Course Syllabus

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ADVANCED THEORY OF STATISTICAL INFERENCE

STAT 583 / BIOST 585 – SPRING 2025

Department of Statistics, College of Arts and Sciences

Department of Biostatistics, School of Public Health

University of Washington

LEARNING OBJECTIVES

After successful completion of this course, the student will be able to:

- define weak convergence of a stochastic process and the notion of a Donsker class, and use these concepts to establish the weak convergence of an empirical process;
- define asymptotic linearity and compute the influence function of an asymptotically linear estimator;
- describe various forms of functional differentiation, and apply the functional delta method;
- characterize the behavior of U-statistics and carry out inference on the basis of such statistics;
- define and establish pathwise differentiability of a statistical parameter over a given model space, and compute gradients of this parameter relative to this model;
- define the efficient influence function and describe its role in determining efficiency bounds;
- describe and apply methods for constructing asymptotically efficient estimators in infinite-dimensional models.

COURSE DETAILS

Lectures:

Monday + Wednesday, 10:00-11:20 (3 credits)

Modality: in-person lectures (ARC 160) + live-streamed and recorded lectures (Zoom)

Instructors:

Marco Carone (mcarone@uw.edu (mailto:mcarone@uw.edu))

Online office hours: TBD

Teaching assistant:

Daniel Suen (dsuen@uw.edu (mailto:dsuen@uw.edu))

Office hours: TBD

Weekly discussion section: TBD

Prerequisites:

All enrolled students are required to have successfully completed STAT 581 & 582. Knowledge of mathematical analysis at the level of MATH 424, 425 & 426 or STAT 559 is assumed.

Required text:

- van der Vaart, A.W. (2000). *Asymptotic statistics.* Cambridge University Press.

Useful resources:

- Bickel, P.J., Klaassen, C.A.J., Ritov, Y, Wellner, J.A. (1998) *Efficient and adaptive estimation for semiparametric models.* Springer.
- Bickel, P.J. and Doksum, K. (2015) *Mathematical Statistics: Volume II.* CRC Press.
- Pfanzagl, J. (1990) *Estimation in semiparametric models.* Springer.
- Serfling, R.J. (2001) *Approximation theorems of mathematical statistics*. Willey.
- Shao, J. (2003) *Mathematical statistics.* Springer.
- van der Vaart, A.W., Wellner, J.A. (2023). *Weak convergence and empirical processes: with applications to statistics.* Springer.

Software:

Students may be expected to perform basic simulations in any programming language (e.g., R, Julia, Python) of their choice.

Assessment:

- Homework will include 5 or 6 assignments (= 40% of course grade).
- A midterm exam (= 25% of course grade) will be held near the middle of the quarter.
- A final exam (= 35% of course grade) will be held during the final exam period.

Homework policy:

- Homework will be assigned through Canvas.
- Homework write-ups must be turned in electronically on their due date.
- Students are encouraged to seek help from the instructor, teaching assistant, or other students with the written homework problems. However, the work handed in should reflect only that student's work. In other words, obtaining help from others to learn the methods of solution is allowed, but copying another student's solution is *not*.
- The best time to ask the instructor for help on the assignment is during office hours. However, if you do ask questions by email, please note that queries about homework may not receive replies on

weekends or within 24 hours of a due date.
- You may use up to three ‘grace days’ during the quarter. For each grace day used, a 24-hour extension will be given on an assignment without any deduction for late submission. Multiple grace days may be used on a single assignment. If you use grace days, clearly indicate this at the top of your assignment. Once you have used all your grace days, late homework write-ups will receive no credit. Exceptions to this policy can be made in case of extenuating circumstances (e.g., illness) at the discretion of the instructor.

Tentative list of topics covered: (subject to change)

1. Weak convergence of empirical processes

- Weak convergence
- Donsker classes

2. Asymptotic study of estimators

- Asymptotic linearity
- Study of U-statistics
- Functional derivatives and the functional delta method

3. Asymptotic efficiency

- Review of parametric efficiency theory
- Pathwise differentiability of statistical parameters and gradients
- Characterizing the set of influence functions
- Efficiency bounds and the efficient influence function (EIF)
- Strategies for finding the EIF

4. Construction of asymptotically efficient estimators

- Plug-in estimation and inherited bias
- Estimating equations framework
- One-step correction procedure
- Targeted maximum likelihood (or minimum loss-based) estimation

ACCESS AND ACCOMMODATIONS

Your experience in this class is important to us. If you have already established accommodations with Disability Resources for Students (DRS), please communicate your approved accommodations to the instructor at your earliest convenience so your needs in this course can be discussed.

If you have not yet established services through DRS, but have a temporary health condition or permanent disability that requires accommodations (conditions include but not limited to; mental health, attention-related, learning, vision, hearing, physical or health impacts), you are welcome to contact DRS

at 206-543-8924 or **uwdrs@uw.edu (mailto:uwdrs@uw.edu)** or **disability.uw.edu (http://disability.uw.edu/)**. DRS offers resources and coordinates reasonable accommodations for students with disabilities and/or temporary health conditions. Reasonable accommodations are established through an interactive process between you, your instructor(s) and DRS. It is the policy and practice of the University of Washington to create inclusive and accessible learning environments consistent with federal and state law.

RELIGIOUS ACCOMMODATIONS

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 UW's 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 Accommodation Request form (https://registrar.washington.edu/students/religious-accommodations-request/)**.

ACADEMIC INTEGRITY

Students at the University of Washington (UW) are expected to maintain the highest standards of academic conduct, professional honesty, and personal integrity. Plagiarism, cheating, and other misconduct are serious violations of the UW Student Conduct Code (WAC 478-120). We expect you to know and follow the University's policies on cheating and plagiarism. Any suspected case of academic misconduct will be handled according to UW regulations. For more information, see the UW Community Standard and Student Conduct website.

CLASSROOM CLIMATE

Diverse backgrounds, embodiments, and experiences are essential to the critical thinking endeavor at the heart of university education. Therefore, we expect you to follow the UW Student Conduct Code in your interactions with your colleagues and the instructor in this course by respecting the many social and cultural differences among us, which may include, but are not limited to: age, cultural background, disability, ethnicity, family status, gender identity and presentation, citizenship and immigration status, national origin, race, religious and political beliefs, sex, sexual orientation, socioeconomic status, and veteran status. Please immediately contact the instructor if you experience disrespect in this class, so that we may work to address it in an educational manner. **DCinfo@uw.edu (mailto:DCinfo@uw.edu)** is a resource for students with classroom climate concerns.

Course Summary:

Date	Details	Due
Mon Mar 31, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248176&include_contexts=course_1802391)	10am to 11:30am
Wed Apr 2, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248177&include_contexts=course_1802391)	10am to 11:30am
Sat Apr 5, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248178&include_contexts=course_1802391)	10am to 11:30am
Mon Apr 7, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248179&include_contexts=course_1802391)	10am to 11:30am
Wed Apr 9, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248180&include_contexts=course_1802391)	10am to 11:30am
Sat Apr 12, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248181&include_contexts=course_1802391)	10am to 11:30am
Mon Apr 14, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248182&include_contexts=course_1802391)	10am to 11:30am
Wed Apr 16, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248183&include_contexts=course_1802391)	10am to 11:30am
Sat Apr 19, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248184&include_contexts=course_1802391)	10am to 11:30am

Date	Details	Due
Mon Apr 21, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248185&include_contexts=course_1802391)	10am to 11:30am
Wed Apr 23, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248186&include_contexts=course_1802391)	10am to 11:30am
Sat Apr 26, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248187&include_contexts=course_1802391)	10am to 11:30am
Mon Apr 28, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248188&include_contexts=course_1802391)	10am to 11:30am
Wed Apr 30, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248189&include_contexts=course_1802391)	10am to 11:30am
Sat May 3, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248190&include_contexts=course_1802391)	10am to 11:30am
Mon May 5, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248191&include_contexts=course_1802391)	10am to 11:30am
Wed May 7, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248192&include_contexts=course_1802391)	10am to 11:30am
Sat May 10, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248193&include_contexts=course_1802391)	10am to 11:30am

Date	Details	Due
Mon May 12, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248194&include_contexts=course_1802391)	10am to 11:30am
Wed May 14, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248195&include_contexts=course_1802391)	10am to 11:30am
Sat May 17, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248196&include_contexts=course_1802391)	10am to 11:30am
Mon May 19, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248197&include_contexts=course_1802391)	10am to 11:30am
Wed May 21, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248198&include_contexts=course_1802391)	10am to 11:30am
Sat May 24, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248199&include_contexts=course_1802391)	10am to 11:30am
Mon May 26, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248200&include_contexts=course_1802391)	10am to 11:30am
Wed May 28, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248201&include_contexts=course_1802391)	10am to 11:30am
Sat May 31, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248202&include_contexts=course_1802391)	10am to 11:30am

Date	Details	Due
Mon Jun 2, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248203&include_contexts=course_1802391)	10am to 11:30am
Wed Jun 4, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248204&include_contexts=course_1802391)	10am to 11:30am
Sat Jun 7, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248205&include_contexts=course_1802391)	10am to 11:30am
Mon Jun 9, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248206&include_contexts=course_1802391)	10am to 11:30am
Wed Jun 11, 2025	BIOST 585 A Sp 25: Advanced Theory Of Statistical Inference III (https://canvas.uw.edu/calendar?event_id=4248207&include_contexts=course_1802391)	10am to 11:30am