Shanghai Jiao Tong University

MA413 Time Series & Random Processes in Linear Systems

Instructor Information:	Wanchunzi Yu Home Institution: Bridgewater State University Email: wyu@bridgew.edu Office Hours: Determined by Instructor		
Term:	December 16, 2019 - January 7, 2020	**Credits:**	4 units
Class Hours:	Monday through Friday, 160 mins per teaching day		
Discussion Sessions:	2 hours each week, conducted by teaching assistant(s)		
Total Contact Hours:	64 contact hours (1 contact hour = 45 mins, 2880 mins in total)		
Required Texts (with ISBN):	John Hull, Options, Futures & Other Derivatives.9th Global Edition, 2018. ISBN-10: 1-292-21289-6 ISBN-13: 978-1-292-21289-0		
Prerequisite:	Financial Mathematics related courses are needed before enrolling in this lesson		

Course Overview

Estimation: maximum of likelihood and method of moments. Multivariate distributions. Confidence intervals. Analysis in the time domain including partial autocorrelation stationary models, autocorrelation.
ARMA and ARIMA models. Use of ITSM.
State-space models. Kalman filter. Empirical Orthogonal Functions and other Eigen.
Analysis in the frequency domain (Spectral analysis): linear and digital filters, cross-correlations and cross-spectrum, spectrum, periodogram, spectral estimators, confidence interval for the spectral density.
Methods.

Course Goals

The course aims to help students:

1. Understand the models of autoregression and moving averages and their combinations;
2. Analyse time series data using the ITSM package.
3. Articulate the concept of stationary time series;
4. Manipulate the concept of projection and its use in forecasting;
5. Analyse time series in time domain as well as frequency domain;
6. Apply the Kalman filter to random systems;

Grading Policy

Homework	10%
Assignment 1	10%
Assignment 2	10%
Midterm Test	10%
Examination	60%

Grading Scale is as follows

Number grade	Letter grade	GPA
90-100	A	4
85-89	A-	3.7
80-84	B+	3.3
75-79	B	3
70-74	B-	2.7
67-69	C+	2.3
65-66	C	2
62-64	C-	1.7
60-61	D	1
≤59	F (Failure)	0

Class Schedule

Date	Lecture	Chapter
Day 1	Linear Systems: linear difference equations with impulse response, constant coefficients, shift operator and transfer function, input- output relations and convolution, ARMA process state space representation	Chapters in textbook and readings
Day 2	Linear Systems: linear difference equations with impulse response, constant coefficients, shift operator and transfer function, input- output relations and convolution, ARMA process state space representation	Chapters in textbook and readings
Day 3	Linear Systems: Fourier series and its properties	Chapters in textbook and readings
Day 4	Linear Systems: Frequency domain analysis	Chapters in textbook and readings
Day 5	Linear Systems: Spectral density of stationary processes and linear systems	Chapters in textbook and readings
Day 6	Probability theory: random variables, probability distribution, expectation, mean and variance	Chapters in textbook and readings
Day 7	Probability theory: random vectors, covariance matrix and its properties, orthogonal projection	Chapters in textbook
Day 8	Probability theory: random vectors, covariance matrix and its properties, orthogonal projection	Chapters in textbook and readings
Day 9	Probability theory: random processes and examples, stationary processes in the wide sense and examples	Chapters in textbook and readings
Day 10	Statistical Estimation: Nonparametric density estimation	Chapters in textbook and readings

Day 11	Statistical Estimation: prediction and filtering problems, frequency domain approach	Chapters in textbook and readings
Day 12	Statistical Estimation: prediction and filtering problems, frequency domain approach	Chapters in textbook
Day 13	Statistical Estimation: Parametric estimation	Chapters in textbook and readings
Day 14	Statistical Estimation: Kalman filter	Chapters in textbook and readings
Day 15	Statistical Estimation: general introduction and examples	Chapters in textbook and readings