Study track at IST/UL

OLOs – Checkpoints

1. Making value judgement and sustainability competencies
2. Entrepreneurship skills and competencies
3. Creativity skills and competencies
4. Innovation skills and competencies
5. Research skills and competencies
6. Intellectual transforming skills and competencies
7. Leadership skills and competencies

Modules	1	2	3	4	5	6	7
Network Science					X	X	
Data Science					X	X	
Data Analysis and Integration					X	X	
Information Visualization	X		X				
Business Process Engineering and Technology	X		X	X	X	X	
Advanced Algorithms					X	X	
Natural Language					X	X	
Information Processing and Retrieval					X	X	
Deep Learning					X	X	
Parallel and Distributed Computing	X				X	X	

EIT Health is supported by the EIT, a body of the European Union

Cloud Computing and Virtualization	X				X	X	
Anatomy and Histology					X	X	
Computational Biology					X	X	
Biomedical Decision and Information Technology	X	X	X	X	X	X	
Hands-On Epigenetics: Multi-Omic Data Analysis	X			X	X	X	
Medical Imaging	X			X	X	X	
Biosignals and Biomedical Image Processing					X	X	
Introduction to Systems and Control in Bioengineering					X	X	
Information Systems Project Management	X	X		X			X
User-Centered Design and Evaluation		X	X	X	X	X	X
Regulatory Science – Medicinal Products and Medicinal Devices	X	X	X	X		X	X
Technology Based Entrepreneurship	X	X	X	X		X	X
Bioengineering and Entrepreneurship	X	X	X	X		X	X
Entrepreneurship, Innovation and Technology Transfer	X	X	X	X		X	X
Digital Service Innovation	X	X	X	X	X	X	X
Product and Service Development	X	X	X	X	X	X	X

Design Thinking	X	X	X	X	X	X	X
2nd Cycle Integrated Project in Computer Science and Engineering	X	X	X	X	X	X	X
Project in Precision Medicine	X	X	X	X	X	X	X
Master Thesis	X	X	X	X	X	X	

Common Core (20ECTS):

- (semester 1, period 1) Network Science (6.0 ECTS)
- (semester 1, period 1) Data Analysis and Integration (6.0 ECTS)
- (semester 1, period 1) Information Visualization (6.0 ECTS)
- (semester 1, period 2) Data Science (6.0 ECTS)
- (semester 1, period 2) Deep Learning (6.0 ECTS)

Master's electives (20 ECTS):

- (semester 1, period 2) Business Process Engineering and Technology (6.0 ECTS)
- (semester 1, period 1) Natural Language (6.0 ECTS)
- (semester 2, period 3) Advanced Algorithms (6.0 ECTS),
- (semester 2, period 4) Cloud Computing and Virtualization (6.0 ECTS)
- (semester 2, period 3) Parallel and Distributed Computing (6.0 ECTS)

HMDA specialization (20 ECTS):

- (semester 2, period 3) Biomedical Decision and Information Technology (6.0 ECTS)
- (semester 1, period 1) Computational Biology (6.0 ECTS)
- (semester 1) Anatomy and Physiology (6.0 ECTS)
- (year 2) [MOOC] Hands-On Epigenetics: Multi-Omic Data Analysis (4 ECTS recommended)
- (semester 2) Medical Imaging (6 ECTS)
- (semester 1, period 1) Biosignals and Biomedical Image Processing (3.0 ECTS)
- (semester 1, period 2) Introduction to Systems and Control in Bioengineering (3.0 ECTS)

I & E 1 (10 ECTS):

- (semester 1, period 1) Innovation Management and Design Thinking (6.0 ECTS)
- (semester 1, period 2) User-Centered Design and Evaluation (6.0 ECTS)

- (semester 1, period 2) Regulatory Science – Medicinal Products and Medicinal Devices (6.0 ECTS)
- semester 1) Technology Based Entrepreneurship (6 ECTS)
- (semester 1, period 1) Bioengineering and Entrepreneurship (6 ECTS)

I & E 2 (Medical Specialization, 10 ECTS):

- (semester 1) 2nd Cycle Integrated Project in Computer Science and Engineering (12 ECTS).
- (semester 1) Project in Precision Medicine (12 ECTS). (incoming students only)

I & E 3 (10 ECTS):

- (semester 2, Period 3) Information Systems Project Management (6.0 ECTS),
- (semester 2, period 3) Digital Service Innovation (6.0 ECTS)
- (semester 2, period 4) Product and Service Development (6.0 ECTS)
- (semester 2, period 4) Design Thinking (6.0 ECTS)
- (semester 2) Entrepreneurship, Innovation and Technology Transfer (6.0 ECTS)

1st year, 1st semester (autumn/winter semester)

INNOVATION AND ENTREPRENEURSHIP 1 (10 ECTS)

INFORMATION SYSTEMS PROJECT MANAGEMENT

Responsible lecturer: Rosário Bernardo
ECTC: 6.0
Course type and weekly hours: lecture (2h) + laboratory (1.5 h)
Exam type: written test (50%), project (40%), Presentation component of project (10%)
The GPI assessment is defined by an individual theoretical component (50%, Individual Grade), a practical group work component (40%, Project Grade) and a presentation component of a project management theme (10%, Presentation Grade).

FinalGrade = Round (0.5 * IndividualGrade + 0.4 * ProjectGrade + 0.1 * PresentationGrade)

Contents:

The objectives of GPI are aligned with the same objectives as defined for the course "IS 2010.4 IS Project Management" of the curriculum "ACM/AIS IS 2010 Curriculum Guidelines", namely:
1. Understand the concepts of project and project management in the organizational context
2. Understand the project management process groups
3. Understand and properly relate the project management processes with the different projects development lifecycles approaches
4. Make use of project scope planning methods and techniques
5. Make use of project scheduling methods and techniques
6. Identify the project stakeholders, make use of project organization and responsibilities planning methods and techniques and develop the project communication planning
7. Identify the main cost components and be capable to use cost planning methods and techniques to define the project budget
8. Make use of quality planning, quality assurance and quality control in the project management context
9. Make use of risk identification, assessment, treatment and control methods and techniques
10. Understand the procurement management processes and the management of different project contract types
11. Make use of information and tools to support project control, project close and suitable metrics
12. Identify the main Project Manager technical, behavioral and contextual competence elements
13. Understand the concepts of project based organization, change management, project value, programme management, portfolio management and governance of projects.
14. Make adequate use of MS-Project functionalities on practice exercises

Learning outcomes and competencies:

The syllabus of GPI is closely aligned with the course "IS 2010.4 IS Project Management" defined in the "ACM / AIS IS 2010 Curriculum Guidelines" having the following main topics:

1. Project management related concepts in an organizational perspective
2. Project basics
3. Life Cycles models
4. Scope management
5. Time management
6. Project Organization and Communication management
7. Stakeholders management
8. Cost management
9. Quality management
10. Risk management
11. Procurement management
12. Project control
13. Project closure
14. Project Management competence elements
15. Projects alignment with the Organization and the Business

Literature:

- Rethinking Project Management. An organizational perspective: Erling S. Andersen 2008 Pearson Education, UK
- Managing Information Technology Projects, Revised 6th Edition (International Edition): Kathy Schwalbe, 2011 Cengage Learning
- Project Management for Information Systems -Fifth Edition: Cadle, James & Yeates, Donald 2008, Pearson Education, UK
- Gestão de Projetos de Software (5.ª Edição Atualizada), António Miguel, 2014, FCA - Editora de Informática
- UML, Metodologias e Ferramentas CASE, 2ª Edição, Volume II, Alberto Silva, Carlos Videira, 2008, Editora Centro Atlântico

Keywords: Project Planning, Innovation, Entrepreneurship, Sustainability.

USER-CENTERED DESIGN AND EVALUATION

Responsible lecturer: Nuno Jardim Nunes
ECTC: 6.0
Course type and weekly hours: lecture (2 h) + laboratory (1.5 h)
Exam type: Project (60%, minimum grade of 9.5), Laboratories (40%, minimum grade of 9.5)

The course will be taught using a studio-learning approach. Lectures will be short and given only when necessary. Students will conduct research, design, development, making, and reflection tasks throughout the semester. Students will work in group projects.

Emphasis is placed on the quality of the students' ideas and their ability to give form to their design concepts.

Contents:

- **Lectures**

This course introduces the main methods and techniques of user-centered research and evaluation. Through an open-ended practical group project, students are exposed to problems of increasing complexity in which they can practice the methods and techniques described. The learning objectives are: i) collect and analyze information about the different participants in a system; ii) choose research techniques to design and develop interactive systems and services; (iii) trackably synthesize research findings into innovative concepts and ideas; iv) work as a team managing various perspectives and talents; v) communicate and negotiate with different participants the design and alternatives for the different solutions.

- **Laboratory:**

Workshops with the following themes:

- ✓ Who are the Users?
- ✓ What the Users want?
- ✓ Applying Cultural Probes
- ✓ Workshops with Users
- ✓ Initial Requirements
- ✓ Validation of Requirements
- ✓ Conceptual Model and First
- ✓ Low Fidelity Prototypes.
- ✓ Usability Testing.
- ✓ Low Fidelity Prototypes.
- ✓ Functional Prototype.

Learning outcomes and competencies:

1. Introduction: historical perspective of the importance of user-centered design and evaluation.
2. Methods and techniques for analysing users: ethnographic methods, survey and contextual design, affinity diagrams and models.
3. Methods and techniques for synthesizing results by archetypes and stereotypes: personas and scenarios vs. actors / roles and use cases.
4. Methods and techniques for prototype development and evaluation: storyboarding and low, medium and high fidelity prototypes.
5. Field assessment techniques and tools: heuristic assessment, think aloud, tools and platforms.

Literature:

- Contextual Design: Defining Customer-Centered Systems, Beyer, H. & Holtzblatt, K. 1998, Morgan Kaufmann: San Francisco, CA. ISBN 1-55860-411-1
- Rapid Contextual Design: A How-To-Guide to Key Techniques for User-Centered Design, Holtzblatt, K., Wendell, J. B., & Wood, S. 2005, Elsevier, Inc.: San Francisco, CA. ISBN 0-12-354051-8
- The UX Book: Process and Guidelines for Ensuring a Quality User Experience, Rex Hartson and Pardha Pyla 2012
- Observing the User Experience, Goodman, E., Kuniavsky, M., & Moed, A. 2012
- Contextual Design Evolved, Holtzblatt & Beyer
- Innovating for People, LUMA Institute

Keywords: User-Centered Design. Usability Engineering. Human-Computer interaction.

REGULATORY SCIENCE – MEDICINAL PRODUCTS AND MEDICINAL DEVICES

Responsible lecturer:
ECTC: 3
Course type and weekly hours:
Exam type: Flash presentations on specific topics of the program (Groups of 2 students) (35%)
Quizzes (25%)
Roadmap Challenge - Presentation of Case studies about approval procedures of Medicinal Products and Medical Devices (Groups of 3-4 students) (40%)

Contents:

The curricular unit will allow students to understand how the translational process of getting medicinal products and medical devices from research to the market is implemented, under a regulated environment, according to European, North-American and global (International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use (ICH)) rules. After the training program students will be able to design strategies on how to transfer knowledge to the market in these areas, under a highly regulated environment, allowing to better design research and the lab to market transfer process.

Learning outcomes and competencies:

1. General overview of regulation in Healthcare.
2. Regulatory structure for the European and north-american procedures for market access of medicinal products (biotech drugs & Advanced Therapy Medicinal Products (ATMPs)) and medical devices.
3. Regulatory standards for the translational research of medicinal products, with particular detail on biotech products.
4. Regulatory standards for the translational research of medicinal products, with particular detail on ATMPs.
5. Orphan medicines and role of regulatory scientific advice.

6. Regulation of medical devices.
7. Global harmonization of health technologies innovation.
8. Clinical research and regulatory compliance.
9. Critical examples for translational research and the issues on regulation of hybrid systems.
10. Risk management and pharmacovigilance systems.
11. Global trends in regulatory science development.
1. 12.Quality Management Systems under regulatory supervision (GMPs, GLPs, GCPs).
2. 13.Roundtable with specialists.

ENTREPRENEURSHIP, INNOVATION AND TECHNOLOGY TRANSFER

Responsible lecturer: José Epifânio da Franca
ECTC: 6
Course type and weekly hours: lecture (3h) + laboratory (1.5 h)
Exam type: A team project, consisting of a business plan (65%) and the development of a product in terms of engineering, marketing and manufacturing (35%).

Contents:

To develop the necessary skills of the business entrepreneur to generate and evaluate innovative ideas, to develop and materialize innovation in products and services, and to structure a business plan to incubate and explore technology based innovation, with a specific knowledge of market mechanisms, finance and management.

Learning outcomes and competencies:

1. Innovation, entrepreneurship and competitivity.
2. Innovation factors and processes.
3. Technology transfer and intellectual property.
4. Connections between technology, products and services, and the market.
5. The product development process.
a. Creativity and product planning.
b. Customer needs and product specifications.
c. Concept generation, selection and testing.
d. Product architecture.
e. Industrial Design, engineering and prototyping.
6. Risk management. Identification and evaluation of risk factors and contingency plans.
7. Design for manufacturing and assembly. Design for the environment.
8. Design for cost, Target price / Target cost.
9. Economic analysis and sources of financing.
10. Legal aspects associated to enterprise creation.
11. Business plan.
a. Marketing Plan.
b. Production Plan / operations

c. Management Plan and enterprise organization.
d. Financial Plan.
12. Design discussions and meetings / business plan discussions.

Literature:

- Proactive risk management: Controlling uncertainty in product development: Preston G. Smith, Guy M. Merritt2002Productivity Press
- Creating Breakthrough Products: J. Cagan & C. Vogel2002Prentice Hall, ISBN 0-13-969694-6
- Product Design & Development, 3rd Ed:K. T. Ulrich, S. D. Eppinger2003McGraw-Hill, ISBN 0071232737

Keywords: Entrepreneurship, Innovation.

TECHNOLOGY BASED ENTREPRENEURSHIP

Responsible lecturer: Luis Caldas de Oliveira
ECTC: 6
Course type and weekly hours: Until further notice, all classes will be online. The Technology-Based Entrepreneurship course follows an adapted version of the Lean LaunchPad (LLP) methodology named LLP@Técnico. It uses a Team-based learning model together with an Experiential learning process. Teams have to present their progress in a weekly 3 hour Flipped classroom class.
Exam type: Evaluation criteria:

i) Team work:
• The presentation and delivery of a case-study, a mid-term and a final report
ii) Individual work:
• Report (case-study) and Participation in class.

Teaching will draw on different methodologies. The conceptual approach to entrepreneurship and innovation and its potential to foster job creation and socioeconomic development will be addressed mainly through readings and classroom discussions. Identifying technology-based business opportunities, analyzing markets, customers and competitors; selecting an intellectual property protection and funding strategy will be covered through readings, case studies, classroom discussion, presentations and the final report. Students will also learn how to assess and develop human capital in the workplace from the experience of working together with colleagues originating from different backgrounds and nationalities.

Contents:

- To understand the process of opportunity recognition and analysis of technology based activities.
- To understand the criteria used in evaluating opportunities and to develop venture screening criteria.

- To understand the necessary procedures for protecting the intellectual property of technology that supports the business idea.
- To understand the basic financial tools necessary for analyzing financial requirements and forecasting the profitability of new businesses.
- To understand the types of venture partners and alliances that might be beneficial for venture success.
- To identify the various sources of financing for ventures.
- To understand the role of teams in the entrepreneurial process and the type of team partners thatentrepreneurs must seek.
- To identify the organizational aspects relative to development, production and commercialization activities of new products and services.
- To realize how these preliminary steps lay the ground work for the creation of an effective business plan.

Learning outcomes and competencies:

- Chapter I. Introduction: Innovation and Entrepreneurship
- Chapter II. Technology and opportunity recognition
- Chapter III. Universities and technology commercialization
- Chapter IV. The process of venture creation
- Chapter V. Market research and industry analysis
- Chapter VI. Opportunity planning and assessment
- Chapter VII. Intellectual property protection
- Chapter VIII. Financial planning
- Chapter IX. Sources of financing for new technology-based ventures
- Chapter X. The entrepreneurial team and organizational model
- Chapter XI. The business plan

BIOENGINEERING AND ENTREPRENEURSHIP

Responsible lecturer:
ECTC: 3
Course type and weekly hours:
Exam type: Evaluation includes:

I. Presentations: 10% Idea definition on technology features, medical need identification and suggest product/service/therapy; 15% Action plan; 25% Final Pitch.

II. Other elements: 15% Class participation; 5% Interviews; 10% Memorandum (2 pages) on a selected topic (e.g. Target Product Profile, Patent claims, Clinical Trial design); 20% Final report: Executive summary of 2 pages + self-explanatory PPT slides deck with business plan elements and supporting info.

Contents:

This UC challenges students to come up with an answer for medical need, including regenerative and precise medicine approaches, aiming at the creation of a new product or service following a bioengineering strategy, and developing the respective business project/idea. The UC includes learning outcomes on:

A. Ideation and market assessment: Identification and characterization of a medical need and business opportunity, technology assessment, unique features and competitive advantages, product/service/therapy definition, IP protection, market size and growth, identification and needs of different stakeholders.

B. Manufacturing and Business development: Technological plan, regulatory requirements including pre and clinical trials, manufacture and operation plan, business model for the new enterprise. team composition, commercialization plan, investment needs, finances and funding.

The students' hands-on project will develop a business idea based on a previously disclosed technology.

Learning outcomes and competencies:

This UC is organized on two learning tracks:

A. Sessions promoting entrepreneurial go-to-market attitude on:

1. Introduction to innovation, purpose and attitude. Methodology overview. Entrepreneurship. Data Mining. Interview skills.
2. Technology, Product features, User needs. Stakeholders. Innovation. Disruptive products. Sustaining (r)evolutionary vs disruptive innovation. Why innovation fails? Examples.
3. Value creation and capturing. Consumer value proposition, Problem and solution, impact. Business Canvas
4. Technology disclosure and intellectual property protection. Technologic plan. Regulation. Clinical Trials. Approval. Reimbursing.
5. Manufacturing and operation plan. Good Manufacturing Practice.
6. Marketing principles. Commercialization plan. Value chain. Industry mapping. Supply chain. Competitive analyses.
7. Revenue model and cost structure. Business models. Finances and funding.

B. Project: Identification of a medical need and design of a new product/service.

DIGITAL SERVICE INNOVATION

Responsible lecturer: Valentina Nisi
ECTC: 6
Course type and weekly hours: Online classes twice a week (2 h periods); The main exchanges, communications and interactions will happen through the Slack channel.
Exam type: The evaluation of the development process and the quality of the work is done by means of presentations and written reports.

Contents:

During this course, students will learn how to think systemically and holistically about digital services and innovation. Students will learn how to map the territory of their design brief and extract models that will help them to illustrate, create and analyze their design concepts. The students will then learn how to communicate their concept, prototype it, refine it and deliver a final presentation to the client. Students will also learn how to draft the value proposition and the business model.

- By the end of this course, students should be able to:
- Identify a service, a product service system, and a platform, and talk about the components of each.
- Design and represent a service and a product service system, through the use of models typically used in service design.
- Explain and demonstrate how a service unfolds through design and communication.
- Engage in a critique of their own and others' work.
- Draw actionable insights from a critique of their own and others' work.

Learning outcomes and competencies:

- The experience economy: historical background and relevance of the digital service economy.
- The service design process: definition; ideation and discovery; framework and strategy; creating and expressing digital service innovations; refining and evaluating prototypes; value proposition and business model.
- Key techniques: ethnographic research; ideation; directed storytelling; enactment; customer journeys; service blueprints.

PRODUCT AND SERVICE DEVELOPMENT/ PRODUCT DEVELOPMENT AND ENTREPRENEURSHIP

Responsible lecturer: Marco Leite; Paulo Peças
ECTC: 6
Course type and weekly hours:
Exam type: Maximum grades: Design report and presentation – 13; Exercise – 3; Prototype – 2; Patent submission – 2.

Contents:

At the end of the course, the student will be able to: identify customer needs and build a set of product specifications; understand the entire process of product development, from the first product drafts to production ramp-up, with a special attention to the financial part of the business; design a product within a team, innovating based on market needs, having a clear understanding of the IPR issue; implement a structured methodology, reducing the time to market; analyse the risk inherent in a product development; com-municate with all the individuals.

Learning outcomes and competencies:

1. Introduction
2. Inovation and competitivity
3. Technology transfer and intellectual property
4. Products and services
5. Criativity in product development
6. The product development process organization a. Product planning. b. Identifying customer needsc. Establishing product specifications d. Concept generation e. Concept selection f. Concept testing g. Product architecture h. Industrial design.

7. Risk management. Identifying and evaluating risk factors and contingency palnning
8. Design for manufacturing
9. Design for the environment
10. Economic analysis and sources of financing
11. Legal aspects of business criation
12. Business plan
13. Design discussions

DESIGN THINKING/ INNOVATION MANAGEMENT AND DESIGN THINKING

Responsible lecturer: Joana Mendonça
ECTC: 6
Course type and weekly hours:
Exam type: Evaluation: the course of the work performed during the semester and the development of a project to be presented in 2 sessions: 1) Pitch Party and Team Finalization (40%); 2) Final Presentations (60%).

Contents:

This course introduces the concept of Design Thinking, an approach to innovation and creative problem resolution that can be used in different disciplines. Design Thinking has emerged as a fundamental approach to face complex challenges at a corporate, social and cultural level. In addition, it promotes an innovative culture in start-ups, small firms and also large firms. Design thinking is a people centered approach and an immersion process promoting creativity as a means to explore opportunities. In this context, this discipline incorporates and explores the role of users in innovation processes (user innovation), and the growing importance of user centered experiences in the development and production of products and services.

Learning outcomes and competencies:

• Introduction to Strategic Innovation
• Design Thinking as the Next Competitive Advantage
• The Design Thinking Process Overview: harness the designer mindset and uncovering unmet challenges
• Applying Design thinking to the idea development process
• Inspiration through empathy and qualitative research
• Creativity, Spaces and Ideation Techniques
• Rapid Prototyping Techniques + Feedback Wall
• User Innovation
• User Experience and user centred innovation
• Implementing Design Thinking in Your Organization and Team (Spaces, Skills and Culture)

HMDA Common Core (20 ECTS)

NETWORK SCIENCE

Responsible lecturer: Francisco Correia dos Santos
ECTC: 6.0
Course type and weekly hours: lecture (2 h) + laboratory (1.5 h)
Exam type: Project developed by groups of 2-3 students (50%); Exam (50%); Each student must achieve at least the mark 7.5 in one of the exams.
Contents:

The course aims at providing practical knowledge in complex networks, including algorithms, models and applications. This is an interdisciplinary course where students with different backgrounds are welcome to apply. Students get acquainted with the fundamental concepts of network science and complex systems, including network models and measures, graph algorithms and data structures for the study large complex networks, and dynamics on and of networks, with applications in the social sciences, physics, biology, and economics. Applications are numerous and include web search engines, information diffusion in social networks and blogs, network resilience, network-driven phenomena in epidemiology, opinion formation, evolutionary and learning dynamics, and human decision-making. The course follows a problem-based learning approach where techniques and methods are constructively explored, including relevant implementation techniques.

Learning outcomes and competencies:

Part I. Introduction to complex systems, network science and computational science: Theory and basic concepts. Introduction to graph algorithms, data structures and network measures. Properties and characterization of biological, social and technological networks. Power-laws and scale-free properties. Network models and random graphs. Multidimensional networks.

Part II. Efficient representation of large (sparse) networks. Succinct data-structures and coding strategies. Design and analysis of efficient and scalable algorithms for large network processing and analysis. Random walks. Community finding and graph partitioning. Ranking algorithms. Methods for network visualization.

Part III. Dynamical processes on complex networks: the impact of network structure on economic, social and biological systems. Introduction to stochastic processes and Monte-Carlo simulations of large-scale multi-agent systems. Robustness of networks to random failures and targeted attacks. Cascading events and avalanches. Disease spreading and network epidemics. The dynamics of peer-influence, social learning and opinion formation. Human decision-making in (static and adaptive) social networks. Game theory and population dynamics. Reputation dynamics, cooperation, and social norms.

Literature:

- Networks, Crowds, and Markets: Reasoning about a Highly Connected World: Easley, D. and Kleinberg, J.2010Cambridge University Press
- Networks: An Introduction: M. E. J. Newmann2010Oxford University Press
- Network Science:Barabási, A.-L.2016Cambridge University Press

- Lectures on Complex Networks:Dorogovtsev, S.N.2010Oxford University Press
- Mining of Massive Datasets: J. Leskovec, A. Rajaraman, J. D. Ullman2014Cambridge Univ. Press
- Dynamical processes on complex networks: Barrat, A., M. Barthelemy, and A. Vespignani2008Cambridge University Press

Keywords: Network Science, Complex Networks

DATA SCIENCE

Responsible lecturer: Cláudia Antunes
ECTC: 6.0
Course type and weekly hours: lecture (2h) + laboratory (1.5 h)
Exam type: Project and Lab (50%), Exam (50%)

Grading is based on three components: E: exam, P: project, L: labs (optional)
The final grade is given by 50%E + max(10%L + 40%P, 50%P), constrained to: E>=9.5 e P>=9.5
Oral assessment when P-E>=4

Contents:

Students should be able to understand and to apply the knowledge discovery process over tabular and temporal data, in all of its steps. In particular, to:
1. Explore data through basic data profiling and visualization techniques,
2. Apply mining techniques in the training of models for classification, segmentation, pattern discovery, anomaly detection and forecasting,
3. Choose the most adequate data preparation approaches to enhance the performance of mining techniques,
4. Assess models performance and identify the impact of training choices.
Orthogonally, students should be able to:
1. Understand the challenges faced when mining complex and large-scale data.
2. Identify sensitive data that might be subject to processing restrictions and data anonymization techniques that enable privacy-preserving data mining.

Learning outcomes and competencies:

1. Data Science and the knowledge discovery process. Performance evaluation: metrics, strategies, estimation and the Occam's razor.
2. Data profiling and information visualization principles.
3. Data preparation: scaling, discretization, reduction and balancing. Labelling. Missing values imputation. Feature engineering.
4. Classification. The five tribes overview. Ensembles. Overfitting.
5. Regression: linear, logistic and non-parametric.
6. Pattern Mining: association rules and sequential patterns.
7. Clustering: partitioning, hierarchical, density and model-based approaches. Biclustering.
8. Anomaly detection.
9. Temporal data analysis. Time series pre-processing, mining and forecasting.

10. Introduction to Social Networks Analysis.
11. Mining complex data: spatiotemporal, relational and multi-dimensional data.
12. Large-scale data: distributed and stream data mining. The notion of concept-drif.
13. Ethical Legal and Sociail Implications of data. The GDPR. Anonymization techniques.

Literature:

- Data Mining and Analysis: Fundamental Concepts and Algorithms: Mohammed J. Zaki, Wagner Meira, Jr. 2014 Cambridge University Press
- Data Mining: Concepts and Techniques: Jiawei Han, Micheline Kamber, and Jian Pei 2011, Morgan Kaufmann http://hanj.cs.illinois.edu/bk3/
- GDPR - General Data Protection Regulation 2016, Regulation (EU) 2016/679 of the European Parliament and of the Council

Keywords: Data Science, Data Mining, Data Analytics.

DATA ANALYSIS AND INTEGRATION

Responsible lecturer: Helena Galhardas
ECTC: 6.0
Course type and weekly hours: lecture (2h) + laboratory (1.5 h)
Exam type: Exam (60%), Project (40%)
Minimum grade of 9.5 in both components.
Evaluation by exam in special cases.

Contents:

Understand and implement data extraction, transformation, and loading processes using state-of-the-art methods and tools.

Study the different architectural types and design options for large data warehouses. Apply multidimensional analysis methods and tools over data warehouses.

Learning outcomes and competencies:

SQL review.
ETL processes and tools.
Data sources and data integration.
Data matching and mapping.
String matching.
Data profiling and data cleaning.
Duplicate detection and removal.
Data warehousing.

Logical and physical design for data warehouses.
ETL processes for data warehouses.
Multidimensional analysis over data warehouses.
SQL language extensions and MDX language.
Reporting tools.
Key performance indicators.

Literature:

- Principles of Data Integration: Anhai Doan, Alon Halevy and Zachary Ives.2012 Morgan Kaufmann.
- Data Warehouse Systems: Design and Implementation Alejandro Vaisman and Esteban Zimányi 2014 Springer https://www.springer.com/gp/book/9783642546549

Keywords: Information Integration, Data Warehousing, OLAP, Data Quality.

INFORMATION VISUALIZATION

Responsible lecturer: Daniel Gonçalves
ECTC: 6.0
Course type and weekly hours: lecture (2h) + laboratory (1.5 h)
Exam type: Exam (30%), Project (70%)

Contents:

The main goal is to provide students with knowledge in the área of Information Visualization, that allows them to design and develop high-impact visualizations of data and information, to effectively transmit qualitative and quantitative data. The area of Information Visualization will be introduced, after which we'll teach a methodology for analyzing problema domains and conceiving effective visualizations. Afterwards, we'll discuss the different kinds of variables, datasets (tabular, networks, text, etc.) and patterns to visualize. Next, we'll describe the different relevant physiological and psychological factors (memory, visual processing, etc.) relevant for the creation of good visualizations. We'll study the most common kinds of visualizations adequate for different information types (graphs, time series, etc.) and interaction techniques. Finally, we'll address issues related with the evaluation of InfoVis.

Learning outcomes and competencies:

1. Introduction
2. Design Methodology
3. Datasets and variables
4. Human Factors in InfoVis
5. Visualization Types and Techniques
6. Integration, Dynamic visualizations and animations
7. Dealing with complexity
8. Legibility and fidelity of visualizations
9. Evaluation of InfoVis Solutions

10. Applications

Literature:

- Visualization Design and Analysis: Abstractions, Principles, and Methods: Tamara Munzner 2014 AK Peters -(Draft version: http://www.cs.ubc.ca/~tmm/courses/533-11/book/)
- Interactive Data Visualization: Foundations, Techniques, and Applications, Second Edition: Matthew O. Ward, Georges Grinstein, Daniel Keim 2015 A K Peters/CRC Press ISBN 9781482257373
- Introduction to Information Visualization Riccardo Mazza ? Springer - ISBN 1848002181

Keywords: Information Visualization.

1st year, 2nd semester (spring/summer semester):

Innovation and Entrepreneurship 2 (10 ECTS) –Medical specialization

COMPUTATIONAL BIOLOGY

Responsible lecturer: Susana Vinga
ECTC: 6.0
Course type and weekly hours: lecture (2h) + laboratory (1.5 h)
Exam type: Practical evaluation (40%, lab reports) and Theoretical evaluation (60%, final exam).

Contents:

Computational Biology aims at developing computational methods and algorithms to process biological data and uses mathematical and statistical modelling to generate testable hypotheses about biological entities and processes .The goal of this course is to introduce the basic techniques that support the most recent developments on this field. Additionally, it enables the development of the ability to critically assess research publications in this field. Practical assignments during the course aim at developing the student's ability to develop software for bioinformatics.

Learning outcomes and competencies:

1. Introduction to Computational Biology.
2. Primers on molecular biology and algorithms.
3. Pairwise and multiple sequence aligment.
4. Probabilistic models: Markov Chains and Hidden Markov Models.
5. Biostatistics and supervised learning methods: data mining analysis, Generalized Linear Models (multiple linear regression, logistic regression), survival analysis (Cox regression); applications to regularized optimization to omics data (Lasso, Ridge, Elastic Net).
6. Unsupervised learning: Clustering Analysis (k-means, hierarchical), Principal Components Analysis (PCA); applications to Molecular Phylogenetics and Transcriptomics (microarray analysis and RNA-seq).
7. Integrative data analysis in biological and clinical databases, genotype-phenotype interactions.
8. Bioethics seminar.

Literature:

- An Introduction to Bioinformatics Algorithms: N. C. Jones and P. Pevzner2005MIT Press
- Biological Sequence Analysis -Probabilistic models of proteins and nucleic acids :R. Durbin, S. Eddy, A. Krogh, G. Mitchison1998Cambridge
- Data Mining: Practical Machine Learning Tools and Techniques :Ian H. Witten, Eibe Frank, Mark A. Hall2011http://www.cs.waikato.ac.nz/ml/weka/book.html

- Bioinformatics and Biomarker Discovery: "Omic" Data Analysis for Personalized Medicine: Francisco Azuage2010Wiley Blackwell

Keywords: Bioinformatics Algorithms.

MEDICAL IMAGING

Responsible lecturer: Patrícia Figueiredo
ECTC: 6
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: Two tests or Final exam (70%) + Lab work (30%)

Contents:

1. Introduction
   1.1. Historical perspective
   1.2. General imaging principles
2. X ray imaging
   2.1. X rays
   2.2. Planar radiography
   2.3. Computed Tomography (CT)
   2.4. Image reconstruction
   2.5. Specialized imaging techniques
3. Nuclear medicine imaging
   3.1. Radionuclides
   3.2. Scintigraphy
   3.3. Single Photon Emission Computed Tomography (SPECT)
   3.4. Positron Emission Tomography (PET)
   3.5. Corrections and image reconstruction
4. Magnetic Resonance Imaging (MRI)
   4.1. Nuclear Magnetic Resonance (NMR)
   4.2. Image formation and reconstruction
   4.3. Instrumentation
   4.4. Contrast mechanisms
   4.5. Imaging sequences
   4.6. Rapid imaging
   4.7. Specialized imaging techniques
5. Ultrasound imaging
   5.1. Ultrasounds
   5.2. Transducers
   5.3. Imaging modes
   5.4. Doppler ultrasonography.

Learning outcomes and competencies:

The goal of this course is to provide both a theoretical and a practical background in biomedical imaging techniques, focusing on the main modalities and covering physical principles of image acquisition; basic

instrumentation; image reconstruction and analysis methods; and applications in disease diagnosis and monitoring.

By the end of the semester, the student should be familiar with 1) the physical principles and basic instrumentation used for the acquisition of the main biomedical imaging techniques; 2) the most important image reconstruction and analysis methods; and 3) the main applications in disease diagnosis and monitoring.

Literature:

- Introduction to Biomedical Imaging: Andrew Webb 2003 Wiley ISBN: 0-471-23766-2.

Keywords: X-Ray, Nuclear Imaging, MRI, Ultrasound.

Master´s Electives (20 ECTS)

BUSINESS PROCESS ENGINEERING AND TECHNOLOGY

Responsible lecturer: Pedro Sousa
ECTC: 6.0
Course type and weekly hours: Seminar (1.5h) + OT (1.5h)
Exam type: The evaluation of the course has 3 components:

1.Individual written exam or two tests. Minimum score: 10,0 points out of 20,0. Weight: 60%
2.Group project. Minimum score: 10,0 points out of 20,0. Weight: 40% •
3.Individual assignments: No minimum scobe: Weight: 10% •

Contents:

1. Understand the Role of BP within and between organizations.
2. Understand the Relationships and dependencies between BP, systems and information.
3. Design and analyse BP Architectures.
4. Model BP and perform Qualitative and Quantitative analysis.
5. Perform BP simulation and BP Mining using tools
5. Redesign and optimize BP for Time, Cost, Flexibility and Quality.
6. Specify BP for autmation in BPM Systems

Learning outcomes and competencies:

1. Introduction to BPM
2. Process Identification
3.Process Modeling
4.Process Discovery
5.Qualitative Process Analysis.
6.Quantitative Process Analysis
7.Process Redesign.
8.Process-Aware Information Systems
9.Process Implementation with Executable Models .
10.Process Monitoring
11.BPM as an Enterprise Capability.

Literature:

- Fundamentals of Business Process Management: Marlon Dumas, Marcello La Rosa, Jan Mendling, Hajo A. Reijers. 2013 Springer.
- BPMN Method and Style: A levels-based methodology for BPM process modelling and improvement using BPMN 2.0 Bruce Silver 2009 Cody-Cassidy Press
- Process Mining Wil M.P. van der Aalst 2011 Springer

Keywords: Business Process Management. Business Process Modeling and Analysis. Process Mining.

NATURAL LANGUAGE

Responsible lecturer: Luísa Coheur
ECTC: 6.0
Course type and weekly hours: lecture (2 h) + laboratory (1.5 h)
Exam type: 1 exam (50%), 2 projects (each 15%), a series of exercises (20%)

The final grade is based in three components:
- a series of exercises (20%)
- 2 mini-projects (30% - 15% each)
- 1 exam (50%)
In "época especial": exam (70%) + 2 mini-projects (30%). Miniprojects can be carried out in the normal season, as long as they are delivered as individual work.

Contents:

- Learn the basic concepts, main formalisms, techniques and algorithms, knowledge bases and corpora, used in the Natural Language Processing area.
- Understand the main tasks involved in the processing of a sentence, paragraph or text and understand the main challenges of each one of these tasks.
- Learn the main applications and be able to identify the associated technology.
- Understand which are the tasks that can be done considering the current state of the art.

Learning outcomes and competencies:

1. Introduction to Natural Language Processing.
2. Methodology: Training/test corpus, Cross-validation, Evaluation measures, etc.
3. Regular Expressions.
4. Similarity measures.
5. N-Grams and Smoothing Techniques.
6. Morphology: Transducers, Part-of-Speech tagging, HMMs and Viterbi algorithm.
7. Sintax: Grammars, Syntactic Parsing.
8. Semantics: Meaning representation (clasic and via embeddings), Lexical semantics, Distributional Semantics, Semantic Roles, Semantic Parsing.
9. NLP tasks that can be approach as classification and/or as sequence labeling problems.
10. Main deep learning architectures used in NLP.
11. Applications: QA systems, Chatbots, Machine Translation, Speech Processing, etc.

Literature:

- Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition, Second Edition: Daniel Jurafsky & James H. Martin2009Prentice-Hall
- Introduction to Natural Language Processing, Jacob Eisenstein 2019, MIT PRESS https://jacobeisenstein.github.io

Keywords: Natural Language Processing, Text Mining.

BIOSIGNALS AND BIOMEDICAL IMAGE PROCESSING

Responsible lecturer: João Miguel Sanches
ECTC: 3
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: Exam (40%), Laboratory works (30%), Project (30%)

Contents:

This UC aims to provide students with fundamental concepts and tools for the storage, visualization and processing of biomedical signals and images, with emphasis on physiological signals and the main modalities of medical imaging and microscopy.
Students should know, understand and apply the basic principles of:
1 - Linear algebra applied to the manipulation and processing of signals and images.
2 - Most common forms of storage and transmission of biomedical data.
3 - Conditioning and improvement of signal and image.
4 - Linear and non-linear filtering. FIR, IIR filtering and convolution masks.
5 - Detection and segmentation in noisy, distorted and incomplete data.
6 - Contours and active surfaces.
7 - Signal and image reconstruction algorithms.

Learning outcomes and competencies:

1 - Motivation for the processing of biomedical signals and images.
2 - Introduction to MatLab and Phyton image and signal processing packages.
3 - Mathematical representation of signs and images.
4 - Linear and non-linear digital filtering. FIR, IIR and median filters.
5 - Multi-resolution analysis and wavelet decomposition.
6 - Image segmentation. Contour detectors. Contours and active surfaces.
7 - Statistical processing of signal and image. Refocusing and noise removal.
8 - Tomographic reconstruction of medical image. CT, PET and SPECT.
9 - Linear discriminating analysis of main components and independent components.
10-Acquisition and reconstruction of microscopy image. Fluorescence and confocal microscopy.

Literature:

- Discrete-time signal processing: Alan V. Oppenheim and Ronald W. Schafer-Prentice-Hall
- Understanding Digital Signal Processing (3rd Edition): Richard G. Lyons-Pearson

Keywords: Signals, Transforms, Sampling, Systems, Feedback, and control.

INTRODUCTION TO SYSTEMS AND CONTROL IN BIOENGINEERING

Responsible lecturer: João Miguel Sanches
ECTC: 3
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: Exame (40%) + Laboratories (30%) + Project (30%)

Contents:

The discipline of Systems and Control in Bioengineering addresses the fundamental topics of feedback and control theory essentially within the framework of linear systems. We highlight the mathematical bases necessary for its understanding, the fundamental concepts of Feedback Systems Theory and applications in the field of medicine and biology of these concepts.

Students should know and understand:
1 - Fundamental concepts of the theory of feedback linear and non-linear systems.
2 - Complex algebra and Laplace and Z transforms.
3 - Rational transfer functions. Concepts of poles and zeros concepts. Characteristic equation.
4 - Response characterization of of 1st and 2nd order sections in time and frequency domains. Stationary and transient regimes.
5 - Concept and construction rules root-locus diagrams.
6 - Canonical control topologies on time and frequency domains.
7 - Methodologies for Identification of systems.

Learning outcomes and competencies:

1- Introduction and motivation to dynamic systems and control theory using real cases from the field of biology, medicine and biotechnology.
2- Fundamentals of complex algebra. Laplace and Z transfroms. ROCs.
3-Linear and Non-linear feedback systems.
4- Transfer function and responses in time and frequency domains. Final and initial value theorem.
5- Block diagram and canonical topology of a control system.
6- Open and closed loops transfer functions. Systems Identification.
7- Characteristic equation and stability criteria.
8- Effects of feedback and steady-state tracking errors.
9- Root-locus diagram. Construction rules.
10- Design of controllers in the time domain. Controllers, P, PI, PD and PID.

ADVANCED ALGORITHMS

Responsible lecturer: Alexandre Francisco
ECTC: 6.0
Course type and weekly hours: lecture (2 h) + laboratory (1.5 h)
Exam type: Exam (50%), Pratical work (50%)

Exam and practical work. The exam contributes 50% to the final mark (FM) and a student must achieve at least the mark 7.5 in one of the exams. The practical component contributes 50% to the final mark (FM).
FM = 0.5 * max(E1, E2) + 0.5 * P
Approved if max(E1, E2) >= 7.5 and FM >= 9.5.

Contents:

Data structures and algorithms are the basic building blocks of any computer system and they become even more relevant when such systems have to process huge volumes of data and/or have to meet real time processing requirements. The aim of this course is to provide advanced training in techniques for the development and implementation of efficient algorithms and applications, with particular focus on advanced data structures and algorithms for indexing, on randomization, sampling and approximation schemes, taking into account real time and/or large data processing requirements. This course will follow a problem based learning approach where techniques and methods will be intuitively and constructively explored, including relevant implementation techniques.

Learning outcomes and competencies:

1. Design and analysis of advanced data structures such as B-trees, splay-trees and Cartesian trees.
2. Priority queues based on Fibonacci, binomial, and relaxed heaps.
3. Amortized analysis.
4. Succinct/compact data structures.
5. Algorithms and data structures for efficient string processing, such as suffix trees and arrays.
6. Algorithms and data structures for efficient tree and graph processing.
7. Combinatorial optimization.
8. Probabilistic and game theory techniques applied to the analysis and design of algorithms and data structures.
9. Approximation algorithms.
10. Algorithms with random choices.
11. Streaming and online algorithms.
12. Algorithms and data structures for processing large volumes of data.
13. Implementation techniques, practical usage, and experimental evaluation.

Literature:

- Randomized Algorithms: Rajeev Motwani and Prabhakar Raghavan 2000, Cambridge University PressGenome-Scale Algorithm Design: Veli Mäkinen, Fabio Cunial, Djamal Belazzougui, and Alexandru I. Tomescu 2015, Cambridge University
- Introduction to Algorithms: Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein 2009, MIT Press
- Probability and Computing: Randomized Algorithms and Probabilistic Analysis Michael Mitzenmacher and Eli Upfal 2005, Cambridge University Press
- Combinatorial Optimization: Polyhedra and Efficiency, Alexander Schrijver 2004, Springer
- Combinatorial Optimization: Theory and Algorithms Bernhard Korte and Jens Vygen 2008, Springer

- Mining of Massive Datasets: Jure Leskovec, Anand Rajaraman, and Jeff Ullman 2019, Cambridge University Press
- Art of Computer Programming: Donald E. Knut 1998, Addison-Wesley

Keywords: Algorithms.

DEEP LEARNING

Responsible lecturer: Manuel Cabido Lopes
ECTC: 6.0
Course type and weekly hours: lecture (2h) + laboratory (1.5 h)
Exam type: Mini-tests during the class period, which may include a laboratory component (50%) + final exam (50%).

Contents:

Deep learning is a class of methods (from the broader area of machine learning) that over the last decade has had a huge impact on many applications, from image analysis to natural language processing. The aim of this course is to provide students with a general knowledge of modern deep learning techniques and the ability to develop, implement, and test methods of this class. Another objective is to provide students with the necessary training so that they can access the modern literature in this area, thus enabling them to update their knowledge in this rapidly evolving area.

Learning outcomes and competencies:

1. Supervised learning. Regression and classification. Loss functions, expected risk and empirical risk, and generalization.
2. Multi-layer perceptrons. Activation functions. Fully-connected layers and convolutional layers. Pooling. Residual networks. Probabilistic interpretations.
3. Optimization and the backpropagation algorithm. Regularization. Stochastic optimization. Initialization strategies.
4. Deep networks for vision and image processing (segmentation, classification, object detection, reconstruction).
5. Deep nets for natural language processing. Learning word representations. Recurrent networks. Backpropagation through time. Gated units: LSTMs and GRUs. Encoder-decoder architectures for sequence-to-sequence learning.
6. Deep generative models and unsupervised learning. Variational auto-coders and adversarial generative networks.
7. Advanced topics: attention and memory mechanisms.

Literature:

- Artificial Intelligence Engines: A Tutorial Introduction to the Mathematics of Deep Learning James Stone 2019, Sebtel Press
- Introduction to Deep Learning: Eugene Charniak 2019, MIT Press

- Deep Learning: Ian Goodfellow, Yoshua Bengio, Aaron Courville 2016, MIT Presshttp://www.deeplearningbook.org/
- Deep Learning with Python: François Chollet 2017, Manning Publicationshttp://https://www.manning.com/books/deep-learning-with-python

Keywords: Machine Learning.

2nd year, 1st semester (autumn/winter semester)

INNOVATION AND ENTREPRENEURSHIP 3 (10 ECTS)

THE HMDA´S SCHOOL ON LEARNING FROM HEALTH DATA

This summer school is offered and held by UGA for all HMDA students, and includes the preparation, execution, and documentation of a practical project, which is based upon a real use case in the healthcare context.

ANATOMY AND HISTOLOGY

Responsible lecturer: Carlos Plancha
ECTC: 6.0
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: Quizzes (20%), Seminar (20%), Exam (60%)

Contents:

1. Major cell types and tissues Epithelium. Connective. Muscle. Nerve.
2. Stem cells and cell therapy Concept of stem cell, embryonic stem cells, in vitro models. Induced pluripotent cells. Clinical applications.
3. Musculoskeletal System Bone: ossification / Remodeling, Repair in traumatology. Joins and Movement. Prostheses. Skeletal muscle: contraction; kinetic evaluation.
4. Nervous system Brain / Spinal Cord / Spinal Nerves / Cranial Nerves / Autonomic nervous system. Neurosurgical procedures.
5. Blood and Immune System Cells and plasma; differential blood cell count. Lymphoid organs: Bone marrow / Thymus / Lymph nodes /Spleen / Tonsils; Flow cytometry and transplantation.
6. Digestive System Esophagus and Gastrointestinal tract, glands attached to the gut; endoscopy / biopsies.
7. Respiratory system Airways / Lung / Ventilation. Assisted ventilation.
8. Endocrine System Hypothalamus / Pineal / Thyroid / Parathyroid / Adrenal / Pancreas
9. Cardio-Vascular System Heart and circulatory system. Major arteries and veins. Valvular and vascular prostheses.
10. Urinary System Kidney and urinary tract. Dialysis.
11. Reproductive System (Male and Female) Testis and spermatogenesis. Ovary and follicle development. Infertility and Medically Assisted Reproductive Technology
12. Eye and Vision; Ear and Hearing

Learning outcomes and competencies:
At the end of the curricular unit the student must know:

1. the basic structure of cells, tissues, and organs, being able to correlate them with their respective functions in the body.

2. the language used in these scientific areas of Medicine, that will greatly facilitate the future interactions with the different health professionals.

Literature:

- Introduction to the Human Body: The Essentials of Anatomy & Physiology, 9th Edition: Gerard J. Tortora, Bryan Derrickson 2011 John Wiley & Sons
- Color Atlas of Cytology, Histology and microscopic Anatomy, 4th Edition: Wolfgang Kuehnel 2003 Thieme

Keywords: Human Anatomy and Physiology.

INFORMATION PROCESSING AND RETRIEVAL

Responsible lecturer: Bruno Martins
ECTC: 6.0
Course type and weekly hours: lecture (2 h) + laboratory (1.5 h)
Exam type: Final exam (60%), Class Project (40%)

40% Class Project (P) with two parts (P1, P2) + 60% Final Exam (E) ;
Final Grade: 0.2xP1 + 0.2xP2 + 0.6xE
Minimum Grade: 9,5 on (P) and 9,5 on (E)
Working-Students (must be formally recognised as such): must complete the project but may develop it individually.

Contents:

The course provides an introduction to the key-concepts and technologies used for data processing in the areas of Information Retrieval, Information filtering and Information Extraction.
Students of this course will learn the basic theoretical concepts and acquire the practical skills needed to:
1. Design modern solution for processing, managing and querying large volumes of information;
2. Classify and group automatically sets of resources (e.g. large sets of textual documents);
3. Design search and filtering mechanisms for large collections;
4. Design systems to extract information from text and/or the Web;
5. Evaluate empirically such systems.

Learning outcomes and competencies:

1. Introduction to Information Retrieval and Information Extraction
2. Non-structured data models
3. Evaluation of Information Retrieval Systems
4. Semi-structured data models and Web data extraction
5. Link analysis and Web information retrieval
6. Indexing and querying non-structured information
7. Similarity search
8. Recommendation Systems
9. Distributed processing for information retrieval and extraction

10. Applications: Enterprise search and expert search, Digital libraries, Opinion mining, Digital Advertising

Literature:

- Modern Information Retrieval, the concepts and technology behind search -2nd edition: Ricardo Baeza-Yates and Berthier Ribeiro-Neto2011Addison-Wesley Professional
- Web Data Mining: Exploring Hyperlinks, Contents and Usage Data -2nd edition: Bing Liu2011Springer.

Keywords: Search, Information Extraction, Text mining, Opinion Mining, Recommendation Systems.

2ND CYCLE INTEGRATED PROJECT IN COMPUTER SCIENCE AND ENGINEERING

Responsible lecturer: Daniel Gonçalves
ECTC: 12
Course type and weekly hours: Individually supervised self-study
Exam type: For project types 1 and 2, a report must be submitted for evaluation and discussion by a jury of at least) two professors.
For project type 3, evaluation will be continuous, with 3 moments of public exposure (initial pitch (30%) + midterm presentation (30%) + final presentation (40%)); The submitted elements will be guided for the development of a portfolio of variable content, depending on the project (website, report/poster, presentation, dissemination video). Evaluation should be conducted by a jury of (at least) two professors, and include peer-evaluation (5% at each stage).

Contents: /

Learning outcomes and competencies:
The project is initially defined by the supervisors or under the supervisors guidance. It can be carried out individually or in groups, and take place at IST or outside IST (universities, research centers or companies). The following modalities are possible:

1. Scientific project: an in-depth and academically rigorous analysis of a scientific, technological or management challenge. May include experimental and/or computacional work.
2. Company project: individual project focused on a specific challenge posed by a host company that requires a solution or analysis targeted for short term implementation.
3. SCOPE project: multidisciplinary team work based on real and complex problems/challenges posed by companies or other institutions that require inputs from students from different courses of IST or the University of Lisbon.

Literature: /

Keywords: Project Planning, Innovation, Entrepreneurship, Sustainability.

PROJECT IN PRECISION MEDICINE

Responsible lecturer:
ECTC: 12
Course type and weekly hours:
Exam type: The assessment is based on a report organized in the form of a scientific paper in English, containing the experimental, computer and / or modeling work done, and its presentation and discussion.

Contents:

The objective of this course is the development of an individual project of interdisciplinary scientific and / or technological nature that fits within the scope of training in Precision Medicine. The specific learning objectives will depend on the specific project, but in general the students should apply, extend and integrate the knowledge previously acquired in the different curricular units of this master. This project could serve as a seed for the master dissertation theme.

Learning outcomes and competencies:

The learning topics will depend on the specific project, but should use concepts and tools from stem cell biology and engineering, genomics, artificial intelligence and information systems and databases, and potentially provide new diagnostics and personalized treatments in hematologic, oncologic, cardiovascular, neurodegenerative and musculoskeletal diseases, among many others, resulting in an advanced training in Precision Medicine. In this context, the project should respond to research or innovation challenges and use advanced experimental and computational techniques.

Literature:/

Keywords: Project Planning, Innovation, Precision Medicine.

HMDA specialization (20 ECTS)

BIOMEDICAL DECISION AND INFORMATION TECHNOLOGY

Responsible lecturer: Mário Gaspar da Silva
ECTC: 6.0
Course type and weekly hours: lecture (2 h) + laboratory (10 h) + TC (0.5h)
Exam type: 50% homeworks (average of 4 homeworks, no minimum grade) + 50% written exam (90min; 9.5 minimum grade)

Contents:

The general objective of the course is to provide the fundamental principles and concepts related to the use of information technology in health care. Students will acquire essential competencies and knowledge on the use of information technology in biomedical research and its crucial role in the provision of health care services.

Learning outcomes and competencies:

1. Information Technology in the life sciences.
2. Acquisition processing and use of biomedical data.
3. The Electronic Health Record.
4. Clinical information systems.
5. Tele-monitoring and Tele-Health.
6. Natural language processing and biomedical text mining.
7. Thesauri and Ontologies.
8. Health Informatics data interchange standards.
9. Information Search.
10. Clinical Decision-support Systems.
11. Bioinformatics and Biomedical Research Infrastructures.
12. Genetics and epigenetics of human health.
13. Precision medicine.
14. Ethical, Legal and Social Issues in IT in Health.
15. Public Health Informatics.
16. IT for Healthy Living and Active Ageing.
17. Consumer Health Informatics.
18. IT in user training and education of health professionals.

Literature:

- Biomedical Informatics: Computer Applications in Health Care and Biomedicine: Edward H Shortliffe and James J. Cimino2014ISBN: 978-0-38728986-1
- Medical Informatics: Knowledge Management and Data Mining in Biomedicine:Hsinchun Chen, Sherrilynne S . Fuller, Carol Friedman, William Hersh (eds.)2005Springer. ISBN: 978-0387-2438 1-8

Keywords: Biomedical Informatics, Health ICT.

HANDS-ON EPIGENETICS: MULTI-OMIC DATA ANALYSIS (MOOC)

Responsible lecturer: Prof. Rui Henriques
ECTC: 4.0 (recommended)
Course type and weekly hours: MOOC i
Exam type: um midterm quiz per topic

Contents:

Topic 1

- genetic and epigenetic stances on human health and disease
- essentials of cell behavior and coordination with other cells
- the human genome, its mutation profile and link with disease
- the role of proteins and ncRNAs on human health
- genomic, epigenomic, transcriptomic, proteomic and metabolomic markers of disease

Topic 2

- epigenetic markers and human health
- major epigenetic mechanisms: DNA methylation, histone modifications and RNA-mediated regulation
- the interplay between epigenetic mechanisms
- the epigenetic code and its link with disease, including oncological and neurodegenerative disorders

Topic 3

- structured view on current and future therapeutics targeting the biological mechanisms driving disease
- molecularly targeted therapies and human health: antibody therapy, immunotherapy and neoantigen therapy
- external sources of protein and RNA supplementation
- epigenetic drugs and human health
- stem-cell science therapeutics: cell transplant, dialysis, somatic cell nuclear transfer, dedifferentiation
- comprehensive view on molecular medicine and oncological disorders

Topic 4

- epigenetics and (non-)identical twins, links between our biology and the environment
- the epigenetics of memory, childhood neglect and abuse, depression, weight, neurological disorders, aging, and addiction
- the epigenetics of inheritance
- advances on epigenetics' research from the stance of lab experiments

- consolidated view on epigenetic-driven study, prediction and treatment of human diseases

Learning outcomes and competencies:

On the foundations of human health:

- master the essentials of cell behavior and coordination with other cells
- understand the role of our human genome and its link with disease
- acquire a structured view on the regulatory mechanisms of the cell
- contrast the genetic and epigenetic stances on human health and disease
- be familiar with the molecular fingerprint of cells (including their genome, transcriptome, proteome and metabolome)
- autonomously establish hypotheses on the biological mechanisms driving disease

On the epigenetic mechanisms:

- understand the role of epigenetic markers and how they vary within our body and amongst us
- master the major epigenetic mechanisms of our cells, including DNA methylation, histone modifications and RNA-mediated regulation
- understand the interplay between the previous epigenetic mechanisms and their link with disease
- glimpse view on epigenetic-driven breakthroughs to study human disorders

Keywords: epigenetics, multi-omic data analysis, precision medicine.

CLOUD COMPUTING AND VIRTUALIZATION

Responsible lecturer: Luís Antunes Veiga
ECTC: 6.0
Course type and weekly hours: lecture (2 h) + laboratory (1.5 h)
Exam type: Exam (40%), Project (45%), Paper presentation (10%)+ Attendance/Participation (5%)

Normal Method: Exam (40%), Project (45%), Paper Presentation (10%) and Attendance/Participation (5%). There is a checkpoint to the Project whose grade can only improve the final grade. It has a weight of 15% in the global Project grade.
Student-Workers: Exam (45%), Project (45%), Paper Presentation (10%).
"Época Especial": Exam (50%), adapted Project (50%).
Minimum grade for Exam and Project: 8 points.

Contents:

Attain an integrated perspective of cloud computing and virtualization, with combined approaches for the design of modern large scale and distributed computing systems, and with their underlying mechanisms and algorithms.
Understand a vertical approach to the various virtualization and cloud computing technologies, enhancing applications and services with improved flexibility, resource and economic efficiency, scalability and adaptability.
To be able to develop reliable and scalable systems and applications, on cloud computing over current virtualization platforms and applications models.

To be able to assess and evaluate solutions, given the alternatives and tradeoffs involved in the employment and management of virtualization infrastructure for cloud computing.

Learning outcomes and competencies:

1. Introduction to Virtualization and Cloud Computing, IaaS, PaaS, SaaS.
2. System virtualization: system VM architecture, CPU virtualization, memory; hardware support; case studies (VMWare, QEMU/KVM, Xen).
3. Cloud computing systems (Amazon EC2, OpenStack, Microsoft Azure); VM scheduling, migration and replication; monitoring and scalability (CloudWatch, Autoscaling).
4. Process-level virtualization: Java VM specification and architecture, security model, just-in-time compilation and optimization, garbage collection, case studies (Jikes RVM).
5. Cloud computing platforms (Google App Engine, Azure); monitoring and scalability (Azure Fabric Controller).
6. Big-Data storage: block storage, file storage, key-value stores (Dynamo, S3, Datastore), tabular (BigTable, Percolator).
7. Big-Data Processing: Map-reduce, dataflows (Pig, Dryad/LINQ), streams (Spark, Flink). Cross-cutting concerns: energy efficiency, dynamic provisioning, energy centered design.

Literature:

- Virtual Machines: Versatile Platforms for Systems and Processes: James Smith and Ravi Nair2005Morgan Kaufmann
- Cloud Computing: Theory and Practice_ Second Edition Dan C. Marinescu 2017 Morgan Kaufmann_ISBN 9780128128107
- Cloud Computing for Science and Engineering Ian Foster and Dennis B. Gannon 2017 MIT Press_ISBN: 97802620372420

Keywords: Cloud Computing.

PARALLEL AND DISTRIBUTED COMPUTING

Responsible lecturer: José Monteiro
ECTC: 6.0
Course type and weekly hours: lecture (2 h) + laboratory (1.5 h)
Exam type: Exam (40%), Project (60%); Minimum grade of 7,5 in each component.

Contents:

Understand the models, techniques, and programming methods for parallel algorithms. Learn to analyse and design parallel programs. Hands-on experience on developing programs for shared- and distributed-memory systems. Overview of parallel algorithms in different application areas.

Learning outcomes and competencies:

1. Parallel computing architectures.
2. Flynn's taxonomy.
3. Programming models: multicores and multicomputers; memory organization; overheads.
4. Analysis and synthesis of parallel algorithms: problem partitioning; data organization; communication and synchronization; load balancing; scheduling.
5. Performance metrics.
6. Programming shared-memory systems: OpenMP, threads, race conditions, deadlock detection.
7. Programming distributed-memory systems: interconnection networks; message-passing, MPI.
8. Hybrid programming.
9. Heterogenous computation: GPU; FPGA.
10. Application areas: numerical methods: matrix multiplication, systems of linear equations; algorithms on graphs; sorting; search and optimization algorithms; Monte Carlo methods; others.

Literature:

- Parallel Programming: Michael Quinn 2003, McGrawHill
- Parallel Programming: Techniques and Applications Using Networked Workstations and Parallel Computers: Barry Wilkinson and Michael Allen 2005, Prentice Hall
- Designing and Building Parallel Programs: Concepts and Tools for Parallel Software Engineering, Ian Foster 1995, Addison Wesley

Keywords: parallel programming, distributed computing.

2nd year, 2nd semester (spring/summer semester)

MASTER THESIS IN COLLABORATION WITH INDUSTRY PARTNER OR HOSPITAL (30 ECTS)

Objective and learning outcomes:

- The master thesis in Biomedical Engineering is typically a research project or study, or an extended analysis of a topic of scientific or technological nature. The goal is for students to perform research and apply the knowledge acquired during their studies while at the same time developing skills like initiative, autonomy skills, decision, and organization.
- The main learning output of this master thesis is the students' ability to work on a BME program, and to translate research into applications –in cooperation with a non-academic business partner. This innovative approach is based on the mobility of students, exchanging experiences in different disciplines, and establishing a common high-quality standard in education and training.
- At the end of the master thesis students work should reflect the EIT OLOs 1-6.

Content:

The program is defined according to the supervisor orientation and to the type of theme and it is developed during one of the semesters of the last year of the MSc Course. Following the MSc procedures, the Education Committees has assessed the scientific quality and feasibility of the master thesis proposals. It is anticipated that the thesis will be relevant to the student's track and will address a question of importance in the student's field of expertise. Students are expected to design a research project, write a formal research protocol, perform the study described in it, and prepare a comprehensive scholarly scientific paper reporting the results. Optionally, part of the master project could be done at another institute or company outside Partner Universities, but in this case, it is always under supervision of a Partner University staff member. To achieve their research project, students are required to write a scientific paper under guidance of their research supervisors, and to give a presentation about the research performed. The scientific paper must be approved by the academic supervisor and be suitable for submission to an international, scientific journal. The thesis can take place at universities, research centers or companies. As mentioned above, the thesis requires an advisor from the Engineering side and a co-advisor from a non-academic partner.