

Course guide 270716 - CN - Complex Networks

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Unit in charge:	Barcelona School of Informatics
Teaching unit:	1042 - URV - Universitat Rovira i Virgili.
Degree:	MASTER'S DEGREE IN ARTIFICIAL INTELLIGENCE (Syllabus 2017). (Optional subject).

Academic year: 2024 ECTS Credits: 5.0 Languages: English

LECTURER

Coordinating lecturer:

SERGIO GÓMEZ JIMÉNEZ - ALEJANDRO ARENAS MORENO

Others:

PRIOR SKILLS

Prior skills on Algorithmics and Programming:

- Abstract data types and computational cost

- Graphs, trees and algorithms

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

CEA11. Capability to understand the advanced techniques of Computational Intelligence, and to know how to design, implement and apply these techniques in the development of intelligent applications, services or systems.

CEP2. Capability to solve the decision making problems from different organizations, integrating intelligent tools.

Generical:

CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.

Transversal:

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT6. REASONING: Capability to evaluate and analyze on a reasoned and critical way about situations, projects, proposals, reports and scientific-technical surveys. Capability to argue the reasons that explain or justify such situations, proposals, etc.. CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Basic:

CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.

TEACHING METHODOLOGY

Master classes, practice with computers, resolution of practical exercises.



LEARNING OBJECTIVES OF THE SUBJECT

1.Detection of systems which may be represented using complex networks

2.To know how to study and characterize the structure of complex networks

3.To know models of complex networks and their implementation

4. To know the main dynamics on top of complex networks

 $5. \ensuremath{\text{To}}$ know how to perform and validate Monte Carlo simulations

6.To know how to apply the knowledge in complex networks to extract information of systems which can be described using this framework

STUDY LOAD

Туре	Hours	Percentage
Hours large group	16,0	12.80
Hours medium group	16,0	12.80
Self study	80,0	64.00
Guided activities	5,0	4.00
Hours small group	8,0	6.40

Total learning time: 125 h

CONTENTS

Introduction

Description:

Examples of complex networks in many knowledge fields. Complex network types.

Structure of complex network

Description:

Main topological and structural characteristics of complex networks: degree distribution, small-world, transitivity, assortativity, community structure, centrality. Community detection algorithms.

Complex network models

Description:

Erdös-Rényi random networks, Barabási-Albert model, Watts-Strogatz model, configuration model.

Dynamics on complex networks

Description:

Most important dynamics on complex networks: epidemic spreading, synchronization, diffusion, evolutionary games, percolation. Monte Carlo simulations. Phase transitions.



ACTIVITIES

Introduction

Description: Introduction

Specific objectives:

1

Related competencies :

CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.

CEP2. Capability to solve the decision making problems from different organizations, integrating intelligent tools.

CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.

Full-or-part-time: 2h

Theory classes: 2h

Structure of complex network

Description: Development of the topic

Specific objectives:

2

Related competencies :

CEA11. Capability to understand the advanced techniques of Computational Intelligence, and to know how to design, implement and apply these techniques in the development of intelligent applications, services or systems. CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Full-or-part-time: 26h 30m Self study: 10h Guided activities: 2h Theory classes: 12h Laboratory classes: 2h 30m



Complex network models

Description: Development of the topic

Specific objectives:

3

Related competencies :

CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Full-or-part-time: 30h Self study: 20h Guided activities: 2h Theory classes: 6h Laboratory classes: 2h

Dynamics on complex networks

Description: Development of the topic

Specific objectives: 4, 5

Related competencies :

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Full-or-part-time: 24h Self study: 10h Guided activities: 2h Theory classes: 10h Laboratory classes: 2h



Project

Description: Complex networks project

Specific objectives:

1, 2, 3, 4, 5, 6

Related competencies :

CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.

CEA11. Capability to understand the advanced techniques of Computational Intelligence, and to know how to design, implement and apply these techniques in the development of intelligent applications, services or systems.

CEP2. Capability to solve the decision making problems from different organizations, integrating intelligent tools.

CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT6. REASONING: Capability to evaluate and analyze on a reasoned and critical way about situations, projects, proposals, reports and scientific-technical surveys. Capability to argue the reasons that explain or justify such situations, proposals, etc.. CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Full-or-part-time: 42h Self study: 40h Guided activities: 1h Laboratory classes: 1h

Delivery of practical exercises about structure of complex networks

Description:

Delivery of practical exercises about structure of complex networks

Specific objectives:

2

Related competencies :

CEA11. Capability to understand the advanced techniques of Computational Intelligence, and to know how to design, implement and apply these techniques in the development of intelligent applications, services or systems.

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Delivery of practical exercises about complex networks models

Description:

Delivery of practical exercises about complex networks models

Specific objectives:

3

Related competencies :

CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.



Delivery of practical exercises about community detection

Description:

Delivery of practical exercises about community detection

Specific objectives:

2

Related competencies :

CEA11. Capability to understand the advanced techniques of Computational Intelligence, and to know how to design, implement and apply these techniques in the development of intelligent applications, services or systems. CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Delivery of practical exercises about simulation of dynamics

Description:

Delivery of practical exercises about simulation of dynamics

Specific objectives:

4,5

Related competencies :

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Interview of the project

Description: Interview of the project

Specific objectives:

1,6

Related competencies :

CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.

CEA11. Capability to understand the advanced techniques of Computational Intelligence, and to know how to design, implement and apply these techniques in the development of intelligent applications, services or systems.

CEP2. Capability to solve the decision making problems from different organizations, integrating intelligent tools.

CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT6. REASONING: Capability to evaluate and analyze on a reasoned and critical way about situations, projects, proposals, reports and scientific-technical surveys. Capability to argue the reasons that explain or justify such situations, proposals, etc..

Full-or-part-time: 0h 30m Guided activities: 0h 30m



GRADING SYSTEM

Resolution of practical exercises Development of a complex networks project

BIBLIOGRAPHY

Basic:

- Newman, M.E.J. Networks. 2nd ed. Oxford: Oxford University Press, 2018. ISBN 0198805098.

- Boccaletti, S.; Latora, V.; Moreno, Y.; Chavez, M.; Hwang, D.-U. "Complex networks: structure and dynamics". Physics Reports [on line]. 424 (2006) 175-308 [Consultation: 04/03/2020]. Available on: <u>https://www.sciencedirect.com/science/journal/03701573</u>.-Fortunato, S. "Community detection in graphs". Physics Reports [on line]. 486 (2010) 75-174 [Consultation: 04/03/2020]. Available on: <u>https://www.sciencedirect.com/science/journal/03701573</u>.

RESOURCES

Hyperlink:

- <u>http://deim.urv.cat/~sergio.gomez/radatools.php- http://gephi.github.io/</u>- <u>http://igraph.org/</u>- <u>http://pajek.imfm.si/doku.php-https://networkx.github.io/</u>