CYA Syllabus

CIS 376|PHYS 376 AI Innovations: Bridging Theory and Practice in Applied Sciences

Fall 2024

Course Instructors: P. Krokidas AND Ch. Rekatsinas

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Class Times (days, hours):

(Office) Hours Available:

Course Description

Artificial intelligence (AI) in Applied Sciences is designed to equip third-year undergraduate students in applied sciences with a deep understanding of AI's fundamental concepts, its methodologies, and the transformative role it plays in various fields. The course unfolds over eight modules, each focusing on a distinct aspect of AI, starting from its historical evolution and moving through its sub-domains, practical applications, and ethical considerations.

The first module, "Demystifying AI," lays the groundwork by exploring the history and evolution of AI, and addressing common misconceptions to ensure that students possess a clear foundational knowledge. Subsequent modules delve into specific AI sub-domains, including machine learning algorithms, neural networks, and natural language processing, providing students with a broad understanding of the technical aspects of AI. The course also emphasizes the significance of data management, highlighting techniques for collecting quality data and data annotation, critical for training AI models.

A unique feature of this course is its focus on AI's role in enhancing the research project life cycle and its practical applications in research and development. Through a series of case studies, students will explore how AI technologies are applied across various stages of research, from ideation to dissemination of findings.

Course Approach

The course adopts a hands-on approach, combining theoretical instruction with practical exercises, discussions, and project work. Students will engage with real-world case studies, participate in group discussions, and undertake projects that apply AI concepts to practical problems.

Learning Objectives

By the end of this course, students will have a comprehensive understanding of artificial intelligence, its capabilities, limitations, and potential impact on society. They will be well-prepared to apply AI technologies in their future research and development projects, with a keen awareness of the ethical considerations involved in deploying AI solutions.

Specifically, students will:

- Understand the fundamental concepts of AI.
- Differentiate between AI sub-domains.
- Understand the importance of quality data collection and annotation techniques.
- Analyze and evaluate AI technologies.
- Stay abreast of emerging trends in AI.
- Choose among the main AI tools that can be integrated in traditional research processes in the field of applied sciences.

Course Requirements

- Midterm Assessment – In-class presentation assignment: The student chooses a subject that they wish to solve by utilizing AI methods. The student has to search the current state of the art and

present the already applied methods to the class. The presentation should be in the range of 7-10 slides, excluding the introduction and the conclusions.

- Participation – In-class participation includes physical and mental presence in the classroom, arriving on time, preparation, participation in class discussions, and posting occasionally on the Moodle forum. Reading assignments are to be completed before each class session. Class contribution is one of the most important factors for determining your grade for the semester.

- Final Project – The final project is complementary to the midterm assignment. The student has to take an additional step and, within an essay of 10 pages (font size 11), state:
  - the current state of the art (introduction),
  - the objectives,
  - the challenges,
  - how their proposed solution differs from what has already been applied, and
  - the outcome and benefits or limitations of their proposed method (conclusion).

Details about assignments and exams will be given in advance. No late assignments or make-up exams will be accepted or arranged, unless discussed with the instructors beforehand. If unable to attend class, please notify the instructors beforehand.

Evaluation and Grading

Midterm Assessment – 30%

Participation – 20%

Final Project – 50%

Regulations and Accommodations

Attendance Policy

CYA regards attendance in class and on-site (in Athens or during field study trips) as essential, so attendance at all scheduled meetings is required. All absences are recorded and have consequences that may affect your grade. Illness or other such compelling reasons which result in absences should be reported immediately at the Report Medical Issue form.

Academic Accommodations

Students are required to submit an official letter from the office at their school that handles academic accommodations (generally the Office of Disability Services), or to have that office send a letter. Students who have submitted such a letter to CYA should also talk to their professors individually to discuss how these accommodations will work in each specific course.

Site Visits and Accessibility

NCSR "Demokritos", Institute of Informatics and Telecommunications (room to be confirmed).

Policy on Original Work

Plagiarism is literary theft. As such, it is a serious offense, which will not be tolerated, whether at students' home institution or at CYA. Plagiarism on an examination or in a paper will result in an F grade for the course. Students must cite the author of any and all ideas that are not common knowledge or their own. If in doubt, it is safest to cite the source. Submissions should be original and reflect the students' own ideas and thoughts. If students are unsure about what counts as original work, they are advised to consult with

their professor and refer to the Student Handbook.

Use of Laptops

In-class or onsite use of laptops and other devices is permitted if this facilitates course-related activities, such as note-taking, looking up references, etc. Laptop or other device privileges will be suspended if devices are not used for class-related work.

Upgrade to 400-level Course

Courses can be upgraded to a 400-level. This typically requires an additional 25% of work on the part of the student. The option to upgrade becomes available during the second week of classes. If you are interested in this option, please talk to your professor.

Class Schedule

Class Day	Day/Date/Place (if applicable)	Topic / Readings / Assignments Due
	Sept 5 – 7	**Field Study: Delphi and Ancient Olympia**
1	Tue Sept 10	**A brief summary of AI history and Evolution** Explore the historical milestones and key developments that have shaped the field of artificial intelligence. *Readings* Applied Machine Learning and AI for Engineers page 8 • A Brief History of Artificial Intelligence: What It Is, Where We Are, and Where We Are Going
2	Thu Sept 12	**AI: Definitions and misconceptions** Clarify common AI terms and debunk myths, providing a clear understanding of what AI is and what it is not. *Readings* ▪ A Brief History of Artificial Intelligence: What It Is, Where We Are, and Where We Are Going
3	Tue Sept 17	**Introduction to Machine Learning & Deep Learning** Gain insights into the foundational algorithms and models that power machine learning and deep learning. *Readings* ▪ **ML:** Applied Machine Learning and AI for Engineers, pages 4-8 Fundamentals of Machine Learning for Predictive Data Analytics, 3-15 ▪ **ML and Deep Learning:** Handbook of Big Data Research Methods, pages 149-154 ▪ **Deep Learning:** Fundamentals of Machine Learning for Predictive Data Analytics, pages 381-384 Applied Machine Learning and AI for Engineers, pages 177-186
	Sept 18 – 21	**Field Study: Crete**
4	Tue Sept 24	**Natural Language Processing (NLP)**

		Understand how machines interpret, understand, and generate human language through NLP techniques. *Reading* ▪ Applied Machine Learning and AI for Engineers, Chapter 13
5	Thu Sept 26	**Knowledge representation and reasoning** Discover the methods AI uses to represent knowledge and make logical deductions or predictions. *Reading* ▪ Lecture notes
6	Tue Oct 1	**AI Integration, trends and challenges** Learn how ML, NLP and Knowledge representation complement each other, and what are the current trends and challenges in AI *Reading* ▪ Lecture notes
7	Thu Oct 3	**Classification, Regression, Clustering, Optimization** Explore the core machine learning algorithms used for prediction, analysis, and data grouping, along with optimization techniques. *Readings* ▪ **Regression** Handbook of Big Data Research Methods 155 Applied Machine Learning and AI for Engineers pgs 29-50 ▪ **Classification** Applied Machine Learning and AI for Engineers 53-70 ▪ **Journal article** MACHINE-LEARNING-DRIVEN HEALTH MONITORING DIAGNOSTICS FOCUSED ON COMPOSITE STRUCTURES UTILIZING SMART LAYERWISE SPECTRAL ELEMENTS
8	Tue Oct 8	**Supervised vs Unsupervised Learning** Understand the differences and applications of supervised and unsupervised learning in AI systems. *Readings* ▪ Applied Machine Learning and AI for Engineers, pages 9-27 ▪ **Supervised Learning** Handbook of Big Data Research Methods, pages 154-158 ▪ **Unsupervised Learning** Handbook of Big Data Research Methods, 158-160 Fundamentals of Machine Learning for Predictive Data Analytics, 597-636
9	Thu Oct 10	**Active and Reinforcement Learning** Dive into the dynamic learning processes of AI through active and reinforcement learning strategies. *Readings* ▪ AI-guided Design and property prediction for zeolite and nanoporous materials 13.4.4

		▪ **Reinforcement Learning** Fundamentals of Machine Learning for Predictive Data Analytics, 637-680
10	Tue Oct 15	**Neural Networks** Learn about advanced neural network architectures (LSTM, CNN, PINNs, GNNs). *Readings* ▪ Handbook of Big Data Research Methods, page 157 ▪ Applied Machine Learning and AI for Engineers, Chapters 8 (Deep Learning) and 9 (Neural Networks) ▪ Fundamentals of Machine Learning for Predictive Data Analytics, pages 384-403 ▪ Applied Machine Learning and AI for Engineers, pages 177-217
11	Thu Oct 17	**Ethical Considerations and trustworthiness in AI Applications** Explore the ethical challenges and considerations in developing and deploying AI technologies. *Readings* ▪ Limits and Possibilities for "Ethical AI" in Open Source: A Study of Deepfakes ▪ On educating ethics in the AI era: Why business schools need to move beyond digital upskilling, towards ethical upskilling ▪ Ethical risks of AI-designed products: bespoke surgical tools as a case study ▪ How to teach responsible AI in Higher Education: Challenges and opportunities
12	**Tue Oct 22**	**Midterm Week** **Ensuring Reliability and Explainability in AI Systems** Focus on the importance of building AI systems that are reliable, understandable, and transparent. *Readings* ▪ Explainable Artificial Intelligence (XAI) 2.0 - A manifesto ▪ Trustworthy Artificial Intelligence: A Review
13	**Thu Oct 24**	**Midterm Week** **Understanding Big Data Challenges** Definition and characteristics of big data, data capture, storage and processing. **Midterm assignment presentation** *Reading* ▪ Lecture notes
	Oct 25 – Nov 3	**Fall Break**
14	Tue Nov 5	**Tools and Techniques for Data Analysis** Delve into the complexities and challenges of handling big data in today's digital landscape. *Reading* ▪ Big Data Research Methods
15	Thu Nov 7	**Collecting Quality Data** Understand the importance and methodologies for collecting high-quality data for AI projects. *Reading* ▪ Big Data Research Methods

	Nov 12 – 15	**Field Study: Peloponnese**
16	Tue Nov 19	**Data Annotation Techniques** Learn about different data annotation techniques essential for training accurate AI models. *Reading* ▪ Lecture notes
17	Thu Nov 21	**Introduction to AI in Research and Development** Explore the evolution of AI in R&D, understanding its impact and the key technologies that have shaped its integration into research processes. *Reading* ▪ Lecture notes
18	**Fri Nov 22**	**Make-up T|TH class** **AI-driven Data Collection and Analysis** Delve into how AI streamlines data collection and analysis, enhancing the efficiency and effectiveness of research methodologies.
19	Tue Nov 26	**Case Studies in AI-enhanced R&D** Analyze real-world case studies where AI has been successfully applied in research and development across various fields. *Reading* ▪ Lecture notes
	Nov 28 – Dec 1	**Thanksgiving Break**
20	Tue Dec 3	**Future Trends and Ethical Considerations** Examine emerging trends in AI for R&D and discuss the ethical considerations and governance of AI technologies in research. *Reading* ▪ Lecture notes
21	Thu Dec 5	**AI-based inverse design: Concept and Applications** *Introduces the revolutionary concept of AI-based inverse design, exploring its fundamental principles and wide-ranging applications in various industries.* *Reading* ▪ Journal Article: Inverse Design of Materials by Machine Learning
22	**Fri Dec 6**	**Make-up T|TH class** **AI-based inverse design: Case Studies in Applied Sciences** Presents detailed case studies highlighting the practical implementation and success stories of AI-based inverse design across different scientific and engineering domains. *Reading* ▪ Journal Article: Open-Source Implementation and Validation of a 3D Inverse Design Method for Francis Turbine Runners
23	Tue Dec 10	**Planning and Implementing AI Projects** Gain insights into effective strategies for planning and implementing successful AI projects. *Reading*

		▪ Journal Article: Implementation of artificial intelligence system and traditional system: a comparative study
24	Thu Dec 12	**Deployment, Evaluation, and Maintenance** Understand the critical phases of deploying, evaluating, and maintaining AI projects for long-term success. *Reading* ▪ OA Journal Article: Implementation of Artificial Intelligence (AI): A Roadmap for Business Model Innovation
	Tue Dec 17	**Final Exam Week**
	Thu Dec 19	**Final Exam Week**

N.B.: The course schedule, in terms of subjects and readings, may be subject to change to benefit student learning and to keep up to date with current research.

Schedule at a Glance

Day #	Date	Session	Venue
	Sep 5-7	**Field Study**	**Delphi and Ancient Olympia**
1	Sep 10	A brief summary of AI history and Evolution	NCSR "Demokritos"
2	Sep 12	AI: Definitions and misconceptions	NCSR "Demokritos"
3	Sep 17	Introduction to Machine Learning & Deep Learning	NCSR "Demokritos"
	Sep 18 – 21	**Field Study**	**Crete**
4	Sep 24	Natural Language Processing (NLP)	NCSR "Demokritos"
5	Sep 26	Knowledge representation and reasoning	NCSR "Demokritos"
6	Oct 1	AI Integration, trends and challenges	NCSR "Demokritos"
7	Oct 3	Classification, Regression, Clustering, Optimization	NCSR "Demokritos"
8	Oct 8	Supervised vs Unsupervised Learning	NCSR "Demokritos"
9	Oct 10	Active and Reinforcement Learning	NCSR "Demokritos"
10	Oct 15	Neural Networks	NCSR "Demokritos"
11	Oct 17	Ethical Considerations and trustworthiness in AI Applications	NCSR "Demokritos"
12	**Oct 22**	**Midterm Week** Ensuring Reliability and Explainability in AI Systems	NCSR "Demokritos"
13	**Oct 24**	**Midterm Week** Understanding Big Data Challenges	NCSR "Demokritos"
	Oct 25 – Nov 3	**Fall Break**	
14	Nov 5	Tools and Techniques for Data Analysis	NCSR "Demokritos"
15	Nov 7	Collecting Quality Data	NCSR "Demokritos"
	Nov 12 - 15	**Field Study**	**Peloponnese**

Day #	Date	Session	Venue
16	Nov 19	Data Annotation Techniques	NCSR "Demokritos"
17	Nov 21	Introduction to AI in Research and Development	NCSR "Demokritos"
18	**Nov 22**	**Make-up T|TH class** AI-driven Data Collection and Analysis	NCSR "Demokritos"
19	Nov 26	Case Studies in AI-enhanced R&D	NCSR "Demokritos"
	Nov 28 – Dec 1	**Thanksgiving Break**	
20	Dec 3	Future Trends and Ethical Considerations	NCSR "Demokritos"
21	Dec 5	AI-based inverse design: Concept and Applications	NCSR "Demokritos"
22	**Dec 6**	**Make-up T|TH class** AI-based inverse design: Case Studies in Applied Sciences	NCSR "Demokritos"
23	Dec 10	Planning and Implementing AI Projects	NCSR "Demokritos"
24	Dec 12	Deployment, Evaluation, and Maintenance	NCSR "Demokritos"
	Dec 17	**Final Exam Week**	
	Dec 19	**Final Exam Week**	

Course Bibliography

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[14] J. Prosise, A. Prosise, *Applied Machine Learning and AI for Engineers : Solve Business Problems That Can't Be Solved Algorithmically*, O'Reilly Media, Inc, Sebastopol, **2023**.

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