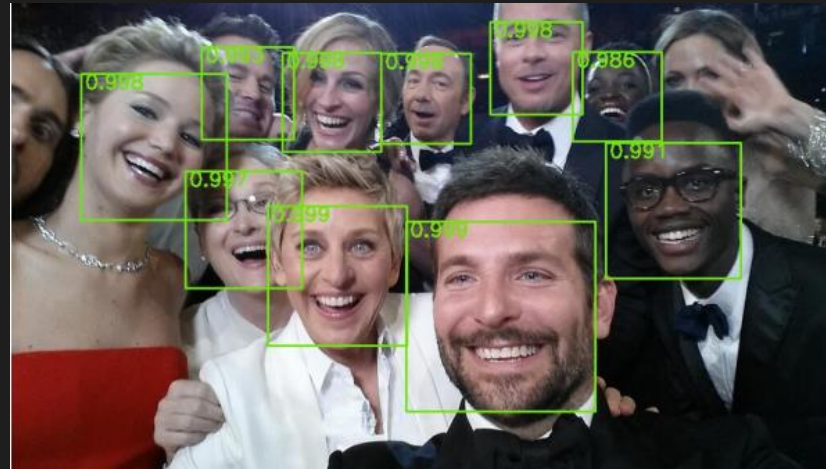


FUNDAMENTALS OF
MACHINE LEARNING
COMPSCI 4ML3

LECTURE 0

HASSAN ASHTIANI

WHAT IS MACHINE LEARNING?



1	2	5	9	7	6	3	5	0	8
4	5	8	6	9	3	2	9	7	2
3	3	3	9	5	0	3	2	3	0
1	1	4	0	2	1	5	3	3	6
8	6	2	0	4	0	4	5	3	9
8	5	4	2	2	7	1	6	0	9
1	7	0	3	9	1	7	0	7	7
2	6	5	1	6	4	2	2	2	9
4	4	4	2	0	6	9	4	8	3
1	5	0	3	4	6	8	2	5	1



Monet \leftrightarrow Photos



Monet \rightarrow photo



photo \rightarrow Monet

Zebras \leftrightarrow Horses



zebra \rightarrow horse



horse \rightarrow zebra

- CYCLEGAN
[HTTPS://JUNYANZ.GITHUB.IO/CYCLEGAN/](https://junyanz.github.io/CycleGAN/)



- “A STILL OF KERMIT THE FROG IN SPIRITED AWAY (2001)”
- “A STILL OF KERMIT THE FROG IN BLADE RUNNER 2049 (2017)”

DALLE

[HTTPS://TWITTER.COM/HVNSLSTANGEL/STATUS/1531506455714492416?s=21&t=PSJY4ETM_DLKBWFRGHY1YA](https://twitter.com/hvnslstangel/status/1531506455714492416?s=21&t=PSJY4ETM_DLKBWFRGHY1YA)

- <https://twitter.com/divbyzero/status/1609649684066213893>

Write a New Years poem based on the Fibonacci numbers.

As we say goodbye to the year that's past,
We look ahead to a new one at last.
The Fibonacci numbers guide our way,
As we start anew on this New Year's day.

One, the first number, represents a start,
A fresh beginning with an open heart.
One leads to two, then three and five,
A progression, as we strive to thrive.

Eight and thirteen come next in line,
A reminder that we're all intertwined.
Twenty-one, thirty-four, and fifty-five,
All part of the cycle, the cycle of life.

So here's to a new year, full of hope and cheer,
May the Fibonacci sequence guide us, never steer us wrong.
Happy New Year!

AI VS ML VS PATTERN RECOGNITION

- **ARTIFICIAL INTELLIGENCE (AI):** GET MACHINES TO
 - THINK/ACT LIKE HUMANS
 - THINK/ACT INTELLIGENTLY/RATIONALLY
- **MACHINE LEARNING (ML):** MAKING MACHINES INTELLIGENT BY
 - ALLOWING THEM TO LEARN FROM EXPERIENCE/DATA
 - INSTEAD OF GIVING DETAILED INSTRUCTIONS TO A MACHINE, WE PROGRAM IT TO “FIND” GOOD INSTRUCTIONS BASED ON THE GIVEN EXAMPLES
- **MACHINE LEARNING** IS A TERM USED (INITIALLY) BY COMPUTER SCIENTISTS
- **PATTERN RECOGNITION** IS AN OLDER TERM, USED (INITIALLY) BY ENGINEERS
- FOR THE MOST PART, ML AND PR ARE NOW USED INTERCHANGEABLY, THOUGH ML IS SOMEWHAT BROADER AND HAS MORE EMPHASIS ON DATA

FORMS OF MACHINE LEARNING

- **SUPERVISED LEARNING** (PREDICTION)
- **REINFORCEMENT LEARNING** (CONTROL)
- **UNSUPERVISED LEARNING**

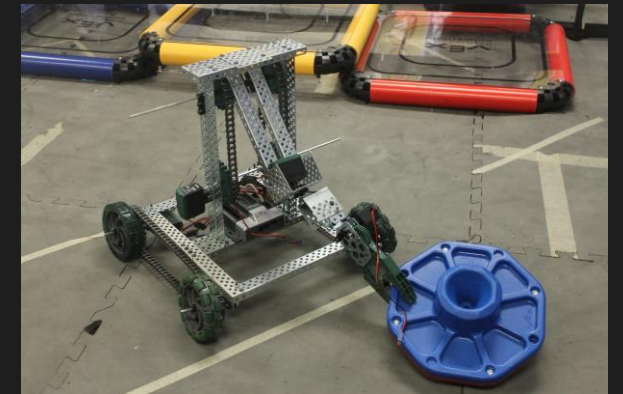
FORMS OF MACHINE LEARNING

- **SUPERVISED LEARNING** (PREDICTION)
 - **GOAL:** GIVEN NEW INPUT, PREDICT THE OUTPUT
 - **EXAMPLE:** DIGIT CLASSIFICATION
 - **TRAINING DATA:** INPUT-OUTPUT PAIRS
 - **“SUPERVISED”:** SOMEONE PROVIDED THE OUTPUT

1	2	5	9	7	6	3	5	0	8
4	5	8	6	9	3	2	9	9	2
3	3	3	9	5	0	3	2	3	0
1	1	4	0	2	1	5	3	3	6
8	6	2	0	4	0	4	5	3	9
9	5	4	2	2	7	1	6	0	9
1	7	0	3	9	1	7	0	7	7
2	6	5	1	6	4	2	2	2	9
4	4	4	2	0	6	9	4	8	3
1	5	0	3	4	6	8	2	5	1

FORMS OF MACHINE LEARNING

- **REINFORCEMENT LEARNING (CONTROL)**
 - (SEQUENTIAL) DECISION MAKING TO ACHIEVE A DESIRED OUTCOME, OR MAXIMIZE THE “REWARD”
 - THE AGENT OBSERVES THE WORLD, MAKES AN ACTION, RECEIVES A (DELAYED) REWARD
 - MAY INVOLVE PLANNING, PREDICTION, ETC.
 - EXAMPLE: ROBOTICS, PLAYING BOARD GAMES (ALPHAGO)



FORMS OF MACHINE LEARNING

- **UNSUPERVISED LEARNING**

- ALL SORTS OF THINGS OUTSIDE SUPERVISED LEARNING
- TRAINING DATA: JUST **UNANNOTATED** INPUT EXAMPLES
- EXAMPLE: CLUSTERING (ORGANIZE PHOTO ALBUM INTO FOLDERS)
- EXAMPLE: COMPRESSION (DESCRIBE DATA USING FEWER PARAMETERS)
- EXAMPLE: UNSUPERVISED IMAGE GENERATION

FORMS OF MACHINE LEARNING

- THIS TAXONOMY IS COARSE/INACCURATE
- TAXONOMY BASED THE “GOAL” OR THE “TECHNIQUES”?
- USING UNSUPERVISED TECHNIQUES FOR SUPERVISED LEARNING
 - DIMENSIONALITY REDUCTION, ZERO-SHOT LEARNING
- COMBINING SUPERVISED, UNSUPERVISED, REINFORCEMENT LEARNING
 - EXAMPLE: LANGUAGE MODELS (CHATGPT)
- SEMI-SUPERVISED LEARNING
- ...

COMPSCI 4ML3

- FOCUSES MOSTLY ON **SUPERVISED LEARNING**.
 - THE CURRENT SUCCESS OF ML IS MOSTLY DUE TO THE PROGRESS IN SUPERVISED LEARNING METHODS.
- TOPICS INCLUDE
 - LINEAR AND NON-LINEAR REGRESSION
 - PROBABILISTIC/BAYESIAN INFERENCE
 - LINEAR AND NON-LINEAR CLASSIFICATION
 - NEURAL NETWORKS AND DEEP LEARNING

COMPSCI 4ML3

- OTHER TOPICS (TIME PERMITTING)
 - ENSEMBLE LEARNING
 - GENERATIVE ADVERSARIAL NETWORKS
 - ADVERSARIAL PERTURBATIONS
 - INTRO TO SELF-SUPERVISED LEARNING
 - INTRO TO LEARNING THEORY
 - TRANSFORMERS

COMPSCI 4ML3: APPROACH

- EMPHASIS ON **MATHEMATICAL MODELING**
 - THERE IS A LOT OF MATH IN ML.
 - EXPRESSING PROBLEMS/METHODS BY MATH HELPS OBTAINING A CLEAR UNDERSTANDING AND A PRINCIPLED APPROACH
 - IT IS IMPORTANT TO **WRITE YOUR OWN NOTES** IN CLASS!
 - SLIDES WILL BE UPLOADED BEFORE CLASS
 - ANNOTATIONS WILL BE UPLOADED AFTER CLASS

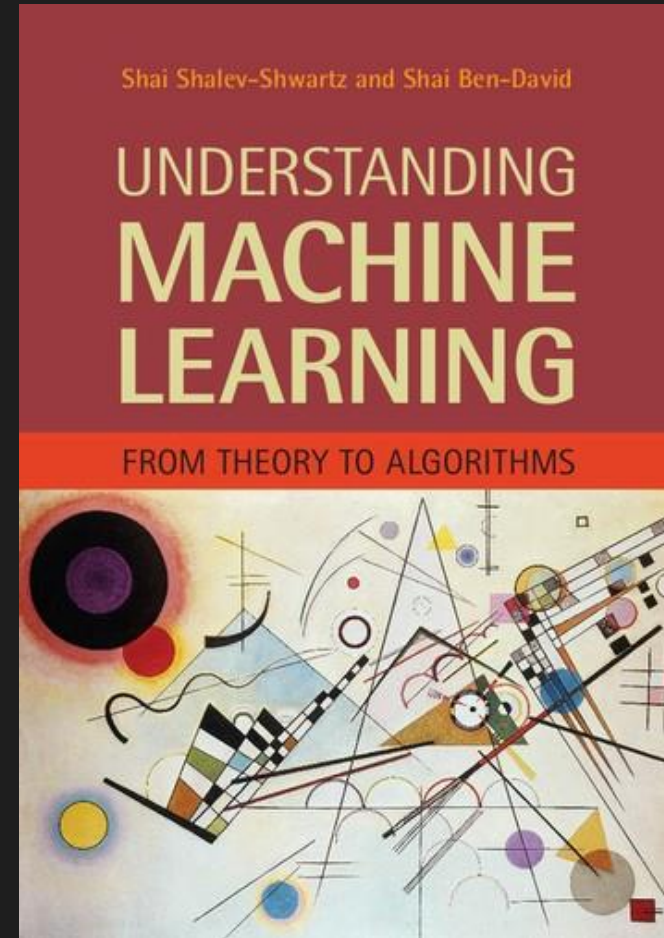
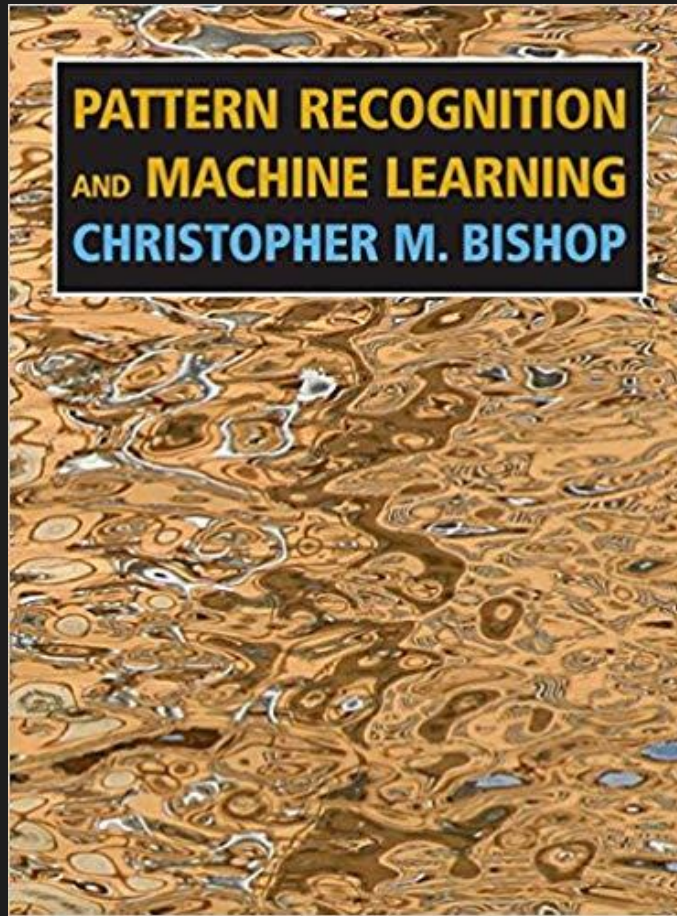
COMPSCI 4ML3: APPROACH

- WHAT KIND OF MATH IS INVOLVED? (AND WHY?)
 - LINEAR ALGEBRA (DATA IS REPRESENTED AS MATRICES)
 - PROBABILITY AND STATISTICS (TO MODEL RANDOMNESS IN DATA)
 - CALCULUS (FUNCTIONS AND DERIVATIVES ARE CENTRAL TOOLS)
- SOME REVIEW IN TUTORIALS

COMPSCI 4ML3: APPROACH

- EMPHASIS ON **PRINCIPLES**
 - NOT JUST A LONG LIST OF ML METHODS/TECHNIQUES
 - NOT JUST USING ML PACKAGES
 - IF NOT CAREFUL, THEY CAN BE USED INAPPROPRIATELY
 - THEY GET OUTDATED QUICKLY
 - UNDERSTANDING EACH METHOD DEEPLY
 - ASK QUESTIONS!
 - FOCUS ON THE PRINCIPLES/IDEAS BEHIND EACH METHOD
 - YOU CAN THEN USE THOSE PRINCIPLES IN VARIOUS CONTEXTS

RECOMMENDED BOOKS



COMPSCI 4ML3 POLICIES

- COURSE OUTLINE IS AVAILABLE ON AVENUE
- MAKE SURE TO READ IT THOROUGHLY