## Introduction to machine learning

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## Timeline of AI ascendance in biomedicine

1950 **Turing test**indidesigned a te

Turing designed a test to uncover whether computers are capable of human intelligence.

1986 **DXplain** 

Software for differential diagnosis using a pseudo-probabilistic algorithm.

2016

Google Al

Deep learning models
outperform human
expert in diagnosing
retinopathy from
retinal images

2019

FDA approvals

Al-powered device for cancer diagnosis and deep-learning algorithm for interpretation of brain MRIs

2022

ChatGPT

Launched by OpenAl, based on large language models (LLMs) with broad potential also in biomedicine

1971
INTERNIST-1

Scientists developed a ranking algorithm to reach diagnosis.

2007

**IBM Watson** 

Later used for variety of biomedical application: biomarkers discovery, drug discovery, differential diagnosis

2017

FDA approvals

Al-assisted analysis of MRIs in seconds and Al-powered device for operating-room use.

2020

**AlphaFold** 

Google DeepMind uses
Al to predict a protein's
3D structure from its
amino-acid sequence,

2022

FDA approvals

91 Al-powered devices including EchoGo to detects heart failure from a single echocardiogram.

### Molecular Biosensing

Application: ML-enhanced sensors for real-time disease monitoring <a href="Impact">Impact</a>: 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 <a href="Impact">Impact</a>: 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

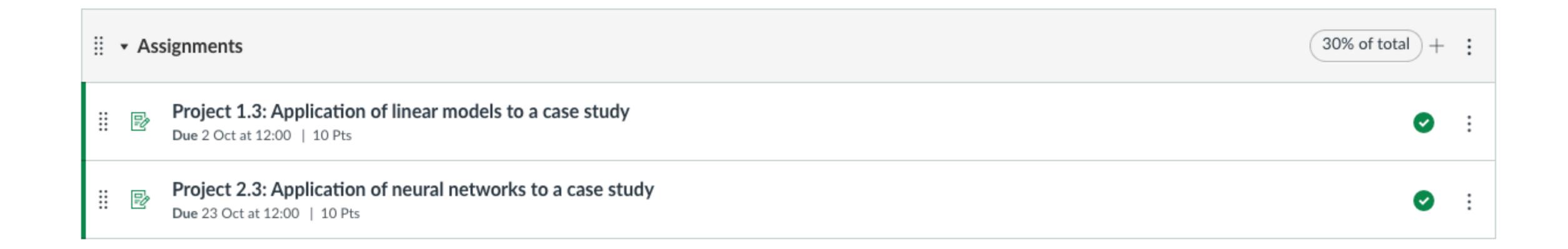
# Lecture slides and practicals in Github

#	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	-
<b>A</b>	31/Oct	Exam		

#### **Practical assignments**

#	Date	Location	Title	Exercises
1	04/Sep	~~ <del>Luna 1.050</del> ~~ 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