Course guide
200649 - AEXNAP - Statistical Learning with Deep Artificial Neural Networks

Last modified: 11/04/2024

Unit in charge: School of Mathematics and Statistics
Teaching unit: 1004 - UB - (ENG)Universitat de Barcelona.

Degree: MASTER'S DEGREE IN STATISTICS AND OPERATIONS RESEARCH (Syllabus 2013). (Optional subject).

Academic year: 2024 **ECTS Credits:** 5.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: ESTEBAN VEGAS LOZANO

Others: Segon quadrimestre:
FERRAN REVERTER COMES - A
ESTEBAN VEGAS LOZANO - A

PRIOR SKILLS

Familiarity with the foundations of calculus in one and more variables. Intermediate studies in probability and inference. Skills using the R environment for statistical computing and programming. Any good online R course may help, like https://www.ub.edu/cursosR/docente.html.

REQUIREMENTS

"Fundamentos de Inferencia Estadística" o "Inferencia Estadística Avanzada"
"Software Estadístico: R y SAS"

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
MESIO-CE2. CE-2. Ability to master the proper terminology in a field that is necessary to apply statistical or operations research models and methods to solve real problems.
MESIO-CE3. CE-3. Ability to formulate, analyze and validate models applicable to practical problems. Ability to select the method and / or statistical or operations research technique more appropriate to apply this model to the situation or problem.
MESIO-CE4. CE-4. Ability to use different inference procedures to answer questions, identifying the properties of different estimation methods and their advantages and disadvantages, tailored to a specific situation and a specific context.
MESIO-CE6. CE-6. Ability to use appropriate software to perform the necessary calculations in solving a problem.
MESIO-CE8. CE-8. Ability to discuss the validity, scope and relevance of these solutions and be able to present and defend their conclusions.
MESIO-CE9. CE-9. Ability to implement statistical and operations research algorithms.

Transversal:
CT1a. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding how companies are organised and the principles that govern their activity, and being able to understand employment regulations and the relationships between planning, industrial and commercial strategies, quality and profit.

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

TEACHING METHODOLOGY

Learning is organized into theoretical-practical sessions with the instructors. All the sessions combine a 50% of expository classes and other 50% of guided practice and workshops.
In the expository part of the sessions, the theoretical aspects are presented and discussed, accompanied by practical examples using slides that will be provided previously to the students.
The fundamental work environment of the practical sessions will be R, of which an intermediate knowledge is presumed (use of the environment and basic programming). Optionally, students can do their homework using Python.
Autonomous learning will consist of the study and resolution of theoretical and practical problems that the student should turn in throughout the course.
Specifically, the planned activities are:
- Study of the learning materials, before and/or after each session with the instructors.
- Detailed analysis of diverse data sets. It will be attempted that each data set serves as a basis for a case study in several methods.
- The completion of theoretical and practical exercises on the studied methods. The practical exercises will require completion of programming tasks in R or Python and preparation of short reports using RMarkdown (or a similar tool such as Python notebook).

LEARNING OBJECTIVES OF THE SUBJECT

To understand the fundamentals of the of Artificial Neural Networks
To know the workflow of machine learning.
To know the evaluation of machine learning models.
To know the packages Keras/TensorFlow for implementing deep learning models.
To understand the monitoring of deep-learning models.
To understand Deep learning for computer vision.
To understand Deep learning for text and sequences.
To understand Generative deep learning.

STUDY LOAD

Type	Hours	Percentage
Hours small group	15,0	12.00
Self study	80,0	64.00
Hours large group	30,0	24.00

Total learning time: 125 h

CONTENTS

Fundamentals of artificial neural networks

Description:
• Artificial intelligence, machine learning and deep learning.
• A first example of a neural network.
• Data representation for neural networks. Tensors and tensor operations.
• How neural networks learn. Backpropagation and gradient descent.

Full-or-part-time: 4h
Theory classes: 4h

Getting started with neural networks

Description:
• The core components of neural networks.
• An introduction to Keras.
• Workflow for approaching machine-learning problems.
• Model validation using K-fold cross-validation.
• Introduction to main deep learning architectures.

Full-or-part-time: 8h
Theory classes: 8h

Deep learning best practices

Description:
• Using Keras callbacks.
• Working with tfruns() package.
• Best practices for developing deep learning models.

Full-or-part-time: 3h
Theory classes: 3h

Deep learning for computer vision

Description:
• Convolutional neural networks.
• Data augmentation.
• Feature extraction.
• Fine-tuning.
• Visualizing heatmaps of class activation. Grad-cam.

Full-or-part-time: 10h
Theory classes: 10h

Deep learning for text and sequences

Description:
• Preprocessing text data into useful representations. Word Embeddings.
• Recurrent neural networks.
• 1D convolutions for sequence processing
• LSTM and GRU layers.

Full-or-part-time: 10h
Theory classes: 10h

Generative deep learning

Description:
• Text generation with LSTM
• Variational autoencoders.
• Generative adversarial networks.

Full-or-part-time: 10h
Theory classes: 10h

GRADING SYSTEM

It is based on two parts:
1) Practical exercises done through the course: 50%
2) Final exam: 50%

BIBLIOGRAPHY

Basic:
- Goodfellow, Ian; Bengio, Yoshua; Courville, Aaron. Deep learning [on line]. Cambridge, Massachusetts: The MIT Press, [2016] [Consultation: 07/07/2023]. Available on: https://www.deeplearningbook.org/. ISBN 9780262035613.
- Chollet, François. Deep learning with Python [on line]. Shelter Island, New York: Manning Publications Co, 2018 [Consultation: 07/07/2023]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=6798497. ISBN 9781617294433.
- Chollet, F. ; Allaire, J. J. Deep Learning with R. Shelter Island, NY: Manning Publications, 2018. ISBN 9781617295546.
- Foster, David. Generative deep learning : teaching machines to paint, write, compose, and play. Sebastopol, CA: O'Reilly Media, 2019. ISBN 9781492041948.

Complementary:
- Pal, S.; Gulli, A. Deep learning with Keras. Birmingham: Packt Publishing Ltd, 2017. ISBN 9781787128422.
- Zaccone, G. Deep learning with TensorFlow. Packt Publishing Ltd, 2017. ISBN 9781786469786.