Module Handbook for M.Sc. Health and Medical Data Analytics

Study track at UL

Please note, that all modules presented are just a selection of elective courses.
For more information, please visit the website of the respective university.

General Content

Curricula at:
https://fenix.tecnico.ulisboa.pt/cursos/meic-a/curriculo
https://fenix.tecnico.ulisboa.pt/cursos/mebiom/curriculo
https://fenix.tecnico.ulisboa.pt/cursos/meec/curriculo (entrepreneurship course only)

1 Alignment

Common Core (20ECTS):

- (sem1) Network Science (7.5 ECTS);
- (sem1) Data Science (7.5 ECTS);
- (sem1) Data Analysis and Integration (7.5 ECTS);
- (sem1) Information Visualization (7.5 ECTS)

Master‘s electives (20 ECTS):

- (sem 1) Business Process Management (7.5 ECTS),
- (sem 1) Natural Language (7.5 ECTS),
- (sem 2) Advanced Algorithms (7.5 ECTS),
- (sem 2) Machine Learning (7.5 ECTS),
- (sem 2) Cloud Computing and Virtualization (7.5 ECTS)
- (sem 2) Parallel and Distributed Computing (7.5 ECTS),

HMDA specialisation (20 ECTS):

- (sem1) Bioinformatics (7.5 ECTS);
- (sem 2) Health ICT (7.5 ECTS);
- (sem 2) Multi-Omic Data Analysis (3 ECTS) (for incoming students only);
- Medical Imaging (6 ECTS);
- Neuroengineering (6 ECTS);
- Signals and Systems in Bioengineering (6 ECTS);

I & E 1 (10 ECTS):

- (sem 1)Information Systems Project Management (7.5 ECTS),
- (sem 1) User Centered Design (7.5 ECTS),
- Entrepreneurship, Innovation and Technology Transfer (6 ECTS)

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

- (sem1, sem2) Master Project in Information and Software Engineering (12 ECTS);
- (sem 1) Project in Biomedical Engineering (6 ECTS) (for incoming students only)

I & E 3 (10 ECTS):

- Information Systems Project Management (7.5 ECTS),
- User Centered Design (7.5 ECTS);
- Entrepreneurship, Innovation and Technology Transfer (6 ECTS

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

2.1 HMDA Common Core :

2.1.1 Network Science

1 Year, 1 Sem.
Responsible lecturer: Francisco Correia dos Santos
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: project developed by group of 2-3 students (50%), exam (50%)

Contents:
This course provides an introduction to the study of complex networks, including algorithms, models and applications to both artificial and real networks, including social, biological and technological networks, all sharing common features and properties. The course addresses the development of scalable algorithms and data structures so that we can efficiently study large complex networks, but also in the creation of theoretical models capable of describing empirically observed patterns. The number of applications is enormous, including web search engines, evolutionary dynamics, information diffusion on Internet, social networks and blogs, network resilience, network-driven phenomena in epidemiology and computer viruses, networks dynamics, with connections in the social sciences, physics, computational biology, and economics.

Learning outcomes and competencies:
Introduction to complex systems and networks science: Theory and basic concepts. Properties and characterization of biological, social and technological networks. Network models and random graphs. 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, including both sampling and randomization techniques. Databases and distributed platforms for the analysis of large networks. Link analysis and random walks. Community finding and graph partitioning. Ranking algorithms. Vertex relabeling. Dynamical processes on complex networks:
The impact of network structure on economic, social and biological systems. Introduction to stochastic processes, Monte-Carlo simulations and large-scale multi-agent systems. Disease spreading and tolerance to attacks. Models of peer-influence and opinion formation. Game theory and population dynamics. Public goods problems, cooperation and reputation dynamics. Decision making on (static and adaptive) interaction networks.

Literature:

- Algorithms on strings Trees, and Sequences: Dan Gusfield 1997 Cambridge press
- Networks, Crowds, and Markets: Reasoning about a Highly Connected World: Easley, D. and Kleinberg, J. 2010Cambridge University Press
- Networks: An Introduction: M. E. J. Newmann 2010 Oxford University Press
- Network Science: Barabási, A.-L. 2016 Cambridge University Press
- Lectures on Complex Networks: Dorogovtsev, S.N. 2010 Oxford University Press
- Graph Theory in the information age: F. Chung. 2010 Notices of AMS, 57(6):726-732
- Mining of Massive Datasets: J. Leskovec, A. Rajaraman, J. D. Ullman 2011 Cambridge Univ. Press
- Dynamical processes on complex networks: Barrat, A., M. Barthelemy, and A. Vespignani 2008 Cambridge University Press

Keywords: Network Science, Complex Networks

2.1.2 Data Science

1 Year, 1 Sem.
Responsible lecturer: Cláudia Antunes
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: project (50%), exam (50%)

Contents:

1. Data Science. What is data science? The multidisciplinary nature. Data engineering vs. Data science. The role of a data scientist.
2. Knowledge Discovery Process. Formulating questions.Exploratory data analysis. Pre-processing overview. Evaluation overview - Occam's razor. Information Visualization overview. Documenting the process: Notebooks.
3. Pre-processing. Data scaling and centring. Data reduction: PCA, SVD, DFT, wavelets, SAX. Data balancing: resampling and SMOTE. Data discretization: equal-width, equal-frequency, taxonomies. Labelling.
4. Pattern Mining. Association rules - apriori algorithm. Closed vs Maximal patterns. Evaluation metrics: support, confidence, lift and Jaccard
5. Clustering. Algorithms: K-means, hierarchical. Evaluation: SSE (MSE), silhouette coefficient, Dunn and DB indexes.
6. Classification and Regression. Supervised learning: overfitting, training strategies, cross-validation. Linear and logistic regression. Classification Algorithms: KNN, Naive Bayes, Decision trees: metrics and pruning. Ensembles: AdaBoost, Random forests. Evaluation: Metrics (Accuracy, sensibility and specificity, f-measure, ROC area, confusion matrix); ROC and Lift charts
7. Outliers detection.
8. Privacy-preserving data mining.
9. Large-scale data mining. Parallelization: map-reduce, online algorithms. Indexing: LSH, Multidimensional.
10. Case Studies / Advanced Topics (9h) Time series and sequential analysis. Social Networks analysis; Mining graphs. Recommender Systems, Computational Advertising. Text and opinion mining. Process Mining. Stream Processing and Mining. Computational biology

Learning outcomes and competencies:
Students should be able to:

- Understand the statistics and data processing concepts used in complex information processes.
- Design systems for knowledge discovery processes automation, and communication of their outcomes using the appropriate algorithms and validation methods at each stage.
- Understand the techniques for frequent patterns recognition and outlier detection in data sets.
- Identify sensitive data that might be subject to processing restrictions and data anonymization techniques that enable privacy-preserving data mining,
- Address large-scale data processing challenges.

Literature:

- Data Mining and Analysis: Fundamental Concepts and Algorithms: Mohammed J. Zaki, Wagner Meira, Jr. 2014 Cambridge University Press

Keywords: Data Science, Data Mining, Data Analytics

2.1.3 Data Analysis and Integration

1 Year, 1 Sem.
Responsible lecturer: Helena Galhardas
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: exam (55%), 3 small projects(45%)

Contents:

1. Main challenges of data integration processes; data integration paradigms. Heterogeneous data sources: XML data management and processing.
2. Heterogeneous data sources: (sensor) data stream management and processing. Virtual data integration: wrappers and mediators; query expression manipulation.
3. Query answering using views; source descriptions.
4. Schema mapping languages: global-as-view and local-as-view; schema mapping and matching.
5. Wrappers: manual and automatic construction.
6. Data warehousing: multi-dimensional modeling and data warehouse conception.
7. OLAP (Online-Analytical Processing) and ETL (Extraction-Transformation-Loading).
8. Caching and partial materialization; reporting. Data Exchange: declarative warehousing.
9. Data cleaning: taxonomy of data quality problems; data quality dimensions.
10. Approximate duplicate detection: string and data matching algorithms.
11. Data fusion. Mash-ups: motivation, creation and application.
12. Data Provenance and Applications

Learning outcomes and competencies:
The course on Data Analysis and Integration aims at teaching the students the most important concepts of data integration according to two different perspectives: virtual data integration, where the data sources can be accessed through a mediator-based architecture; and materialized data integration, where a materialized data repository (named data warehouse) is populated with data coming from the data sources. Additionally, the course will teach techniques that can be used to exploit information: OLAP (On-line Analytical Processing) and reporting in a warehoused architecture, and mash-up systems in a virtual architecture. The data integration processes aim at supplying, among other applications, a uniform view over a set of autonomous and heterogeneous data sources, making it easy the access to source data for analysis and visualization purposes. Their application domains are diverse, ranging from the Business Intelligence systems to scientific research systems (e.g., Bioinformatics).

Literature:

- Principles of Data Integration: Anhai Doan, Alon Halevy and Zachary Ives. 2012 Morgan Kaufmann.

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

2.1.4 Information Visualization

1 Year, 1 Sem.
Responsible lecturer: Daniel Gonçalves
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: exam (35%), labs (25%), project (40%)

Contents:

1. Introduction
2. Design Methodology
3. Datasets and variables
4. Human Factors in InfoVis
5. Visualization Types
6. Visualization Techniques
7. Dynamic visualizations and animations
8. Item and Attribute reduction
9. Legibility and fidelity of visualizations
10. Evaluation of InfoVis Solutions
11. Applications

Learning outcomes and competencies:
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 problem domains and conceiving effective visualizations. Afterwards, we'll discuss the different kinds of variables (continuous, nominal, ratio, etc.), data (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 (focus+context, overview+detail, panning+zoom, brushing, etc). Finally, we'll address issues related with the evaluation of the effectiveness of InfoVis 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

Keywords: Information Visualization

2.2 HMDA specialisation (20 ECTS):

2.2.1 Anatomy and Histology

1 Year, 1 Sem.
Responsible lecturer: Carlos Plancha
ECTC: 6.0 ECTS
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

2.2.2 Bioinformatics (alternative: Computational Biology, 6ECTS, for incoming)

1 Year, 1 Sem.
Responsible lecturer: Susana Vinga
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: 4 laboratory work (20%), 2 tests or 1 exam (70%), 1 seminar (10%)

Contents:

- Introduction, Molecular biology main concepts, Introduction to algorithms and complexity
- Graphs and genetics
- DNA sequence analysis
- Pairwise alignment
- Multiple Sequence alignment
- Motif finding
- NGS data, algorithms and data structures
- Probabilistic models
- Gene expression data analysis
- Data mining
- Unsupervised Learning: Clustering and Biclustering
- Molecular phylogenetics
- Supervised Learning: Decision trees, Bayesian methods Integrative data analysis
- Seminar

Learning outcomes and competencies:
Bioinformatics 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.

Literature:

- An Introduction to Bioinformatics Algorithms: N. C. Jones and P. Pevzner 2005 MIT Press
- Biological Sequence Analysis - Probabilistic models of proteins and nucleic acids : R. Durbin, S. Eddy, A. Krogh, G. Mitchison 1998 Cambridge
- Data Mining: Practical Machine Learning Tools and Techniques : Ian H. Witten, Eibe Frank, Mark A. Hall 2011http://www.cs.waikato.ac.nz/ml/weka/book.html
- Bioinformatics and Biomarker Discovery: "Omic" Data Analysis for Personalized Medicine: Francisco Azuage 2010Wiley Blackwell

Keywords: Bioinformatics Algorithms

2.3 Electives:

2.3.1 Business Process Management

1 Year, 1 Sem.
Responsible lecturer: Pedro Sousa
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: 1 exam (60%), group project (40%)

Contents:

1. Introduction to Business Process Management
2. Process Identification
3. Process Modeling
4. Process Discovery
5. Process Conformance
6. Process Analysis
7. Process Redesign
8. Process Automation

Learning outcomes and competencies:
This course provides an engineering perspective on the fundamental concepts, techniques and tools associated with the business process management life-cycle. The topics addressed in this course focus on the identification, documentation, modelling, validation and verification, and optimization of organizational business processes using process analysis, design and automation techniques. The learning objectives are as follows:

1. Understand the role of business processes within and between organizations.
2. Understand the relationships and dependencies between processes, enterprise architecture and the application and technological infrastructure.
3. Analyse and design business processes using business process modelling languages.
4. Analyse business processes using manual, semi-automated and automated techniques, including architectural principles and process mining.
5. Redesign and optimize business processes while keeping the traceability to the transformation requirements.
6. Understand the role of business process management systems (BPMS).
7. Understand the role of BPM tools, especially modelling and analysis tools.

Literature:

- Fundamentals of Business Process Management: Marlon Dumas, Marcello La Rosa, Jan Mendling, Hajo A. Reijers. 2013 Springer.

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

2.3.2 Natural Language

1 Year, 1 Sem.
Responsible lecturer: Luísa Coheur
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: 4 tests or 1 exam (60%), 2 projects (each 10%), 12 exercises (20%)

Contents:

1. Course overview. (1h)
2. Introduction to Natural Language Processing. (3.5h)
    a. Basic concepts
    b. Ambiguity and linguistic variability
    c. Associated knowledge
    d. Methodology
    e. Train/test corpus, Cross validation, Measures (precision, recall, etc.)
3. Regular expressions and automata (1.5h)
4. N-Grams (4.5 h)
    a. N-grams as language models
    b. Markov assumption and probabilities of an N-gram/sentence
    c. Smoothing techniques
5. Morphology (9h)
    a. Morphology and transducers
    b. Part of speech tagging (POS)
    c. Rule-based and stochastic HMMS and Viterbi algorithm
6. Syntax (9h)
    a. Grammars
    b. Context-free grammars
    c. Dependency grammars ´
    d. Probabilistic grammars
    e. Syntactic analysis
    f. Unification-based Top-down and Bottom-up
    g. Chat-parsers (Earley e CKY)
    h. Probabilistic
7. Semantic (9h)
    a. Meaning representation
    b. Lexical semantics
    c. Thematic roles
    d. Semantic disambiguation
    e. Semantic analysis
    f. Compositional semantic analysis
    g. Statistic-based semantic analysis
    h. Classifiers and their application in semantic analysis
    a. Applications (remaining classes)
    a. Information extraction (named entity recognition, etc.)
    b. Text classification
    c. Question/answering systems
    d. Dialogue systems
    e. Machine translation
    f. Speech recognition

Learning outcomes and competencies:

- 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.

Literature:

- Speech and Language Processing (3rd ed. draft): Dan Jurafsky & James H. Martin 2017https://web.stanford.edu/~jurafsky/slp3/
- Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition, Second Edition: Daniel Jurafsky & James H. Martin 2009 Prentice-Hall

Keywords: Natural Language Processing, Text Mining

2.3.3 Information Processing and Retrieval

1 Year, 1 Sem.
Responsible lecturer: Bruno Martins
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: final exam (55%), 3 mini-projects(45%)

Contents:

1. Introduction to Information Retrieval and Information Extraction
    a. IR system architecture
    b. Document pre-processing
2. Non-structured data models
    a. Boolean model
    b. Vector-space model
    c. Dimensionality reduction
    d. Probabilistic models
3. Information Extraction from text
    a. Classification and clustering of documents
    b. The naive Bayes classifier
    c. Information Extraction with hidden Markov models
4. Evaluation of IR Systems
    a. Evaluation metrics
    b. Reference collections
    c. Cross-validation and other issues
5. Semi-structured data models
    a. Semi-structured data models
    b. The Extensible Markup Language (XML)
    c. Markup languages based on XML (e.g., TEI, METS, MODS)
    d. Other languages (e.g., SGML, HTML e RDF)
6. Web Data Extraction
    a. Wrapper generation
    b. The XQuery language
    c. IR in XML documents

7. Link analysis
    a. Web models
    b. Basic concepts on graphs and link analysis
    c. Using links to rank documents
    d. Web crawling
8. Indexing and querying non-structured information
    a. Regular expressions
    b. Inverted Indexes
    c. Query processing
9. Similarity search
    a. Document shingling and the Jaccard similarity measure
    b. Similarity-preserving summaries of sets and min-hash
    c. Locality-sensitive hashing
    d. Applications in multimedia retrieval
10. Recommendation systems
    a. Context, personalization and information filtering
    b. Content-based recommendations
    c. Collaborative filtering
11. Distributed processing for IR and IE
    a. Data partitioning
    b. Federated search and meta-search engines
    c. Map-Reduce processing
12. IE and IR applications
    a. Enterprise search and expert search
    b. Digital libraries
    c. Opinion mining
    d. Other applications

Learning outcomes and competencies:
This course aims to provide the students with an complete and updated introduction to the key concepts and technologies used for data processing in the areas of Information Retrieval (IR), Information filtering (IF) and Information Extraction (IE). 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.

Literature:
- Modern Information Retrieval, the concepts and technology behind search - 2nd edition: Ricardo Baeza-Yates and Berthier Ribeiro-Neto 2011 Addison-Wesley Professional
- Web Data Mining: Exploring Hyperlinks, Contents and Usage Data - 2nd edition : Bing Liu 2011 Springer

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

3 1st year, 2nd semester (spring/summer semester):

3.1 HMDA specialization

3.1.1 Health ICT (or Biomedical Informatics for Incoming)

1 Year, 2 Sem.

Responsible lecturer: Mário Gaspar da Silva
ECTC: 7.5 ECTS (or 6 ECTS for incoming students)
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: 5 Biweekly assignments (50%) + written exam (90 min.) 50%

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

Learning outcomes and competencies:

The general objective of the course is to provide the fundamental principles and concepts related to the use of information technology in health care. The 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.

Literature:
- Biomedical Informatics: Computer Applications in Health Care and Biomedicine: Edward H Shortliffe and James J. Cimino 2014 ISBN: 978-0-38728986-1
- Medical Informatics: Knowledge Management and Data Mining in Biomedicine: Hsinchun Chen, Sherrilynne S . Fuller, Carol Friedman, William Hersh (eds.) 2005 Springer. ISBN: 978-0387-2438 1-8

Keywords: Biomedical Informatics, Health ICT

3.1.2 Hands-On Epigenetics: Multi-Omic Data Analysis (MOOC)

Responsible lecturer: Prof. Rui Henriques
ECTC: 3
Course type and weekly hours: MOOC (for incoming students)
Exam type: written exam (30 min.)

Contents:

1: Introduction to epigenetics

- The genetic code
- Code and personalized medicine
- Genome-wide association studies
- Limitations of genome-centric studies
- The role of epigenetics
- The central dogma
- Multi-omic data collection
- The need for multi-omic data analysis
- Epigenetics and personalized medicine
- Epigenetics in our daily life
- Case studies on identical twins
- Case studies on ancestral influence

2: Essential background on (biomedical) data analysis

- Sample omic datasets
- Data exploration
- Data preprocessing
- Clustering
- Biclustering and pattern mining
- Classification
- Regression

Module 3: Integrative multi-omics for personalized medicine

- Integrating multiple sources of omic data
- Essentials on heterogeneous data analysis
- The role of exposomics in personalized medicine
- Combining multi-omic and medical data for personalized medicine
- Unsupervised analysis of multi-omic data
- Enrichment analysis as the way of increasing current knowledge on epigenetics
- Comprehensive study of epigenetics from integrative patterns of disease
- Supervised analysis of multi-omic data
- Discovery of multi-source epigenetic markers for personalized medicine

Learning outcomes and competencies:

- structured view on epigenetics and its role in personalised medicine
- be familiar with current findings, opportunities and challenges in personalize medicine (along its prevention, diagnostic and treatment components)
- understand the relevance of genomic, proteomic, metabolomic, clinomic and exposomic data in epigenetics
- master essentials of supervised and unsupervised data analysis
- be able to analyze multiple sources of omic data and master principles on how to learn from heterogeneous multi-omic data

Keywords: epigenetics, multi-omic data analysis, personalised medicine

3.1.3 Epigenetics and Personalized Medicine

(MOOC, to be developed in the future)

Responsible lecturer: Prof. Rui Henriques
ECTC: 3
Course type and weekly hours: MOOC (for incoming students)
Exam type: written exam (30 min.)

Contents:

1. Omic markers for personalized medicine
   - Description and prediction tasks from multi-omic data
   - Specifying the problem at hands: data and learning requirements
   - Discovery of putative regulatory modules from omic data
   - Statistical significance versus biological significance
   - Enrichment analysis as the way of increasing current knowledge on epigenetics
   - Expanding and assessing current knowledge repositories
   - Learning omic markers for personalized diagnostics
   - Learning omic markers for personalized prevention and treatment decisions

2. Epigenetics and personalized medicine: a new era
   - Current findings on oncology: immunotherapy and beyond
   - Current findings on neurodegenerative diseases
   - Other evidence for disease prevention, diagnosis and treatment
   - Drug design from multi-omic findings 2. State-of-the-art epigenetic therapies
   - Structured overview of modules A–D 2. Concluding remarks

Learning outcomes and competencies:

- formulate personalised medicine problems as clustering, pattern mining, biclustering, classification, regression and tasks over one or more sources of omic data
- master state-of-the-art findings of epigenetics and the corresponding cutting-edge therapeutics
- be able to learn integrative markers from multi-omic time series data and critically validate them (statistical significance, robustness to noise and overfitting risks)
- formulate personalised medicine problems using advanced learning tasks
- understand current ways of expanding current knowledge on epigenetics from multi-omic data analysis

Literature:

Keywords: epigenetics, multi-omic data analysis, personalised medicine

3.1.4 Medical Imaging

1st Year, 2 Sem.
Responsible lecturer: Patrícia Figueiredo
ECTC: 6 ECTS
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, Nuclean Imaging, MRI, Ultrasound

3.1.5 Neuroengineering

2nd Year, 1 Sem.
Responsible lecturer: Patrícia Figueiredo
ECTC: 6 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: Exam (70%): covering all the modules' topics + Student presentation (30%): paper or essay regarding one of the course topics

Contents:
1 Current challenges for neuroengineering
2 Neuroscience basics
 a. Neural systems and behavior
 b. Brain cells and circuitry
 c. Neural communication, plasticity and degeneration
 d. Cognitive function and dysfunction
3 Computational neuroscience
 a. Neural coding and neural networks
 b. Computational cognitive neuroscience
4 Neuroimaging
 a. EEG and MEG
 b. Structural and functional MRI
 c. PET
 d. NIRS
5 Neural monitoring and diagnosis
 a. Statistical inference and model-based classification methods
 b. Emotion assessment and human identification c. Longitudinal studies
6 Neural interfaces a. Fundamentals of BCIs: neurophysiology, data acquisition and signal processing
 b. Direct EEG Interfaces, VEP, P300 and ERD/ERS c. Motor imagery and rehabilitation d. Applications
7 Neural modulation
 a. Neurofeedback using EEG and NIRS.
 b. Neural stimulation: DBS, TDCS, TMS
 c. Self-adaptive immersive neural stimulation
 d. Clinical and performance enhancement applications
8 Nanotechnology for neuroengineering
 a. Nanoparticle engineering
 b. Microsystems for neuroscience on a chip
9 Neural tissue engineering
 a. Biomolecular-based strategies for neural regeneration
 b. Cellular-based strategies for neural regeneration and disease modeling
 c. Acellular biomaterial-based strategies for neural regeneration
 d. Advanced tissue engineering strategies
10 Cognitive robotics
 a. Sensorimotor coordination
 b. Non-verbal communication
 c. Tools for rehabilitation

11 Complex brain networks
- a. Theory and basic concepts of complex networks
- b. Properties, representation, processing and analysis of large networks
- c. Applications to brain networks

Learning outcomes and competencies:

The main objective is to provide comprehensive background knowledge of the most important areas in the field of Neuroengineering, including the existing challenges and the main concepts and techniques that can be used to address them. The course comprises a series of modules addressing specific topics, each organized by an expert in the field. Students successfully completing the course are expected to:

1) have basic knowledge about the organization, structure, function and pathological modifications of neural systems;
2) have general knowledge about the principles, methodologies and applications of the main engineering techniques used to study and interact with neural systems, with the objectives of brain monitoring, diagnosing, modulating, repairing, enhancing or interfacing with machines; and
3) be prepared to critically evaluate different problems and techniques in Neuroengineering.

Literature:

- **Neural Engineering: Bin He 2013 2nd Ed., (ISBN-13: 978-1461452263)**

Keywords: Computational Neuroscience, Neuroengineering, Brain Networks

3.1.6 Neuroimaging

2nd Year, 1 Sem.
Semestral (S)
Responsible lecturer: Patrícia Figueiredo
ECTC: 6 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: A. Oral presentation of an assigned scientific paper during the semester (30%); B. Quizes on taught material throughout the semester (30%); C. Written essay and oral presentation on a chosen Neuroimaging topic (40%).

Contents:

1.Introduction
- a.Historical perspective
- b.Overview of the human brain (Functional Specialization, Main Divisions, Brain Systems)

2.Neurophysiology basics
- a.Biophysics of neuronal function
- b.Micro-electrophysiology
- c.Neuronal models: from single neurons to neuronal masses
- d.Brain metabolism and hemodynamics

3.Electrophysiology neuroimaging
- a.Electro-Encephalography (EEG)
- b.Magneto-Encephalography (MEG)
- c.Spontaneous brain rhythms and evoked potentials, synchronization and desynchronization

d.Transcranial Magnetic Stimulation (TMS)

4.Structural neuroimaging and spectroscopy

a.Overview of magnetic resonance imaging (MRI)

b.Structural MRI

c.Diffusion Tensor Imaging (DTI): structural connectivity

d.Magnetic resonance spectroscopy (MRS)

5.Haemodynamic neuroimaging

a.Functional MRI (fMRI): Blood Oxygenation Level Dependent (BOLD) contrast

b.Stimulus/task-related and resting-state activity; functional connectivity

c.Perfusion imaging: Arterial Spin Labeling (ASL)

d.Radiotracer techniques (PET and SPECT)

e.Diffusion optical imaging (DOI)

f.Multimodal techniques: EEG-fMRI, PET-MRI

Learning outcomes and competencies:
The course takes a multidisciplinary approach, in order to provide training in both the principles of Neuroimaging techniques, as well as in their application to the understanding of brain function. Students successfully completing the course are expected to:

1) have general background knowledge of the basic principles, methodologies and applications of the most important Neuroimaging techniques; and

2) to be prepared to critically evaluate the applicability of, and the results provided by, Neuroimaging techniques for different problems in basic and clinical Neuroscience.

Literature:

- Brain Mapping: The Methods: Arthur W. Toga (Editor), John C. Mazziotta (Editor) 2002 Academic Press; 2nd edition. ISBN-10: 0126925402.

Keywords: neurophysiology, electrophysiology, neuroimaging

3.1.7 Signals and Systems in Bioengineering

1st Year, 1 Sem.
Responsible lecturer: João Miguel Sanches
ECTC: 6 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: Tests/Exams (70%) and Labs (30%)

Contents:

1.Introduction to signal and systems

a.Analog and discrete signals

b.Systems

c.Typical biomedical sensors

2.Signal spaces

a.Metric Spaces

b.Norm function and inner product

c.Finite dimension representation and manipulation of continuous spaces

d.Interpolation

3.Transforms

a. Z Transform
b. Fourier Transform of discrete signals
c. Fourier transform properties properties
d. Discrete and fast Fourier transforms, DFT and FFT
e. Short Time Fourier Transform (STFT)
f. Long sequence filtering. Overlapp add and save.

4.Sampling
a. Continuous and discrete sampling
b. Aliasing
c. Sampling of band-pass signals
d. Canaonical ADC and DAC topologies. Anti-aliasing and reconstruction filters

5.Systems
a. Linear and Time Invariant (LTI)
b. Convolution theorem and LTI eigen signals
c. FIR and IIR systems/filters
d. Magnitude and Phase response. Bode plots
e. Canonical topologies of discrete filters

6.Random signals
a. Discrete time random signals
b. Average and correlation sequences
c. Response of LTI systems to random signals

7.Feedback and control
a. Linear feedback systems.
b. Feedback effects. Stability issues
c. Root Locus analysis
d. Bode diagram and Nyquist stability criterion
e. Gain and phase margins

Learning outcomes and competencies:
This course is intended to complement the basic mathematical theory of signals and systems and provide the basic concepts of feedback and control theory in the scope of Bioengineering. The course focuses on the practical aspects related to implementation and use of the fundamental concepts of signals and systems theory but advanced topics will be also addressed such as spaces of signals, time-frequency analysis, canonical structures of digital filters and feedback and control theory. In this latter topic canonical structures of feedback will be addressed as well as some techniques for stability analysis and compensation.

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

3.2 Master's electives:

3.2.1 Advanced Algorithms

1 Year, 2 Sem.
Responsible lecturer: Alexandre Francisco
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: exam (60%), assignments (40%)

Contents:
Advanced data structures. B-trees. Binomial heaps, Fibonacci heaps, and relaxad heaps.
Approximation algorithms for NP-hard problems.
Probabilistic techniques, random algorithms and game theory.
Algorithms with random choices.
Online and real-time algorithms.
Parallel algorithms and algorithms using external memory.
Approximation algorithms for polynomial problems, e.g., linear algorithms for MSTs.
Fast algorithms for minimum cuts.
Graph partitioning.
Approximated counting.
String algorithms and pattern matching.
Suffix trees and suffix arrays.
Tree algorithms, LCA.
Amortized Analysis.

Learning outcomes and competencies:
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 and compression, and on randomization, sampling and approximation schemes, taking into account real time processing requirements and distributed computing environments. This course will follow a problem based learning approach where techniques and methods will be intuitively and constructively explored.

Literature:

- Algorithms on Strings, Trees, and Sequences: Dan Gusfield 1997 Cambridge University Press
- Randomized Algorithms: Rajeev Motwani and Prabhakar Raghavan 2000 Cambridge University Press

Keywords: Algorithms

3.2.2 Machine Learning

1 Year, 2 Sem.
Responsible lecturer: Manuel Cabido Lopes
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: 5 mini-projects, lab projects, individual examination

Contents:

1. Introduction to Machine Learning
2. Background
    a. Probability and information theory
    b. Linear algebra
    c. Optimization
3. Introduction to supervised learning - Linear Methods
    a. Linear regression
    b. Logistic regression and perceptron
4. Fundamentals of learning theory
    a. The bias-variance tradeoff
    b. Overfitting and underfitting
    c. Regularization
    d. Model selection
    e. Statistical learning theory
5. Supervised learning - Non-parametric methods
    a. k-nearest neighbors
    b. Locally weighted regression
6. Supervised learning - Decision Trees and ensemble methods
    a. Decision trees
    b. Regression trees
    c. Ensemble methods
7. Supervised learning - Bayesian methods
    a. Naive Bayes
    b. Bayesian linear regression
    c. Bayes nets
8. Supervised learning - Kernel methods
    a. Max-margin classifiers
    b. Kernel regression
9. Supervised learning - Artificial neural networks
    a. Multilayer perceptron
    b. Backpropagation
    c. Convolutional networks
    d. Recurrent networks
    e. Regularization
10. Unsupervised learning
    a. k-means
    b. Mixture models and Expectation-Maximization
    c. PCA and ICA
    d. Autoencoders
11. Applications
    a. Text classification
    b. Image classification

Learning outcomes and competencies:
This course aims to provide a complete and up-to-date introduction to key concepts in machine learning. After completing the course, students should be able to:

- Understand the main challenges involved in machine learning.
- Understand and correctly apply the steps needed to train and validate a model that is able both to explain a set of data and make predictions about unseen data.
- Understand and correctly apply the more common machine learning algorithms, recognizing their corresponding domain of application.

Literature:

- Machine Learning and Pattern Recognition: C. Bishop 2006 Springer

Keywords: Machine Learning

3.2.3 Cloud Computing and Virtualization

1 Year, 2 Sem.

Responsible lecturer: Luís Antunes Veiga
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: exam (40%), lab project (45%), paper presentation & feedback (15%)

Contents:

- Introduction to Virtualization and Cloud Computing, Infrastructure-as-a-Service, Platform-as-a-Service, Software-as-a-Service.
- System-level virtualization: system VM architecture, CPU virtualization, OS core, memory,
- I/O; hardware support for virtualization, case studies (VMWare, QEMU/KVM, Xen).
- Cloud computing systems (Amazon EC2, OpenStack, XenCloud, OpenNebula); VM scheduling, migration and replication; monitoring and scalability (CloudWatch, Autoscaling).
- Process-level virtualization: Java VM specification and reference implementation, security model, code management and binary translation, just-in-time compilation and optimization,
- garbage collection, case studies (Jikes RVM).
- Cloud computing platforms (Azure, Google App Engine); distributed virtual machines;
- monitoring and scalability (Azure Fabric Controller).
- Data and Storage services: block storage, file storage, key-value stores (Dynamo, S3, Datastore), tabular storage (BigTable, Percolator).
- Cloud computing scalability: Map-reduce, dataflows (Pig, Dryad, OOzie), streams (S4), applications, monitoring, elasticity and optimization.
- Cloud computing cross-cutting concerns: virtualization energy efficiency, dynamic provisioning, energy centered cloud design.

Learning outcomes and competencies:

- 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.

Literature:

- Virtual Machines: Versatile Platforms for Systems and Processes: James Smith and Ravi Nair 2005 Morgan Kaufmann
- The Cloud at Your Service: Jothy Rosenberg and Arthur Mateos 2010 Manning Publications
- Programming Amazon Web Services: James Murty 2008 O'Reilly Media
- Hadoop: The Definitive Guide: Tom White 2012 O'Reilly Media
- Cloud Computing - Theory and Practice : Dan C. Marinescu 2013 9780124046276

Keywords: Cloud Computing

3.2.4 Parallel and Distributed Computing

1 Year, 2 Sem.
Responsible lecturer: José Monteiro
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: exam (40%), project (60%)
Contents:

- Parallel computing models: multiprocessors and multicomputers. Memory organization;
- communication complexity. Interconnection networks. Flynn’s taxonomy.
- Programming message passing systems: MPI.
- Programming shared memory systems: OpenMP, threads, race conditions,deadlock detection. Analysis and synthesis of parallel algorithms: problem partitioning; data organization; synchronization; balancing and scheduling.
- Performance analysis for parallel algorithms.
- Foundations of distributed computing and their applications to parallel algorithms. Limits
- of parallel computing.
- Analysis of parallel algorithms: sorting algorithms; numerical algorithms, matrix multiplication, solving systems of linear equations; algorithms on graphs; search and optimization algorithms.

Learning outcomes and competencies:

- Understanding the models, techniques, and programming methods for parallel algorithms.
- Analyzing and designing parallel algorithms. Understanding the foundations of distributed computing.

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

Keywords: parallel programming, distributed computing

3.3 I&E 2 courses

3.3.1 Master Project in Information and Software Engineering

1st year, 2nd sem, 2nd Year, 1 Sem.
Responsible lecturer: Luis Veiga
ECTC: 12 ECTS
Course type and weekly hours: individually supervised self-study
Exam type: oral exam (1000%)

Contents: /
Learning outcomes and competencies:
Students develop individually a plan for a master dissertation project.
Literature:
Keywords: Project Planning, Innovation, Entrepreneurship, Sustainability

3.3.2 Project in Biomedical Engineering (for incoming students only)

5 Year, 1 Sem.

Responsible lecturer: Mónica Oliveira
ECTC: 6 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: Oral presentation of team projects addressing a challenge. The final document for evaluation will be the presentation slides, complemented by a summary of the solution found by the team.

Contents:
In the beginning of the semester 4 problems/challenges, one in each of the areas that are the majors/profiles of the degree course, will be proposed. These problems will be described in detail in a document that will be made available to the students.
The students will be organized into teams. Each team will study in-depth their chosen problem, gather information either in the literature or through interviews, will review the state-of-the-art, and will develop a proposal to solve the problem which will include both technical aspects and also market analysis, cost assessment, and social impact.
The work will be supported by the teaching staff and by external mentors with practical experience in the area of the proposed problems.

Learning outcomes and competencies:
To develop the capabilities to integrate the knowledge and competencies acquired during prior coursework in the analysis and proposal to solve a practical problem in Biomedical Engineering.

Literature:

Keywords: Project Planning, Innovation, Entrepreneurship, Sustainability

3.4 I&E 1 and I&E 3 courses

3.4.1 Information Systems Project Management

1 Year, 1 Sem.
Responsible lecturer: Rosário Bernardo
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: written test (50%), project (40%), research (10%)

Contents:
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.

Learning outcomes and competencies:
The objectives of GPI are aligned with the same objectives as defined for the course “IS 2010.4 IS

1. Project Management” of the curriculum “ACM/AIS IS 2010 Curriculum Guidelines”, namely: 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

Literature:

- Rethinking Project Management. An organisational 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

Keywords: Project Planning, Innovation, Entrepreneurship, Sustainability

3.4.2 User Centered Design

1 Year, 1 Sem.
Responsible lecturer: Nuno Jardim Nunes
ECTC: 7.5 ECTS
Course type and weekly hours: lecture (3 h) + laboratory (1.5 h)
Exam type: project (80%), laboratories (20%)

Contents:
Lectures:

- Introduction to User Centered Design.
- Users and Stakeholders. Inquiring Users and Experts.
- Observing Users.
- User Involvement and Participation.
- User Needs and Requirements.
- Usability Engineering. Data Analysis and Interpretation.
- Building Prototypes.
- Interface Types.
- Affective Aspects. Accessibility.
- Ethics in User Centered Design.

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:

- Understand the basic principles and the methodologies of interactive systems user centred design.

- Understand users and their needs, how to really acquire them, and the need of user involvement in interactive systems design and implementation. Adapt the above knowledge to user centred design methodologies.
- Design and implement an interactive system involving real users at various levels in light of the above.

Literature:

- Interaction Design: Beyond Human-Computer Interaction (3rd Edition): J. Preece, Y. Rogers, H. Sharp 2011 John Wiley & Sons
- Software for use: a practical guide to the models and methods of usage-centered design: Larry L. Constantine Lucy A. D. Lockwood 1999 Larry L. Constantine and Lucy A. D. Lockwood. 1999. Software for Use: A Practical Guide to the Models and Methods of Usage-Centered Design. ACM Press/Addison-Wesley Publ. Co., New York, NY, USA.

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

3.4.3 Entrepreneurship, Innovation and Technology Transfer

5 Year, 1 Sem. + 2 Sem.
Responsible lecturer: José Epifânio da Franca
ECTC: 6 ECTS
Course type and weekly hours: lecture (3 h) + 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:

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 envirenment.
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.

Learning outcomes and competencies:

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.

Literature:

- Proactive risk management: Controlling uncertainty in product development: Preston G. Smith, Guy M. Merritt 2002Productivity Press
- Creating Breakthrough Products: J. Cagan & C. Vogel 2002 Prentice Hall, ISBN 0-13-969694-6
- Product Design & Development, 3rd Ed: K. T. Ulrich, S. D. Eppinger 2003 McGraw-Hill, ISBN 0071232737

Keywords: Entrepreneurship, Innovation