Subject: Characterization of biological networks and topologies (CBNT)
Code: 32428
Institution: Escuela Politécnica Superior
Degree: Master's program in Research and Innovation in Information and Communications Technologies (I^2-ICT)
Level: Master
Type: Elective [biomedical informatics]
ECTS: 6

COURSE GUIDE: Characterization of biological networks and topologies (CBNT)

Academic year: 2015-2016

Program: Master's program in Research and Innovation in Information and Communications Technologies (I^2-ICT)
Center: Escuela Politécnica Superior
University: Universidad Autónoma de Madrid

Last modified: 2015/05/07
Status: Approved June 8th 2015

1. ASIGNATURA / COURSE (ID)

Caracterización de redes y topologías biológicas.
Characterization of biological networks and topologies (CBNT)

1.1. Programa / program

Máster Universitario en Investigación e Innovación en Tecnologías de la Información y las Comunicaciones (I^2-TIC)

Master in Research and Innovation in Information and Communications Technologies (I^2-ICT) [Officially certified]

1.2. Course code

32428

1.3. Course areas

Computer Science and Artificial Intelligence

1.4. Tipo de asignatura / Course type

Optativa [itinerario: Informática biomédica]
Elective [itinerary: Biomedical informatics]

1.5. Semester

Second semester

1.6. Credits

6 ETCS

1.7. Language of instruction

The lecture notes are in English. The lectures are mostly in Spanish. Some of the lectures and seminars can be in English.

1.8. Recommendations / Related subjects

Knowledge of programming at an introductory level is useful to follow the course.

Related subjects are:

- Neuroinformática [Neuroinformatics]
- Computación bioinspirada [Bioinspired computing]
- Biodispositivos [Biodevices]
- Redes sociales, colaboración en red [Social networks and collaboration on the Internet]

1.9. Lecturers

Add @uam.es to all email addresses below.

Lectures and labs:

Dr. Carlos Aguirre (Coordinator)
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1.10. Objetivos de la asignatura / Course objectives

En esta asignatura se estudian los principales tipos de conectividad que se pueden dar en una red biológica. Se describen además cuales puede ser la mejor estrategia de conexión entre los elementos de una red sujetos a una determinada dinámica. También se proporcionan métodos para calcular los principales parámetros topológicos y de rendimiento de una red dada. Además se estudian redes resistentes a una determinada estrategia de ataque o frente a errores en la red, así como el comportamiento dinámico de los elementos de una red.

This subject studies the main types of connectivity that can be observed in a biological network. We also describe some of the best strategies for connectivity between the elements of a network for a given dynamics. We also provide methods for computing the main topological and performance parameters of a given network. We also study the resistance of networks for a given attack strategy of network errors and the dynamic behavior of the network elements.

At the end of each unit, the student should be able to:

UNIT BY UNIT SPECIFIC OBJECTIVES	
UNIT 1.- Introduction to biological networks	
1.1.	Provide examples of real networks.
1.2.	Know different common characteristics that appear in networks.
1.3.	Know some example of biological networks and its characteristics and differences.
UNIT 2.- Introduction to graph theory	
2.1.	Know some definitions about graph theory.
2.2.	Know some of the main results in graph theory.
2.3.	Implement graphs as models of networks in a computer program.
2.4.	Compute some quantities for a given graph with the help of a computer.
UNIT 3.- Metrics	
3.1.	Know the main metrics relative to networks.
3.2.	Compute the metrics for a given network with the help of a computer.
3.3.	Know the main types of network as a function of its metrics
3.4.	Classify a given network in a given network model.
UNIT 4.- Random networks	
4.1.	Know the main properties of random networks
4.2.	Generate a random network
UNIT 5.- Small world networks	
5.1.	Know the main properties of small-world networks
5.2.	Generate a small-world network.
5.3.	Generate small-world networks with extended requirements.
5.4	Generate bioinspired small-world networks
UNIT 6.- Scale Free Networks	

6.1.	Know the main properties of scale free networks.
6.2.	Generate a scale free network.
UNIT 7.- Network attacks	
7.1.	Know the main concepts of network attacks.
7.2	Know the complexity of networks attack.
7.3	Know the main attack strategies.
7.4	Generate the best attack for a given network.
7.4	Generate a network that is most resistant for an attack strategy.
UNIT 8.- Dynamic Networks	
8.1	Know the main properties of evolutive networks
8.2	Know the main growing mechanisms in networks
8.3	Implement a dynamic network on the computer.

1.11. Course contents

UNIT 1.- Introduction to biological networks
- 1.1. Examples of real networks.
- 1.2. Biological networks, characteristics.

UNIT 2.- Introduction to graph theory
- 2.1. Definitions.
- 2.2. Main results in graph theory.
- 2.3. Implementation of networks in a computer program.
- 2.4. Paths, Connectivity, Bi-connectivity.

UNIT 3.- Metrics
- 3.1. Main metrics relative to networks.
- 3.2. Computation of metrics in a computer.
- 3.3. Main types of networks.
- 3.4. Networks classification.

UNIT 4.- Random networks
- 4.1. Main properties of random networks.
- 4.2. Generation of random networks.

UNIT 5.- Small world networks
- 5.1. Main properties of small-world networks
- 5.2. Generation small-world networks.
- 5.3. Small-world networks with extended requirements.
- 5.4. Bioinspired small-world networks.

UNIT 6.- Scale Free Networks
- 6.1. Main properties of scale free networks.
- 6.2. Generation of scale free networks.

UNIT 7.- Network attacks
- 7.1. Definitions.
- 7.2. The problem of network attack.
- 7.3. Complexity of networks attacks.
- 7.4. Main attack strategies.
- 7.5. Efficiency of some attack strategies.
- 7.6. Resistance of networks to attack strategies.

UNIT 8.- Dynamic Networks
- 8.1 Properties of evolutive networks.
- 8.2 Growing mechanisms in networks.

1.12. Course bibliography

Graph Theory.
1. Diestel, Graph Theory, Springer

Random Graphs.
2. Bella Bollobas, Random Graphs. Cambridge Studies in Advanced Mathematics.

Small world networs.
3. D.J. Watts, Small Worlds, Princeton University Press.

Scale free networks.
4. Barabasi, A.-L. and R. Albert, 1999, Science 286, 509.

Dynamic networks
5. Dogorotsev and Mendes, Evolution of Networks: From Biological Nets to the Internet and Www.

Attacks
6. R. Albert, H. Jeong, and A. **Barabasi**, Error and attack **tolerance** of complex networks, Nature 406, 378-382 (2000).

Other general references
7. A.L. Barabasi, Linked, Penguin Books.
8. D.J. Watts, Six Degrees, Norton & Company.
9. S Strogatz, Sync, Hyperion.
10. Reka and Barabasi, Statistical Mechanics of complex networks

1.13. Coursework and evaluation

The course involves lectures, weekly assignments, lab assignments, and a seminar presentation.

In both the ordinary and the extraordinary exam period it is necessary to have a pass grade (≥ 5) in each of the assignments to pass the course.

- In the ordinary exam period, the evaluation will be made according to the following scheme
    - 30% Exercises.
    - 30% Lab assignments
    - 40% Seminar presentation on a research topic in biological networks

  The grades of the individual parts are kept for the extraordinary exam period.

- In case of a fail grade in the ordinar period, in the extraordinary period, the student has the opportunity to
    - Turn in all the exercises with corrections
    - Turn in all the lab assignments with corrections.
    - Turn in a report on a research topic in biological networks.

  The grade will be determined by
    - Oral examination
        - 30 % Exercises [only if the exercises are turned in]
        - 30 % Lab assignments [only if the lab assignments are turned in]
        - 40 % Report [only if the report is turned in]

          If the student does not turn in some of these items, the grades used will be those corresponding to the ordinary exam period.