SC475 – Time Series Analysis

Course Placement: Time Series Analysis is an elective course offered to third and fourth year students of the B.Tech program.

Course format: It is **3 hours' lecture** every week

Prerequisites: A basic course in statistics and probability, Linear Algebra, Calculus, either Nonlinear Dynamics or Modelling and Simulation. Python, R or Matlab programming skills.

Course content: This course will introduce students to the essential tools and concepts in time series analysis in both time and frequency domains. Time series typically arises in many processes requiring consecutive quantity measurements. Understanding a time series' basic structure and information requires concepts often used in signal and image processing, statistics, dynamical systems, and statistical physics. The course aims to develop a working foundation at the undergraduate level that would allow for systematic analysis of time series arising in various disciplines. The course mainly focusses on traditional methods from statistics that are used in time series analysis. In addition, it also aims at exposing students to some modern challenges and selected nonlinear methods that are used extensively in the research literature. We will primarily focus on EEG and financial time series to develop more hands-on understanding of the concepts discussed in class.

A single textbook is insufficient for this course. Some of the relevant resources that will be referred to are:

Reference Books:

- George E. P. Box, Gwylim M. Jenkins, Gregory C. Reinsel, Greta M. Ljung, *Time Series Analysis. Forecasting and Control*, Fifth Edition, Wiley, 2016
- Donald B. Percival, Andrew T. Walden, *Wavelet Methods for Time Series Analysis*, Cambridge University Press, 2000
- Holger Kantz, Thomas Schreiber, *Nonlinear Time Series Analysis*, Springer, 1999
- R. H. Shumway and D. S. Stoffer, *Time Series Analysis and Its Applications: With R Examples*, fourth edition. Springer 2017.
- C. Chatfield, and H. Xing, *The Analysis of Time Series. An Introduction with R,* seventh edition. Chapman & Hall/CRC 2019.
- *Analyzing Neural time series data*, Theory and Practice, Mike X Cohen, MIT press, 2014.
- *Analysis of Financial time series,* R. S. Shay, Wiley, 2010.
- *Econophysics: An introduction*, Sitabhra Sinha, Arnab Chatterjee, Anirban Chakraborti, and Bikas K. Chakraborti, Wiley 2010.
- *An introduction to Econophysics, Correlations and Complexity in Finance*, R. N. Mantegna and H. E. Stanley, Cambridge, 2004.

Course Outcomes:
After completing the course, the students would be able to analyze time series using variety of methods. In particular, they would be able to do a systematic analysis of time series, especially the ones that fall in the broad domain of complex systems.

- Apply the knowledge of mathematics and computer science to model complex problems in science (**P1,P2,P3,P12**).
- Carry out model based investigations to derive insight into the problem at hand **(P4).**
- Communicate effectively through vivas, course presentation and report writing **(P10)**

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
X	X	X	X					X	X		X

Evaluation Policy (tentative- to be finalized in the first week of the semester)
- **Exam (60%):** Mid-semester (30) + Final (30)
- **Project (40%):** Project will allow applying the learning in the course to a real data set. A relevant published paper will have to identified in the first month of the semester. Students will reproduce the key results in the paper and then further analyze the data set. Group projects are encouraged.

Lecture Schedule *

Sl. No.	Description	No. of Lectures
1	**Overview and Introductions**	**2-3**
	Examples of time series, Trends in Time Series: Parametric, Non-parametric trends, Periodicity, seasonality etc	
2	**Fundamental Concept from Probability and Random Variables**	**3-4**
	Time Series and Stochastic Processes, Covariance and autocorrelation etc.	
3	**Autocorrelation processes and spectrum of stationary processes**	**6-7**
	Basic properties and linear processes, Introduction to ARMA models	
4	**Linear Stationary Models**	**6-7**
	Autoregressive and moving average processes, mixed autoregressive and moving average processes.	
4	**Linear Nonstationary Models**	**8-10**
	Autoregressive Integrated Moving Average processes, Integrated Moving Averages processes	

5	**Spectral Analysis of Time Series**	**5-8**
	Spectral representation and Spectral Distribution, estimating the spectrum.	
6	**Other Topics**	
	Time Series models of Heteroscedasticity, ARCH, GARCH and Stochastic Volatility Models, Nonlinear models, Some concepts for dynamical systems etc.	

* The number of topics covered will depend on the overall enthusiasm and commitment of the class