THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC

Time Series Analysis & Modeling

DATS 6450

Wednesdays , 15:30-18:00 (section I)

Wednesdays , 18:10-20:40 (section II)

Fall 2020

Dr. Reza Jafari

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Lecture Webex addres : https://gwu.webex.com/meet/rjafari
Dr. Jafari's office Hours: Tuesday 4pm-5pm
Teaching assistant section I: Thursday 4pm-5pm
Teaching assistant section II: Monday 4pm-5pm

Course Description: The main focus of this course is to understand, analyze, model & predict time-series dataset. In this course fundamental concepts of stochastic systems, estimation theory, time series analysis and model validation will be discussed. The course has several important keys as follows: Random variables, random processes and density function, conditional density, biased & unbiased estimators, time series analysis, model validation, auto-correlation function, partial auto-correlation and generalized partial auto-correlation function and implementation nonlinear optimization of algorithm. **Python** program will be mainly used throughout the course.

Course Objectives: At the completion of this course, students will be able to analyze time series dataset and be able to find the best linear model that represents time series dataset. Understand the fundamental concepts of stochastic systems and parameter estimations. Understand the concept of biased & unbiased estimator and various other estimators. Exercise different statistical techniques to derive the best model of real dataset and perform multiple ahead step predictions. Here are the list of topics to be covered:

1. Seasonal & stationary dataset
2. Various forecasting Methods: Average, Naïve , Drift, Exponential smoothing, Holt-Winter
3. Time series Decomposition
4. Multiple Linear Regression & Multicollinearity
5. ARMA, ARIMA & SARIMA Model
6. Box-Jenkin Model
7. Order estimation using Partial & Generalized Partial Autocorrelation Function
8. Linear & Nonlinear Least Square Estimator
9. Normal Equations and Yule-Walker Equations
10. Parameter estimation using Maximum Likelihood Estimation
11. Levenberg Marquardt Algorithm

12. Model validation & Hypothesis test
13. Multi-step ahead Prediction and Survival Analysis

Prerequisites:

- Introduction to Data Science
- Multivariate Calculus
- Linear Algebra and Stochastic System

Text(s):

1. *Lessons in Estimation Theory for Signal Processing, Communications and Control*, **Author(s):** Lerry M. Mendel **ISBN-13:** 0-13-120981-7

2. *Forecasting Principles and Practice* , 2 nd Edition **Author(s):** Rob J Hyndman George Athanasopoulos **ISBN-13:** 9780987507112

3. *Deep Learning for Time Series Forecasting, Predict the Future with MLPs, CNN and LSTM in Python* **Author(s):** Jason Brownlee

4. *Statistical Methods for Survival Data Analysis*, 4^{th} edition, **Author(s)**: Elsa T. LEE and John Wenyu Wang, ISBN-13 : 978-1118095027

Grading Policy:

- The top 3 scores from the homework and quizzes, LABs, Exam I and Exam II will be picked and will be added to final project score to obtain the total grade for the course. The final term project is a required part of the course and can not be replaced. All exams and quizzes may be in class or take home. Homework will be collected or quiz will be given (every two weeks). No make-up exams unless previous arrangement have been made. Students will be expected to attend class and prepare assignments. Habitual failure to do so will result in a reduced grade. An incomplete grade will only be given when a student misses a portion of the semester due to medical reason or miliary deployment. Cheating on examinations, plagiarism and other forms of academic dishonesty are serious offenses and may subject the student to penalties ranging from failing grades to dismissal. The course grade breakdowns are calculated as follows:

Homework and Quizzes	25 pts
LABs	25 pts
Exam I	25 pts
Exam II	25 pts
Term Project (Required)	25 pts

- **Labs and Assignments:**

Tentative Course Outline (Subject to Change)

week	Topic	comments	Date
1	Stationary & non-stationary dataset		Sep 2^{nd}
2	Probability Theory and Random Processes		Sep 9^{th}
3	Simple Forecasting Methods		Sep 16^{th}
4	Time series decomposition		Sep 23^{rd}
5	Multiple linear Regression Model		Sep 30^{th}
6	Auto-regressive and Moving Average (ARMA) Model		Oct 7^{th}
7	ARIMA & SARIMA Model	**Exam I**	Oct 14^{th}
8	Least Square Estimator		Oct 21^{st}
9	Partial Auto-correlation		Oct 28^{th}
10	Generalized Partial Auto-correlation		Nov 4^{th}
11	Optimization and Levenberg Marquardt Algorithm (LM)		Nov 11^{th}
12	Normal Equations and Yule-Walker Equations		Nov 18^{th}
13	No Class	Thanksgiving	Nov 25^{th}
14	Validation, Model Verification: Statistical Chi-Square test	**Exam II**	Dec 2^{nd}
15	Survival Analysis		Dec 9^{th}
16	**Final Project Presentation and Submission**		Dec 16^{th}

- The homework will be associated with each module; the homework might be collected or a quiz will be taken. However, the homework associated with python will be definitely collected.
- No late assignments will be accepted unless it is **true emergency** .

Security:

- In the case of an emergency, if at all possible, the class should shelter in place. If the building that the class is in is affected, follow the evacuation procedures for the building. After evacuation, seek shelter at a predetermined rendezvous location.

Disability Support Services (DSS): Any student who may need an accommodation based on the potential impact of disability should contact the Disability Services office at $(202)-994-8250$ in the Marvin Center, Suite 242 to establish eligibility and to coordinate reasonable accommodations. The University Counseling Center (UCC Phone: $(202)-994-5300$) offers 24/7 assistance and referral to address students' personal, social, career, and study skills problems. Services for students include:

- crisis and emergency mental health consultations
- confidential assessment, counseling services (individual and small group), and referrals

Academic Integrity: The code of academic integrity applies to all courses in the George Washington School ("Academic dishonesty is defined as cheating of any kind, including misrepresenting one's own work, taking credit for the work of others without crediting then and without appropriate authorization, and the fabrication of the information"). In the spirit of the code, a student's word is a declaration of good faith acceptable as truth in all academic matters. Cheating and attempted cheating, plagiarism, lying, and stealing of academic work and related materials constitute

Honor Code violations. These will not be tolerated. Please become familiar with the code. All students are expected to maintain the highest level of academic integrity throughout the course of the semester. Please note that acts of academic dishonesty during the course will be prosecuted and harsh penalties may be sought for such acts. Students are responsible for knowing what acts constitute academic dishonesty. The code may be found at https://studentconduct.gwu.edu

University Policies: Students should notify faculty during the first week of the semester of their intention to be absent from class on their day(s) of religious observance. Faculty should extend to these students the courtesy of absence without penalty on such occasions, including permission to make up examinations. Faculty who intend to observe a religious holiday should arrange at the be beginning of the semester to reschedule missed classes or to make other provisions for their course-related activities.

Email Etiquette: In the age of technology, when most forms of communication are electronic, it is important to adopt a proper etiquette to communicate with one another. It is asked that students use salutation when sending emails to their instructors and also make sure to SIGN their name and include their class/section at the end of the email. The instructor reserves the right NOT to reply to emails that are not properly addressed or do not have a signature. Students should also use their GWU email for any correspondence with the instructors. Students are required to check their emails daily and especially the morning before class.

Average Amount time learning per week: Students are expected to spend a minimum of 100 minutes of out-of-class work for every 50 minutes of direct instruction, for a minimum total of 2.5 hours a week. A 3-credit course should include 2.5 hours of direct instruction and a minimum of 5 hours of independent learning or 7.5 hours per week.