MATH 446/546 Introduction to Time Series

Course Description: This course introduces the basic time series analysis and forecasting methods. Topics include stationary processes, ARMA models, spectral analysis, model and forecasting using ARMA models, nonstationary and seasonal time series models, multivariate time series, state-space models, and forecasting techniques. Credit may not be granted for both MATH 446 and MATH 546. (3-0-3)

Enrollment: Elective for B.S. in Statistics, B.S. in Applied Math, M.S. in Applied Math, Ph.D. in Applied Math, and all the professional master programs of the AMATH.

Textbooks: Brockwell, Peter J. and Davis, Richard A. (2002). *Introduction to Time Series and Forecasting,* 2nd edition. Springer-Verlag, New York.

References:

1. Box, G.E.P., Jenkins, G.M. and Reinsel, G.C. (1994). *Time Series Analysis: Forecasting and Control*, 3rd Edition, Prentice Hall, New Jersey.
2. Chatfield, C. (1996). *The Analysis of Time Series*, 5th edition, Chapman and Hall, New York.
3. Shumway, R.H., Stoffer, D.S. (2006). *Time Series Analysis and Its Applications (with R examples)*. Springer-Verlag, New York.
4. James D. Hamilton (1994). *Time Series Analysis*, 1st Edition, Princeton University Press,
5. Galit Shmueli and Kenneth C. Lichtendahl Jr (2016). *Practical Time Series Forecasting with R: A Hands-On Guide,* 2nd Edition, Axelrod Schnall Publishers.

Software: R

Prerequisites: MATH 475 or ECE 511 with min. grade of C

Objective:

1. Students will learn about important time series models and their applications in various fields.
2. Students will be able to formulate real life problems using time series models.
3. Students will be able to use statistical software to estimate the models from real data, and draw conclusions and develop solutions from the estimated models.
4. Students will learn to use visual and numerical diagnostics to assess the soundness of their models.
5. Students will learn to communicate the statistical analyses of substantial data sets through explanatory text, tables and graphs.
6. Students will learn to combine and adapt different statistical models to analyze larger and more complex data.

Lecture Schedule: Two 75-min sessions per week.

Course Outlines

1. Introduction (2 hours)
    - Examples of time series
    - Stationary models and autocorrelation function
    - Estimation and elimination of trend and seasonal components
2. Stationary Process and ARMA Models (5 hours)
    - Basic properties and linear processes
    - Introduction to ARMA models, properties of sample mean and autocorrelation function
    - Forecasting stationary time series
    - ARMA(p, q) processes, ACF and PACF
    - Forecasting of ARMA processes
3. Spectral Analysis (3 hours)
    - Spectral densities
    - Time-invariant linear filters
    - The spectral density of an ARMA process
4. Modeling and Forecasting with ARMA Processes (5 hours)
    - Preliminary estimation
    - Maximum likelihood estimation
    - Diagnostics
    - Forecasting
    - Order selection
5. Nonstationary and Seasonal Time Series Models (4 hours)
    - ARIMA models
    - Identification techniques
    - Unit roots in time series
    - Forecasting ARIMA models
    - Seasonal ARIMA models
    - Regression with ARMA errors
6. Multivariate Time Series (3 hours)
    - Second-order properties of multivariate time series
    - Estimation of the mean and covariance
    - Multivariate ARMA processes
    - Best linear predictors of second-order random vectors
    - Modeling and forecasting
7. State-Space Models (3 hours)
    - State-space representations
    - The basic structure model
    - State-space representation of ARIMA models
    - The Kalman Recursions
    - Estimation for state-space models

8. Forecasting Techniques (3 hours)
    - The ARAR algorithm
    - The Holt-Winter algorithm
    - The Holt-Winter seasonal algorithm
9. Estimation of time series models (2 hours)

Assessment

Homework	20—30%
Mid-Exam(s)	30—20%
Project	20%
Final Exam	30%

Drafted by: Lulu Kang and Tomasz R. Bielecki 02/28/2018