TÉCNICO LISBOA

Planning, Learning and Decision Making

Course overview

Faculty

Francisco S. Melo

OFFICE TIME:

- **Tuesday, 14h00-15h30**
- **Friday, 9h30-11h00**

Faculty

Alberto Sardinha

OFFICE TIME:

- **Tuesday, 9h30-11h00**

Faculty

João Ribeiro

OFFICE TIME:

- **Monday, 10h00-11h30**

Faculty

Miguel Faria

OFFICE TIME:

- **Wednesday, 9h00-10h30**

Faculty

Miguel Vasco

OFFICE TIME:

- **Thursday, 9h00-10h30**

Faculty

Diogo Carvalho

OFFICE TIME:

- **Friday, 8h00-9h30**

TÉCNICO LISBOA

Schedule (Alameda)

	Monday	Tuesday	Wednesday	Thursday	Friday
8:00			8:00-9:30 L LAB 8/Zoom		
9:00					
10:00					
11:00		11:00-12:30 L LAB 11/Zoom	11:00-12:30 L LAB 13/Zoom		
12:00					
13:00		12:30-14:00 T Zoom		12:30-14:00 L LAB 11/Zoom	
14:00				14:00-15:30 T Zoom	
15:00			15:00-16:30 L LAB 13/Zoom		
16:00				15:30-17:00 L LAB 13/Zoom	
17:00		17:00-18:30 L LAB 11/Zoom			
18:00					

Schedule (TagusPark)

	Monday	Tuesday	Wednesday	Thursday	Friday
8:00					
9:00					
10:00					
11:00					11:00-12:30 T Zoom
12:00					
13:00					12:30-14:00 L 0-14/Zoom
14:00					14:00-15:30 L 0-14/Zoom
15:00	15:00-16:30 T Zoom				
16:00					
17:00					
18:00					

Schedule (office time)

	Monday	Tuesday	Wednesday	Thursday	Friday
8:00					8:00-9:30 Office time (D. Carvalho)
9:00		9:30-11:00 Office time (A. Sardinha)	9:00-10:30 Office time (M. Faria)	9:00-10:30 Office time (M. Vasco)	
10:00	10:00-11:30 Office time (J. Ribeiro)				9:30-11:00 Office time (F. Melo)
11:00					
12:00					
13:00					
14:00		14:00-15:30 Office time (F. Melo)			
15:00					
16:00					
17:00					
18:00					

Contact

padi@padi.tecnico.ulisboa.pt

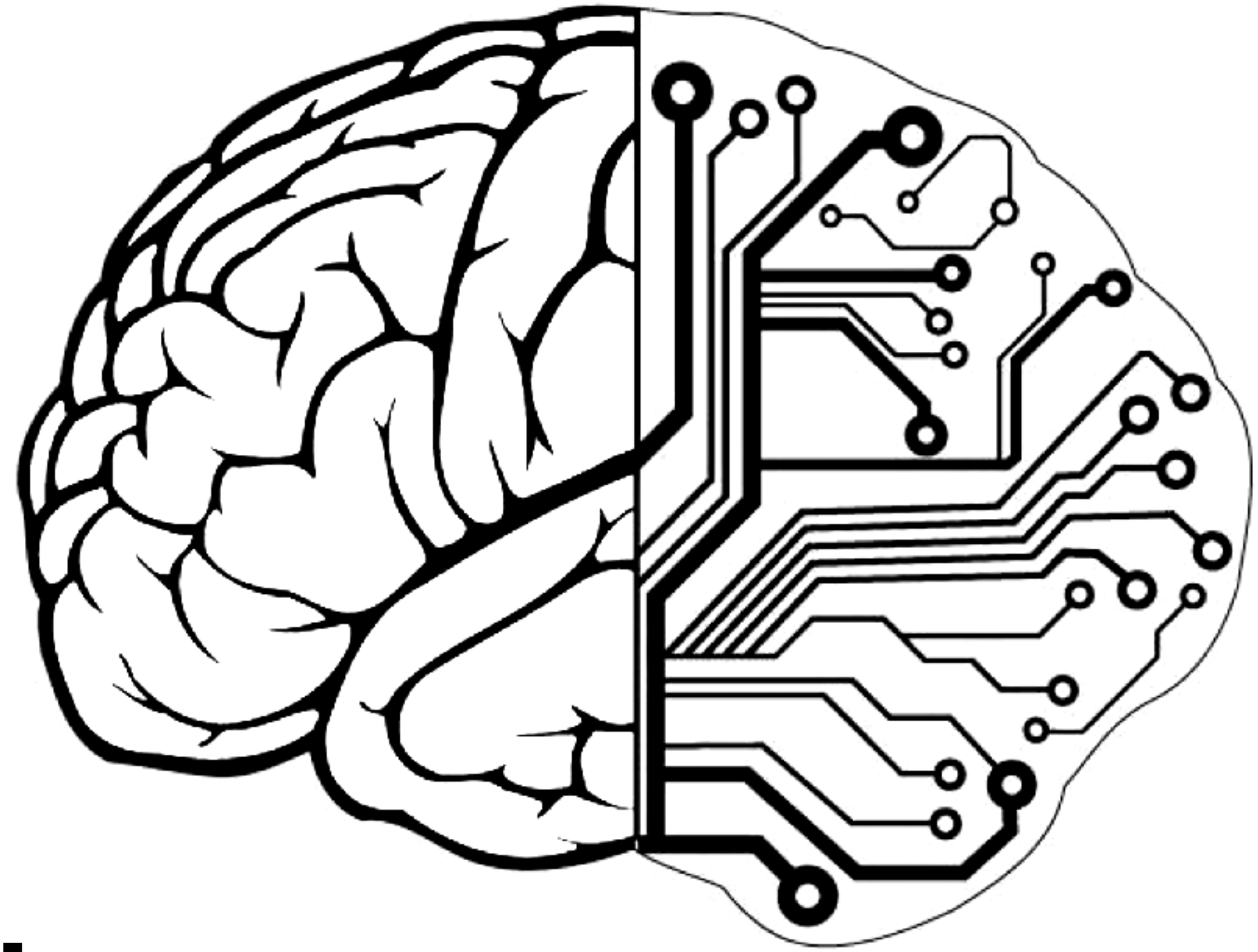
- For matters concerning the “logistics” of the course

- **Questions about course material → office hours.**

"I'm wondering, why are you here?"

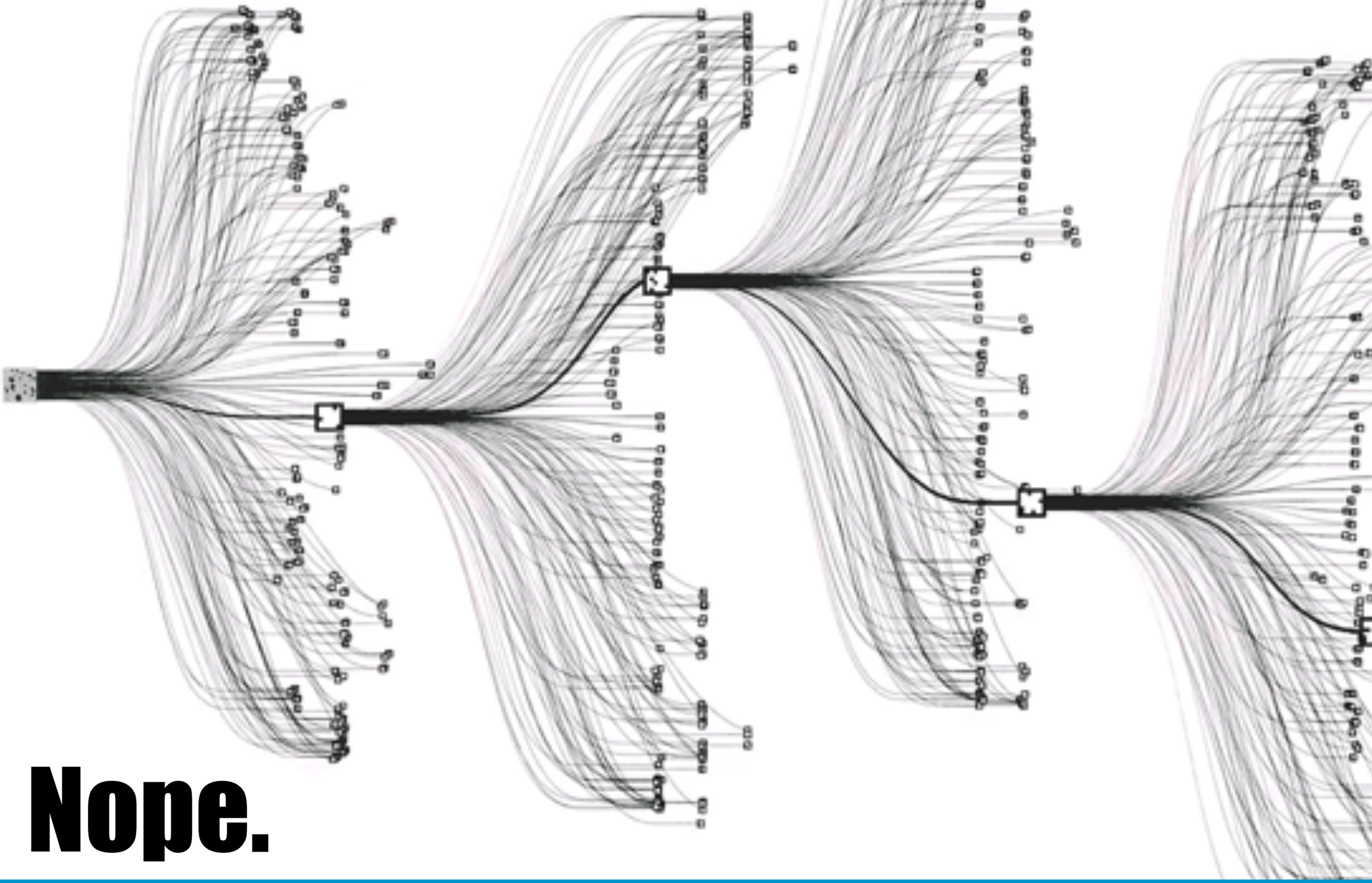
–Master Yoda, Star Wars V

Why I am here



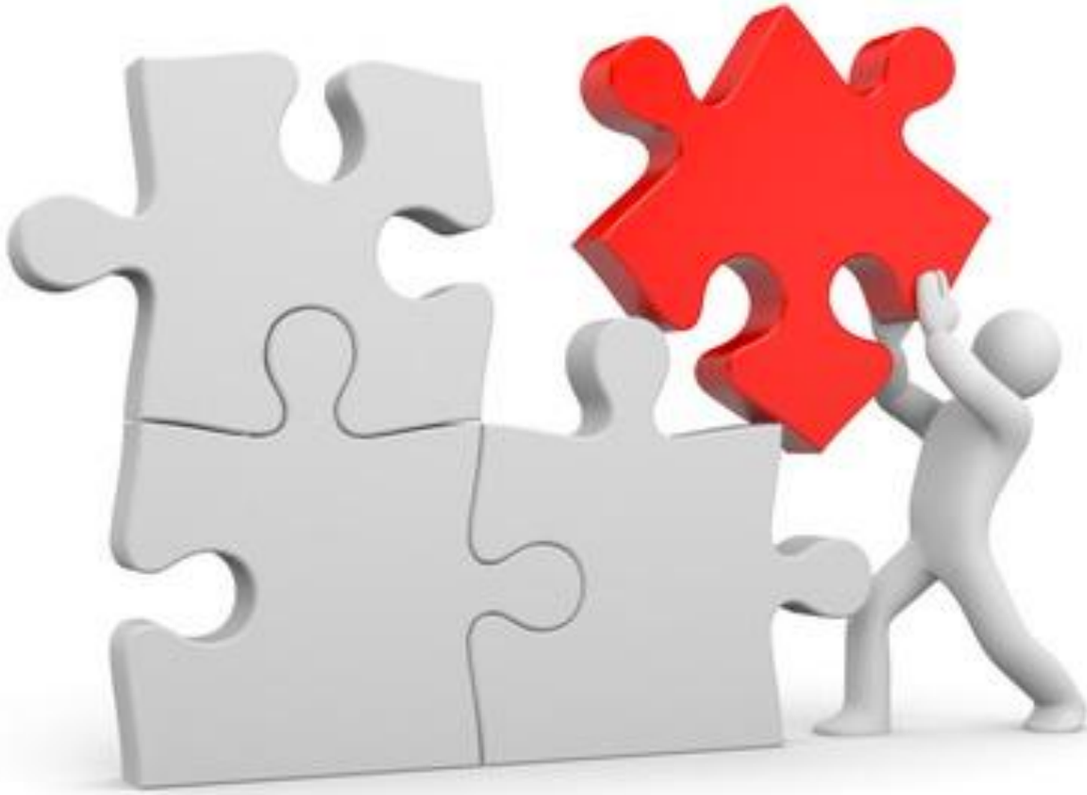
A.I.


Are you talkin’ to ME??



Nope.

Uncertainty



Planning

Learning

TÉCNICO LISBOA

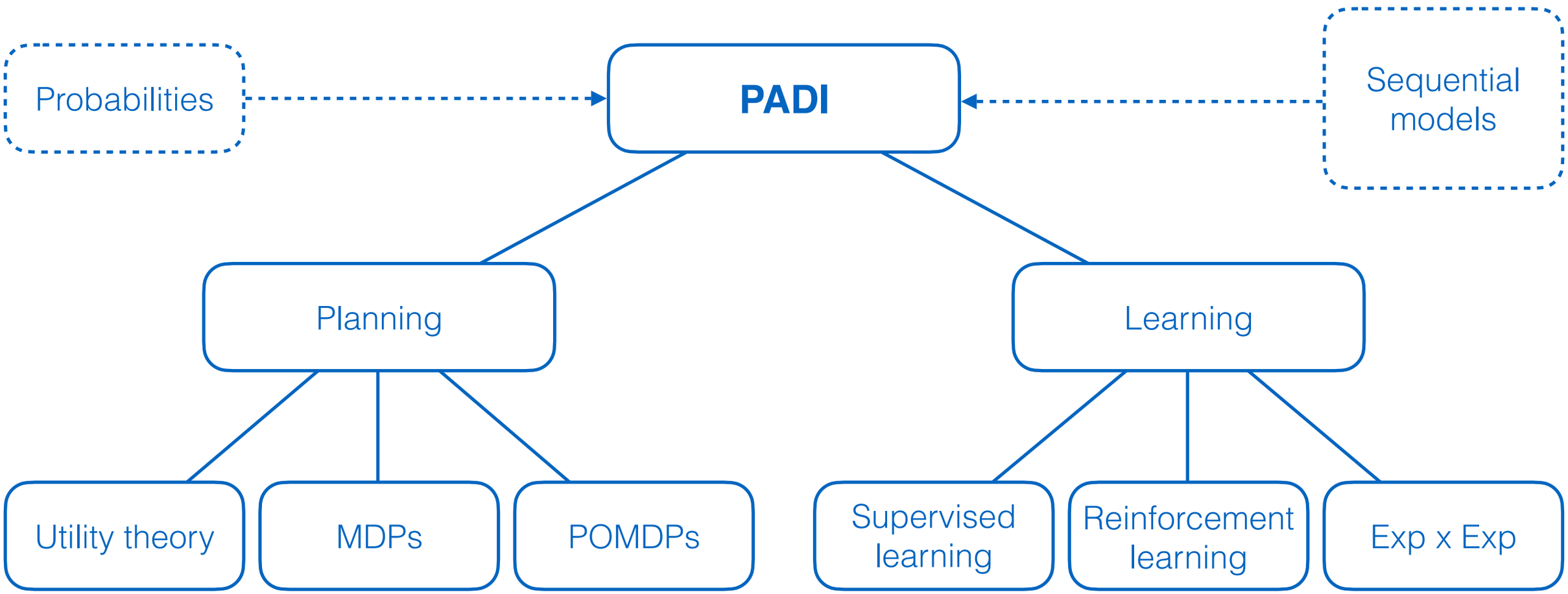
DECISION MAKING

The course

Goals

- Understand the main issues involved in **decision making**, in face of **uncertainty**
- Familiarize with some of the main tools for **planning** and **learning** in such settings

Learning and Decision Making



Syllabus

- **Introduction**
  - Chance and uncertainty
  - Modeling sequential processes
- **Decision making**
  - Making simple decisions
  - Sequential decision problems
  - Deciding with incomplete information
- **Learning**
  - Learning from examples
  - Learning by trial and error
  - Predictions, gambling and luck
- **Applications**

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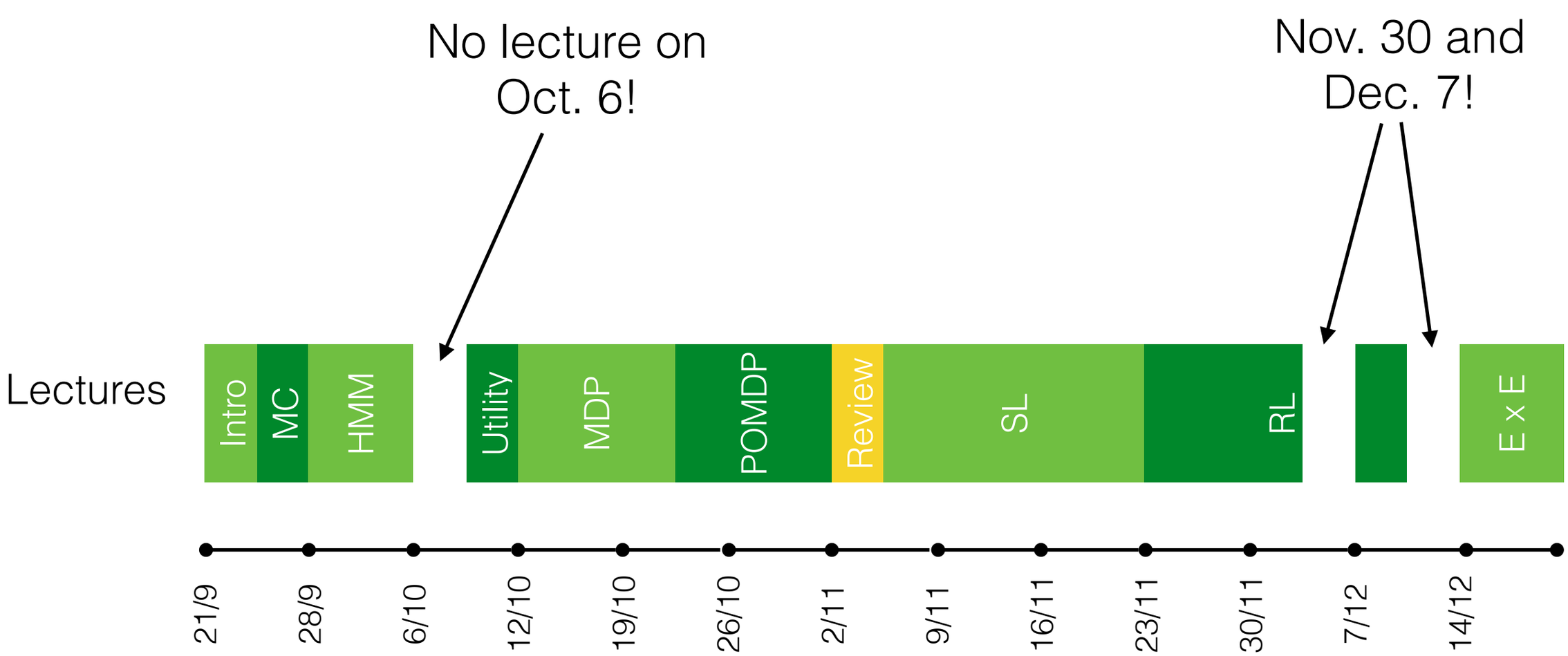
Syllabus

- **Introduction**
  - Review of probabilities
  - Markov chains and hidden Markov models
- **Decision making**
  - Utility theory
  - Markov decision problems
  - Partially observable Markov decision problems
- **Learning**
  - Supervised learning
  - Reinforcement Learning
  - Exploration vs. exploitation
- **Applications**

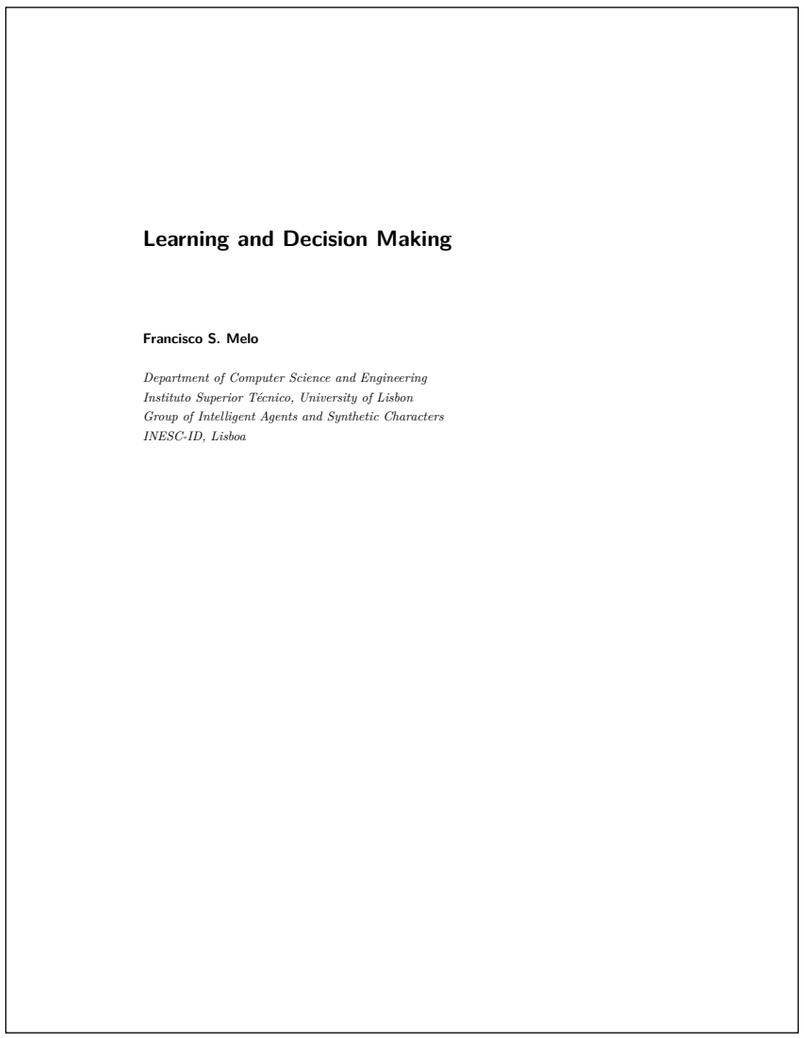
Lecture plan



Bibliography

Bibliography

- Main reference:



Learning and Decision Making

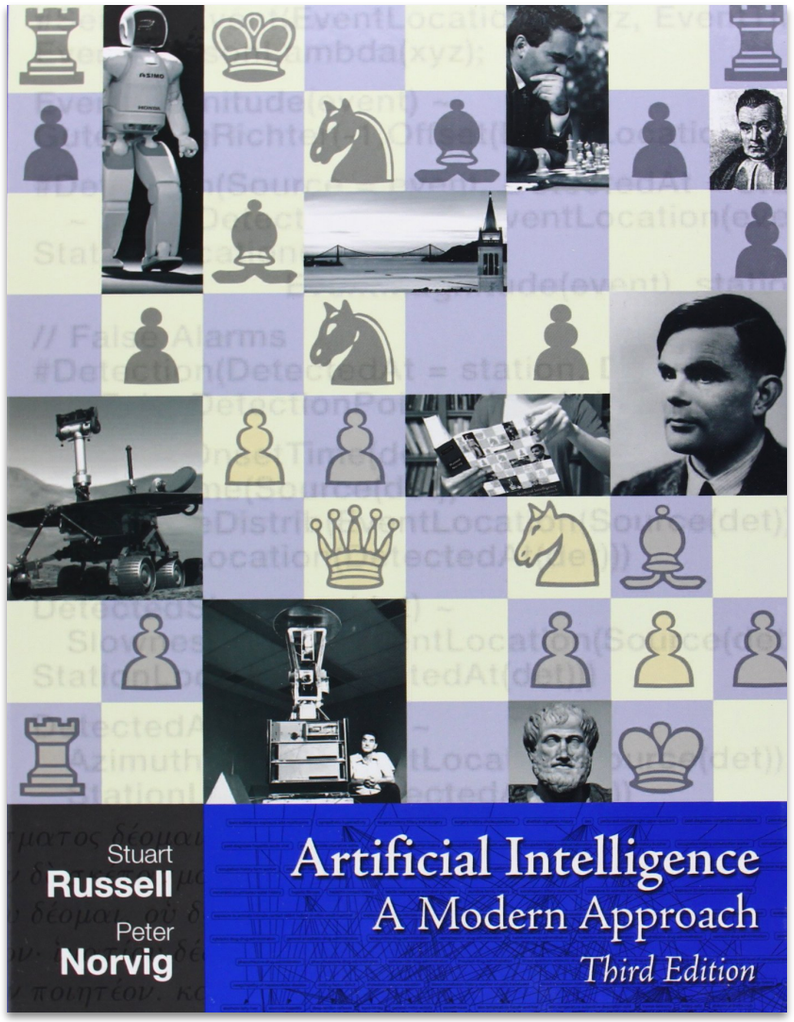
Francisco S. Melo

Department of Computer Science and Engineering
Instituto Superior Técnico, University of Lisbon
Group of Intelligent Agents and Synthetic Characters
INESC-ID, Lisboa

Updated version from last year

Bibliography

- You can also find most material here

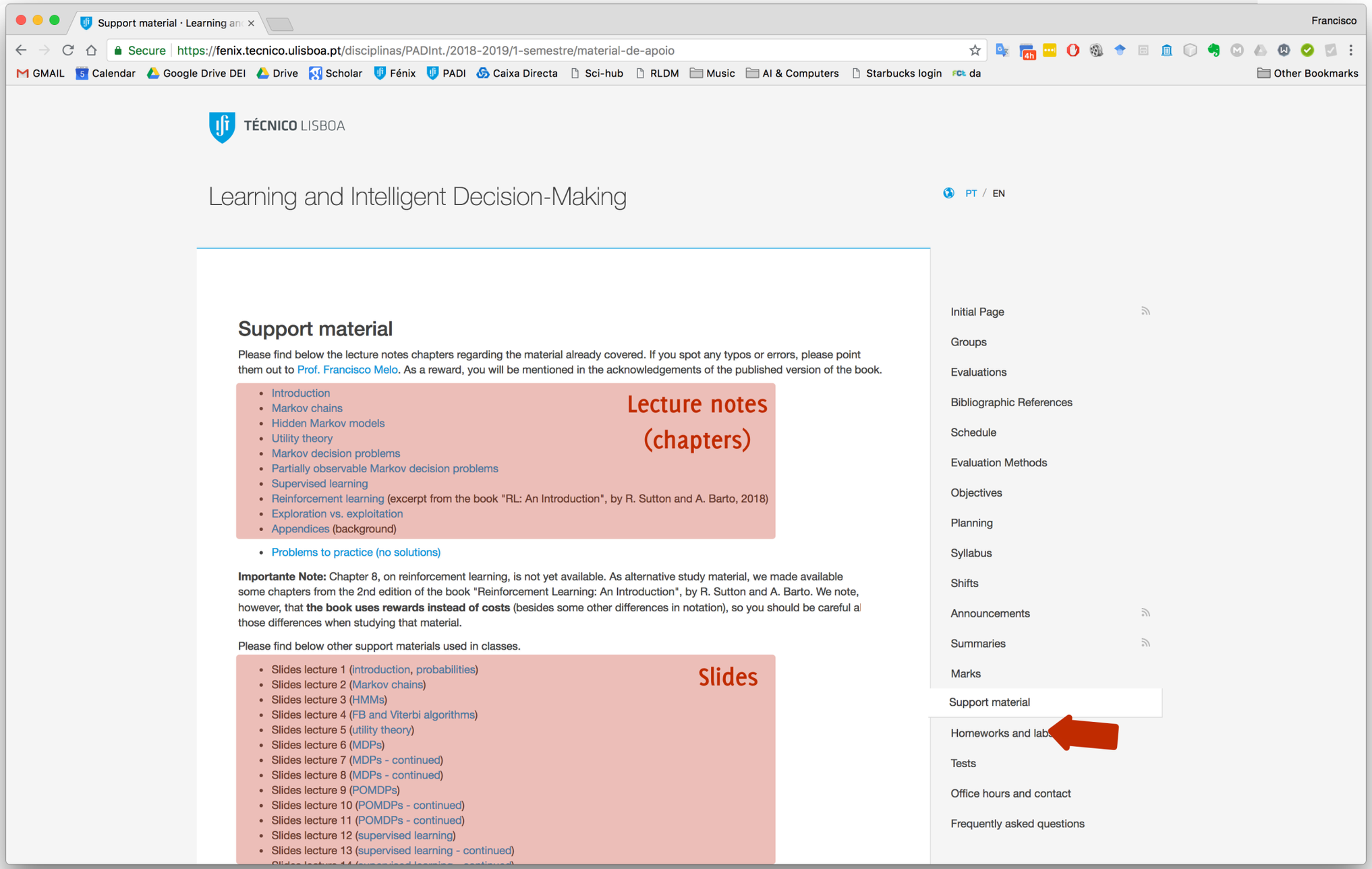


Some topics not covered

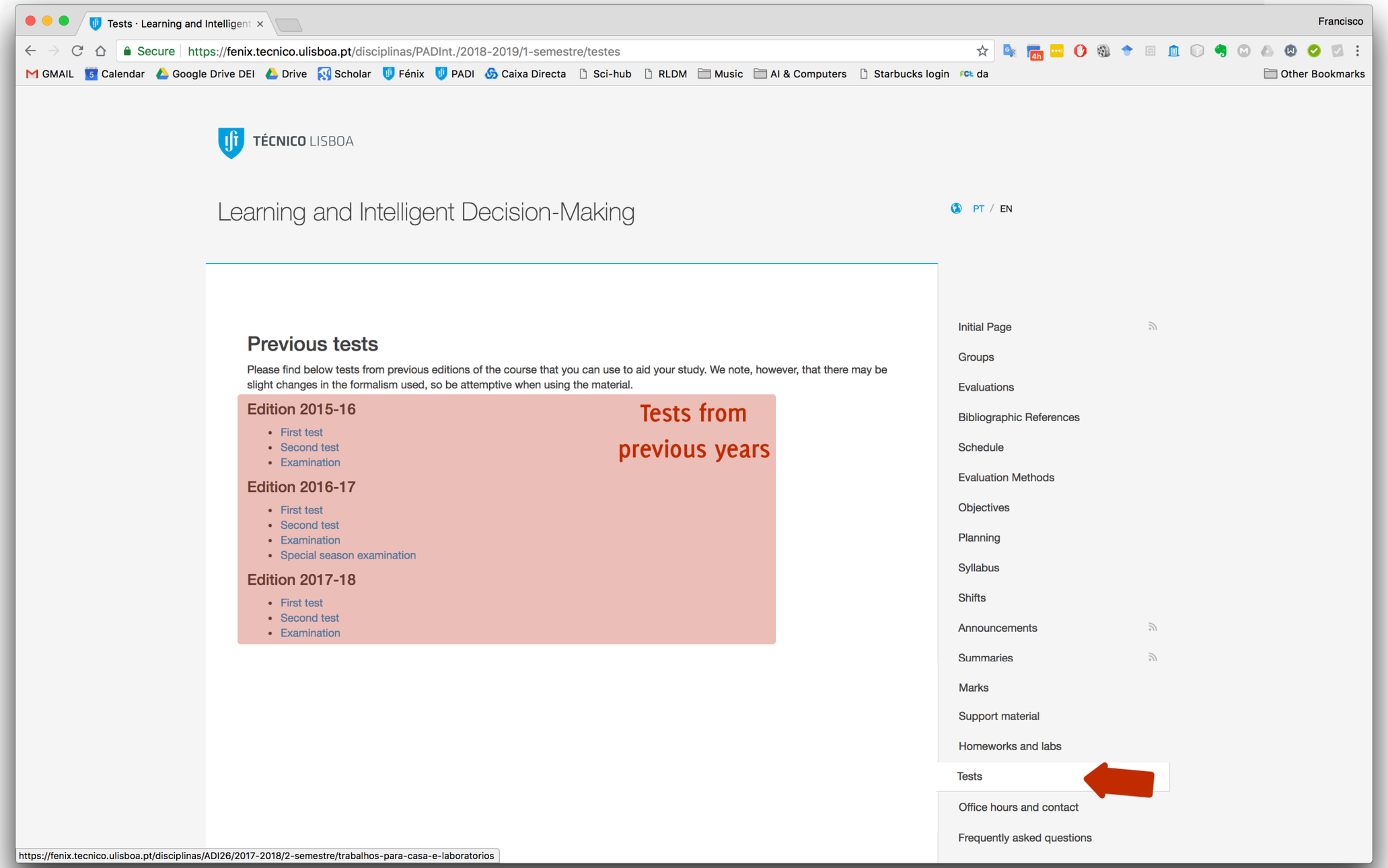
Variable level of detail in presentation

Different notation

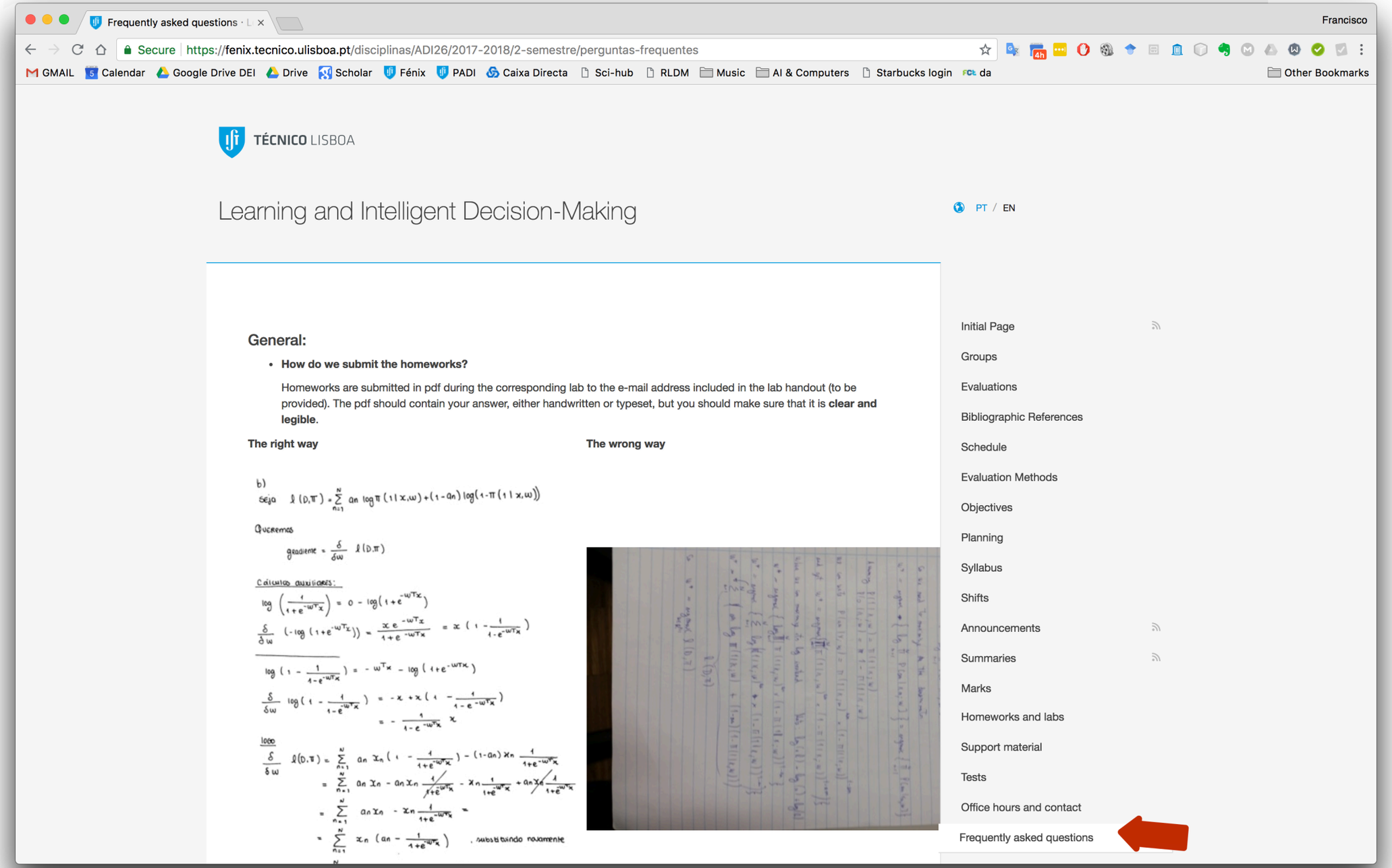
Other support material



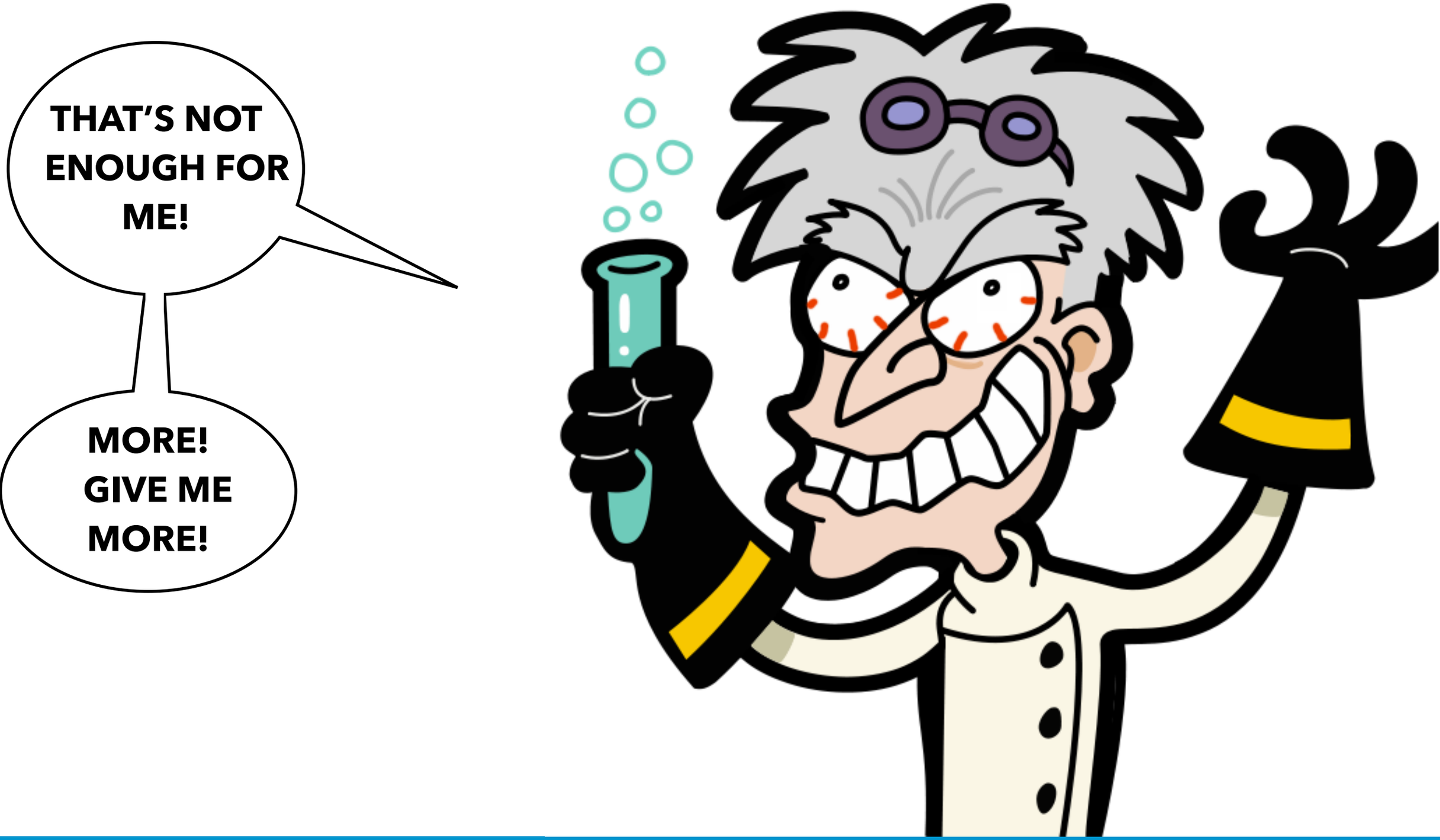
Other support material



Other support material

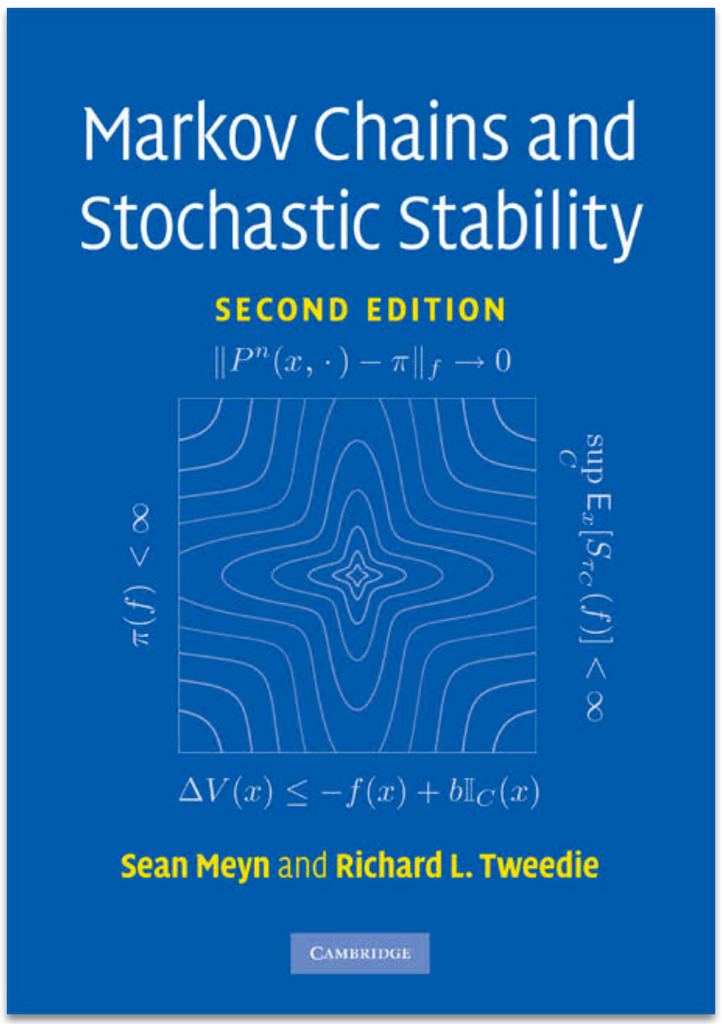


Bibliography



Bibliography

- Markov chains

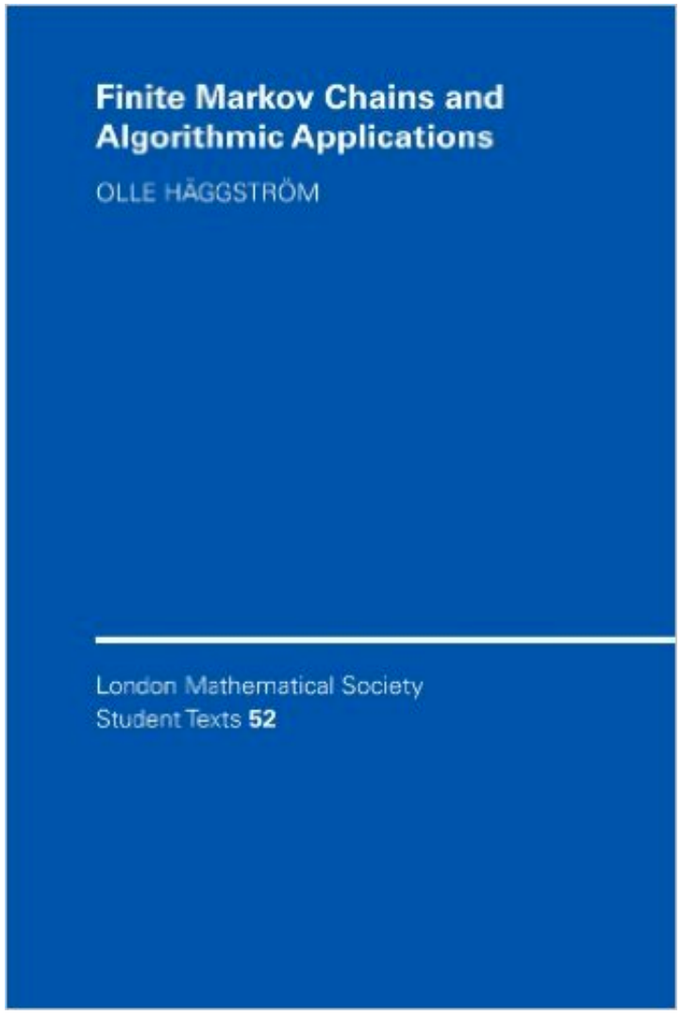


Very complete — focus on stability

Hard core math

Bibliography

- Hidden Markov models

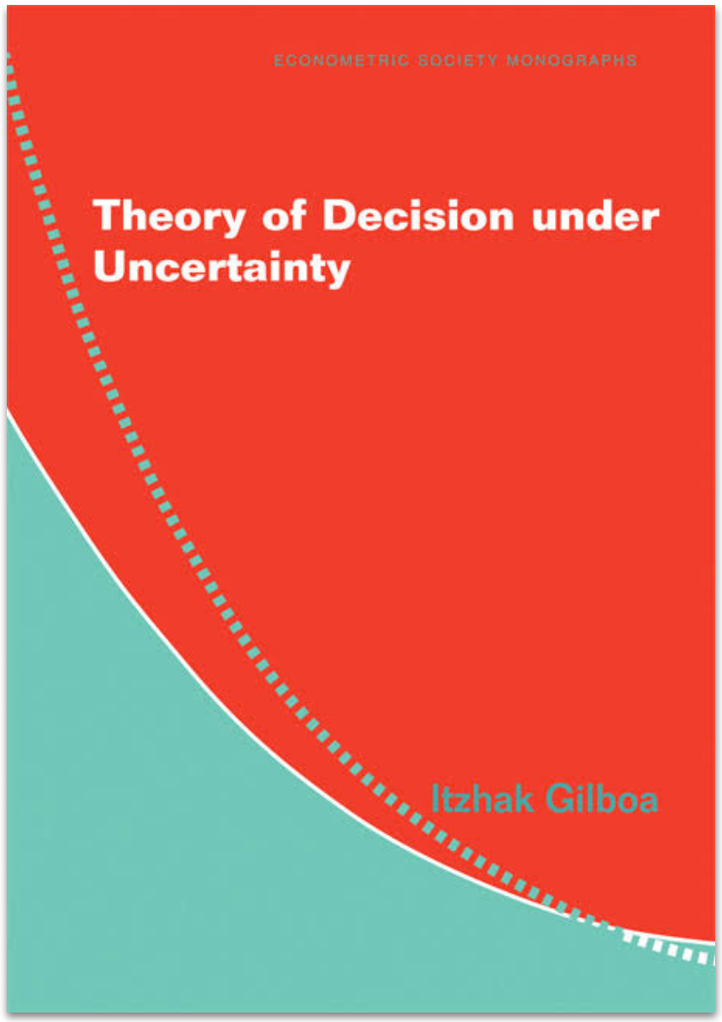


Accessible and complete

Focus on algorithms and sampling

Bibliography

- Utility theory

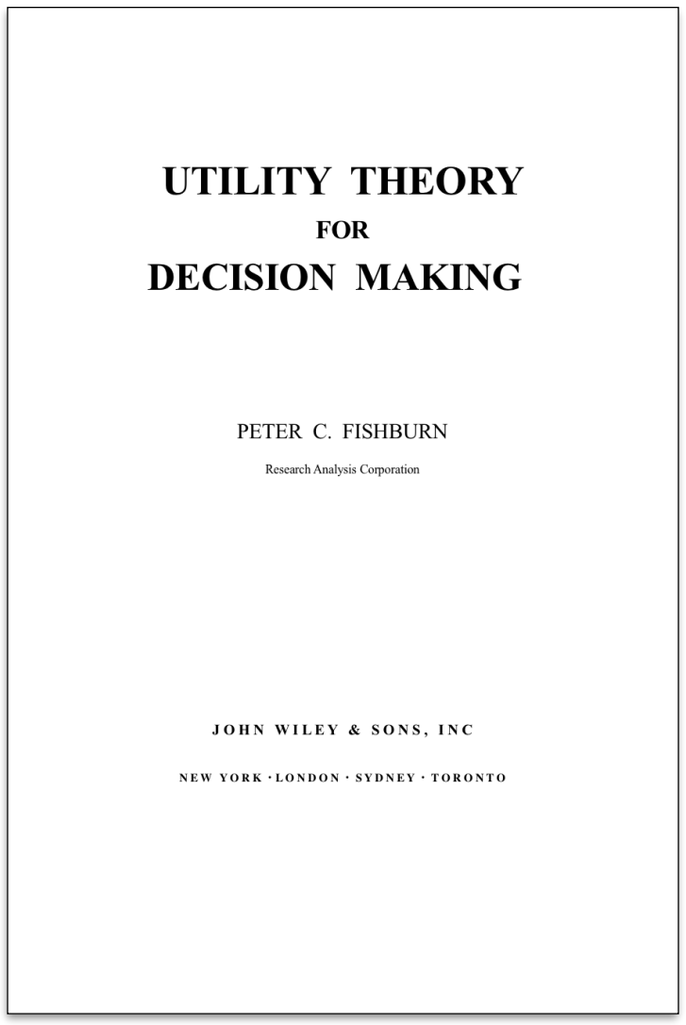


Not very mathematical

More philosophical — very interesting

Bibliography

- Utility theory



UTILITY THEORY
FOR
DECISION MAKING

PETER C. FISHBURN

Research Analysis Corporation

JOHN WILEY & SONS, INC

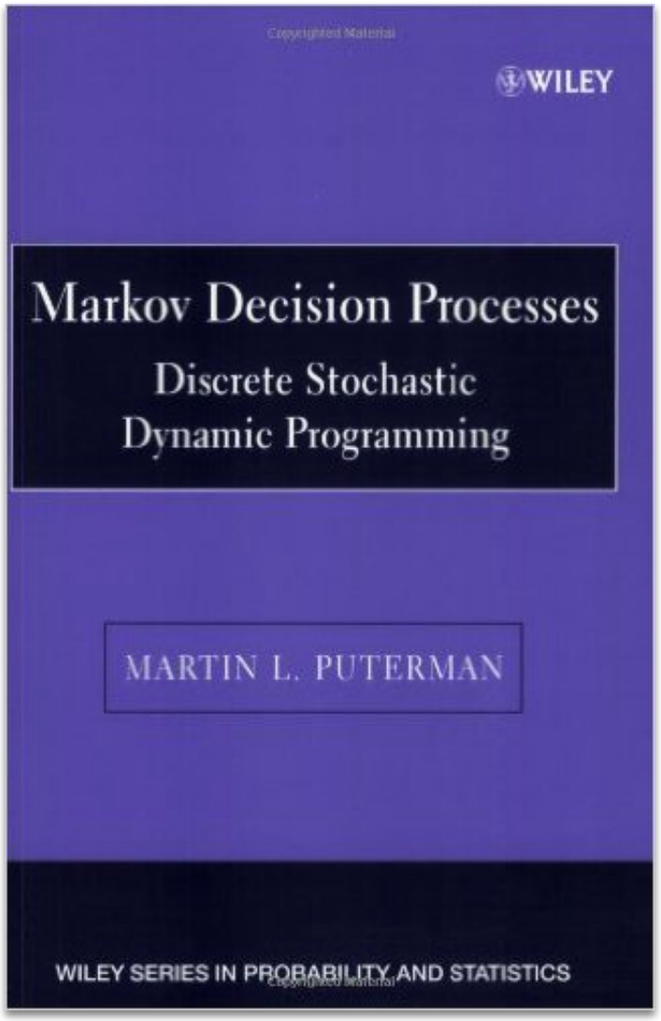
NEW YORK · LONDON · SYDNEY · TORONTO

Classical text

Very complete — and very mathematical

Bibliography

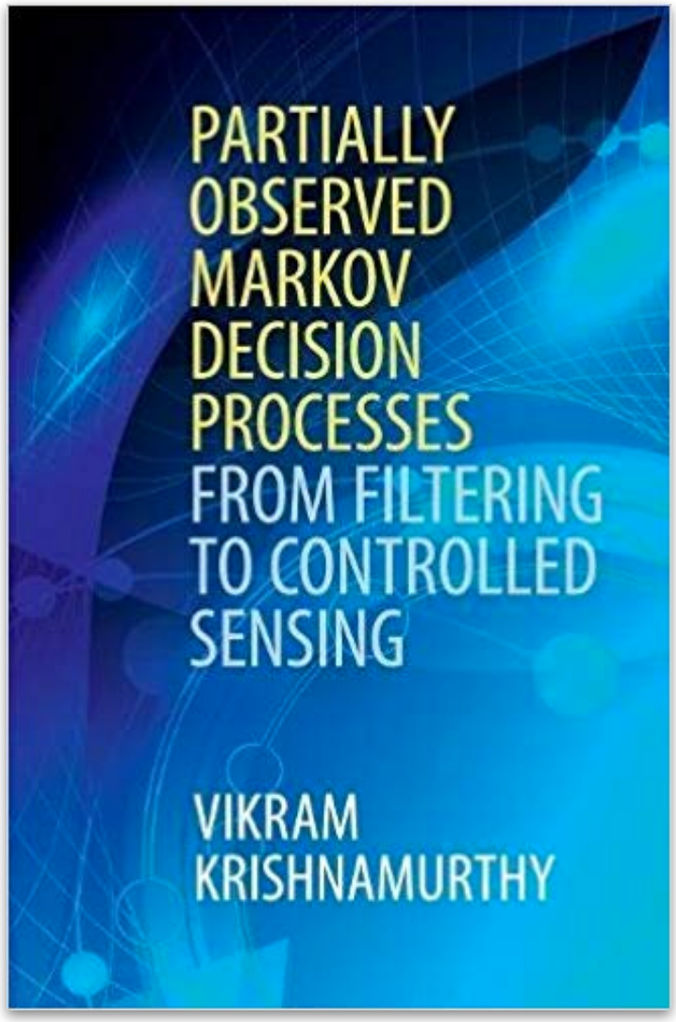
- Markov decision problems



THE reference

Bibliography

- Partially observable MDPs

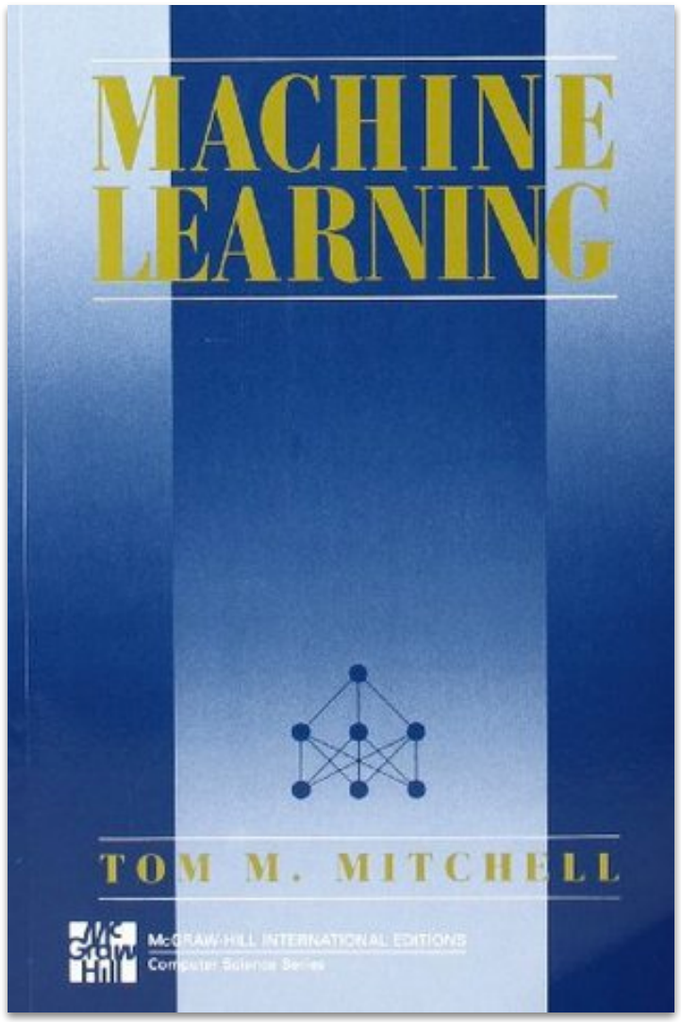


Covers **a lot** more than we need

Somewhat math intensive

Bibliography

- Supervised learning



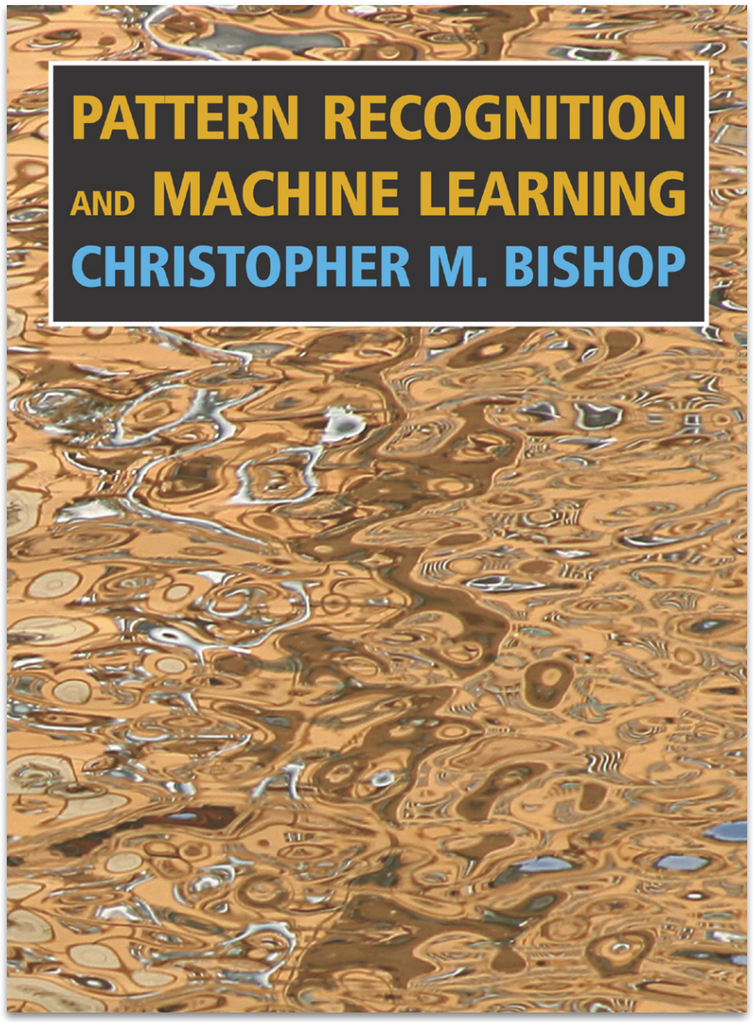
Great introductory book

Very accessible

Somewhat outdated

Bibliography

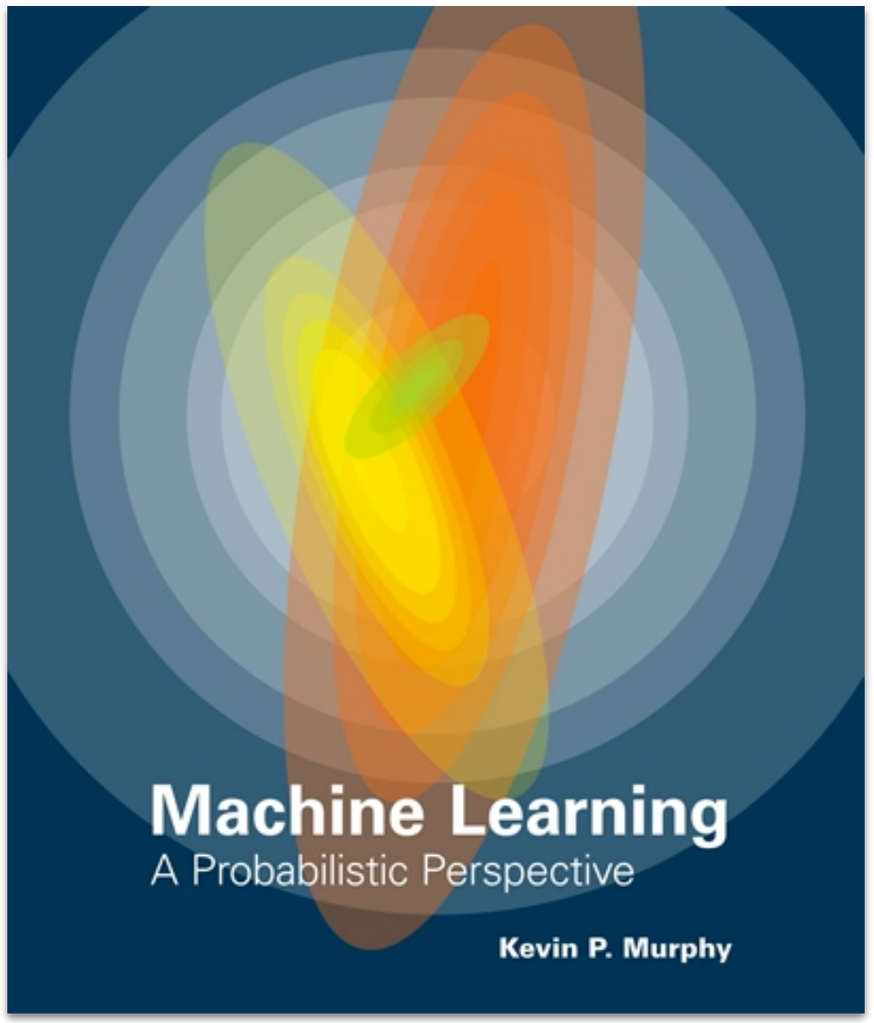
- Supervised learning



One of the best books (in my opinion)

Bibliography

- Supervised learning



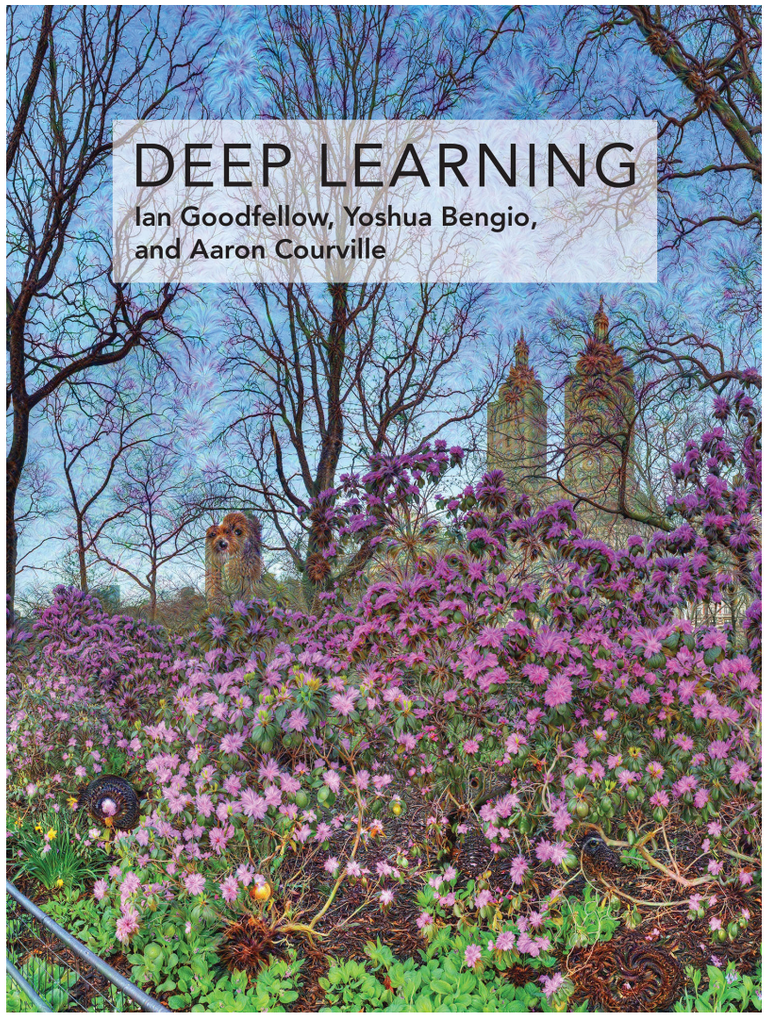
Very complete

Very up-to-date

Variable level of detail

Bibliography

- Supervised learning



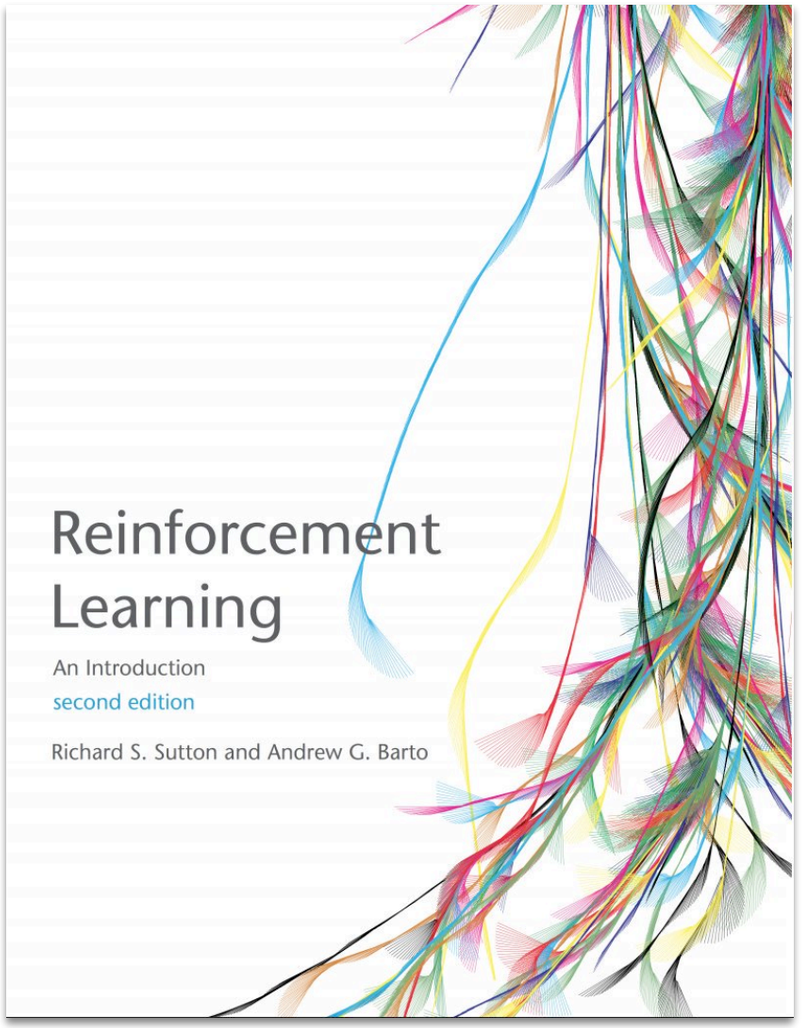
For those more “trendy”

Great reference

Available online

Bibliography

- Reinforcement learning

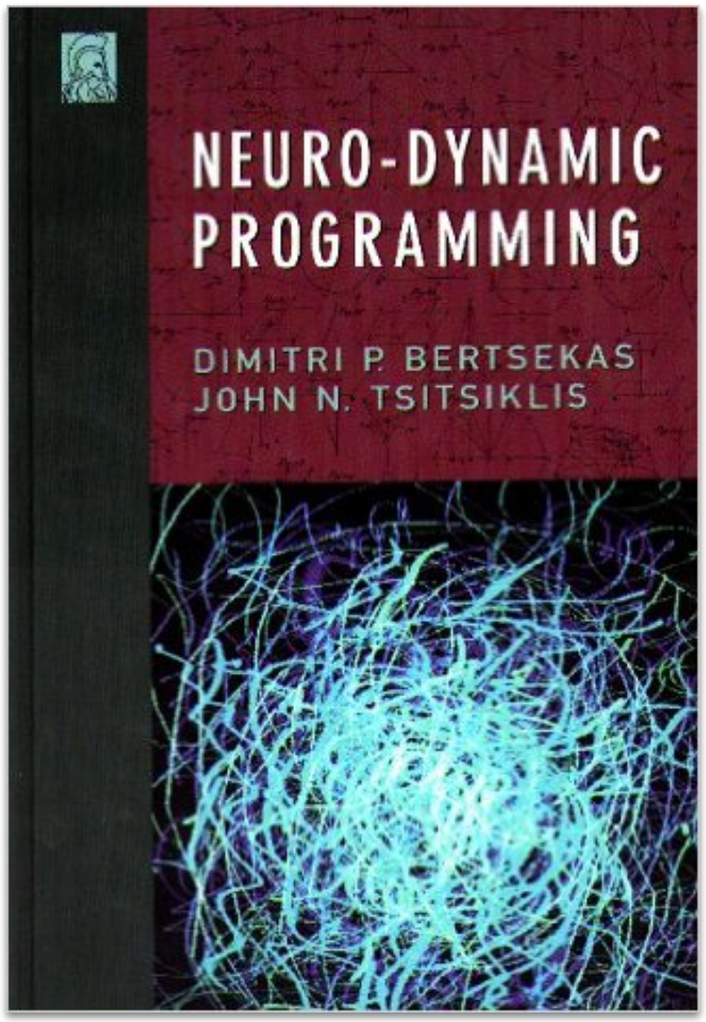


Great introduction

New edition

Bibliography

- Reinforcement learning

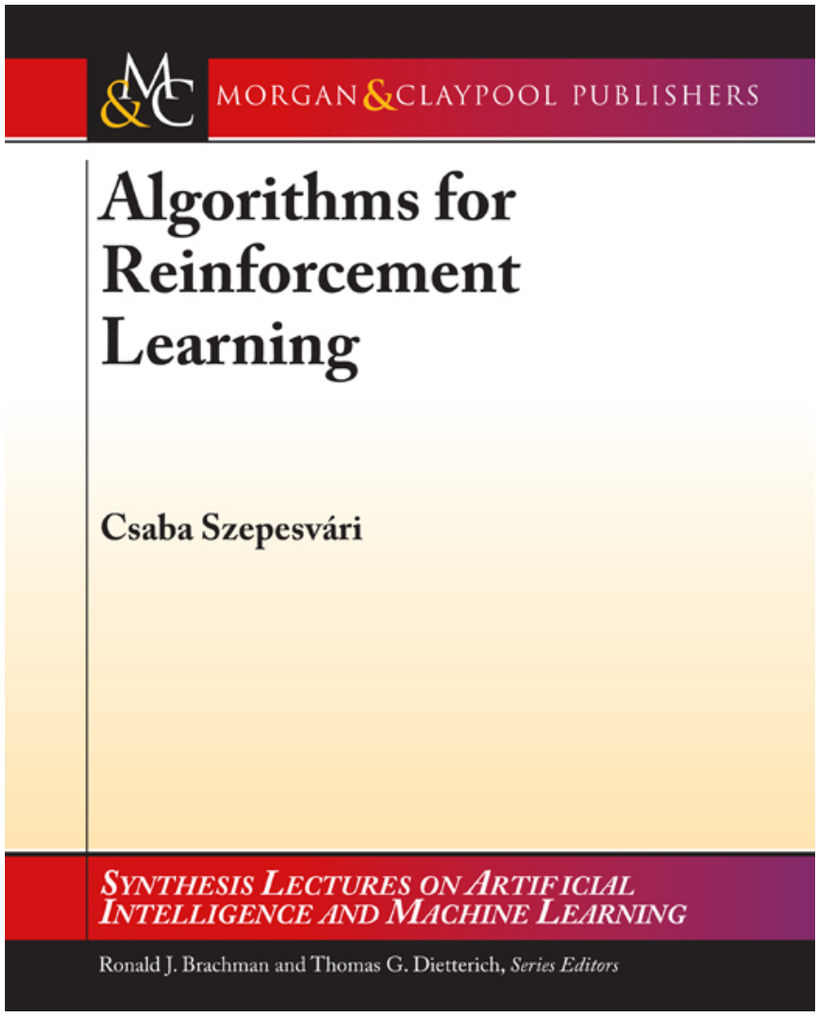


More in-depth coverage

Very mathematical

Bibliography

- Reinforcement learning

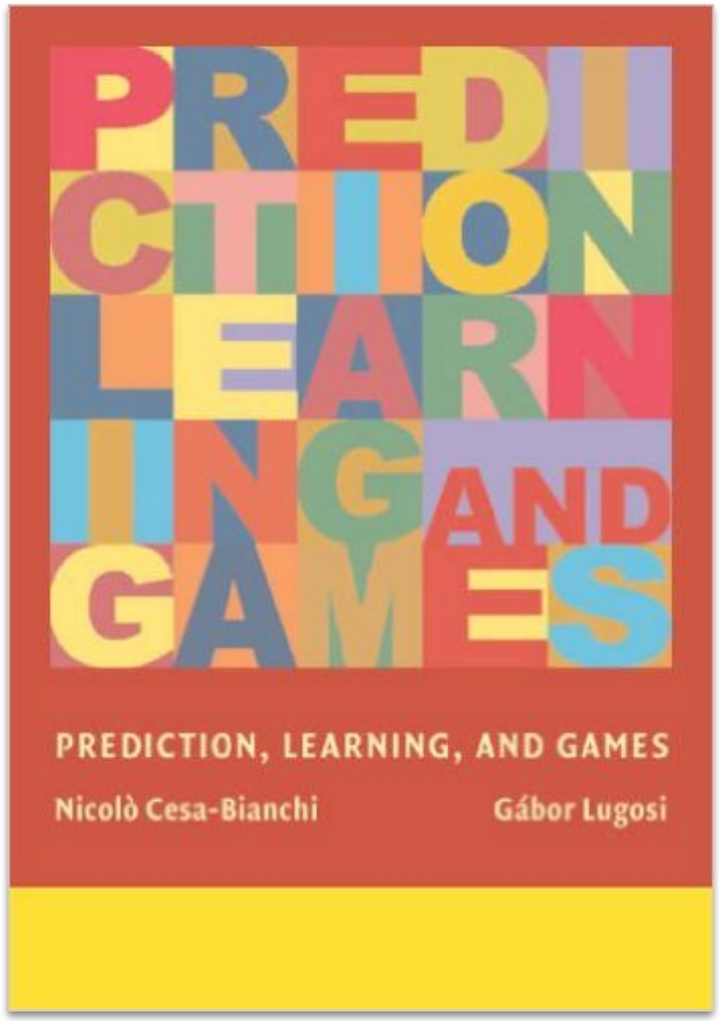


Up-to-date reference

Very concise

Bibliography

- Exploration vs exploitation

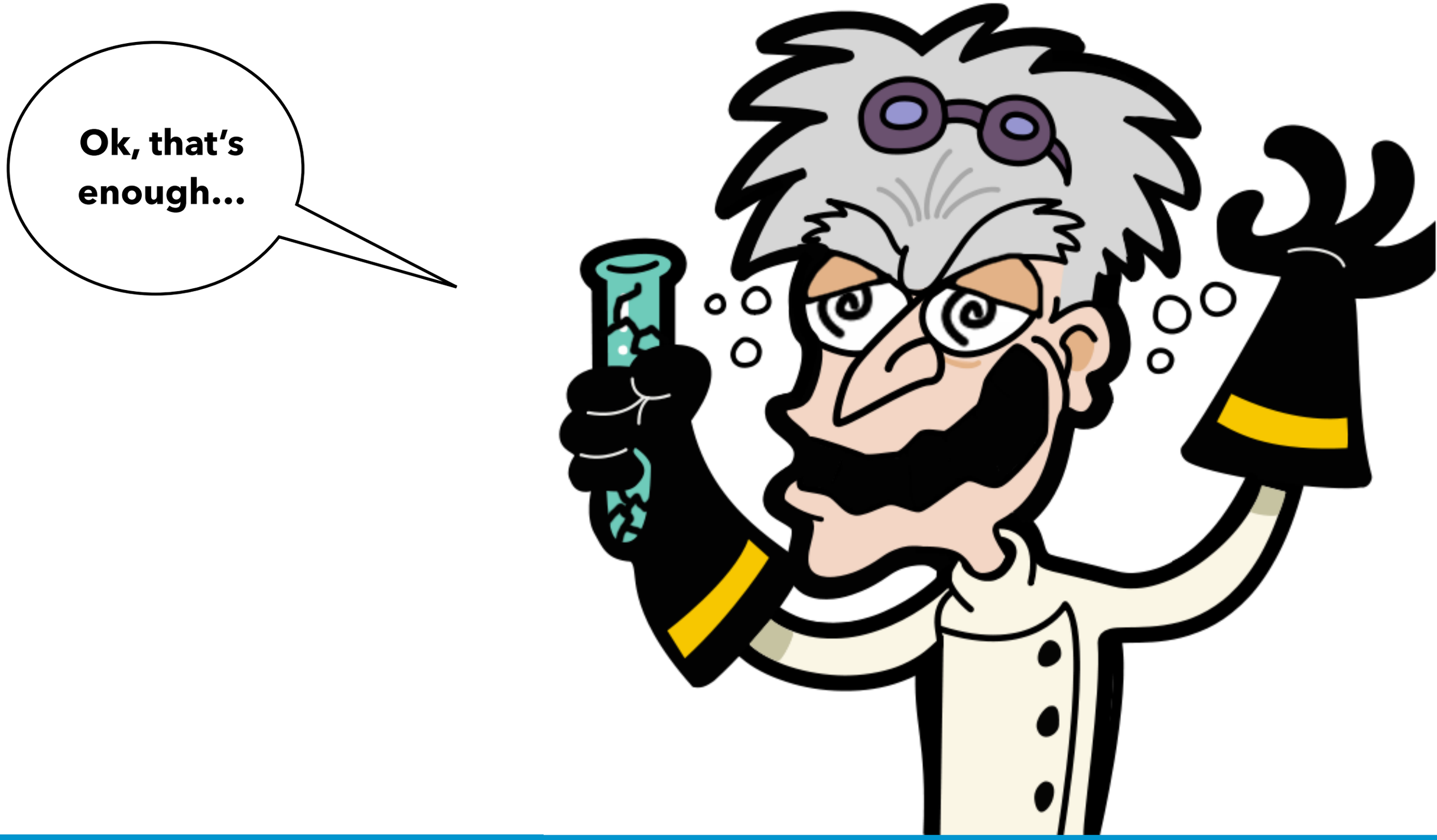


Very complete and unified

Somewhat hard to parse

Very mathematical

Bibliography



TÉCNICO LISBOA

Labs

Labs

- Work in groups
- 2 people (no more, no less)
- Groups are defined upon registration

Lab registration

- **Through Fenix, 23/09/2019 (9.00-17.00)**

- Registrations work in a first come - first served basis

- You must register **the group**

  (individual registrations not possible)

- Ideal group should have a **student A** and a **student B**

Lab registration

- If you don’t have a group, we will find you a group, but you will be subject to the shifts available at the time
- If you have schedule limitations, you should be pro-active and try to find a group by yourself

Lab registration

No group registrations:

- Thursday, 24/09, 12h30-14h00
- Zoom link for registration will be made available in the course's webpage

Labs

- Total of **5 lab assignments**, each with one specific topic

- Each lab assignment includes:

  - **1 (one) homework task**, completed during the week before, in preparation for the lab

  - **2 (two) lab sessions**, where you do the actual lab work

Labs

- At the end of a lab assignment, you will have submitted:
  - Answer to homework in **pdf** format (by the end of **first lab session**)
  - Lab work as in **.py** format (by the end of the **second lab session**)

Items submitted in formats other than those above **will not be graded**

Homework

b)

Seja $l(D,\pi) = \sum_{n=1}^{N} a_n \log \pi(1|x,w) + (1-a_n)\log(1-\pi(1|x,w))$

Queremos

$$\text{gradiente} = \frac{\delta}{\delta w} l(D,\pi)$$

Cálculos auxiliares:

$$\log\left(\frac{1}{1+e^{-w^T x}}\right) = 0 - \log(1+e^{-w^T x})$$

$$\frac{\delta}{\delta w}(-\log(1+e^{-w^T x})) = \frac{x\, e^{-w^T x}}{1+e^{-w^T x}} = x\left(1 - \frac{1}{1-e^{-w^T x}}\right)$$

$$\log\left(1 - \frac{1}{1-e^{-w^T x}}\right) = -w^T x - \log(\ \ e^{-w^T x})$$

$$\frac{\delta}{\delta w}\log\left(1 - \frac{1}{1-e^{-w^T x}}\right) = -x\left(1 - \frac{1}{1-e^{-w^T x}}\right)$$

$$\frac{1}{e^{-w^T x}}\, x$$

Logo

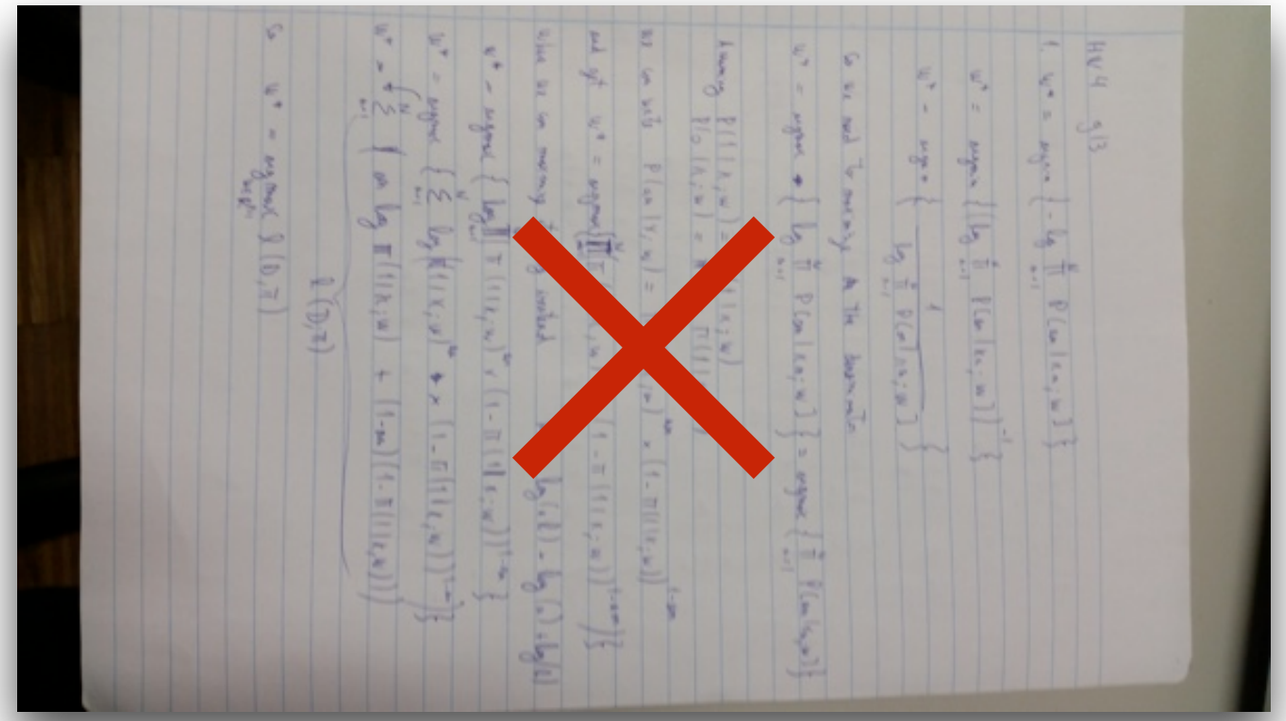
$$\frac{\delta}{\delta w} l(D,\pi) = \sum_{n=1}^{N} a_n x_n\left(1 - \frac{1}{1+e^{-w^T x}}\right) - (1-a_n)x_n \frac{1}{1+e^{-w^T x}}$$

$$= \sum_{n=1}^{N} a_n x_n - a_n x_n \frac{1}{1+e^{-w^T x}} - x_n \frac{1}{1+e^{-w^T x}} + a_n x_n \frac{1}{1+e^{-w^T x}}$$

$$= \sum_{n=1}^{N} a_n x_n - x_n \frac{1}{1+e^{-w^T x}} =$$

$$= \sum_{n=1}^{N} x_n\left(a_n - \frac{1}{1+e^{-w^T x}}\right)$$, substituindo novamente

$$= \sum_{n=1}^{N} x_n\,(a_n - \pi(1|x_n,w)) \qquad \text{C.q.d.}$$

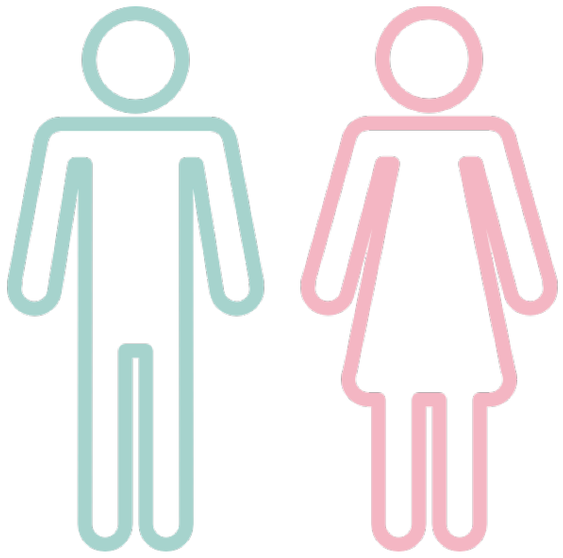


Labs

- Submit to:
  - adi.tecnico@gmail.com
  - Topic: [<*group n.*>] LAB <*lab n.*>

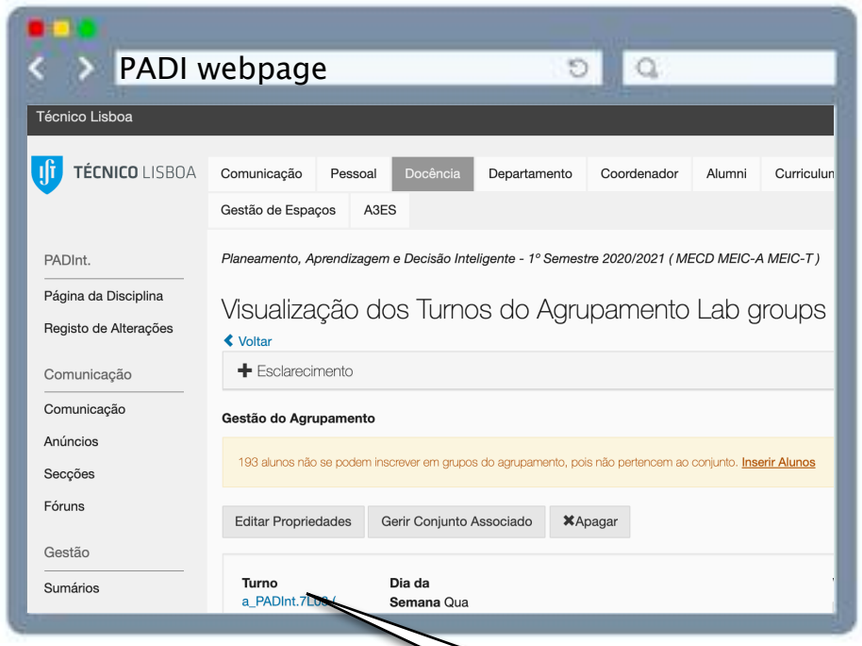
This e-mail is strictly for submissions (we do not reply to messages sent here)

Lab attendance



Adam
67890

Beth
12345



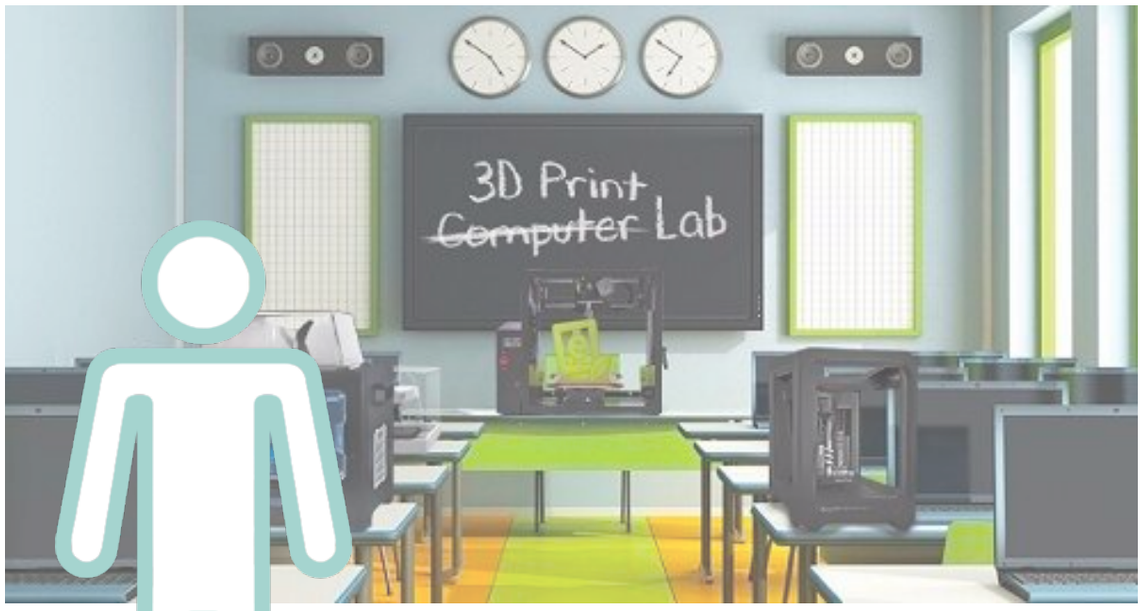
Shift L1 - Group 1:

12345
67890

Ignore the distinction between shifts A or B

Lab attendance

- Lab 1, first session

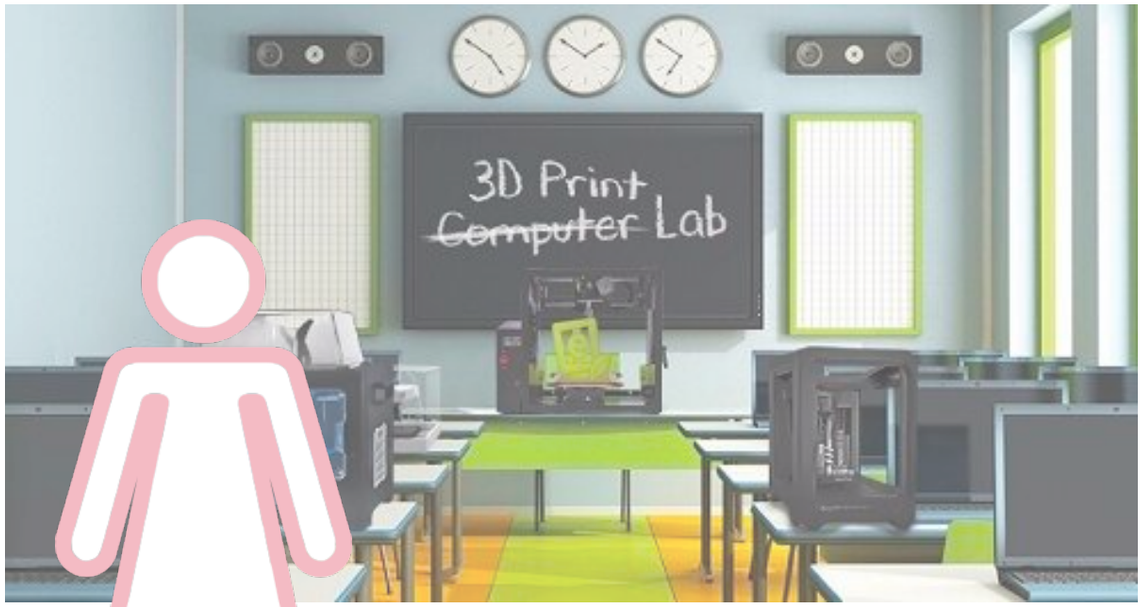


Physically present at the lab

Remotely connected to the lab

Lab attendance

- Lab 1, second session



Physically present at the lab

Remotely connected to the lab

Lab attendance

For grading purposes, only those elements submitted by students that attended the corresponding lab session will be considered.

Lab attendance

- Each student is expected to attend 10 lab sessions, 5 physically present, and 5 remotely
- When attending physically, you should attend at least 60 minutes of the class and have the teacher sign your presence;
- When attending remotely, you should attend at least 60 minutes of the class and be present when faculty visits the breakout room

Labs

Homework and lab assignments are to completed by each group individually. Any cheating will lead to immediate failing of all students involved.

Labs

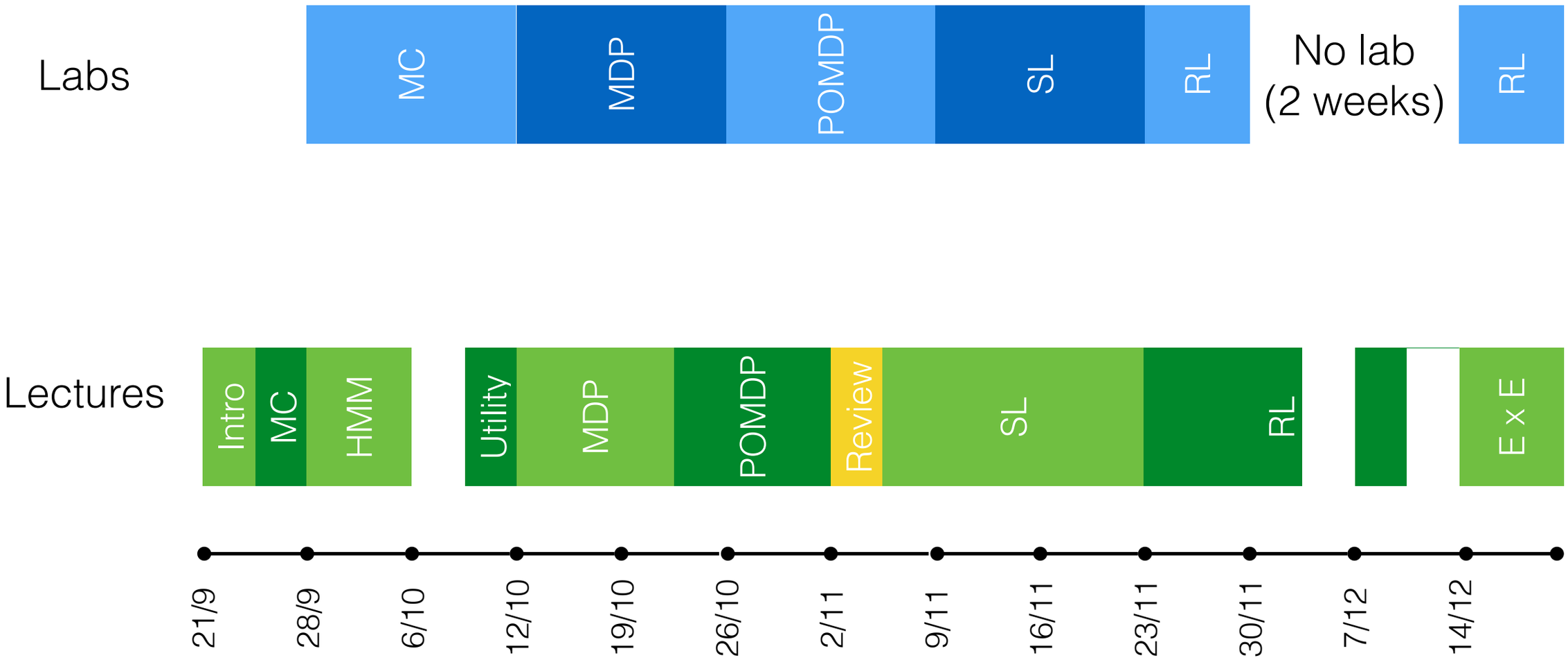
- Lab “zero” (to do at home)
- Introduction to Python scientific computing

Labs

- To install in your own computer:

*Note: make sure you use **Python 3***
to ensure compatibility with code that
may be provided

Lab plan


Labs
MC
MDP
POMDP
SL
RL
No lab
(2 weeks)
RL
Lectures
Intro
MC
HMM
Utility
MDP
POMDP
Review
SL
RL
E x E
21/9
28/9
6/10
12/10
19/10
26/10
2/11
9/11
16/11
23/11
30/11
7/12
14/12

Grading

Grading

- Labs (NL)

- Tests (NT)

- The final grade (NF) is computed as:

$$NF = 0.5 \times NL + 0.5 \times NT$$

Grading

- NT is the average test grade:

$$NT = 0.5 \times T1 + 0.5 \times T2$$

Grading

- NL is the average lab grade:

$$NL = (HW1 + \ldots + HW\ 5 + L1 + \ldots + L5 - M1 - M2) / 4$$

- HW1, … HW5 are the homework grades (between 1 and 10)
- L1, … L5 are the lab grades (between 1 and 10)
- M1, M2 are the two worse among HW1, …, HW5, L1, …, L5

Grading

- Passing requirements:
  - NT ≥ 8.0
  - NL ≥ 9.5
  - NF ≥ 9.5

Tests

- First test: November 12, 2020 (18:30-20:00)
- Second test: January 26, 2021 (11:30-13:00)
- Repetition: February 10, 2021 (15:00-18:00)

Grading plan