

# STA 6341: Modern Robust Statistics: Methods and Applications

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**Lecture:** TuTh 9:45AM - 11:00AM

**Instructor:** Yiyuan She, Statistics 337 ([yshe@stat.fsu.edu](mailto:yshe@stat.fsu.edu))

**Office hours:** Tuesday, Thursday 12:50pm – 1:20 pm and by appointment

**Text:** None. I will make lecture notes and slides.

Some useful classical reference books (optional):

1. *Robust Statistics, 2nd Edition, Huber and Ronchetti, 2009*
2. *Robust Statistics, 2nd Edition, Maronna, Martin, and Yohai, 2008*
3. *Robust Statistics: The Approach Based on Influence Functions, Hampel, Ronchetti, Rousseeuw, and Stahel, 2011*
4. *Robust Nonparametric Statistical Methods, Hettmansperger and McKean, 2011*
5. *Empirical Likelihood, Owen, 2001*

**Prerequisites:** Basic linear algebra and linear regression (STA5207 or STA5208 or STA5167 or permission of instructor).

**Course Objectives:** Robust statistical estimation and inference methods are indispensable to real-life statistical data analysis. By the end of this course, students will be able to 1) use influence functions and breakdown points to characterize the effect of outliers in robust estimation; 2) design proper redescending psi functions to gain outlier resistance; 3) build a universal connection between M-estimators and sparsity-based learning; 4) apply trimming-based methods in robust modeling beyond robust regression, as well as the technique of progressive quantiles via L0-optimization with theoretical guarantees; 5) define rank-based regression and show the nonparametric nature of its effective noise; 6) perform robust principal component analysis and reduced-rank regression; 7) given a general set of estimating equations, derive the associated empirical likelihood statistic and its asymptotic distribution for nonparametric inference; 8) extend location depth to a general process of Tukeyfication, to test a simple or composite hypothesis and obtain a deepest point estimate; 9) describe manifold-based data depth and slacked data depth for problems with constraints and nondifferentiable objectives; 10) implement and use fast and scalable algorithms and packages for robust estimation and inference in real data applications.

**Course Description:** The course of modern robust statistics involves a wide range of methods, computational tools, and theoretical topics, as well as real world applications in

statistics, biostatistics, machine learning, finance, signal processing, and related research areas.

Some of the topics include:

*Influence functions, statistical efficiency, breakdown point, M-estimators, concomitant scale estimation, redescending psi's, iterative reweighted least squares, quantile regression, mean-shift outlier model, relationships between sparsity-promoting penalties and robust losses, thresholding functions and psi functions, generalized Moreau's envelope, thresholding-based iterative procedure for outlier detection, robust generalized linear models, L-estimators, least trimmed squares, progressive iterative quantile-thresholding, R-estimators, rank regression and rank lasso, robust covariance estimation, principal component pursuit and variants, robust orthogonal complement principal component analysis, robust reduced rank regression, robust model selection, effective noise, nonasymptotic robust analysis and minimax optimality.*  
*Robust nonparametric inference, empirical likelihood, estimating equations, dual likelihood, mirror descent, Nesterov's accelerations, Bartlett's correction, location depth, regression depth, GLM depth, tangent depth, covariance depth, invariance, depth computation, deepest point estimation, local depth, projected cone depth, polished subspace depth, covariance depth, composite depth, data depth on manifolds, order-2 Tukeyfication, slacked data depth for penalized/constrained estimation, robust tests, saddlepoint test.*

**Exams:** There will be no exams.

**Homework (50%):** There will be regular homework assignments. Each student must hand in a complete set of their own solutions. The homework must be neatly written. Illegible homework will not be evaluated by the course grader. Penalty for late homework: 10% of the maximum score per day. For problems requiring programming, both the program and the output should be turned in. All questions about scores should be directed to the TA via email or in person during the TA's office hours.

**Project (50%):** You may choose to apply one or multiple methods taught in class to solve a robust estimation or inference problem. In addition to conducting simulation studies for a comparison with some relevant methods on synthetic data, you must perform detailed real-life data analysis. You **MUST** discuss with me your problem and research goal. You are required to turn in a 10-15 page typed paper by 11:59pm on May 2.

**Course Website:** All pertinent information for this class will be posted on the course website at [FSU's Canvas](#).

**Grades:** Your course grade is based on homework (50%) and project (50%).

Grading scale: 90-100 A, 80-89 B, 70-79 C, 60-69 D, Below 60 F

**Syllabus Change Policy:** Except for changes that substantially affect implementation of the evaluation (grading) statement, this syllabus is a guide for the course and is subject to change with advance notice.

**University Attendance Policy:**

Excused absences include documented illness, deaths in the family and other documented crises, call to active military duty or jury duty, religious holy days, and official University activities. These absences will be accommodated in a way that does not arbitrarily penalize students who have a valid excuse. Consideration will also be given to students whose dependent children experience serious illness.

**Academic Honor Policy:**

The Florida State University Academic Honor Policy outlines the University's expectations for the integrity of students' academic work, the procedures for resolving alleged violations of those expectations, and the rights and responsibilities of students and faculty members throughout the process. Students are responsible for reading the Academic Honor Policy and for living up to their pledge to "...be honest and truthful and...[to] strive for personal and institutional integrity at Florida State University." (Florida State University Academic Honor Policy, found at <http://fda.fsu.edu/Academics/Academic-Honor-Policy>)

**Americans with Disabilities Act:**

Florida State University (FSU) values diversity and inclusion; we are committed to a climate of mutual respect and full participation. Our goal is to create learning environments that are usable, equitable, inclusive, and welcoming. FSU is committed to providing reasonable accommodations for all persons with disabilities in a manner that is consistent with academic standards of the course while empowering the student to meet integral requirements of the course.

To receive academic accommodations, a student: (1) must register with and provide documentation to the Office of Accessibility Services (OAS); (2) must provide a letter from OAS to the instructor indicating the need for accommodation and what type; and, (3) should communicate with the instructor, as needed, to discuss recommended accommodations. A request for a meeting may be initiated by the student or the instructor. Please note that instructors are not allowed to provide classroom accommodations to a student until appropriate verification from the Office of Accessibility Services has been provided. This syllabus and other class materials are available in alternative format upon request. For more information about services available to FSU students with disabilities, contact the Office of Accessibility Services, 874 Traditions Way, 108 Student Services Building, Florida State University, Tallahassee, FL 32306-4167; (850) 644-9566 (voice); (850) 644-8504 (TDD), [oas@fsu.edu](mailto:oas@fsu.edu), <https://dsst.fsu.edu/oas/>

**Confidential campus resources:**

Various centers and programs are available to assist students with navigating stressors that might impact academic success. These include the following:

<p>Victim Advocate Program University Center A, Room 4100, (850) 644- 7161, Available 24/7/365, Office Hours: M-F 8-5 <a href="https://dsst.fsu.edu/vap">https://dsst.fsu.edu/vap</a></p>	<p>University Counseling Center, Askew Student Life Center, 2ndFloor, 942 Learning Way (850) 644-8255 <a href="https://counseling.fsu.edu/">https://counseling.fsu.edu/</a></p>	<p>University Health Services Health and Wellness Center, (850) 644-6230 <a href="https://uhs.fsu.edu/">https://uhs.fsu.edu/</a></p>
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