Statistics 910: Time Series Analysis
Spring 2011 Syllabus

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Office hours are in the afternoons on the days that we have class, running from about 3 to 5 p.m. on Tuesdays and Thursdays. For other times, please make an appointment. The easiest way to contact me is via e-mail.

Overview

This course introduces the theory and practice of time series analysis, with an emphasis on practical skills. Having completed this course, you will be able to model and forecast a time series as well as read papers from the literature and start to do original research in time series analysis. More generally, you will acquire an appreciation for the role of dependence in statistical modeling.

In keeping with the tone of the text, we will look at quite a bit of data along the way. Every now and then, I will supplement the text with readings or handouts that extend the discussion in the text or offer an alternative view from the presentation in the text. By and large, though, the course will follow the list of topics in this book:

> R. H. Shumway and D. S. Stoffer (2006), *Time Series Analysis and Its Applications (With R Examples, Second Edition)*. Springer, New York.

As you can guess from the title, we'll use the software package **R**. There's no required text for the use of the software as I assume many of you (at least those who are doctoral students from Statistics) already know how to use **R**. If not, visit the on-line site at

`http://cran.r-project.org/`

for more information. The site has the software itself (which is free and runs on basically any computer) as well as links to documentation and hundreds of specialized packages.

Any handouts (such as this syllabus) or other notes that I prepare for the course will be on-line at my web page located at

`http://www-stat.wharton.upenn.edu/~stine/`

Follow the links at the top of the web page to the section on teaching and then locate the material for this course.

Requirements

I will assign problems from the text, and some subset of these will be collected and graded. These exercises require a mix of computing and math. I will also require a small project which extends the classroom discussion and text. Such a project could be a data analysis, a literature review, programming, or a bit of theorem proving. You'll need to present a summary of your work to the class. A final exam at the end of the course completes the grade.

Assignments	30%
Project	30%
Exam	40%

Topics

The following list approximates the sequence of topics in the course. Occasionally, we may spend more time than indicated here on a specific topic. In that case, lectures will fall "off of the bottom" of the syllabus. The topics after the first 19, such as multivariate time series or unit roots, are optional. We'll see which of these get covered as the semester develops.

	Topic	Text	Comment
1	Overview	1.1-1.4	signal vs noise, graphics
2	Stationary processes	1.4-1.5	ensemble, random walk vs trend, periodicity, linear process
3	Estimators	1.6	mean, ACF, PACF, variogram
4	Properties	1.6	covariance of covariance, normality
5	Regression	2.1-2.3	models for trend, differencing, backshift operator B
6	Harmonic regression	2.3, 4.1-4.2	periodogram, signal processing, novel asymp
7	Nonparametric regression	2.4	smoothing, periodic functions
8	Model selection	2.2, E2.4-2.5	AIC, BIC, SIC, bias-variance trade-off
9	ARMA models	3.1-3.3	polynomial approximation, causality, notation
10	Covariances	3.4	identification
11	Prediction	3.5	recursion, estimation
12	Estimation	3.6	MLE, LS, forward-backward
13	State-space models	6.1-6.2	Kalman filter, hidden state, Markovian rep, HMM
14	Properties	6.2-6.3	equivalence with ARMA, nonlinear models
15	Switching models	6.8	hidden Markov models (HMM)
16	Hilbert spaces	App B	infinite dimension, L_2, martingale
17	Spectral representation	4.3, App C	integral representation, Wold decomposition
18	Periodogram	4.4	discrete Fourier transform (DFT)
19	Spectral estimation	4.5, 4.7-4.8	linear filters
20	Information theory	notes	model selection
21	Integrated models	3.7, 5.2	ARIMA, unit root, tests, differencing, long memory
22	Multivariate time series	1.7, 4.12	VAR, cross-correlation, trans function, spectral regr
23	Cointegration	5.6-5.7	principal components
24	Seasonality	3.9, 2.3	X-11, regression models, seasonal differencing
25	Heteroscedasticity	5.3	GARCH, stochastic volatility, financial models
26	Wavelets	4.9, notes	multiresolution analysis
27	Spatial time series	notes	kriging, spatial AR models