Machine Learning

Computer Engineering

Fabio Vandin

September 30th, 2022

Machine Learning

6 credits:

- 48 hours in class lectures
  - Some hours will be in a lab: more decisions to come later
- **<u>102 hours individual study</u>**

Everything (lectures, exams, homeworks) in English!

Note: if you are enrolled in “ICT for Internet and Multimedia” or in “Control Systems Engineering”, you should follow a different section

Course Website

Course website: from https://stem.elearning.unipd.it/

Register today if not done yet!

Lectures: When and where

Tuesday 12:30-2:30pm, room Le:

- 12:30-1:15pm; 10 mins break; 1:25-2:10pm

Friday 10:30am-12:30pm, room Le:

- 10:30-11:15am; 10 mins break; 11:25-12:10pm

Labs and Homeworks

Labs:

- some lectures will be done in the lab, dates to be fixed

Homeworks:

- (up to) 3 homeworks
- will give up to 3 points for the final grade
- not compulsory but highly recommended
- will require to complete the code in Jupyter notebooks
- typical schedule:
  - day X: homework released
  - day X+14: deadline for homework submission

Grading

Written test: see sample tests from previous years in elearning

- will be graded on a scale from 0 to 30L.

Homeworks [not compulsory]: some (3?) homeworks. Up to 3 points as a bonus on the written test grade.

Final Grade = grades written test + homeworks

Example

24.5 written test + 2.66 homeworks = 27 final grade

Note: there may be an oral exam just to confirm the vote of the written exam.

Final Exam: dates

1. **Tuesday, January 31st, 2023**
   - time: 2:00pm
   - rooms: Ae, Be, Le

2. **Thursday, February 16th, 2023**
   - time: 2pm
   - room: Ke, Ve

3. **Tuesday, July 4th, 2023**
   - time: 9:30am
   - room: Ae

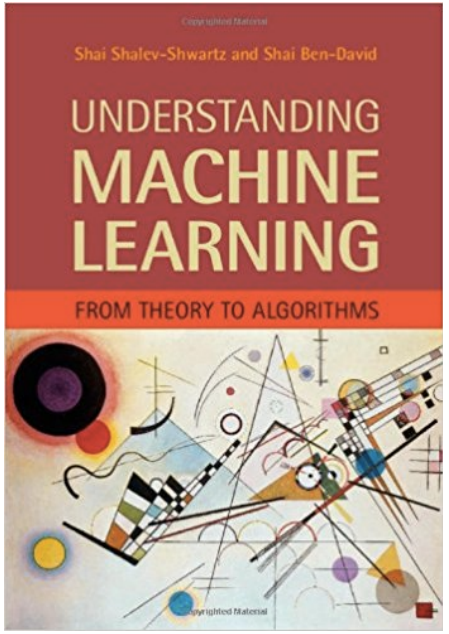
4. **Monday, September 11th, 2023**
   - time: 9:30am
   - room: Ke

Duration: (around) 2 hours

Material

Main Book

- [UML] Shalev-Shwartz, S. and Shai Ben-David. *Understanding machine learning: From theory to algorithms*. Cambridge University Press, 2014.



Material in class will be related to the book as much as possible

PDF available from the authors

http://www.cs.huji.ac.il/~shais/UnderstandingMachineLearning/copy.html

Material (2)

Other Books (NOT Mandatory)

- M. Hardt, B. Recht, *PATTERNS, PREDICTIONS, AND ACTIONS - A story about machine learning*. Princeton University Press, 2022 (available from the authors at https://mlstory.org/).

- T. Hastie, R. Tibshirani, J. Friedman. *The Elements of Statistical Learning*. Springer, 2008.
  PDF from authors online
- C. M. Bishop. *Pattern Recognition and Machine Learning*. Springer, 2006
- K.P. Murphy. *Machine Learning A Probabilistic Perspective*, MIT Press. 2012.
- Yaser S.Abu-Mostafa, M. Magdon-Ismail, H. Lin. *Learning from Data*. AMLBook, 2012.

Part of other books may be used: will provide handouts whenever possible…

Additional material: course website (*stem.elearning.unipd.it*)

- draft slides: provided sometime (…) before the lecture
- slides used in class: published after lectures
- links, etc.

If you are missing background notions (probability, algebra): ask me for material

Programming and more

Language:  (https://www.python.org)

Some libraries: scikit-learn, numpy,…

Jupyter lab:

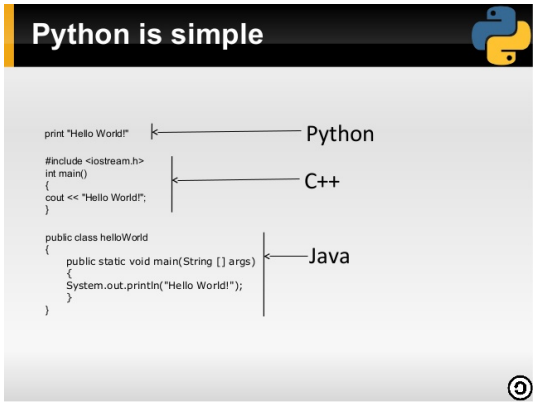
- https://jupyterlab.readthedocs.io/en/stable/getting_started/overview.html
- Allows for a mix of text and code;
- **Suggestion: install it through Anaconda** as suggested on Jupyter website, you get a lot of other packages/ libraries for ML, visualization, etc.

  https://www.anaconda.com/download/

  (That's what we are going to use for homeworks, etc.)

Why Python

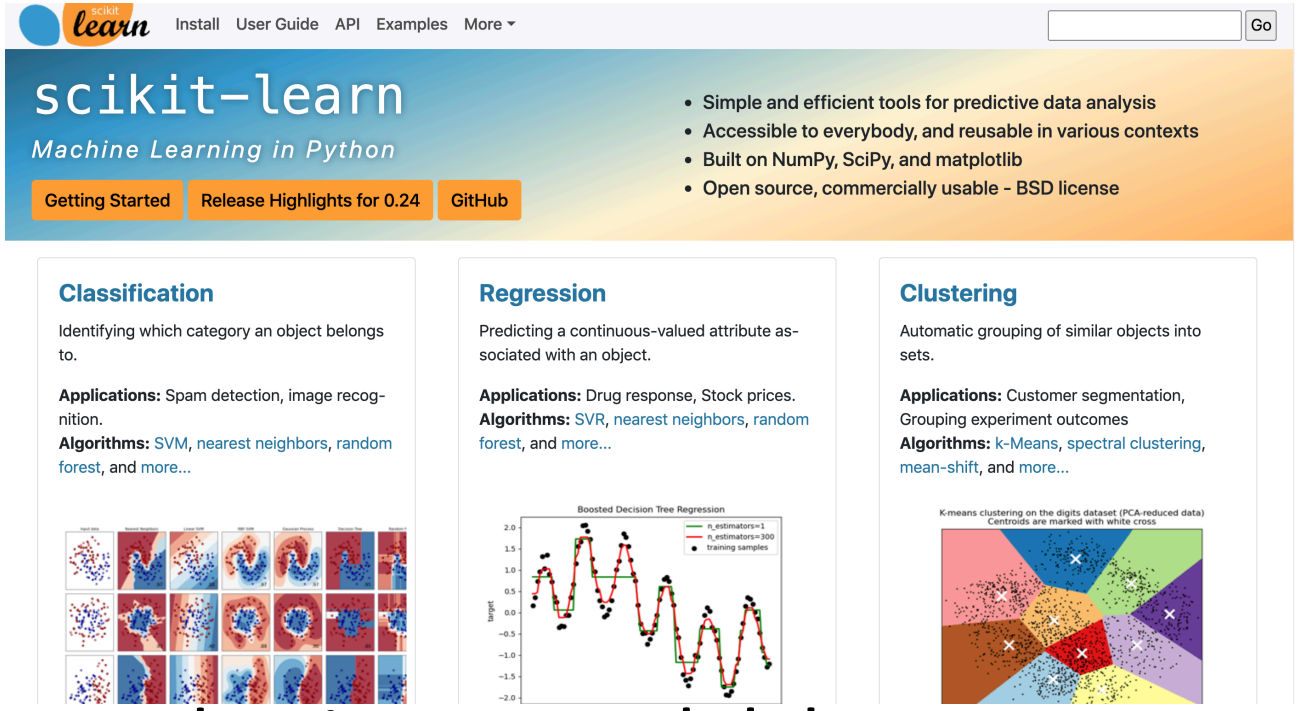
Easy! (…)




```
def quicksort(arr):
    if len(arr) <= 1:
        return arr
    pivot = arr[len(arr) / 2]
    left = [x for x in arr if x < pivot]
    middle = [x for x in arr if x == pivot]
    right = [x for x in arr if x > pivot]
    return quicksort(left) + middle + quicksort(right)

print quicksort([3,6,8,10,1,2,1])
```

A lot of support for ML!



Used in industry, academia, research labs…

Homework 0

1. Go home and install Anaconda (version with Python 3.9):
   - https://www.anaconda.com/download/

2. Go through the following tutorial (it's for Python 3.7, but still useful):
   - http://cs231n.github.io/python-numpy-tutorial/

3. Read Chapter 1 and Chapter 2 from *Data Structures and Algorithms in Python* [Goodrich, Tamassia, Goldwasser]
   - available on course website

4. Get used to Jupyter lab/Jupyter notebooks

5. Go through the following tutorial running the Jupyter notebook and in script mode
   - https://github.com/marcc-hpc/python3-tutorial/blob/master/python3-tutorial.ipynb

Lecturer

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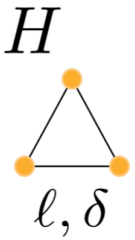
Office hours:

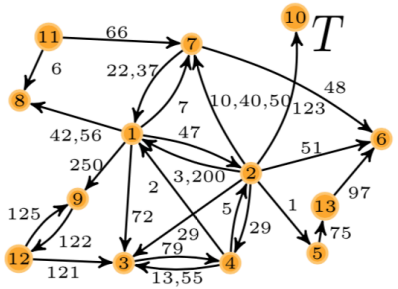
- Thursday, 3-4pm, by appointment (email before Tuesday at 6pm)
- Other time slots: by appointment (may take 1 week to schedule)

Lecturer

CV

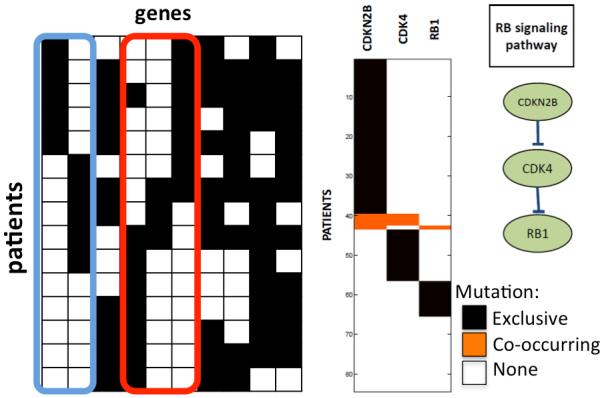
- Laurea Triennale in Computer Engineering (2004)
- Laurea Specialistica in Computer Engineering (2006)
- Ph.D. at DEI (2010)
- 2010-May/2015: Researcher/Assistant Prof.
  - Brown University (USA)
  - University of Southern Denmark
- 2015-2020: Associate Prof. at DEI
- February 2020-now: Prof. at DEI





Research Interests:

- Methods: algorithms for machine learning, data mining, and big data
- Applications: Biology, Medicine, Social Networks, …



Example: Ad Click Prediction

Goal: predict if a user will click on a given ad if the ad is shown to the user

Why is it important?

Social networks…

How would you solve the problem?

You have data about the user and about the ad

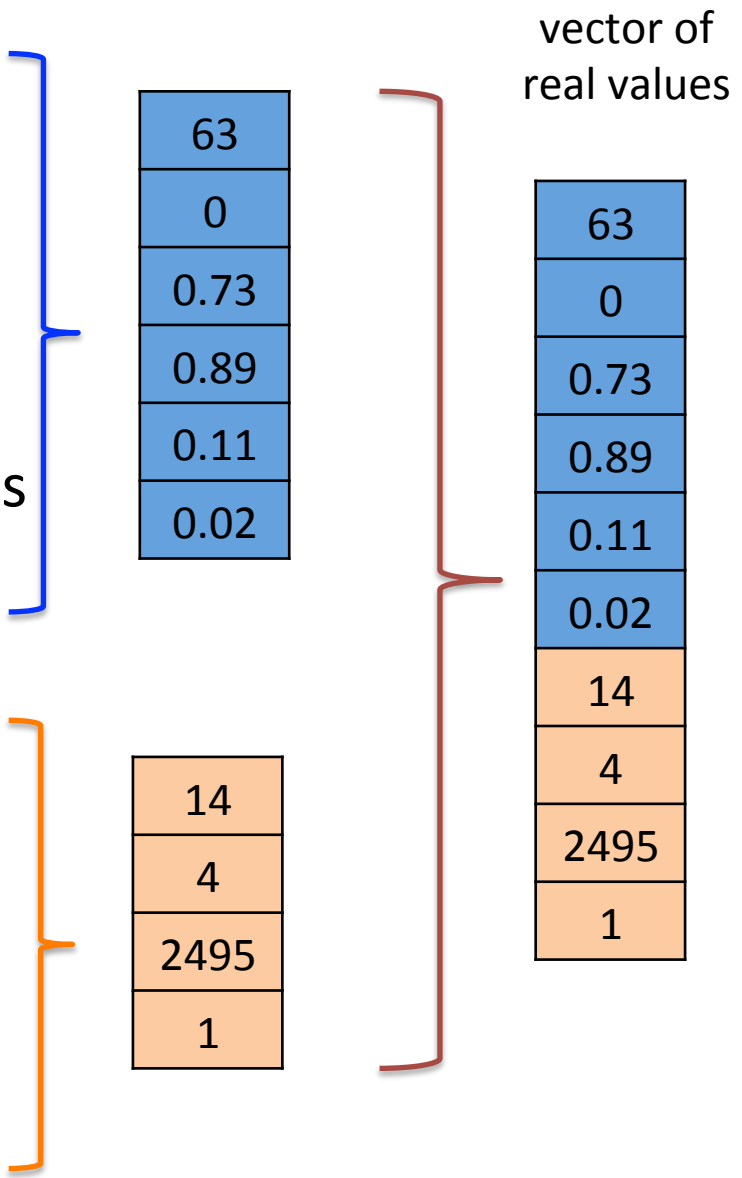
Ad Click Prediction: Data

User Data:

- Age
- Gender
- How much he/she likes music
- How much he/she likes sports
- How much he/she likes books
- How frequently he/she clicks on ads
- …

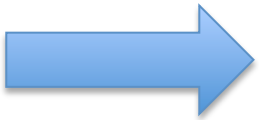
Ad data:

- Topic
- Colors
- Image (what is shown?)
- Does it contain the word “song”?
- …



A Solution that is NOT Machine Learning

Somebody (an "expert") *manually* builds a *model/formula/algorithm* that decides if the user will click on the ad or not

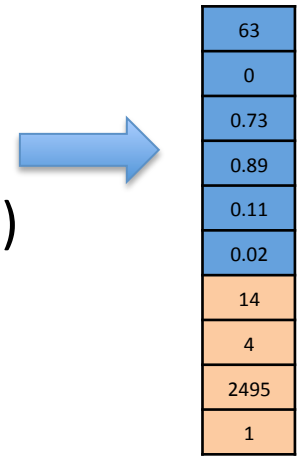


"If the age is <25
and
the gender is male
and
the ad is about soccer
then
he will click on the ad"

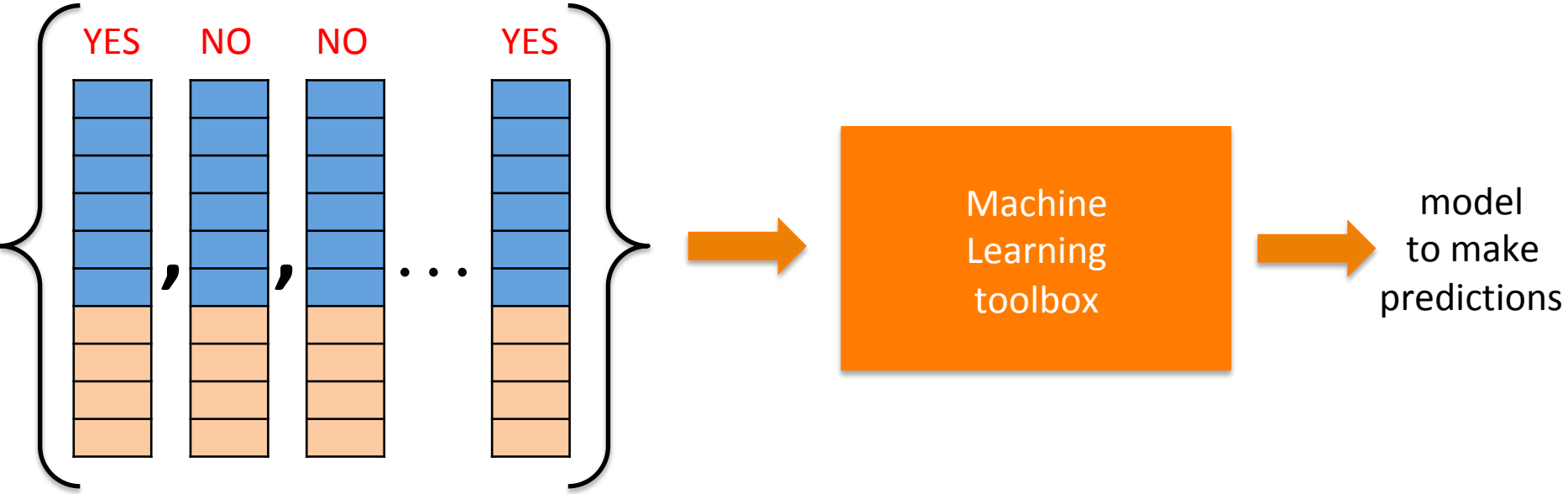
A Machine Learning Solution

You use previous data about:

- user and ad that was displayed to user
- whether the user clicked on the ad (label: YES/NO)



You give a lot of such pairs (vector,label) to a machine learning system which then produces in output a *model* to make the prediction



Learning: A Difficult Problem

Note: coming up with a model that performs very well on the data I already have is very easy!

How?

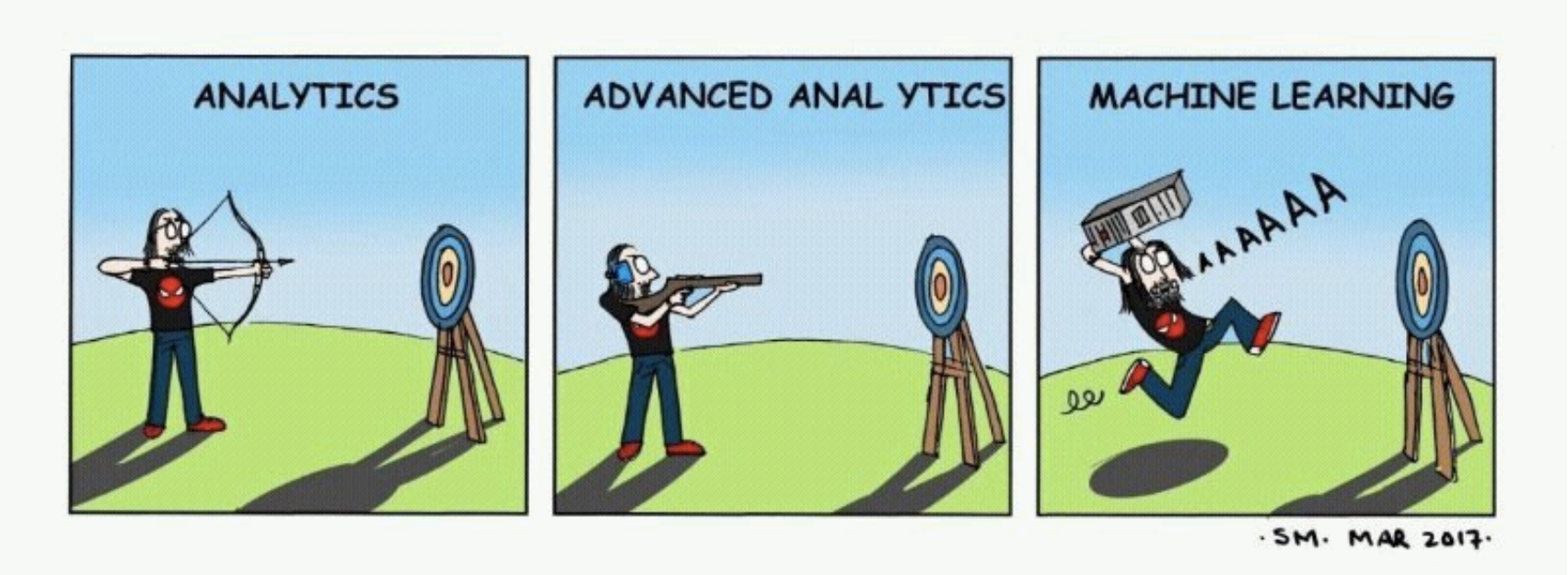
The difficulty is about making predictions for data we have not seen!

What is Machine Learning?

Given a collection of examples (called training data), we want to be able to make *predictions* about novel, but *incomplete*, examples.

"Prediction is very difficult, especially if it is about the future"

Niels Bohr



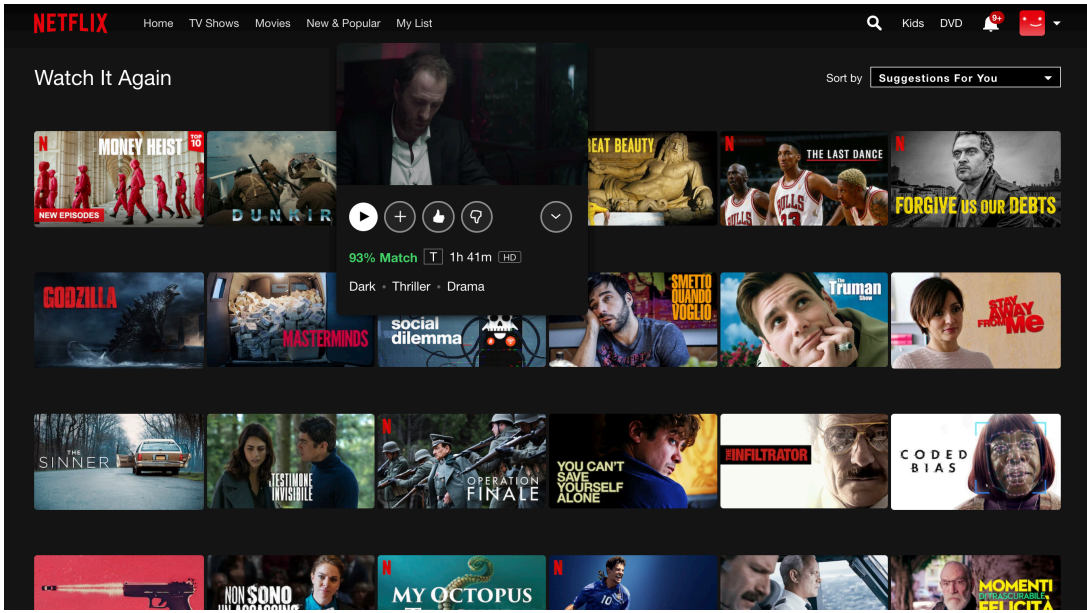
Example: Movie Rating Prediction

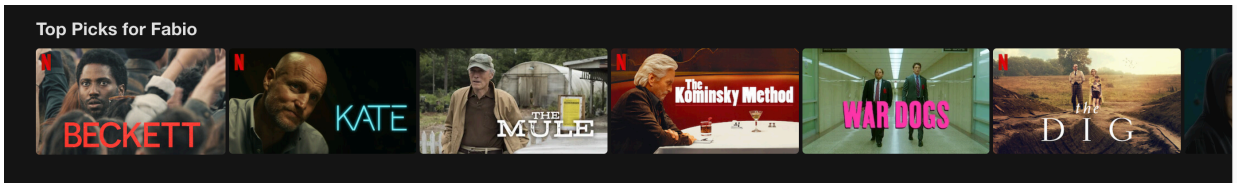
Prediction: What will be the user rating (liked/not liked) on a movie?

Challenge: Must target *current* user preferences

Noisy training data: ratings of all users on movies

Prediction: will the user like a movie?





The *essence of learning*:

- We believe a pattern exists
- We do not know it, i.e. we cannot pin it down mathematically or with very simple rules
- We have data to try to “learn” it

Netflix Challenge

Given: data set of 100,480,507 ratings that 480,189 users gave to 17,770 movies.

Goal: beat Netflix prediction by ≥ 10%.

Prize: $1,000,000

Oct. 2006: challenged open by Netflix

Sept. 2009: prize awarded!

Questions?

Example

Want to predict whether a student that just graduated from LM Ing. Informatica will have a fun job or not based on some features:

- age at graduation
- LM final grade
- Machine Learning (ML) grade
- height

See Jupyter notebook.