

AST 4031: Statistical Astrophysics - Spring 2015

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Text: Eric D. Feigelson G Jogesh Babu 2012: Modern Statistical Methods for Astronomy, Cambridge University press (copy are available in the astro-reading room)

This course is meant for senior undergraduate and graduate students in physics and astronomy. Familiarity with calculus and other basic mathematical techniques is assumed, but no extensive prior knowledge in statistic is required.

Modern astrophysics research relies on sophisticated statistical methods to interpret and analyze the large amount of data characteristic of new experiments. In this course, students will learn the key principles and methods of statistical analysis, with applications to current research in astrophysics.

Course Content:

1) Part one

The first part of the course will cover probability theory and the foundation of statistical inference: \square overview of probability and random variables \square discrete and continuous distributions \square limit theorems \square Concepts of statistical inference: classical vs. Bayesian statistical inference \square Maximum likelihood estimation \square least square method \square confidence intervals (the Bootstrap and the Jackknife) \square hypothesis testing techniques \square probability distribution functions (Binomial, Poissonian, Normal and Lognormal, power-law, Gamma) \square non-parametric statistics: concept of nonparametric inference, univariate problems (Kolmogoroc-Smirnov test).

2) Part two

The second part of the course will deal with applied statistical techniques that are based on the foundations presented in part one. These applied techniques include: \square data smoothing and density estimation: histograms, kernel density estimators, adaptive smoothing \square regression: least-square linear regression, weighted least-squares, non linear models, model validation, selection and misspecification \square multivariate analysis: multivariate distances and normal distribution, hypothesis tests, multiple linear regression, principal component analysis, outliers, nonlinear methods; multivariate visualization \square clustering, classification and data mining: definition and scope of clustering, supervised classification \square time series analysis: time-domain analysis of evenly and unevenly spaced data; spectral analysis of evenly and unevenly spaced data \square spatial point processes: tests of uniformity, spatial autocorrelation, model-based spatial analysis, tessellation.

For each applied statistical technique, the astronomical context will be emphasized with examples based on specialized literature. The statistical methods learned during the course will be put into practice using real-world data sets and python-based codes.

Course Format: Most of the course will be in the form of lectures; a week of the course will be devoted to student-led seminars presenting group projects completed by the students.

Grading:

Homework	25%	
Presentations (1 presentations per student)		25%
In-class participation	15%	
Final exam	35%	

Any changes in the grading policy or in the syllabus will be communicated to the students.

Suggested Book:

Zeljko Ivezić, Andrew J. Connolly, Jacob VanderPlas & Alexander Gray *Statistics, data mining and Machine learning in Astronomy 2013* Princeton series in modern observational astronomy although this is not required.