requested within the first two weeks of this course using the Religious Accommodations Request form (https://registrar.washington.edu/students/religious-accommodations-request/).