



Academic year	2018-19
Subject	11012 - Modeling and Dynamics of Neural Systems
Group	Group 1

Syllabus

Subject

Subject / Group	11012 - Modeling and Dynamics of Neural Systems / 1
Degree	Master's Degree in Physics of Complex Systems
Credits	3
Period	Second semester
Language of instruction	English

Professors

Lecturers	Office hours for students					
	Starting time	Finishing time	Day	Start date	End date	Office / Building
Claudio Rubén Mirasso Santos claudio.mirasso@uib.es	12:30	13:30	Monday	03/09/2018	01/07/2019	202 Edificio Institutos Universitarios de Investigación

Context

Professor: Claudio Mirasso received the Ph.D. degree in physics from the Universidad Nacional de La Plata, Buenos Aires, Argentina, in 1989. He has held Postdoctoral positions in Spain and The Netherlands. He is a Full Professor at the Physics Department, Universitat de les Illes Balears, Palma de Mallorca, Spain, and Researcher of the Institute for Cross-Disciplinary Physics and Complex Systems.

His current research interests include synchronization and control of dynamical systems, information processing, neuronal dynamics, dynamics and applications of delayed coupled systems and applications of nonlinear dynamics in general.

He has six years of teaching periods and five years of research periods recognized.

Subject

The aim of this subject is to introduce the students into the computational neuroscience. The subject covers an introduction to the brain, a modeling part for individual neurons, the synapsis, the model of neuronal populations, noise effects as well as synchronization aspects and methods to measure characteristics of physiological signals.

Requirements



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Recommended

It is recommended that the student has basic concepts on numerical integration of differential equations as well as Fortran, C, Python or Matlab programming.

Skills

Specific

- * E2: Development and optimal application of numerical algorithms for the simulation of complex systems. .
- * E6: To understand and to model processes subject to fluctuations. .
- * E8: To know to characterize generic behavior of dynamical systems and their instabilities. .

Generic

- * TG2: To acquire the capacity to develop a complete research plan covering from the bibliographic research and strategy to the conclusions. .
- * TG4: To acquire the ability to ask questions, read and listen critically and participate actively in seminars and discussions. .
- * TG5: To knowing to disseminate and present the concepts acquired at a non-expert. .

Basic

- * You may consult the basic competencies students will have to achieve by the end of the Master's degree at the following address: http://estudis.uib.cat/master/comp_basiques/

Content

Range of topics

- Introduction. Introduction
 - Membrane potential and electrical currents.
 - Neuronal activity: generalities
 - Nerve impulse
 - Voltage dependent channels
- Models of individual neurons. Models of individual neurons
 - Hudgkin-Huxley experiment
 - Hudgkin-Huxley model; pulses and bursts
 - Reduced models; Integrated & Fire, Morris Leccar, FitzHugh Nagumo, Izhikevich, etc.
- Synapsis. Synapsis
 - Chemical and electrical synapses
 - Neurotransmitters and receptors.
 - Synaptic and postsynaptic conductance.

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Short- and Long-term plasticity
 Dynamic of coupled neurons.
 Synchronization. Synchronization
 Introduction
 Synchronization of identical systems
 Synchronization of nonidentical systems
 Interacting systems. Interacting systems
 Characterization of time series
 Calculations of autocorrelation and cross-correlation
 Mutual entropy.
 Populations of neurons.
 Neural networks
 Information Encoding. Information Encoding
 Temporal coding
 Rate Coding
 Effects of noise. Effects of noise
 Gaussian white noise, color noise and Poisson noise
 Effect of background activity of neuronal systems.
 Exampes. Exampes

Teaching methodology

In-class work activities (0.77 credits, 19.25 hours)

Modality	Name	Typ. Grp.	Description	Hours
Theory classes	Theoretical Lectures	Large group (G)	Explanation of thoretical concepts by the professor.	14
Seminars and workshops	Oral presentation	Medium group (M)	Oral presentation to the whole class of an assigned paper.	2.5
Practical classes	Hands-on sessions	Large group (G)	Development of computational programs to study neuronal dynamics	1.75
Assessment	Questionnaire	Large group (G)	4-5 Questionnaires, related to the subject topics,will be responded by the students during the course	1

At the beginning of the semester a schedule of the subject will be made available to students through the UIBdigital platform. The schedule shall at least include the dates when the continuing assessment tests will be conducted and the hand-in dates for the assignments. In addition, the lecturer shall inform students as to whether the subject work plan will be carried out through the schedule or through another way included in the Aula Digital platform.

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Distance education tasks (2.23 credits, 55.75 hours)

Modality	Name	Description	Hours
Individual self-study	Program development	The student has to prepare a software program to solve an specific problem.	35.75
Individual self-study	Preparation on the oral presentation	The student must read some papers and organize a presentation	20

Specific risks and protective measures

The learning activities of this course do not entail specific health or safety risks for the students and therefore no special protective measures are needed.

Student learning assessment

The subject will be evaluated by both the oral presentation of a certain paper, the questionnaires and the numerical work

Frau en elements d'avaluació

In accordance with article 33 of Academic regulations, "regardless of the disciplinary procedure that may be followed against the offending student, the demonstrably fraudulent performance of any of the evaluation elements included in the teaching guides of the subjects will lead, at the discretion of the teacher, a undervaluation in the qualification that may involve the qualification of "suspense 0" in the annual evaluation of the subject".

Oral presentation

Modality	Seminars and workshops
Technique	Oral tests (non-retrievable)
Description	Oral presentation to the whole class of an assigned paper.
Assessment criteria	
Final grade percentage:	10%

Hands-on sessions

Modality	Practical classes
Technique	Student internship dissertation (retrievable)
Description	Development of computational programs to study neuronal dynamics
Assessment criteria	
Final grade percentage:	35%with a minimum grade of 5

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Questionnaire

Modality	Assessment
Technique	Short-answer tests (retrievable)
Description	4-5 Questionnaires, related to the subject topics, will be responded by the students during the course
Assessment criteria	
Final grade percentage: 15% with a minimum grade of 5	

Program development

Modality	Individual self-study
Technique	Papers and projects (retrievable)
Description	The student has to prepare a software program to solve a specific problem.
Assessment criteria	Report on the numerical results
Final grade percentage: 40% with a minimum grade of 5	

Resources, bibliography and additional documentation

Basic bibliography

1. Neurophysiology, D. Stratton, LIMUSA, 1981.
2. Theoretical Neuroscience, P. Dayan and L. F. Abbott, MIT Press, 2001.
3. Spiking Neuron Models, W. Gerstner and W. Kistler, Cambridge University Press, 2002.
4. Dynamical Systems in Neuroscience: The Geometry of Excitability and Bursting, E. Izhikevich, The MIT press, 2007.
5. The synchronization of chaotic Systems, S. Boccaletti; J. Kurths; G. Osipov; D.L. Valladares; C.S. Zhouc, Physics Reports 366 (2002) 1–101.

Other resources

6. Characterizing synaptic conductance fluctuations in cortical neurons and their influence on spike generation, Z Piwkowska, M. Pospischil, R Brette, Julia Sliwa, M. Rudolph-Lilith, T. Bal, A. Destexhe, Journal of Neuroscience Methods 169 (2008) 302–322.