Course Title: Time Series Analysis
Course code: MTH442
Semester: Fall/Odd
Academic Year: 2024-2025
Start Date: 30/07/2024
Class Schedule: Tuesday, Wednesday, Thursday 8:00 AM - 8:50 AM
Lab Schedule: Tuesday 6:00 PM - 7:00 PM
Location: L05, TBA (Lab)

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Course Purpose

The basic objective of the course is to study fundamental concepts and understand the mathematical foundations of time series models and analysis. Important concepts like stationarity, autocorrelation and partial autocorrelation functions, standard univariate and multivariate stationary processes and their properties, statistical parameter estimation techniques and prediction, order estimation, spectral density function, spectral distribution function, and periodogram analysis will be covered in the course. At the end of the course, it is expected that a student who has done the course would know the concepts well and would also have the confidence to handle and solve real-life time series data.

Learning Outcomes

After completing this course, students will learn the concepts of time series analysis, the key differences between methods for analyzing independently and identically distributed data (heights of randomly selected 100 BS students across India) and data obtained in a time ordered fashion (daily average temperature data at IIT Kanpur weather station, are they independent?), and they will have the ability to do basic data analyses.

Prerequisites

1. MTH211A: Theory of statistics
2. MTH418A: Inference-1
3. MTH416A: Regression Techniques (not mandatory but would be helpful)
4. Statistical computing using R

Materials

We will follow the following book: *Time Series Analysis and Its Applications* by Robert H. Shumway and David S. Stoffer, by Springer. The fourth edition of this book can be purchased from https://link.springer.com/book/10.1007/978-3-319-52452-8. An Indian edition is also available, check in Amazon.in. A free PDF can be downloaded (as of 28/07/2024) from http://www.stat.ucla.edu/~frederic/415/S23/tsa4.pdf.

Other books that can be read for this course are:

1. Introduction to Time Series and Forecasting, P. J. Brockwell & R. A. Davies, Springer, 2013.
2. Time Series: Theory & Methods, P. J. Brockwell & R. A. Davies, Springer, 2019.
3. Time Series Analysis, J. D. Hamilton, Princeton University Press, 2020.
4. Introduction to Statistical Time Series, Wayne A. Fuller, Wiley, 1995.

Grading

Assignments: 5 X 10 = 50 (both analytical as well as coding)
Mid-semester exam: 25 (only analytical)
End-semester exam: 25 (only analytical)

Remember that each assignment contains a 10% weight of the full course and hence they will require long hours to finish!

Tentative schedule

Lectures

- Introduction and preliminary tests of time series (3)
- Mathematical formulation of time series and stationarity concepts (3)
- ACF of stationary time series and its properties (2)
- Linear stationary processes and their time domain properties- AR, MA, ARMA (4)
- Invertibility of AR, MA, ARMA (3)
- Autocovariance generating function (2)
- Multivariate time series processes and their properties-VAR, VMA, VARMA (4)
- Random sampling from stationary time series (2)
- Parameter estimation of AR, MA, and ARMA models (3)
- Best Linear predictor and Partial autocorrelation function (3)
- Model order estimation techniques (1)
- Spectral density, its properties, and estimation (3)
- The spectral density function of stationary linear processes (3)
- Cross-spectrum for multivariate processes (2)
- Spectral distribution function (2)
- Periodogram analysis (2)
  Total 42

Lab

- Handling of time series datasets (1)
- Testing for existence of trend and seasonality and estimation (2)
- Computation of ACF, PACF (1)
- Modeling of univariate and multivariate time series (3)
- Model order estimation (1)
- Residual analysis (1)
- Periodogram analysis (1)
- Other topics (4)
  Total 14

Active learning

To create an active learning experience, this course combines lectures, computer demonstrations, readings, and discussions.

Policy on Academic Integrity

Any copying, if identified, will be heavily punished. Disproportionate scores between Assignments (out of 50) and Exams (out of 25+25=50) will be considered as a red flag while grading!

Attendance

Not mandatory, but it can affect the overall impression of a student. It is natural that the impression of a student is determined by regular attendance, involvement in discussions, and following academic integrity. No need to come to the class regularly just to sleep sitting on the last row!

Grading policy

Relative. A slightly easier grading will be opted for BS SDS students as it is a compulsory course for them. The instructor holds the right to grade based on assignments and exams separately, i.e., if a student receives 49 out of 50 in Assignments and 20 out of 50 combining two written exams, he/she cannot expect the same grade as someone receiving 20 out of 50 in Assignments and 49 out of 50 in the written exams. For borderline cases, students **should not make (formally or informally)** any request to the instructor to put them in the category of better grades or to increase their marks. Unnecessary arguments with the instructor (trying to justify wrong answers by providing weird logics) will be considered as a red flag!