ADVANCED STATISTICS: THEORY AND METHODS
Monsoon 2023, 5th Semester

Class: Tuesdays, Thursdays 9:00 AM – 10:30 AM
Room No. 1102

Instructor: Professor Nandini Kannan
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Course Description

This course covers fundamental concepts in statistical theory and methodology. Topics include

(a) Principles of inference (including Bayesian inference), maximum-likelihood estimation, likelihood ratio tests, goodness-of-fit tests, bootstrap and computer-intensive methods, and least squares.
(b) Generalized linear and nonlinear models, including models for count and categorical responses; generalized additive models.
(c) Fixed, random and mixed-effects ANOVA models.
(d) Models for Dependent Data including time series data.

If time permits, we will cover topics in Multivariate Analysis and Statistical Learning.

We will use R software for data-analytic applications.

Course Overview

The course will begin with a brief overview of probability models, sampling distributions, and hypothesis testing. Building on this foundation, the first part of the course will focus on the principles of statistical inference including estimation and testing of hypothesis, properties of estimators and tests, with emphasis on the underlying assumptions and limitations of the different approaches. This section of the course will introduce fundamental probabilistic and statistical concepts that form the core of data science.

The second part of the course will focus on modeling and analysis of complex datasets using different statistical methods. These include generalization of linear regression to account for non-Gaussian errors, methods for time-to-event data, and models for dependent data. This section will also introduce ideas of model assessment, selection, and validation.

Learning Outcomes

By the end of this course, each student will have had the opportunity to:

1. **Compute** estimators using different techniques and **compare** their performance;
2. **Derive** tests of hypotheses for different parameters and **compare** the power using analytical and computational methods;
3. **Analyze** complex data using different statistical methods and **identify** the limitations of the different approaches;
4. **Compare** and **Contrast** different statistical and computational methods;
5. **Design** a detailed plan for solving a data-driven problem that includes identifying the target population, designing the experiment, developing a data collection plan, exploratory data analysis, hypothesis generation, modeling, and generating key insights for decision making.

Reference Texts

1. *Introduction to Mathematical Statistics*, Eighth Edition, Pearson
   Robert V. Hogg, Joseph W. McKean, Allen T. Craig

2. *Mathematical Statistics with Applications*, 7th Edition
   Dennis Wackerly, William Mendenhall, Richard L. Scheaffer

3. *Applied Linear Statistical Models*, Fifth Edition,
   M.H. Kutner, C.J. Nachtsheim, J. Neter, and W. Li.

4. *An Introduction to Statistical Learning with Applications in R*
   Gareth James , Daniela Witten , Trevor Hastie , Robert Tibshirani

Grading

- Attendance (**5%**)
- In-class Quizzes (**15%**) [*Short quizzes every 1-2 weeks*]
- Two Exams (**20%**; 10% each) [*Tentatively scheduled for mid-September and mid-November*]
- Final Group Project (**30%**)
- Assignments and Homework (**30%**)

Incompletes

An "Incomplete" grade will be awarded in case a student does not complete any assessment or evaluation exercise as a result of which they do not meet the passing criterion. [This is only for medical/social emergencies beyond control of students or cases of pending disciplinary investigation and must be approved by the Office of Academic Affairs].

Scholastic Dishonesty | Academic Integrity

Situations involving academic integrity are governed by the UG academic policy. Here are the specifics: The instructor shall report case to the Academic Integrity Committee, which, after taking into due consideration the nature of the evaluation component and the intensity of the offence, as well as the number of times the student has committed prior offenses, will prescribe the appropriate corrective action.

Advising and Office Hours

To make a phone or in-person appointment, please contact my **Teaching Fellow, Abhishek Thakur** at email abhishek.thakur@plaksha.edu.in or for quick response contact him on **Microsoft Teams Chat**.

E-mail: This is the best way to contact me. I check e-mail frequently and, unless I am out of town, I will usually respond to your e-mail within 24 hours.