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

2019/20 - Semester 2

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	93000947 - Bio-inspired Learning
No of credits	3 ECTS
Type	Optional
Academic year ot the programme	First year
Semester of tuition	Semester 2
Tuition period	February-June
Tuition languages	English
Degree programme	09AT - Master Universitario en Teoria de la Señal y Comunicaciones
Centre	09 - Escuela Tecnica Superior de Ingenieros de Telecomunicacion
Academic year	2019-20

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
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

* 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

3.1. Recommended (passed) subjects

- Fundamentos De OptimizaciÓn

- Teoría De La InformaciÓn

- Tratamiento De SeÑal Multimedia

- 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

- Digital Signal Processing fundamentals

- Knowledge of MATLAB

- Computer Science fundamentals

- Signal Processing fundamentals

4. Skills and learning outcomes *

4.1. Skills to be learned

CB06 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación

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

CB10 - 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

CE01 - Analizar y aplicar técnicas para el diseño y desarrollo avanzado de equipos y sistemas, basándose en la teoría de la señal y las comunicaciones, en un entorno internacional

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.

CETFM - Capacidad de realizar un trabajo o proyecto integrando y relacionando las competencias adquiridas en las distintas asignaturas del máster, junto con la capacidad de defenderlo en público ante un grupo de personas expertas en el tema del trabajo

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

RA34 - Capability to develop and evaluate machine-learning techniques and to design big data learning systems

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

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 to tacle emergent propierties as Cognition and the Simulation of Intelligent Systems, and provides practical use cases in different application scenarios.

5.2. Syllabus

1. Biological Computation Concepts
    1.1. Presentation
    1.2. Bioinspired Learning, a key to the origin, present and future of Machine Learning
    1.3. Role in Industrial revolution 4.0
    1.4. Objective and Ethics
    1.5. Brainstorming exercise
2. Biological Information and Computing: successful imprecision and complexity processing
    2.1. Fractality and Fuzziness in Nature
    2.2. Fractal Properties and Scalability
    2.3. Natural Data Clustering
    2.4. The concept and relevance of Atypicality in Big Data
    2.5. Fractasl & Chaos
    2.6. Brianstorming Exercise
    2.7. Forming successful Work Teams: Collaboration and competition rules for creativity and sustainability
3. Neuroengineering: From Biological Learning to Artificial Design
    3.1. Neuroengineering: the bridge between natural and artificial brains
    3.2. Supervised Learning in Artificial Neural Networks
    3.3. Unsupervised Learning in Artificial Neural Networks
    3.4. Reinforcement Learning and Associative Networks
    3.5. Automated classification and decision
    3.6. .Integration of networks and Deep Networks
    3.7. Plasticity and Metaplasticity of neurons for Bioinspired Deep Learning implementation
    3.8. Case study: The Koniocortex-Like Network
    3.9. Brainstorming exercise
4. Collective (emergent) Intelligence: Swarms and System of Systems Engineering.
    4.1. Swarm Intelligence
    4.2. Evolutionary Computation

4.3. Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Bees Algorithm

4.4. System of Systems Engineering, a technology for the 21st Century Technological Revolution

5. Multidisciplinary Applications

5.1. Case Study 1. Decision Theory: taking complex Decisions

5.2. Case study 2. Ecology: A Neural Network to solve Air Pollutant Level Estimation

5.3. Case study 3. Medicine: ROI Identification for Computer Aided Diagnosis

5.4. Case study 4. Economy: Credit Scoring and Bankrupt Prediction with a Neural Net

5.5. Case study 5. Image processing: ACO for Edge detection

5.6. Case study 6 Clustering Big Data. Swarm algorithm for Clustering

5.7. Case study 7 Security: Dangerous Task allocation and Dealing

5.8. Case Study 8 Education. Neuroeducation

6. Practice Classes

6.1. Data Mining Atypical Data

6.2. Experiential learning: a wide range of appplications as your divergent thinking is

6.3. Final Work Orientation and presentation of proposals

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	**Presentations** Duration: 02:00 Problem-solving class **Biological Computation Concepts** Duration: 01:00 Lecture **Braistorming** Duration: 01:00 Problem-solving class			
2	**Biological Information in Nature: Fractal and Fuzzy Processing** Duration: 02:00 Lecture **Brainstorming** Duration: 02:00 Problem-solving class			
3	**Neuroengineering: from biological learning to artificial design** Duration: 02:00 Lecture **Brianstorming** Duration: 02:00 Problem-solving class			
4	**Neuroengineering: from biological learning to artificial design** Duration: 02:00 Problem-solving class **Collective Intelligence: Swarms as System of Systems Engineering** Duration: 02:00 Lecture			
5	**Applications** Duration: 02:00 Lecture **Brainstorming** Duration: 02:00 Problem-solving class			

6		**Practices** Duration: 04:00 Laboratory assignments		
7		**Practices** Duration: 02:00 Laboratory assignments		**Presentations** Individual presentation Continuous assessment Duration: 01:00 **Team Work Examination** Group presentation Continuous assessment Duration: 01:00
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				**Written examination, alternative to continuous evaluation** Written test Final examination Duration: 02:00 **Individual Final Work** Individual work Continuous assessment Duration: 07:00

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 theorical planning of the subject plan and might go to 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
7	Presentations	Individual presentation	Face-to-face	01:00	40%	/ 10	CB08 CB09 CT01 CB07 CB06 CB10 CT03 CT04 CT05 CE01
7	Team Work Examination	Group presentation	Face-to-face	01:00	30%	/ 10	CB06 CB08 CB09 CT01 CB07 CT03 CE02 CT05 CE01 CETFM
17	Individual Final Work	Individual work	Face-to-face	07:00	30%	/ 10	CB08 CB09 CT01 CB07 CT03 CE02 CT04 CT05 CE01 CETFM CB06 CB10

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	CB10 CB08 CB09 CT01 CB07 CT03 CE02 CT04 CT05 CB06 CE01 CETFM

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:

EXAMINATION: Students will be partcipate individually and in teams to cooperate and compete in common tasks. They the will prepare and deliver common presentation and written tasks.

EVALUATION PARAMETERS:

- Technical (Expert Thinking)

- Presentations (Flipped Classroom)

- Team Work and Brianstorming (Divergent thinking)

- Atitude & participationin in class (Soft skills: Motivation, Maturity, leadership, etc)

30%

- Practice results (Experiential Learning - Lab)

40%

- Individual final work:

30 %

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

MAXIMUM SCORE 30% OF TOTAL.

TOTAL100 %

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-Barcena, J Jimenez-Trillo, JA Pinuela. "Artificial metaplasticity neural network applied to credit scoring". International Journal of Neural Systems 21 (04), 311-317 (2011)

Biological Data processed by Fuzzy Logic means	Bibliography	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)
Deep Learning applied to Big Data example	Bibliography	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)

9. Other information

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.