FORECASTING FOR TIME SERIES

Bachelor in Data and Business Analytics BDBA SEP-2023
FTS-DBA.2.M.A

Area Others
Number of sessions: 15
Academic year: 23-24
Degree course: SECOND
Number of credits: 3.0
Semester: 2º
Category: COMPULSORY
Language: English

Professor: **JUAN GARBAYO DE PABLO**

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Juan Garbayo de Pablo is a MSc Aerospace Engineer (Universidad Politécnica de Madrid / RWTH Aachen) with a specialization in spacecraft design and graduate of Airbus' Master in Aircraft Systems (Universidad Carlos III de Madrid).

Juan's career has been focused on engineering systems of multiple industries: railroad (Deutsche Bahn AG), Aircaft (Airbus SE) and Intralogistics (Jungheinrich AG). He is currently working as a Data Scientist at Jungheinrich AG, helping transform the business model leveraging the potential of IoT to bring added value to the company and its clients.

Office Hours

Office hours will be on request. Please contact at:

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The one and only requirement is to have studied in detail prior to the tutorial.

SUBJECT DESCRIPTION

The analysis of data that have been observed at different points in time leads to new and unique problems in statistical modelling and inference. The obvious correlation introduced by the sampling of adjacent points in time can severely restrict the applicability of the many conventional statistical methods, traditionally dependent upon the assumption that these adjacent observations are independent and identically distributed (Shumway and Stoffer, 2017). Specific methods and techniques are therefore necessary to handle time series data.

The first part of the subject deals with the analysis of time series to explore the data, decompose the series, compute statistics, analyze the importance of autocorrelation, judge its stationarity... All these concepts are paramount for the second part of the course: time series forecasting, where the focus will be on building models to predict future values of a time series based on the data collected to the present.

Time series analysis and forecasting are intrinsic to econometrics, finance, business, supply chain management, climate and weather forecasting, predictive maintenance and so many more disciplines. Examples of time series data include the continuous monitoring of a person's heart rate, hourly readings of air temperature, daily closing price of a company stock, monthly rainfall data, yearly sales figures...

PREREQUISITES FOR TAKING THIS SUBJECT:

- Fundamentals of Probability and Statistics.
- Fundamentals of Data Analysis.
- Programming and Data Visualization in R.
- Time Series Analysis (time series subject from previous semester).

LEARNING OBJECTIVES

This course builds upon the course *TIme Series Analysis* from the previous semester and delves into forecasting using some of the most classic me

- Produce forecasts with Exponential Smoothing, Arima Models, Regression models and ML Algorithms such as XGBoost.
- Properly evaluate and select among such models.
- Produce aggregated forecasts with hierarchical data and deal with complex seasonality.
- Analyze complex seasonality with harmonic regression
- Analyze bi-directional relationships with Vector Autoregression
- Use of information criteria to refine time-series specific regressors.

TEACHING METHODOLOGY

IE University teaching method is defined by its collaborative, active, and applied nature. Students actively participate in the whole process to build their knowledge and sharpen their skills. Professor's main role is to lead and guide students to achieve the learning objectives of the course. This is done by engaging in a diverse range of teaching techniques and different types of learning activities such as the following:

Learning Activity	**Weighting**	**Estimated time a student should dedicate to prepare for and participate in**
Lectures	40.0 %	30.0 hours
Discussions	6.67 %	5.0 hours
Exercises in class, Asynchronous sessions, Field Work	13.33 %	10.0 hours
Group work	13.33 %	10.0 hours
Individual studying	26.67 %	20.0 hours
TOTAL	100.0 %	75.0 hours

PROGRAM

SESSION 1 (LIVE IN-PERSON)

REVIEW - EXPONENTIAL SMOOTHING

- Review of exponential smoothing methods
- Simple
- Trended
- Seasonal

Note: it is paramount that the student is familiar with the models taught in the first part of the subject: Time Series Analysis.

Book Chapters: Forecasting Principles and Practice (see references)

SESSION 2 (LIVE IN-PERSON)

REVIEW: ARIMA MODELS

- Diferentiation and Stationarity
- ARMA Models
- Non-seasonal ARIMA Models

Note: it is paramount that the student is familiar with the models taught in the first part of the subject: Time Series Analysis.

Book Chapters: Forecasting Principles and Practice (see references section)

SESSION 3 (LIVE IN-PERSON)

SEASONAL ARIMA MODELS

- Seasonal differences to remove seasonality.

Exercises to practice

Book Chapters: Forecasting Principles and Practice - 3rd Edition (see references section of the syllabus).

SESSION 4 (LIVE IN-PERSON)

TIME SERIES REGRESSION MODELS

Application of regression to model trend, seasonality, or specific events.

Book Chapters: Forecasting Principles and Practice; (See references)

SESSION 5 (LIVE IN-PERSON)

USE OF FOURIER TERMS FOR LONG-TERM AND COMPLEX SEASONALITY

- Exercises to practice this topic.

Book Chapters: Forecasting Principles and Practice (see references)

SESSION 6 (LIVE IN-PERSON)

HIERARCHICAL FORECASTING

- Top down and bottom-up approaches
- Methods for forecast reconciliation

Exercises on the matter will be proposed and solved.

SESSION 7 (LIVE IN-PERSON)

HIERARCHICAL FORECASTING - EXERCISES

- Anysis and forecasting of time series with multiple seasonal periods

Exercies on this topic will be provided.

SESSION 8 (LIVE IN-PERSON)

EXERCISES TO PREPARE MIDTERM

Exercises to prepare the midterm.

SESSION 9 (LIVE IN-PERSON)

MIDTERM

SESSION 10 (LIVE IN-PERSON)

VECTOR AUTOREGRESSION

- Feedback relationships between the variables

Book Chapters: Forecasting Principles and Practice; Chapter 7 (See Bibliography)

SESSION 11 (LIVE IN-PERSON)

USE OF CLASSICAL ML ALGORITHMS IN TIME SERIES CONTEXTS

- Transformation of data to fit the model
- Example case with XGBoost

Book Chapters: Forecasting Principles and Practice; (see references)

SESSION 12 (LIVE IN-PERSON)

ADVANCED FORECASTING EXERCISES

SESSION 13 (LIVE IN-PERSON)

ADVANCED FORECASTING EXERCIES

SESSION 14 (LIVE IN-PERSON)

GROUP PRESENTATIONS

SESSION 15 (LIVE IN-PERSON)

FINAL EXAM

EVALUATION CRITERIA

criteria	percentage	Learning Objectives	Comments
Final Exam	30 %		Final exam - session 20
Intermediate tests	30 %		Midterm exam
Group Presentation	20 %		Forecasting project chosen by the students
Group Work	10 %		Group assignment (1 assignment)
Class Participation	10 %		Homework delivery

RE-SIT / RE-TAKE POLICY

BIBLIOGRAPHY

Compulsory

- Hyndman, R J & Athanasopoilos, G. *Forecasting Principles and Practice.* 3rd Edition. OTexts. ISBN 0987507133 (Digital)

- Robert H Shumway, David S. Stoffer. (2019). *Time Series: A Data Analysis Approach Using R.* CRC Press. ISBN 9780367221096 (Digital)

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