Introduction to machine learning

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Timeline of AI ascendance in biomedicine

2019 2022 2016 1950 1986 ChatGPT Google Al FDA approvals **DXplain** Turing test Deep learning models Al-powered device for Launched by OpenAI, Software for Turing designed a test based on large language outperform human cancer diagnosis and to uncover whether differential diagnosis deep-learning algorithm models (LLMs) with expert in diagnosing computers are capable using a pseudobroad potential also in retinopathy from for interpretation of probabilistic algorithm. of human intelligence. biomedicine retinal images. brain MRIs. 2022 2007 2017 2020 1971 **IBM Watson** FDA approvals **AlphaFold** FDA approvals **INTERNIST-1** Later used for variety of 91 Al-powered devices Al-assisted analysis of Google DeepMind uses biomedical application: including EchoGo to Scientists developed a MRIs in seconds and Al-Al to predict a protein's detects heart failure biomarkers discovery, ranking algorithm to powered device for 3D structure from its from a single reach diagnosis. drug discovery, amino-acid sequence. operating-room use. differential diagnosis. echocardiogram.

Molecular Biosensing

Application: ML-enhanced sensors for real-time disease monitoring Impact: Immediate feedback for patient management

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Systems Biology

Application: Modelling biological systems and pathways

Impact: Deeper understanding of life processes

Wearable Tech

Application: Monitoring chronic diseases (e.g., diabetes)

Impact: Real-time health insights for patient management

Drug discovery

Application: Virtual screening for drug candidates

<u>Impact</u>: Faster drug development

Medical Imaging

Application: Cancer detection from CT, MRIs Impact: Early diagnosis with high accuracy

Machine

learning in

Biomedical

Engineering

Personalised Medicine

Application: Tailoring treatments based on patient data

Impact: Optimised therapy with minimal side effects

Signal Processing

Application: Real-time heart disease monitoring (ECG)

Impact: Early warning of cardiac events

Soft Tissue Engineering

Application: ML-driven design of biomaterials for tissue repair Impact: Improved outcomes in tissue regeneration

Protein engineering

Application: Designing proteins using ML for targeted therapies Impact: Innovations in drug development

Healthcare operations

Application: Predicting hospital admissions

Impact: Efficient resource management

Nanomedicine

Application: ML for designing and optimising nanoparticle drug delivery systems

Impact: Targeted treatment with reduced side effects

Topics covered in this course

Week	Lecture	Practical		
1	Machine learning fundamentals	Project 0: Introduction		
2	Linear and logistic regression	Project 1.1:Linear and logistic regression		
3	Regularization for linear models	Project 1.2: Regularization for linear models		
4	Methods for classification	Project 1.3: Application of linear models to a case study		
5	Neural networks, part 1	Project 2.1:Neural networks, part 1		
6	Neural networks, part 2	Project 2.2: Neural networks, part 2		
7	Unsupervised learning	Project 2.3: Application of neural networks to a case study		

Week 1-7 lectures and practicals (all on Wednesday). Week 8 (the week before the exam) has no lecture nor practical.

The course in a nutshell

- Assessment
 - ► 70% written exam
 - 30% practicals

All topics from the lectures are covered in the written exam. Some of the topics (linear models and neural networks) are also covered in the practicals.

- GitHub repository is used for material dissemination
- Canvas is used for communication and submission/grading
- Lecture schedule is in My Timetable and on GitHub (note that the room for the first practical has been changed, both My Timetable and GitHub are already updated).

Study material

- Main guidance: lecture slides and practicals
- Book: "An introduction to statistical learning with applications in python:, G. James, D. Witten, T. Hastie, R. Tibshirani, J. Taylor

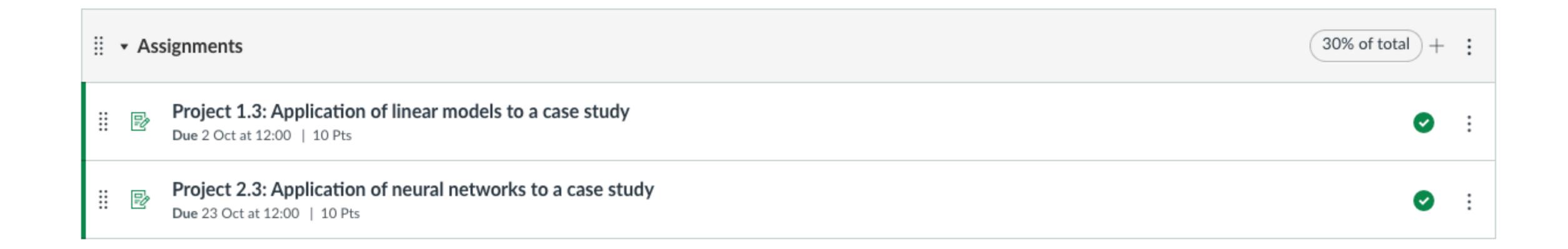
Lecture slides and practicals in Github

#	Date	Location	Title	Slides
1	04/Sep	Aud.15	Machine learning fundamentals	intro, lectures
2	11/Sep	Aud.15	Linear and logistic regression	
3	18/Sep	Aud.15	Regularization for linear models	
4	25/Sep	Aud.15	Methods for classification	
5	02/Oct	Aud.15	Neural networks, part 1	
6	09/Oct	Aud.15	Neural networks, part 2	
7	16/Oct	Aud.15	Unsupervised learning	
8	23/Oct	-	No lecture	-
A	31/Oct	Exam		

Practical assignments

#	Date	Location	Title	Exercises
1	04/Sep	~~ Luna 1.050 ~~ Gem-Z 3A.05 *	Project 0: Introduction	practicals
2	11/Sep	Aud. 07	Project 1.1: Linear and logistic regression	
3	18/Sep	He. 0.01	Project 1.2: Regularization for linear models	
4	25/Sep	Aud. 07	Project 1.3: Application of linear models to a case study	
5	02/Oct	Aud. 07	Project 2.1: Neural networks, part 1	
6	09/Oct	Aud. 07	Project 2.1: Neural networks, part 2	
7	16/Oct	Aud. 07	Project 2.1: Application of neural networks to a case study	
8	23/Oct	-	No practical	-

Submission in Canvas



Practicals

- Work in group of up to 5 students
- Distributed as Python notebooks
- Divided in 3 projects
 - Project 0: Introduction
 - Project 1: Linear models
 - Project 1.2: Linear and logistic regression
 - Project 1.2: Regularisation for linear models
 - ► Project 1.3: Application of linear models to a case study
 - Project 2: Neural networks
 - Project 2.1:Neural networks, part 1
 - Project 2.2: Neural networks, part 2
 - ► Project 2.3: Application of neural networks to a case study

Project 1.3 and Project 2.3 will be graded

Practicals

- Deliverables, a zip file with :
 - A single Python notebook that contains the experiments, visualisation of results and answer to the questions
 - Python functions and/or classes (.py files) that you have developed to implement the basic functions, if used in the Python notebook.
- ► The assessment rubric for the practicals can be found in GitHub
- 5 teaching assistants will be present during the practicals
- You are encouraged to use Canvas Discussion to ask general questions

Feedback

Any type of (constructive) feedback you might have during or after the course is very welcome!