



POLITÉCNICA

INTERNATIONAL  
CAMPUS OF  
EXCELLENCE

COORDINATION PROCESS OF  
LEARNING ACTIVITIES  
PR/CL/001



E.T.S. de Ingenieros de  
Telecomunicación

# ANX-PR/CL/001-01

## LEARNING GUIDE

SUBJECT

**93000947 - Bio-inspired learning**

DEGREE PROGRAMME

09AT - Master Universitario En Teoria De La Señal Y Comunicaciones

ACADEMIC YEAR & SEMESTER

2018/19 - Semester 2

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DRAFT VERSION

## 1. Description

### 1.1. Subject details

<b>Name of the subject</b>	93000947 - Bio-inspired learning
<b>No of credits</b>	3 ECTS
<b>Type</b>	Optional
<b>Academic year of the programme</b>	First year
<b>Semester of tuition</b>	Semester 2
<b>Tuition period</b>	February-June
<b>Tuition languages</b>	English
<b>Degree programme</b>	09AT - Master universitario en teoria de la señal y comunicaciones
<b>Centre</b>	09 - Escuela Tecnica Superior de Ingenieros de Telecomunicacion
<b>Academic year</b>	2018-19

## 2. Faculty

### 2.1. Faculty members with subject teaching role

<b>Name and surname</b>	<b>Office/Room</b>	<b>Email</b>	<b>Tutoring hours *</b>
Diego Andina De La Fuente (Subject coordinator)	C-310	d.andina@upm.es	Sin horario. Appointment arranged by email
Martin Javier Alarcon Mondejar	C-309	martin.alarcon@upm.es	Sin horario. Appointment arranged by email

Juan Isidoro Seijas Martinez- Echevarria	C-319	juan.seijas@upm.es	Sin horario. Appointment arranged by email
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\* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

### 3. Prior knowledge recommended to take the subject

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#### 3.1. Recommended (passed) subjects

- Tratamiento de señal multimedia
- Fundamentos de optimización
- Teoría de la información
- Tratamiento estadístico de señales

#### 3.2. Other recommended learning outcomes

- Computer Science and Signal Processing fundamentals. Probability and Estimation Theory for Engineers. Digital Signal Processing fundamentals. Knowledge of MATLAB is required.
- Probability and Estimation Theory for Engineers
- Knowledge of MATLAB
- Computer Science fundamentals
- Signal Processing fundamentals
- Digital Signal Processing fundamentals

## 4. Skills and learning outcomes \*

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### 4.1. Skills to be learned

CB07 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio

CB08 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios

CB09 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades

CE02 - Evaluar y sintetizar los resultados de un trabajo en equipo en proyectos relacionados con la teoría de la señal y las comunicaciones, en un entorno internacional.

CT01 - Capacidad para comprender los contenidos de clases magistrales, conferencias y seminarios en lengua inglesa

CT03 - Capacidad para adoptar soluciones creativas que satisfagan adecuadamente las diferentes necesidades planteadas

CT04 - Capacidad para trabajar de forma efectiva como individuo, organizando y planificando su propio trabajo, de forma independiente o como miembro de un equipo

CT05 - Capacidad para gestionar la información, identificando las fuentes necesarias, los principales tipos de documentos técnicos y científicos, de una manera adecuada y eficiente

## 4.2. Learning outcomes

RA46 - Knowledge of using the methods for real-world applications and coding your own algorithms.

RA44 - To develop an understanding of the concepts and mathematical properties of Biological signal and systems to model them as artificial systems

RA45 - To achieve insight in biologically inspired as well as traditional machine learning methods for search, optimization and classification

RA42 - knowledge on Big Data technologies and their application to multimedia content

RA7 - Capacidad para desarrollar y evaluar técnicas de aprendizaje automático y diseñar sistemas de aprendizaje para datos masivos

RA41 - Ability to select and apply adequate machine learning techniques to large-scale multimedia datasets and evaluate their performance

\* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

## 5. Brief description of the subject and syllabus

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### 5.1. Brief description of the subject

The goal of this course is to develop biologically-inspired approaches to Machine Learning. The course starts with an introduction to Intelligent Systems. It then addresses the role of Artificial Neural Networks in Machine Learning and presents the main principles in Neurocomputing Systems and Deep Learning. The course also introduces Processing of Biological and Nature signals, that are characterized by Fractality and Fuzzyness. Swarm Systems are studied as biologically-inspired approaches based on robust collective behaviour. The course also covers System of System Engineering and the Simulation of Intelligent Systems, and provides practical use cases in different application scenarios.

## 5.2. Syllabus

1. Biological Computation Concepts
  - 1.1. Introduction
  - 1.2. Fractality and Fuzziness in Nature
  - 1.3. Sensors, Information extraction and data classification
  - 1.4. Biological Brains: Plasticity, learning and memory
  - 1.5. Emergent Intelligence
2. Biological Information in Nature: Fractal and Fuzzy Processing
  - 2.1. Fractal Properties and Scalability
  - 2.2. Clustering Big Data
  - 2.3. Hybrid Algorithms and Fuzzy C-Means
  - 2.4. The concept and relevance of Atypicality in Big Data
  - 2.5. Sub-Segmentation
3. Neuroengineering: From Biological Learning to Artificial Design
  - 3.1. Supervised Learning in Artificial Neural Networks
  - 3.2. Unsupervised Learning in Artificial Neural Networks
  - 3.3. Associative Networks and Evolutionary Algorithms
  - 3.4. Automated classification and decision
  - 3.5. Hybrid Networks for Deep Learning
  - 3.6. Higher order Plasticity for higher order Learning
  - 3.7. Artificial Metaplasticity, Intrinsic Plasticity and Deep Learning
4. Collective Intelligence: Swarms as System of Systems Engineering
  - 4.1. Ant Colony Optimization
  - 4.2. Particle Swarm Optimization
  - 4.3. Bees Algorithm
  - 4.4. System of Systems Engineering, a technology for the 21st Century
5. Multidisciplinary Applications
  - 5.1. Case study 1: A Neural Network to solve Air Pollutant Level Estimation

- 5.2. Case study 2: ROI Identification for Computer Aided Diagnosis
- 5.3. Case study 3: Credit Scoring and Bankrupt Prediction
- 5.4. Case study 4: UAV path optimization
- 5.5. Case study 5: Edge detection
- 5.6. Case study 6: Big Data clustering
- 5.7. Case study 7: Task allocation

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## 6. Schedule

### 6.1. Subject schedule\*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Other face-to-face activities	Assessment activities
1	<p><b>Biological Computation Concepts</b> Duration: 02:00 Lecture</p> <p><b>Biological Information in Nature: Fractal and Fuzzy Processing</b> Duration: 02:00 Lecture</p>			
2	<p><b>Team Work</b> Duration: 01:00 Cooperative activities</p>			<p><b>Team Work Examination</b> Group work Continuous assessment Duration: 01:00</p> <p><b>Individual Presentation</b> Individual presentation Continuous assessment Duration: 02:00</p>
3	<p><b>Neuroengineering: from biological learning to artificial design</b> Duration: 04:00 Lecture</p>			
4	<p><b>Team Work</b> Duration: 01:00 Cooperative activities</p>			<p><b>Individual presentation</b> Individual presentation Continuous assessment Duration: 01:00</p> <p><b>Individual test</b> Written test Continuous assessment Duration: 01:00</p> <p><b>Team Work Examination</b> Group work Continuous assessment Duration: 01:00</p>
5	<p><b>Collective Intelligence: Swarms as System of Systems Engineering</b> Duration: 04:00 Lecture</p>			
6	<p><b>Team Work</b> Duration: 01:00 Cooperative activities</p>			<p><b>Individual test</b> Written test Continuous assessment Duration: 01:00</p> <p><b>Individual presentation</b> Individual presentation Continuous assessment Duration: 01:00</p> <p><b>Team Work Examination</b></p>

				Group presentation Continuous assessment Duration: 01:00
7	<b>Multidisciplinary Applications</b> Duration: 04:00 Lecture			
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				<b>Delivery of final individual work</b> Individual work Continuous assessment Duration: 02:00  <b>Written examination, alternative to continuous evaluation</b> Written test Final examination Duration: 02:00

The independent study hours are training activities during which students should spend time on individual study or individual assignments.

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

\* The subject schedule is based on a previous theoretical planning of the subject plan and might go through experience some unexpected changes along throughout the academic year.

## 7. Activities and assessment criteria

### 7.1. Assessment activities

#### 7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
2	Team Work Examination	Group work	Face-to-face	01:00	10%	3 / 10	CB08 CT01 CT03 CE02
2	Individual Presentation	Individual presentation	Face-to-face	02:00	5%	3 / 10	CB09 CB07 CT04 CT05
4	Individual test	Written test	Face-to-face	01:00	5%	4 / 10	CB09 CB07 CT04 CT05
4	Individual presentation	Individual presentation	Face-to-face	01:00	5%	4 / 10	CB09 CB07 CT04 CT05
4	Team Work Examination	Group work	Face-to-face	01:00	10%	4 / 10	CB08 CT01 CT03 CE02
6	Individual test	Written test	Face-to-face	01:00	5%	5 / 10	CB09 CB07 CT04 CT05
6	Individual presentation	Individual presentation	Face-to-face	01:00	10%	5 / 10	CB09 CB07 CT04 CT05
6	Team Work Examination	Group presentation	Face-to-face	01:00	20%	5 / 10	CB08 CT01 CT03 CE02

17	Delivery of final individual work	Individual work	No Presential	02:00	30%	5 / 10	CB08 CB09 CT01 CB07 CT03 CE02 CT04 CT05
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### 7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Written examination, alternative to continuous evaluation	Written test	Face-to-face	02:00	100%	5 / 10	CB08 CB09 CT01 CB07 CT03 CE02 CT04 CT05

### 7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Extraordinary examination will be carried out exclusively by the final assessment method	Other assessment	Face-to-face	02:30	100%	5 / 10	CB08 CB09 CT01 CB07 CT03 CE02 CT04 CT05

## 7.2. Assessment criteria

Students will be qualified through continuous evaluation by default. According to the Normativa de Evaluación del Aprendizaje de la Universidad Politécnica de Madrid, students willing to renounce to continuous evaluation must complete the Moodle task entitled "Renounce to continuous evaluation" within the four first weeks of the course (deadline will be announced in Moodle).

Evaluation will assess if students have acquired all the competences of the subject. Thus, evaluation through final assessment will be carried out considering all the evaluation techniques used in continuous evaluation (EX, ET, TG, etc.), and will be celebrated in the exam period approved by Junta de Escuela for the current academic semester and year. Evaluation activities that assess learning outcomes that cannot be evaluated through a single exam can be carried out along the semester.

Extraordinary examination will be carried out exclusively by the final assessment method.

### **CONTINUOUS EVALUATION:**

**TEAM EXAMINATION:** Students will be clustered in teams and cooperate in a common task. They will prepare and deliver a common written task.

**EVALUATION PARAMETERS:** Team innovativeness and novelty (divergent Team Thinking).

- Number of ideas or hypothesis and their correctness
- Fluidity and originality
- Number of categories of application: cognitive, social, motivational, etc.
- Every other valuable properties can add extra points.
- **MAXIMUM SCORE: 30% OF TOTAL**

**INDIVIDUAL PRESENTATION AND INDIVIDUAL TEST:** Students will present their individual contribution to the Team Work and they will answer questions by class attendants. After all have finished, an individual written test about the scientific and engineering contents of the students presentation will be performed to all class.

**EVALUATION PARAMETERS:** individual creativity and expert thinking.

- Number of concepts presented and question answered.
- Quality and logic of reasoning
- Technical soundness and fitness.
- Every other valuable property can add extra points

MAXIMUM SCORE: 40% OF TOTAL

**FINAL INDIVIDUAL WORK:** in the last week of courses (17th week) the students will deliver a final individual work about a modern neuroengineering application.

MAXIMUM SCORE 30% OF TOTAL.

**EVALUATION PARAMETERS:** individual creativity and expert thinking.

**EXTRAORDINARY EVALUATION:**

Extraordinary examination will be carried out exclusively by the final assessment method: a written exam with a maximum score of 100%.

## 8. Teaching resources

### 8.1. Teaching resources for the subject

Name	Type	Notes
Prediction Case	Bibliography	MG Cortina Januchs, J Quintanilla-Dominguez, A Vega-Corona, D. Andina. "Development of a model for forecasting of PM 10 concentrations in Salamanca, Mexico". Atmospheric Pollution Research 6 (4), 626-634 (2015)
Swarm Intelligence for Robots example	Bibliography	A Jevtic, A Gutiérrez, D Andina, M Jamshidi. "Distributed bees algorithm for task allocation in swarm of robots". Systems Journal, IEEE 6 (2), 296-304 (2012)
Clustering in Big Data	Bibliography	A Jevtic, J Quintanilla-Dominguez, JM Barron-Adame, Diego Andina. "Image segmentation using ant system-based clustering algorithm". Soft Computing Models in Industrial and Environmental Applications, 35-45. Springer Berlin/Heidelberg (2011).
Swarm Intelligence for Image Processing example	Bibliography	A Jevtic, D Andina. "Adaptive artificial ant colonies for edge detection in digital images". IECON 2010-36th Annual Conference on IEEE Industrial Electronics Society, 2813-2816 (2010)
Bio-inspired Artificial Neural Network applied to Business Intelligence	Bibliography	Marcano-Cedeno, A Marin-De-La-Barcelona, J Jimenez-Trillo, JA Pinuela. "Artificial metaplasticity neural network applied to credit scoring". International Journal of Neural Systems 21 (04), 311-317 (2011)

<p>Biological Data processed by Fuzzy Logic means</p>	<p>Bibliography</p>	<p>J Quintanilla, B Ojeda, MG Cortina, R Ruelas, A Vega, D Andina. Image segmentation by fuzzy and possibilistic clustering algorithms for the identification of microcalcifications. Scientia Iranica. 18, 3, 580-589 (2011)</p>
<p>Deep Learning applied to Big Data example</p>	<p>Bibliography</p>	<p>J Fombellida, S Torres, JA Pinuela, D Andina. "Artificial Metaplasticity for Deep Learning: Application to WBCD Breast Cancer Database Classification". Intl. Work-Conf. on the Interplay Between Natural and Artificial Computation. Springer. 399-408 (2015)</p>

## 9. Other information

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### 9.1. Other information about the subject

Course is best enjoyed if students have own access to a PC computer and MATLAB +MATLAB neural networks toolbox.