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230856 - MLN - Machine Learning with Neural Networks

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 723 - CS - Department of Computer Science
Academic year: 2019
Degree: MASTER'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2018). (Teaching unit Optional)
ECTS credits: 4 Teaching languages: Catalan, Spanish, English

Teaching staff

Coordinator: Romero Merino, Enrique
Delgado Pin, Jordi

Opening hours

Timetable: On demand

Prior skills

Strong Mathematical ans Statistical background
Basic programming skills

Requirements

None

Degree competences to which the subject contributes

Basic:

CB10. (ENG) Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

Teaching methodology

MD1 - Master classes: The contents of the course are exposed in the classroom by a teacher without the active participation of the students.
MD4 - Group work: Learning activity that has to be done through collaboration between the members of a group.
MD6 - Problem solving: In the problem solving activity, the teaching staff presents an exercise / problem that the students must solve, whether working individually or in a team.
MD8 - Search for information: The search for information, organized as actively seeking information on the part of the students, allows the acquisition of knowledge directly, but also the acquisition of skills and attitudes related to the obtaining of information.
MD10 - Practice: They allow to apply and configure, at a practical level, the theory of a field of knowledge in a specific context.

Learning objectives of the subject

- Neural Networks Introduction
- Introduction to Machine Learning
- Introduction to multi-layer perceptions
- Detail the Backpropagation learning algorithm so that students can implement it

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- To face the student with the practical problems implied in using a neural network
- Understanding the Rosenblatt Perceptron
- Understanding how the basic ideas of the Perceptron can be extended to more sophisticated machines: The Support Vector Machines
- Offering a detailed explanation of Convolutional Neural Networks
- Show how to solve practical problems that may appear in the training of Neural Networks
- Understanding the difference between a recurrent network and a feed-forward network
- Understanding the Hopfield model as a simple example of a recurrent network
- Understanding the Boltzmann Machines (BM) and the concept of learning a distribution of probability
- Understanding the Boltzmann Restricted Machines (RBM) and the advantages they have over BMs
- Understanding the details of the Contrastive Divergence algorithm to train RBMs
- Understanding the management of sequential data by means of LSTMs
- Relating the mentioned models with Deep Learning.

Study load

Total learning time: 100h	Hours large group:	36h	36.00%
	Self study:	64h	64.00%

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Content

General Concepts of Learning and Neural Networks	Learning time: 8h Theory classes: 5h Self study : 3h

Description:
Students will receive general knowledge related to neural networks, that is, the knowledge common to any type of network, plus the biological and mathematical justification of these concepts. The classification of neural networks will be motivated and the different networks will be described in general terms. The basic concepts of machine learning and its specific implementation associated with neural networks are described (the functionality of a network is achieved through the learning of the network, given some data associated with a specific problem).

Related activities:
The Formal Neuron and Neuronal Networks: Introduction
General Machine Learning Issues
Laboratory: Fundamentals of Python and Introduction to practices: BP and CD-k

Specific objectives:
- Understanding the concept of Neural Network and where it comes from
- Understanding the different types of network
- Understanding the concept of Machine Learning and its experimental particularities
- Understanding how Machine Learning relates to neural networks and how they are implemented

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Feed-forward Neural Networks: Multi-layer Perceptrons, Support Vector Machines and Convolutional Networks.	Learning time: 45h Theory classes: 15h Self study : 30h

Description:
This first block of the course will revolve around feed-forward networks and the Backpropagation training algorithm. The three most commonly used architectures will be explained: The Perceptron and its generalization (Support Vector Machines), the multi-layer perceptrons and the convolutional networks. We will emphasize the practical aspects of the subject matter, putting much detail on the problems that may appear when training these networks with real problems. A practice related to the content of this block will be assessed.

Related activities:
- Multilayer Perceptrons and Backpropagation
- Laboratory: Practical work Backpropagation
- Perceptron and Support Vector Machines
- Convolutional Neural Networks
- Experimental Issues

Specific objectives:
- Introduction to multi-layer perceptions
- Detail the Backpropagation learning algorithm so that students can implement it
- To face the student with the practical problems implied in using a neural network
- Understanding the Rosenblatt Perceptron
- Understanding how the basic ideas of the Perceptron can be extended to more sophisticated machines: The Support Vector Machines
- Offering a detailed explanation of Convolutional Neural Networks
- Show how to solve practical problems that may appear in the training of Neural Networks

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Recurrent Neural Networks: Hopfield networks, Boltzmann Machines and LSTM	Learning time: 39h Theory classes: 13h Self study : 26h

Description:
This second block of the course will focus on recurrent networks, where we will see Hopfield networks and Boltzmann Machines as classic examples of recurrent network and Restricted Boltzmann Machines (RBM) and the LSTM as examples of networks used in practical problems. A practical work will be done on RBMs learning algorithm, called Contrastive Divergence (CD-k).

Related activities:
Hopfield Networks
Máquinas de Boltzmann y Contrastive-Divergence
Laboratory: Practical work CD-k
LSTM Networks
Deep Learning: Introduction

Specific objectives:
- Understanding the difference between a recurrent network and a feed-forward network
- Understanding the Hopfield model as a simple example of a recurrent network
- Understanding the Boltzmann Machines (BM) and the concept of learning a distribution of probability
- Understanding the Boltzmann Restricted Machines (RBM) and the advantages they have over BMs
- Understanding the details of the Contrastive Divergence algorithm to train RBMs
- Understanding the management of sequential data by means of LSTMs
- Relating the mentioned models with Deep Learning

Qualification system

P1 Practical work Feed-forward Networks (part 1)
P2 Practical work Recurrent Networks (part 2)
EF Final Exam
Subject Note: 0.6*EF + 0.4*(0.5*P1 + 0.5*P2)

Regulations for carrying out activities

Exams: Indivdual, written
Practical works: Groups of 2/3 students

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Bibliography

Basic:

Hertz, J.; Krogh, A.; Palmer, R.G. Introduction to the theory of neural computation. Redwood City: Addison-Wesley, 1991. ISBN 0201503956.

Bishop, C.M. Neural networks for pattern recognition. Oxford: Clarendon Press, 1995. ISBN 0198538642.

Coolen, A.C.C.; Kühn, R.; Sollich, P. Theory of neural information processing systems. Oxford: Oxford University Press, 2005. ISBN 9780198530244.

Goodfellow, I.; Bengio, Y.; Courville, A. Deep learning [on line]. Cambridge, Massachusetts: MIT Press, 2016 [Consultation: 10/07/2019]. Available on: <http://www.deeplearningbook.org/>. ISBN 978-0262035613.

Others resources:

Hyperlink

Curs Xarxes Neuronals (Hugo Larochelle)

https://www.youtube.com/watch?v=SGZ6BttHMPw&list=PL6Xpj9I5qXYEcOhn7TqghAJ6NAPrNmUBH