MAI4CAREU

Master programmes in Artificial Intelligence 4 Careers in Europe

MSc Artificial Intelligence

University of Cyprus

Co-financed by the European Union
Connecting Europe Facility

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

MSc Artificial Intelligence – Department of Computer Science – University of Cyprus

Programme Aim

The **MSc Artificial Intelligence** programme, starting in **September 2022**, is offered by the Department of Computer Science of the University of Cyprus (CS-UCY)**.** The programme will be delivered in **English** and was recently certified by the Cyprus Agency of Quality Assurance and Accreditation in Higher Education. CS-UCY is already participating in the delivery of two other postgraduate programmes delivered in English, the MSc Data Science programme, and the MSc Cognitive Systems programme.

The aim of the MSc Artificial Intelligence is to be a modern programme, containing a strong interdisciplinary element as required by human-centric, explainable, and responsible artificial intelligence. Its compulsory courses include courses on artificial intelligence and ethics, as well as on artificial intelligence and entrepreneurship. Providing career counselling to students is a high priority, with the aim of helping all graduates to successfully pursue an AI-related career, possibly set up their own start-ups.

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Co-Funded by the European Union

The development of this new master's programme is co-funded by the European Union (Connecting Europe Facility (CEF) — Telecommunications Sector). Europe's initiative to fund new master's programmes in Artificial Intelligence demonstrates the importance Europe attaches to recent developments in this area, in providing solutions to global problems related to every aspect of human life, contributing to growth and competitiveness. Europe urgently needs more professionals in Artificial Intelligence, entrepreneurs and researchers, capable of paving the way for new innovations for the good of society and pushing the borders of the field towards new challenges. This new generation of AI graduates must be fully familiar with the latest technological developments in terms of the breadth and depth of technical knowledge in Artificial Intelligence, be connected to industry and be fully aware of the ethical issues involved.

The programme's collaboration network includes four European Universities (University of Cyprus, University of Bologna, Technical University of Dresden, and University of Ruse Angel Kanchev), the CYENS Centre of Excellence and four high-tech SMEs (Nodes & Links Labs, 3AeHealth LTD, INJENIA SRL, MLPS AD). Fostering strong links with industry provides significant added value to the educational experience.

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Intended Learning Outcomes

- Grasp the **fundamental principles and techniques** that underline software systems that exhibit **“intelligent” behavior**, be aware of the latest developments in AI and appreciate the wide breath of study that AI requires.
- Acquire a holistic view of **machine learning** enabling them to understand the principles that drive most scientific and industrial AI innovations.
- Understand how to provide computers with the ability to **intelligently process human language**, extracting meaning, information, and structure from text, speech, web pages, and social networks.
- Master key concepts and challenges of relevance to AI and **data-driven entrepreneurship**.
- Be able to apply **methods and tools of AI research**, and be aware of professional practices, and associated technological culture, bearing in mind **EC’s regulatory framework**.
- Understand the basics of implementing systems that are not only highly performing, but also adhere to our **ethical socio-legal cultural values** and to understand how research into AI ethics feeds into policy and how policy requirements affect the development of AI systems.
- Acquire deep knowledge and familiarity with current and future research challenges in several **specialized topics** covered in the elective courses.
- Be aware of the **career opportunities** in the various countries.
- Exhibit **versatility and innovative thinking** in addressing and managing open questions in a variety of contexts, as an essential asset for careers in AI.
- Develop **transferable skills** such as: oral and written scientific communication, near fluent use of scientific English, use of information/communication technology, organization and planning of group work.

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Programme Structure	
Semester/Courses	**ECTS Credits**
Fall Semester 1	**30**
MAI611 AI Fundamentals	8
MAI612 Machine Learning	8
MAI613 Research Methodologies and Professional Practices in AI	4
MAI614 AI on the Edge Webinars I	2
Elective course 1	8
Spring Semester 1	**30**
MAI621 AI Ethics I	6
MAI622 AI Entrepreneurship	8
Elective course 2	8
Elective course 3	8
Summer Period 1 (student participation is optional)	**12**
MAI601 AI Camp	4
MAI602 Research/industrial internship (on the basis of evaluation an internship could count as an elective)	8

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Programme Structure cont.	
Semester/Courses	**ECTS Credits**
Fall Semester 2	**30**
MAI631 AI Ethics II and AI Policy Making	4
MAI632 AI on the Edge Webinars II	2
Elective course 4	8
MAI641 Master Thesis OR Elective course 5 and Elective course 6	16
MSc Total ECTS	**90 - 102**

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Elective courses (8 ECTS each)

MAI623 Natural Language Processing

MAI642 Deep Learning

MAI643 AI in Medicine

MAI644 Computer Vision

MAI645 Machine Learning for Graphics and Computer Vision

MAI646 Cognitive Programming for Human-Centric AI

MAI647 Computational Neuroscience

MAI648 Human-Centered Intelligent User Interfaces

MAI649 Principles of Ontological Databases

MAI650 Internet of Things

MAI651 AI and Creativity

Additional elective courses from MSc Data Science:

DSC511 Data Analytics

DSC551 Data Visualization

DSC516 Cloud Computing

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Elective courses will aim to include 2-3 real world case studies around the material covered, thus integrating theory with practice.

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AI Camp

- Physical meeting at one of the partner Universities
- All students and partner representatives to be invited
- Activities
  - In-depth presentations of research and industry activities of the partners
  - Talks by the students about their project work and experience so far with their studies
  - Discussion items
    - ❑ Evaluation and strengthening of education experience
    - ❑ Open questions regarding research and application of AI
    - ❑ Career prospects of students

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Career Counseling and the Role of the SMEs

A comprehensive plan for student counseling for AI Careers in the EU covering:

- ❑ The setup of structures and processes for targeted information about developments of the AI labor market in EU
- ❑ Counseling sessions of students with staff at the partner SMEs and Universities
- ❑ The fostering of an entrepreneurial culture in students

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Short descriptions of courses

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MAI611 Artificial Intelligence Fundamentals (8 ECTS)

Course purpose and objectives: The purpose of the course is to introduce students to the fundamental principles and techniques that underline software systems that exhibit “intelligent” behavior.

Learning outcomes: Upon completion of this course, students will have acquired a good understanding of modern Artificial Intelligence, the problems that it addresses and the fundamental solution methods that it uses. More specifically the students will know the main knowledge representation techniques and reasoning methods that underlie artificial intelligence problem solving and be able to develop simple solvers for artificial intelligence systems.

Required: Knowledge of a high-level programing language, object-based data concepts and structures.

Teaching methodology: Lectures, discussions of practical examples and (unsupervised) lab activities where the active learning element is encouraged and supported. Students would be strongly guided to view all topics presented and discussed with a critical eye, identifying the limits of AI both in its foundational years and the current situation characterized by an explosion of multimedia data of varying degrees of usability, quality and ethical considerations.

Assessment: Final exam, midterm exam and homework (theoretical and/or programming assignments).

Main text:

S. Russel and P. Norvig, Artificial Intelligence: A Modern Approach, 4th Edition, Pearson, 2021.

Other reading:

R. J. Brachman, H. J. Levesque, Knowledge Representation and Reasoning, Elsevier, 2004.

N. J. Nilsson: The Quest for Artificial Intelligence: A history of ideas and achievements, Cambridge University Press, 2010.

M. Ginsberg: Essentials of Artificial Intelligence, Morgan Kaufman,1993.

P. H. Winston: Artificial Intelligence, 3rd Edition, Addison-Wesley, 1992.

E. Κεραυνού, Τεχνητή Νοημοσύνη και Έμπειρα Συστήματα, Ελληνικό Ανοικτό Πανεπιστήμιο, 2000.

G.F. Luger and W.A. Stubblefield, Artificial Intelligence: Structures and Strategies for Complex Problem Solving, 5th edition, Addison-Wesley, 2005.

G. Weiss (editor), Multiagent Systems: a modern approach to distributed AI, The MIT Press, 2001.

P. Jackson, Introduction to Expert Systems, 3rd edition, Addison-Wesley, 1999.

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MAI612 Machine Learning (8 ECTS)

Course purpose and objectives: Machine Learning (ML) is the branch of Artificial Intelligence (AI) that allows a computational system to improve itself through experience. It involves the development of systems that are trained to discover patterns in datasets, which can later be used to provide predictions on new data. ML is a rapidly evolving field, that has disrupted almost all scientific disciplines. This introductory course aims to provide a holistic view of ML covering sufficient breadth and depth, so that students understand the principles that drive most scientific and industrial AI innovations.

Learning outcomes: After completing this course, the students will: (1) Understand how to structure ML projects and their lifecycle: from the data preparation phase to the development, evaluation and deployment phases; (2) Gain practical experience with various supervised learning models for regression, forecasting and classification problems; (3) Know how to implement unsupervised learning models for visualization, compression, clustering, anomaly detection and recommendation systems; (4) Understand what reinforcement learning is, how it can be used for sequential decision making problems and acquire hands-on experience with it.

Required: Basic programming skills; Basic knowledge of linear algebra, calculus and probability and statistics.

Teaching methodology: The course will be taught physically. The lectures will present the theory, while the laboratories will be complementary by providing the students with more content and tools that will help them understand the respective concepts both intuitively, as well as in more depth.

Assessment: Coursework and Assignments (60%); Final exam (40%)

Bibliography:

Bishop, C. M. (2006). Pattern recognition and machine learning. Springer.

Chollet, F. (2018). Deep learning with Python. Manning Publications.

Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). Deep learning. MIT press.

Haykin, S. (2009). Neural networks and learning machines (3rd edition). Pearson Prentice Hall.

Howard, J., & Gugger, S. (2020). Deep Learning for Coders with fastai and PyTorch. O'Reilly Media.

Murphy, K. P. (2012). Machine learning: a probabilistic perspective. MIT press.

Powell, W. B. (2011). Approximate Dynamic Programming: Solving the curses of dimensionality (2nd edition). John Wiley & Sons.

Sutton, R. S., & Barto, A. G. (2018). Reinforcement learning: An introduction (2nd edition). MIT press.

Theodoridis, S. (2015). Machine learning: a Bayesian and optimization perspective. Academic press.

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MAI613 Research Methodologies and Professional Practices in AI (4 ECTS)

Course purpose and objectives: The purpose of the course on research methodologies and professional practices in AI is to introduce students to the methods and tools of Artificial Intelligence Research, professional practices, and associated technological culture, bearing in mind EC's regulatory framework. Moreover, the course objectives encompass familiarization with reading, reviewing and presenting of relevant literature, technical writing and literature surveying.

Learning outcomes: Upon completion of the course the students will be sufficiently conversant with the key methodological steps involved in carrying out research in AI and the safeguards for mitigating risks in potentially high-risk AI research and applications. Consequently, they will be familiar with the obligatory requirements for professional practices in AI to be characterized as secure, trustworthy and ethical. In addition, they will acquire experience in surveying some topic, writing a technical report on it and presenting it.

Required: Experience in orally presenting some topic to an audience and in writing a structured report (objectives, analysis, conclusions).

Teaching methodology: Lectures, research/professional seminars, and individual assignments (summary of research/professional seminars) and a group study of a research subject under the supervision of a faculty member.

Assessment: Attendance and participation in lectures and several research/ professional seminars, written individual studies, group study of a research subject and technical presentation of the group study. The course grade is Pass/Fail.

Bibliography:

Selected research articles from the international literature.

Course Presentation Slides.

Regulation of the European Parliament and of the European Council in Laying down harmonized rules for Artificial Intelligence ((COM (2021) 206 final).

P.R. Cohen, Empirical Methodology for Artificial Intelligence, MIT Press, 1995.

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MAI614 AI on the Edge Webinars I (2 ECTS) and MAI632 AI on the Edge Webinars II (2 ECTS)

Courses' purpose and objectives: The main objective of these two courses is for the students to be aware of the latest developments in AI and to appreciate the wide breath of study that AI requires.

Learning outcomes: Students will become knowledgeable about a variety of the most recent developments in Artificial Intelligence and will have some appreciation of different AI centers world-wide.

Teaching methodology: A list of Webinars will be maintained and updated weekly from which each student can choose to attend. Students can also suggest other webinars outside the official list of the course, to be approved by the course instructor. The students submit a short report summarizing each talk they have attended and commenting on the significance of its topic to the development of AI. Interactive student discussions coordinated by industrial partners will also be included.

Assessment:. The students are assessed by the quality of their reports for a minimum of 8 webinar talks they have attended for each of the two courses.

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MAI621 AI Ethics I (6 ECTS)

Course purpose and objectives: This course aims to raise awareness of the dangers that can arise from the development, deployment, and usage of intelligent autonomous systems and to introduce the students to socio-technical solutions for mitigating the risk of exhibiting unwanted non-ethical behaviour. Students will understand the basics of implementing systems that are not only high performing, but also adhere to our ethical socio-legal cultural values.

Learning outcomes: The key learning outcomes of the course are: (1) Reflect upon the socio-ethical issues that arise upon the development, deployment, and usage of intelligent systems. (2) Critically discuss commonly occurring narratives and perspectives related to the use of AI. (3) Reason about the decisions made during a system's lifecycle and their relationship to accountability and responsibility. (4) Learn how to develop systems that exhibit a desired ethical behaviour and understand the main research challenges for this. (5) Understand how to judge and evaluate AI systems for their 'ethicacy.' (6) Appreciate the socio-technical mechanisms for the governance of AI systems. By completing the above outcomes, the student will have a fundamental understanding of how intelligent systems influence—and are influenced by—our societies and of the socio-ethical responsibilities they have as developers and users of such tools.

Prerequisites: MAI611 Artificial Intelligence Fundamentals

Required: Basic technical knowledge of AI

Teaching methodology: A variety of teacher-led and student-led activities. Weekly lectures will introduce and provide overview of topics. Students will conduct self-study of the weekly material. Students will be given the opportunity to participate in problem-based solving group exercises, where they will conduct critical analysis and debate timely issues related to AI ethics. In unsupervised technical labs, students will be given the opportunity to test technical solutions for compliance checking and implement machine ethics, i.e., agents with moral reasoning.

Assessment:. 2 major assignments (one group, one individual) and a final exam.

Main Text:

V. Dignum. Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way, Springer, 2019.

Other reading:

M. Coeckelbergh. AI Ethics, MIT-Press, 2020.

D. Gunkel, An Introduction to Communication and Artificial Intelligence, Willie, 2020.

C. O'Neil, Weapons of Math Destruction, Crown Books, 2016.

F. Pasquale, The Black Box Society: The Secret Algorithms That Control Money and Information, Belknap Press, 2014.

Papers, as reading material, will be made available to students on a weekly basis.

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MAI631 AI Ethics II and AI Policy Making (4 ECTS)

Course purpose and objectives: The main purpose of this (second) course on AI Ethics is to help the students understand in depth the major ethical issues that concern various sectors of the society and how these are reflected into AI policy by governments and organizations, particularly by EU policy on AI. The students will understand how research into AI Ethics feeds into policy and how policy requirements affect the development of AI systems.

Learning outcomes: The key learning outcomes of the course are: (1) Grasp the importance role of analysing and mitigating socio-ethical issues by forming AI policies at various levels in the society. (2) Acquire an in-depth knowledge about governmental and intergovernmental AI policy initiatives—particularly by and within the European Union. (3) Understand the relationship between ethical governance and regulatory frameworks. (4) Explore how AI Ethics affects the strategy of large and small companies for the development of their AI systems. (5) Develop a critical understanding of socio-technical mechanisms for the governance of AI systems, recognizing the drawbacks and benefits of each approach. (6) Reflect upon how research in AI feeds into AI policy and how AI policy creates new needs for research into AI Ethics. By completing these outcomes, the student will be able to understand and comment on AI policies and the research challenges emerging from them

Prerequisite: MA621 AI Ethics I

Required: Basic technical knowledge of AI.

Teaching methodology: Bi-weekly lectures will introduce and provide overview of topics. Students will conduct a self-study on a weekly basis by attending seminars with guest speakers on AI Ethics & Policy issues, studying a policy documents, and applying AI policies to their AI projects (e.g., undergraduate dissertations, assignments from other projects, etc). Students will be required to present the results of their study in reports and/or presentations to the class.

Assessment: Bi-weekly short assignments, one group project and final essay exam.

Bibliography:

EU AI Policy documents such as: The ethics of artificial intelligence: Issues and initiatives; Ethics guidelines for trustworthy AI; Artificial intelligence: From ethics to policy

Other AI Policy resources: OECD AI Policy Observatory; AI Policy Forum at MIT

Open Lecture Resources: Ethics in AI seminar series at Oxford; Online Speaker Series on the Ethics of Argumentation; AI Ethics Seminars at Chalmers

Journal of AI Ethics, Springer (launched in February 2021).

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MAI622 AI Entrepreneurship (8 ECTS)

Course purpose and objectives: The course examines issues faced by Startup Founders and Chief Technology Officers who need to innovate at the boundaries of AI, Information Technology and Business by understanding all perspectives.

Learning outcomes: After taking this course, students should be able to: (1) Understand and explain the interplay between Big Data, Machine Learning and various application domains. (2) Evaluate technological ideas and apply the key stages of turning an idea or invention into a commercial product. (3) Apply the Business Model Canvas methodologies in Information Technology and Scientific application contexts. (4) Recognize and undertake the steps of the Disciplined Entrepreneurship methodology, and manage the key activities required to bring an innovative product or service to the market: product definition and market segmentation; value proposition analysis and high-level product specification; market and competition analysis; business model definition and revenue models; customer and user acquisition; minimum viable product definition and product implementation planning. (5) Understand the basics of fundraising and financing options for a startup. (6) Understand the basics of incorporation and company structure. (7) Understand the key challenges for attracting talent, establishing and managing a startup team. (8) Apply tools for project and team management, collaboration, ideation, rapid prototyping: Trello, Slack, SimpleMind, Proto.io, Github, Google AdService, Google Cloud, Heroku, etc. (9) Prepare pitch decks, and pitch in front of potential investors, an AI-related business idea/product/service.

Teaching methodology: Lectures (3 hours weekly), Recitation (1 hour weekly), Team Project (all semester).

Assessment: Final semester project presentation, midterm paper, reading assignments.

Bibliography (indicative):

Cade Metz (2021). “The Genius Makers: The Mavericks Who Brought A.I. to Google, Facebook, and the World.” Random House Business.

Lee, Kai-Fu (2018). “AI Superpowers: China, Silicon Valley, And The New World Order.” Houghton Mifflin Harcourt Company.

Smith, B. and Browne C.A. (2019). “Tools and Weapons. The Promise and the Peril of the Digital Age.” Penguin.

O’Neil, C. (2016). “Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy.” Crown.

Bill Aulet, “Disciplined Entrepreneurship.” Wiley, 2013.

Bill Aulet, “Disciplined Entrepreneurship Workbook.” Wiley, 2017.

Alexander Osterwalder et al, “Value Proposition Design: How to Create Products and Services Customers Want.” Wiley, 2014.

Ben Horowitz, “The Hard Thing about Hard Things.” Harper Business, 2014.

Steven G. Blank, “The Four Steps to the Epiphany. Successful Strategies for Products that Win.” Lulu, 2006.

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MAI623 Natural Language Processing (8 ECTS)

Course purpose and objectives: Natural language processing (NLP) seeks to provide computers with the ability to intelligently process human language, extracting meaning, information, and structure from text, speech, web pages, and social networks. The goal of this course is to provide the fundamental aspects of NLP systems, as well as introduce recent advancements in the field of NLP and Deep Learning. The course is organized into two parts: (1) Fundamental knowledge, concepts, and techniques of NLP. (2) Introduction to Deep Learning methods for NLP.

Learning outcomes: The students who complete this course successfully will be able to: (1) Comprehend various fundamental concepts of NLP: Text processing (normalization, lemmatization, stemming, etc.), language models (N-Grams), word representation (word embeddings), and text classification with Machine Learning. (2) Familiarize with known NLP tasks: Named Entity Recognition (NER), Part-of-Speech tagging (PoS), Dependency and Syntax parsing. (3) Employ Machine Learning (ML) techniques for text classification (e.g., Naive Bayes) and be able to properly apply the NLP feature engineering process. (4) Extend their knowledge with advanced methods in NLP and Deep Learning: Word Vectors, Word2vec algorithm, BERT. (5) Apply their knowledge on real-world research applications of NLP and recognize the societal impact in cases of misinformation and hate-speech identification. (6) Design efficient and effective NLP solutions to a variety of problems, using state-of-the-art tools.

Prerequisites: MAI612 Machine Learning

Required: Familiarity with Python.

Teaching methodology: Students will meet the expected learning outcomes through participation in lectures, active participation and in class discussions, and actual practice with programming assignments and the final project. The lectures will be hybrid, with the possibility of both physical and virtual presence of the students.

Assessment:. Student progress is evaluated continuously through class participation and the assessment of at-home assignments, group project deliverables, and final exam. The final grade is based on the following formula (the percentages are indicative): Assignments and Participation: 30%; Final Project: 40%; Final Exam: 30%

Bibliography:

Dan Jurafsky and James H. Martin. Speech and Language Processing

Jacob Eisenstein. Natural Language Processing

Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit 1st Edition

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MAI601 AI Camp (4 ECTS)

Course purpose and objectives: Raising the awareness that students are studying in an EU wide program. Awareness of the career opportunities in the various countries and further studies at the partner universities. Initiating joint supervision and joint research.

Learning outcomes: Learning to collaborate at a distance in a multi-national group. Learning to present and to defend his or her own work in an international community of peers and experts. Improved social skills of students.

Teaching methodology: One-week retreat in some relatively isolated place so that students and faculty from the universities participating in the network of MAI4CAREU can have a close working interaction. Before the event the students who will participate are given projects to carry out in groups of 3-4 students from different universities. At the event they are asked to finalize their project and present it to the community attending the camp. Groups of Students will also jointly present research studies of some topic in AI. There will also be a special session where students can give feedback on the Masters program that they are attending. Faculty and SMEs will present to the students, current career and further research opportunities in the institutions and other links they have in the EU.

Assessment:. Students will be assessed on their presentations at the event and on their related reports. This will be a simple Pass/Fail assessment.

Bibliography:

Students will be given reading material to help them with their project preparation and with their presentations at the summer camp.

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MAI643 AI in Medicine (8 ECTS)

Course purpose and objectives: The medical domain has presented key challenges to the AI community from the early days of AI research. It is not an exaggeration to say that this pioneering work, particularly in medical expert systems, and its undisputable successes, some in real-life settings, has helped both in restoring confidence in the promise of AI, that at some point was disturbed after its failure to deliver fully on the very ambitious initial goals that it had set, and in paving the way towards more viable paths harnessing the mechanization of knowledge and human expertise. The aim of this elective course is to familiarize students with the past, present and future of Artificial Intelligence in Medicine, illustrating the discussion with several case studies, and pinning down the human-centric and ethical aspects underlying the given applications.

Learning outcomes: Upon completion of the course the students will have a good understanding, from a critical perspective, of the span of applications of AI methods and techniques in the medical domain, and the methodologies used in developing such applications. More specifically the students will understand the importance of time in medical information systems and how time can be modelled, be conversant with data-driven clinical decision-making, and grasp the regulatory, social, ethical and legal issues of Artificial Intelligence in Medicine.

Required: MAI611 AI Fundamentals

Teaching methodology: Lectures and discussions particularly around the presented case studies. Students would be strongly guided to view all topics presented and discussed with a critical eye.

Assessment: Final exam, midterm exam and project assignments.

Main texts:

A.C. Chang, Intelligence-Based Medicine: Artificial Intelligence and Human Cognition in Clinical Medicine and HealthCare, Academic Press, 2020.

C. Combi, E. Keravnou-Papailiou and Y. Shahar, Temporal Information Systems in Medicine, Springer, 2010.

L. Xing, M.L. Giger and J.K. Min (editors), Artificial Intelligence in Medicine: Technical Basis and Clinical Applications, Academic Press, 2021.

Other reading:

A. Panesar, Machine Learning and AI for Healthcare: Big Data for Improved Health Outcomes, Apress, 2021.

T. Lawry, AI in Health: A Leader’s Guide to Winning the New Age of Intelligent Health Systems, CRC Press, 2020.

N. Lavrac, E.T. Keravnou and B. Zupan (editors), Intelligent Data Analysis in Medicine and Pharmacology, Kluwer Academic Publishers, 1997.

E.T. Keravnou (editor), Deep Models for Medical Knowledge Engineering, Elsevier Science Publishers, 1992.

Scientific papers from thematic and/or standard issues of relevant journals, primarily the journal Artificial Intelligence in Medicine (AIME) published by Elsevier.

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MAI644 Computer Vision (8 ECTS)

Course purpose and objectives: This course aims to build a fundamental understanding of classic computer vision, starting at extracting and describing features such as edges and corners from images, moving to mid-level tasks such as model fitting and image stitching, then, high-level tasks such as semantic segmentation, recognition, and detection, and ending with motion and extracting scene geometry from images.

Learning outcomes: At the end of this course, students should: (1)Understand the fundamentals of classic computer vision (2) Be able to identify the recent trends and developments in computer vision (3) Identify limitations of the current state of the field and the immense potential for commercial applications of computer vision (4) Apply mathematical methods in a rigorous manner in order to solve computer vision tasks (5) Know how an image is formed and how cameras work (6) Know what features are and how they are extracted from an image (7) Know what edge and corner detection is (8) Know how features are described, stored and how they are used to solve computer vision problems (9) Understand classic computer vision algorithms such as RANSAC or Normalized cuts as well as methods such as PCA (10) Be confident in camera models and projective transformations (11) Know what camera extrinsic and intrinsic parameters are how to perform camera calibration (12) Understand how stereo and multi-view reconstruction works, and be able to appreciate structure from motion algorithms (13) Understand high-level tasks such as segmentation, recognition, detection, tracking.

Prerequisites: MAI612 Machine Learning

Required: Linear algebra, data structures and algorithms

Teaching methodology: Lectures and labs

Assessment: Final exam (40%); Mid-term exam (30%); Coursework and assignments (30%). To qualify one must: (i) Hand in all assignments and coursework (ii) Achieve at least 50% weighted average in the mid-term and final exam (iii) Achieve at least 50% overall.

Main texts:

David A. Forsyth and Jean Ponce. Computer Vision A Modern Approach, 2nd Edition, Prentice Hall. 2012.

Richard Szeliski. Computer Vision: Algorithms and Applications, 2nd Edition, Springer. 2020

Other reading:

Hartley and Andrew Zisserman. Multiple View Geometry in Computer Vision. Academic Press, 2002.

Christopher Bishop. Pattern Recognition and Machine Learning, Springer, New York, NY. 2006.

This Master is run under the context of Action No 2020-EU-IA-0087, co-financed by the EU CEF Telecom under GA nr. INEA/CEF/ICT/A2020/2267423

MAI645 Machine Learning for Graphics and Computer Vision (8 ECTS)

Course purpose and objectives: This course will offer an introduction to machine learning algorithms, the use of deep learning and its applications in computer vision and graphics. The course will also operate as a graduate-level seminar with weekly readings (1 hour per week), summarizations, and discussions of recent papers.

Learning outcomes: Participants will explore the latest developments in neural network research and deep learning models that are enabling highly accurate and intelligent computer vision and graphics systems. By the end, participants will: (1) Be familiar with fundamental concepts and applications in computer vision and graphics. (2) Grasp the principles of state-of-the art deep neural networks. (3) Gain knowledge of high-level vision tasks, such as object recognition, scene recognition, face detection and human motion categorization. (4) Gain knowledge of high-level graphics tasks, such as composite image generation, style transfer, motion reconstruction, and motion synthesis. (5) Develop practical skills necessary to build highly accurate, advanced computer vision and graphics applications

Required: Experience in programming with Python; Experience with linear algebra, calculus, statistics and probability.

Teaching methodology: 3 hours lectures; 1.5 hours lab; 1 hour for recitation and discussion on recent papers

Assessment:. Exams (30%); Student paper presentations (15%); Programming assignments (25%); Final course project (30%)

Bibliography:

Deep Learning, by Ian Goodfellow, Yoshua Bengio, Aaron Courville, MIT Press, 2016

Computer Vision: Advanced Techniques and Applications, by Steve Holden, CLANRYE INTERNATIONAL, 2019

Pattern Recognition and Machine Learning, Christopher Bishop, Springer, 2016

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MAI646 Cognitive Programming for Human-Centric AI (8 ECTS)

Course purpose and objectives: The introduction of students into the new framework for Cognitive Computing for the development of Cognitive Systems that serve the needs of Human-centric AI. The theoretical understanding of the challenges of such cognitive systems and the development of knowledge for their practical application.

Learning outcomes: The key learning outcomes of the course are for students to master: (1) Properties and Design of Cognitive Systems. (2) Automated Cognitive Decision Making. (3) Argumentation for Human Cognitive Reasoning. (4) Computational Argumentation. (5) Learning & Reasoning in Cognitive Systems. (6) Software Methodology for Cognitive Assistants.

Required: Basic knowledge of AI

Teaching methodology: Weekly lectures will introduce and provide overview of the course topics. In addition, there will be a running project throughout the course for the students to develop a Cognitive Assistant of their own application choice. The students will also undertake a bibliography assignment to review a topic related to Cognitive Computing from other disciplines. Small exercises help the student develop knowledge representation skills in argumentation form and programming skills in the Gorgias system of argumentation.

Assessment: Two major projects, one on research study and one developing a Cognitive Assistant. Four small assignments and a final exam.

Bibliography:

David Vernon, Artificial Cogntive Systems, MIT Press, 2014.

Antonio Lieto, Cognitive Designs for Artificial Minds, Routledge, 2021.

Journal of Cognitive Systems Research, Elsevier.

Journal of Advances of Cognitive Systems.

Journal of Computational Cognitive Science.

Principles of Synthetic Intelligence, Oxford University Press, 2009.

Research Documents on Cognitive Computing

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MAI647 Computational Neuroscience (8 ECTS)

Course purpose and objectives: Computational Neuroscience is an emerging and dynamically developing field aiming to elucidate the principles of information processing by the nervous system. This course aims to develop and apply computational methods for studying brain and behaviour as well as understanding the dynamics of the conscious mind.

Learning outcomes: The learning outcomes for the students are the following: (1) understand and be able to explain the fundamental principles of information processing by neural systems (2) appreciate the importance of computational neuronal models in the quest of understanding the brain and the fact that many aspects of neuroscience cannot be understood without appropriate computational modeling framework (3) understand the most important biophysical neuronal models and the different levels of description and complexity in computational neuronal modelling from the level of the single neuron to that of neural networks (4) understand neuronal dynamics and learn how high dimensional neuronal models can be reduced to low dimensional neural models (5) understand how experimentally recorded physiological signals enable us to understand the functionality of neurons/systems in the brain and how statistical approaches help in the analysis of such data (6) be able to implement/simulate basic computational neuronal models through programming (7) become familiar and be able to use various computational neuroscience simulation software packages for modelling complex biophysical models and experimentally observed phenomena (8) be able to grasp the importance of high-level modelling abstraction from the underlying neuronal principles for understanding brain behaviours (9) critical reading and discussion of recently published scientific papers.

Required: Linear algebra, differential equations, programming

Teaching methodology: Lectures (3 hours weekly), Recitation (1 hour weekly) and Laboratory (2 hours weekly).

Assessment: Final exam, midterm exam and laboratory exercises /oral presentations of selected research papers.

Bibliography (indicative):

P. Dayan and L. Abbott, Theoretical Neuroscience: Computational and Mathematical Modelling of Neural Systems, Cambridge, MA: MIT Press, 2001.

W. Gerstner, W. M. Kistler, R. Naud and L. Paninski, Neuronal Dynamics: From single neurons to networks and models of cognition, Cambridge: Cambridge University Press, 2014.

D. Sterratt, B. Graham, A. Gilles and D. Willshaw, Principles of Computational Modelling in Neuroscience, Cambridge: Cambridge University Press, 2011

W. Gerstner and W. M Kistler, Spiking Neuron Models: Single Neurons, Populations and Plasticity, Cambridge: Cambridge University Press, 2002.

C. Koch, Biophysics of Computation: Information Processing in Single Neurons, Oxford: Oxford University Press, 1998.

T. Trappenberg, Fundamentals of Computational Neuroscience, 2nd Edition, Oxford: Oxford University Press, 2010.

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MAI648 Human-Centered Intelligent User Interfaces (8 ECTS)

Course purpose and objectives: The purpose of the course is to introduce students to fundamental principles and methods within the intersection of Artificial Intelligence and Human-Computer Interaction aiming to design and develop more efficient and effective user interfaces through the use of intelligent computation methods.

Learning outcomes: Upon completion of this course, students will have acquired: *i)* an in-depth understanding of theoretical and practical aspects of intelligent user interfaces; *ii)* skills to design, develop and evaluate intelligent interactive systems by considering a variety of human factors, such as human cognitive and emotional characteristics for improving the efficiency, effectiveness and user experience in interactive systems; and *iii)* abilities to synthesize and evaluate the potential of this knowledge in relation to deploying intelligent user interfaces in real-life applications.

Required: Basic knowledge on AI and HCI; general programming knowledge.

Teaching methodology: Lectures covering the theoretical foundations of intelligent user interfaces, discussion of practical examples, and lab activities for designing and implementing intelligent user interfaces.

Assessment:. Final exam, midterm exam and homework (theoretical and programming assignments).

Bibliography:

Germanakos, P., Belk, M. (2016). Human-Centered Web Adaptation and Personalization - From Theory to Practice. Human-Computer Interaction Series, Springer, doi: 10.1007/978-3-319-28050-9

Brusilovski, P., Kobsa, A., Nejdl, W. (2007). The Adaptive Web: Methods and Strategies of Web Personalization, Springer, doi: 10.1007/978-3-540-72079-9

Shneiderman, B., Plaisant, C., Cohen, M., Jacobs, S., Elmqvist, N., Diakopoulos, N. (2017). Designing the User Interface: Strategies for Effective Human-Computer Interaction (6th Edition), Pearson, ISBN: 9780134380384

Preece, J., Sharp, H., Rogers, Y. (2015). Interaction Design: Beyond Human-Computer Interaction (4th Edition), Wiley, ISBN: 978-1-119-08879-0

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MAI650 Internet of Things (8 ECTS)

Course purpose and objectives: The internet of things (IoT) is a computing concept that describes the idea of everyday physical objects being connected to the internet and being able to identify themselves to other devices. IoT has emerged as a new paradigm aimed at providing solutions for integration, communication, data consumption, and analysis of smart devices. To this end, connectivity, interoperability, and integration are inevitable parts of IoT communication systems. Whereas IoT, due to its highly distributed and heterogeneous nature, is comprised of many different components and aspects, providing solutions to integrate this environment and hide its complexity from the user side is inevitable. In this course, different building blocks of IoT, such as sensors and smart devices, M2M communication, data collection and processing and the role of humans in future IoT scenarios are elaborated upon and investigated. The major focus will be to provide an overview on IoT tools and applications and to introduce hands-on IoT communication concepts through lab exercises.

Learning outcomes: Upon completion of this course, the student should be able to: (1) Explain the definition and usage of the term “Internet of Things” in different contexts. (2) Understand and describe the key components that make up an IoT system. (3) Apply the knowledge and skills acquired during the course to build and test a complete, working IoT system involving prototyping, programming and data analysis. (4) Independently research the technological trends which have led to IoT. (5) Understand where the IoT concept fits within the broader ICT industry and recognize possible future trends. (6) Valuate the impact of IoT on society by analyzing IoT systems with regard to sustainability, safety, integrity and ethics. (7) Appreciate the role of big data, cloud computing and data analytics in a typical IoT system.

Teaching methodology: The course is taught through: (1) Interactive face-to-face lectures. (2) Group activities/discussions. (3) In class/lab activities. (4) Student Presentations. (5) Guest Lectures or significant recorded public lectures.

Assessment: Midterm exam (20%), assignments/project (30%), final exam (50%)

Bibliography:

Rajkumar Buyya, Amir Vahid Dastjerdi, Internet of Things Principles and Paradigms, Morgan Kaufmann; 1st edition, 2016

J. Biron and J. Follett, "Foundational Elements of an IoT Solution", O'Reilly Media, 2016.

Jamil Y. Khan and Mehmet R. Yuce, Internet of Things (IoT) Systems and Applications, 2019, ISBN 9789814800297

David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, and Jerome Henry, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, 2016, Cisco Press.

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MAI651 AI and Creativity (8 ECTS)

Course purpose and objectives: Artificial intelligence (AI) is typically known as a collection of tools for solving hard problems spanning areas such as computer vision, speech and natural language processing. A less known use of AI is its capability for creativity. Through this course, the students will become familiar on how to build creative AI systems, and how various types of AI can be used for creative exploration in art, music and design.

Learning outcomes: Upon completing this course, the students are expected to: (1) understand how AI can be creative (2) implement evolutionary algorithms for open-ended exploration (3) implement generative deep learning models and explore their latent space (4) know how to use AI tools as a creative aid in a variety of applications (5) understand how computer games and AI can work together to find creative solutions for very hard real-world problems (6) become familiar with the cultural and creative industry and follow a series of invited lectures of distinguished individuals with practical examples of their work at the intersection of arts, science and technology.

Prerequisites: MAI611 AI Fundamentals, MAI612 Machine Learning

Teaching methodology: Teaching will be done through lectures given physically.

Assessment: Assignments (20%), Project presentations (40%), Final exam (40%)

Bibliography:

Bentley, P. J., & Corne, D. W. (2002). Creative evolutionary systems. Morgan Kaufmann.

Floreano, D., & Mattiussi, C. (2008). Bio-inspired artificial intelligence: theories, methods, and technologies. MIT press.

Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). Deep learning. MIT press.

McCormack, J. and d'Inverno, M. (eds.) (2012). "Computers and Creativity". Springer, Berlin.

Pereira, F. C. (2007). "Creativity and Artificial Intelligence: A Conceptual Blending Approach". Applications of Cognitive Linguistics series, Mouton de Gruyter.

Veale, T. (2012). "Exploding the Creativity Myth: The Computational Foundations of Linguistic Creativity". Bloomsbury Academic, London.

Veale, T., Feyaerts, K. and Forceville, C. (2013). "Creativity and the Agile Mind: A Multidisciplinary study of a Multifaceted phenomenon". Mouton de Gruyter.

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MAI649 Principles of Ontological Databases (8 ECTS)

Course purpose and objectives: Nowadays we need to deal with data that is very large, heterogeneous, distributed in different sources, and incomplete. At the same time, we have very large amounts of knowledge about the application domain of the data in the form of ontologies that can be used to provide end users with flexible and integrated access to data. This gave rise to ontological databases, which lie at the intersection of traditional databases, and knowledge representation and reasoning. The purpose of the course is to introduce students to the principles of ontological databases and demonstrate the importance of studying data-intensive problems in a mathematically rigorous way, as well as the implications of such studies for real-life applications.

Learning outcomes: Upon completion of this course, the students will be able to: (1) Abstract relational data and relational queries from their physical implementation and formalize them in a rigorous way. (2) Analyze the complexity of querying relational data and isolate the source of complexity. (3) Explain the semantics of Datalog queries, analyze the complexity of evaluating Datalog queries, and model queries in a declarative way. (4) Abstract rule-based ontologies from their physical implementation and formalize them in a rigorous way. (5) Explain and use the main (forward- and backward-chaining) techniques underlying ontological query answering. (6) Analyze the complexity of ontological query answering and isolate the source of complexity.

Required: While there are no formal prerequisites, it is recommended that students have passed an introductory course in Databases (some familiarity with the relational model, and the main relational query languages). It is also recommended that students have some basic familiarity with computational logic (first-order logic), and complexity theory (standard complexity classes such as PTIME and NP).

Teaching methodology: Lectures, discuss solutions to non-trivial problems given in advance (during the weekly recitation hour), review of recent research papers.

Assessment: Engagement component (20%); Essay and in-class presentations (25% + 15%); take-home assignment (40%).

Bibliography:

S. Abiteboul, R. Hull, V. Vianu, Foundations of Databases, 1995

M. Arenas, P. Barcelo, L. Libkin, W. Martens, A. Pieris, Principles of Databases, currently under development, a preliminary version is accessible at https://github.com/pdm-book/community

F. Baader, I. Horrocks, C. Lutz, U. Sattler, An Introduction to Description Logic, 2017

L. Libkin, Elements of Finite Model Theory, 2012

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MAI642 Deep Learning (8 ECTS)

Course purpose and objectives: The objective of this course is to provide a concrete understanding of the fundamental concepts of deep learning used for computer vision applications for image and video processing and understanding. Deep Learning is a key driving force behind Artificial Intelligence (AI) breakthroughs over the past few years and a paradigm shift in most computer vision tasks performed today.

Learning outcomes: A well-balanced understanding of deep learning theoretical concepts and computer vision applications materialized using contemporary deep learning architectures and software tools.

Prerequisites: MAI612 Machine Learning

Required: Digital Image Processing Fundamentals; Basic programming skills.

Teaching methodology: The course balances theory and practice as it involves a significant amount of example case studies that aim to complement both the lectures and hands-on lab training. The students are expected to apply the learning outcomes throughout the duration of the course during the assigned coursework.

Assessment: Assignments and Projects (60%); Mid-term exam (10%); Final exam (30%)

Bibliography:

Deep learning, I. Goodfellow, , Y. Bengio, A. Courville, and Y. Bengio, 2016, MIT press. Freely Available: https://www.deeplearningbook.org/

Deep Learning for Computer Vision with Python, Adrian Rosebrock, 2017.

Hands-On Machine Learning with Scikit-Learn & TensorFlow Concepts, Tools, and Techniques to Build Intelligent Systems, A. Geron, 2nd Edition, O'Reilly Media, 2019.

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MAI641 Master Thesis (16 ECTS)

Course purpose and objectives: The main objective of this course is to enable the students to develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study. The thesis should be written at the end of the programme and offers the opportunity to delve more deeply into and synthesize knowledge acquired. The thesis will place emphasis on the technical and/or scientific aspects of the subject matter.

Learning outcomes: (1) Considerably more in-depth knowledge of the major subject/field of study, including deeper insight into current research and development work. (2) Deeper knowledge of methods in the major subject/field of study. (3) A capability to contribute to research and development work. (4) The capability to use a holistic view to identify, formulate and deal with complex issues critically, independently and creatively. (5) The capability to plan and use adequate methods to conduct qualified tasks in given frameworks and to evaluate this work. (6) The capability to create, analyze and critically evaluate different technical solutions. (7) The capability to integrate knowledge critically and systematically. (8) The capability to clearly present and discuss the conclusions as well as the knowledge and arguments that form the basis for these findings in written and spoken English. (9) A consciousness of the ethical aspects of research and development work.

Prerequisites: A student must complete successfully courses, totaling at least 45 ECTS credits from the MSc AI Programme.

Teaching Methodology: For a student to undertake a Master Thesis a Research Advisor, based on the rules of the University Senate, is assigned to the student before s/he submits the Thesis Proposal. The Thesis must deal with a research topic or a technical issue. It must be of some original contribution or show a thorough and clear understanding of some special topic. A student participating in the AI Camp and/or completing successfully an industrial internship may discuss the possibility of doing his/her Master Thesis in collaboration with an industrial partner.

Assessment: The Master Thesis is submitted at the Department and defended within the time period decided by the Departmental Council and in accordance with the relevant rules and regulations of the Department and the University.

Bibliography: The bibliography of this course will be determined by the Research Advisor.

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DSC511 Big Data Analytics (8 ECTS)

Course purpose and objectives: The purpose of this course is the collection, modeling, and analysis of user data in large-scale online services, such as social networking, e-commerce, search, and advertisement. This class explores several the key functions of such online services that have become ubiquitous over the past decade.

Learning outcomes: Upon completing this course, students will be able to: (1) Explore real-world data from online services. (2) Develop frameworks and models for typical data mining problems in online services. (3) Analyze the efficiency and effectiveness of these models. (4) Utilize data mining and machine learning techniques to concrete real-world problems.

Teaching methodology: Lectures (3 hours weekly), Recitation (1 hour weekly) and Laboratory (2 hours weekly).

Assessment: Final exam, midterm exam, homework (programming and theoretical assignments) and semester project.

Bibliography:

J. Leskovec, A. Rajaraman και J. D. Ullman, *Mining of Massive Datasets*, Cambridge University Press, 2014.

M. Chiang: Networked Life, Cambridge, Cambridge, 2012

C. Bishop, Pattern Recognition and Machine Learning, Springer, 2006

D. Easley, J. Kleinberg: Networks, Crowds, and Markets, Cambridge, 2010

Ch. D. Manning, P. Raghavan, H. Schütze: Introduction to Information Retrieval, Cambridge, 2008

M.E.J. Newman: Networks: An Introduction, Oxford, 2010

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DSC551 Data Visualization (8 ECTS)

Course purpose and objectives: In this course, students will learn how to design, judge, build and present their own interactive data visualizations.

Learning outcomes: (1) visualizations from the idea to the final product according to human perception and cognition. (2) Know the common data-viz techniques for each data domain (multivariate data, networks, texts, cartography, etc.) with their technical limitations. (3) Create interactive visualizations in the browser using HTM5 and Javascript.

Teaching methodology: Lectures (3 hours weekly), Recitation (1 hour weekly) and Laboratory (2 hours weekly).

Assessment: Final exam, midterm exam, homework (programming and theoretical assignments) and semester project.

Bibliography:

Visualization Analysis and Design by Tamara Munzner, CRC Press (2014).

Interactive Data Visualization for the Web by Scott Murray O'Reilly (2013) - D3 - Free online version.

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DSC516 Cloud Computing (8 ECTS)

Course purpose and objectives: The main objective of this graduate-level course is to provide an introduction to and understanding of advanced concepts in the field of Cloud Computing, and enable students to design, develop, deploy, monitor and analyze applications on state-of-the-art Cloud computing platforms.

Learning outcomes: Upon completing this course, students will: (1) Master the fundamental concepts, the main enabling technologies and the key programming and application-development paradigms of modern Cloud Computing services. (2) Be able to design develop, deploy, and monitor highly scalable cloud-based applications by creating and configuring virtual machines, containers, microservices on the cloud. (3) Be familiar with techniques for big data analysis in Cloud Computing environments. (4) Compare, contrast, and evaluate the key trade-offs between multiple approaches to cloud system design, and Identify appropriate design choices when solving real-world cloud computing problems. (5) Write comprehensive case studies analyzing and contrasting different cloud computing solutions. (6) Make recommendations on cloud computing solutions for an enterprise.

Teaching methodology: Lectures (3 hours weekly), Recitation (1 hour weekly) and Laboratory (2 hours weekly).

Assessment: Final exam, midterm exam, homework (programming and theoretical assignments) and semester project.

Bibliography:

Kai Hwang, Geoffrey Fox, Jack Dongarra, “Distributed and Cloud Computing.” Morgan Kaufmann, 2012.

Ian Foster and Dennis Gannon, “Cloud Computing for Science and Engineering.” MIT Press, 2018.

Luiz André Barroso and Urs Hölzle, “The Datacenter as a Computer: An Introduction to the Design of Warehouse-Scale Machines.” 2009.

T. Erl, R. Puttini, and Z. Mahmood, Cloud Computing: Concepts, Technology & Architecture • ISBN-10: 0133387526 • ISBN-13: 9780133387520 ©2013 • Prentice Hall

Marko Lukša, “Kubernetes in Action,” Manning 2017.

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Admission Criteria

- A Bachelor’s degree in pure/applied sciences (computer science, informatics, mathematics, etc.) or engineering (e.g., computer engineering, biomedical engineering) or cognitive science
- Reasonable exposure to AI background topics gained through previous studies or work experience, as well as knowledge of computer programming
- Fluency in the English language

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MAI4CAREU

Master programmes in Artificial Intelligence 4 Careers in Europe

Submission of applications for September 2022 entrance

Applications can be submitted electronically using the online application system http://ucy.ac.cy/postgraduate_appl_en by **Thursday, 31st May 2022 until 12 noon.**

The applications should include the following:

A Curriculum Vitae

Certified copies of university degrees or confirmation of graduation (Admitted candidates will need to submit the certified degrees along with the acceptance of the offer to the University of Cyprus before their registration).

Copies of Transcripts for all university degrees.

A brief statement of personal goals and scientific interests (up to 2 pages).

The names and emails of at least two (2) referees (University Professors) familiar with the candidate and his/her academic performance. Candidates should request letters of recommendation to be sent directly to the University. The Department may request additional confidential information from referees. The reference letters are electronically submitted through the online application system.

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Fees: EUR 5.125

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For additional information contact the Programme Coordinator, Professor E. Keravnou-Papailiou (elpida@ucy.ac.cy)

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