Syllabus

Subject

Subject / Group	11012 - Modeling and Dynamics of Neural Systems / 1
Degree	Master's in Physics of Complex Systems
Credits	3
Period	2nd 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	14:00	16:00	Thursday	06/02/2020	25/06/2020	IFISC Despacho 202

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

Date of publication: 12/07/2019

Recommended

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

Date of publication: 12/07/2019

Short- and Long-term plasticity

Dynamic of coupled neurons.

Synchronization. Synchronization
Introduction

Synchronization of identical systems

Synchronization of nonidentical systems

Interacting systems. Interacting systems
Population dynamics

Neural networks

Characterization of time series

Calculations of autocorrelation and cross-correlation

Mutual entropy

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
Synchronization of neuronal microcircuits

Information routing in neuronal circuits

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 Questionnarires, 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

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whether the subject work plan will be carried out through the schedule or through another way included in the Aula Digital platform.

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 Regulation of academic studies, "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%

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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

Questionnaire

Modality	Assessment
Technique	Short-answer tests **(retrievable)**
Description	4-5 Questionnarires, 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 an 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. Boccalettia; J. Kurthsc, G. Osipovd, D.L. Valladaresb; 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.

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