AST 4031: Interpretation and Analysis of Astrophysical Data

Spring 2015

Instructor:

Prof. Claudia Scarlata
Tate 355
Phone: 612-626-1811
e-mail: mscarlat@umn.edu.

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.

Modern astrophysics research relies on sophisticated 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 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: • overview of probability and random variables • discrete and continuous distributions • limit theorems • Concepts of statistical inference: classical vs. Bayesian statistical inference • Maximum likelihood estimation • least square method • confidence intervals (the Bootstrap and the Jackknife) • hypothesis testing techniques • probability distribution functions (Binomial, Poissonian, Normal and Lognormal, power-law, Gamma).

2) Part two

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

For each applied statistical technique, the astronomical context will be emphasized with examples based on specialized literature. The analysis 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 Ivezic, 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.