

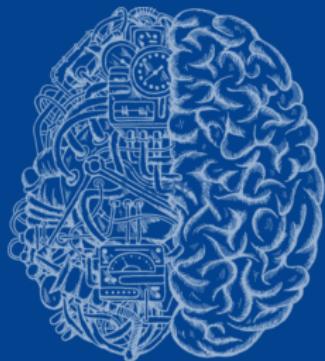


• TVL

## LESSON 1: Introduction

CARSTEN EIE FRIGAARD  
PETER AHRENDT

SPRING 2021



**JEWISH**

# Agenda

## Introduction

1. Kursus intro
  - ▶ Admin (eksamen, læringsmål, etc.)
  - ▶ Blackboard/Discord intro og online undervisning
2. Python/Anaconda intro
  - ▶ Opgave: L01/modules\_and\_classes.ipynb
3. ML intro
  - ▶ Opgave: L01/intro.ipynb

# Undervisere

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# Eksamens

Formel beskrivelse fra kursuskataloget

## Prøveform

- ▶ Undervisningsdeltagelse.

## Bedømmelse

- ▶ Godkendt/Ikke godkendt, ingen censur.

## Bemærkninger

- ▶ "I løbet af kurset skal et antal obligatoriske opgaver afleveres og der skal deltages i et antal obligatoriske præsentationer.

Bedømmelsen af kurset sker på baggrund af én samlet vurdering af de afleverede opgaver og præsentationer, hvor der vil blive lagt vægt på, om den studerende opfylder punkterne i kvalifikationsbeskrivelsen.

Bedømmelsen foretages kun af eksaminator (underviser). "

## Reeksamen

- ▶ " Reeksamen: Næste ordinære eksamenstermin. Der skal afleveres nye opgaver og præsentationer. "

# Eksamensform

## Afleveringer og evalueringer

Eksamensform, godkendelsesfag via:

- ▶ et sæt obligatoriske skriftlige gruppe-opgaver med afleveringsdeadlines ([O1/O2/O3/O4](#)),
- ▶ en poster-session, med aflevering af poster og mundtlig præsentation af poster,
- ▶ en mundtlig gennemgang af den sidste afleveringsopgave ([O4/slut-journal](#)) med alle medlemmer i ITMAL gruppen, samt evaluering af hver gruppemedlems bidrag.

=> Endelig godkendelse af kurset sker på én samlet vurdering af de tre punkter ovenfor.

# Opgaveafleveringer: O1, O2, O3 og O4

O1: Opgavesæt fra L01+L02+.. (se Blackboard)

O2: Opgavesæt fra ..

O3: Opgavesæt fra ..

O4: slut-journal, et mini-projekt:

- ▶ For the final journal, you must design and implement a full machine learning system. You have relative free hands...

Criterions [extract]:

- ▶ Data must be split in a training-test set...
- ▶ Your machine learning algorithm must be described in depth...
- ▶ The system must be evaluated via a suitable performance metric...

NOTE<sub>0</sub>: Afleveringsformat i PDF.

NOTE<sub>1</sub>: O4 vil blive specifieret på BB.

# Læringsmål

## ► ITMAL generelt:

- ▶ **Redegøre** for de væsentligste begreber i machine learning terminologi samt principperne i en machine learning pipeline.
- ▶ **Anvende** metoder til analyse af data, bl.a. med henblik på valg af machine learning model.

## ► ITMAL i relation til praktiske projekter:

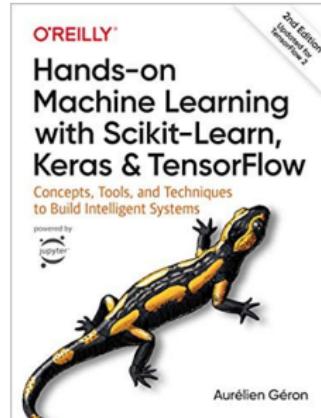
- ▶ **Anvende** udvalgte machine learning teknikker i praktiske opgaver og projekter.
- ▶ **Anvende** udvalgte kodebiblioteker (frameworks) og udviklingsværktøjer til machine learning.

## ► ML Data og algoritmer:

- ▶ **Beskrive** betydningen af datakvalitet i machine learning, samt anvende udvalgte databehandlings-teknikker til at forbedre kvaliteten af datagrundlaget.
- ▶ **Sammenligne og vurdere** forskellige algoritmer og teknikers anvendelighed i forbindelse med praktiske projekter.

# Litteratur

"**Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow**",  
Aurélien Géron, O'Reilly, 2019, (Second Edition)



Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow  
by Aurélien Géron

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Printed in Canada.

Published by O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95457

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Editors: Rachel Roumeliotis and Nicole Tache  
Production Editor: Kristen Brown  
Copyeditor: Amanda Kersey  
Proofreader: Rachel Head

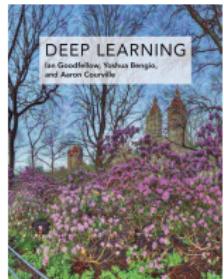
September 2019: Second Edition

#### Revision History for the Second Edition

2019-09-05: First Release  
2019-10-11: Second Release

See <http://oreilly.com/catalog/errata.csp?isbn=9781492032649> for release details.

- ▶ [HOML] → udtales som (Brian) Holm!
- ▶ Ref. til sidetal er for 2.Ed / *Second Release*.
- ▶ Plus yderligere materiale (brug links i BB).



# Lektionsplan (fra Blackboard)

NB: Forlebig lektionsplan, ændringer kan forekomme...						
Uge	Dato	Lektion	Emne	Opgave	Underviser	Kommentar
05	02/02-2021	L01	Intro		CEF	
06	09/02-2021	L02	Klassifikation		CEF	
07	16/02-2021	L03	End-to-end ML		CEF	
08	23/02-2021	L04	Regression	O1 (24/02)	PAH	
09	02/03-2021	L05	Data analyse		PAH	
10	09/03-2021	L06	Neurale netværk (NN)		PAH	
11	16/03-2021	L07	Traening og generalisering	O2 (17/03)	CEF	
12	23/03-2021					Påske (ingen undervisning)
13	30/03-2021	L08	Regularisering og søgning		CEF	
14	06/04-2021	L09	Deep learning (CNN)		CEF	
15	13/04-2021	L10	Probabilistiske modeller	O3 (14/04)	PAH	
16	20/04-2021	L11	Unsupervised learning I (PCA)		PAH	
17	27/04-2021	L12	Unsupervised learning II (Kmeans,GMM)		PAH	
18	04/05-2021	L13	O4 projekt			Ingen lektion
19	11/05-2021	L14	O4 projekt			Ingen lektion
20	18/05-2021	L15	O4 projekt	O4 (19/05) Poster (17/05)		Poster-session
21	25/05-2021		(25/05 defineret som mandag)			Ingen lektion
						Mundtlige O4 præsentationer

# ITMAL Nomenklatur

- [HOML]: Hands-On Machine Learning bog, aka (B.)Holm.
- [GITHOML]: Git repository for [HOML].
- [GITMAL]: Git repository for ITMAL kursus opgaver,  
(bruges meget kun lidt)
- [G]: ITMAL gruppe, med tre studerende, (evt. to/fire).
- [SG]: ITMAL super-gruppe, ved nogle af opgaverne.
- [O1]: opgavesæt 1, osv. (O2/O3/O4).
- [L01]: Lektion 1, osv.

NOTE: se fuld liste på '*BB | Kursusinfo | Kursusforkortelser*'.

# Online undervisnings intro



# Blackboard/Discord intro og online undervisning

- ▶ Intro til BB
- ▶ Intro til Discord
- ▶ Online undervisning: HVORDAMN??
  - ▶ Indlagt feedback på O1+O3+O4+paper.
  - ▶ Hvordan undgåes in-aktivt (passivitet/kedsomst/osv)?
  - ▶ Sociale aktiviteter?
  - ▶ Spil Among-us, Counter-strike, banko?
  - ▶ Andre ideer?

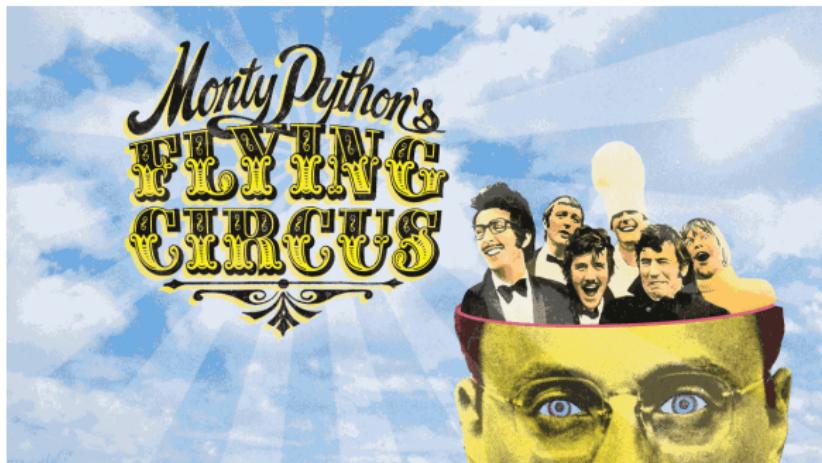
# Monty Python's FLYING CIRCUS

END Kursus intro/  
BEGIN Python intro



# python Introduction

- ▶ Python is an **interpreted** high-level programming language for general-purpose programming. Created by **Guido van Rossum** and first released in 1991, Python has a design philosophy that emphasizes **code readability**, notably using significant whitespace. It provides constructs that enable clear programming on both small and large scales.
- ▶ Python features a **dynamic type system and automatic memory management**. It supports multiple programming paradigms, including **object-oriented, imperative, functional and procedural**, and has a large and comprehensive standard library.
- ▶ Python interpreters are available for many operating systems.



# Anaconda and Jupyter Introduction



- ▶ **Anaconda:** a python distribution [<https://www.anaconda.com>].
- ▶ **Jupyter notebook:** interactive python development environment (GUI IDE), distributed with the Anaconda package.
- ▶ Jupyter is an anagram of: Julia, Python, and R.
- ▶ Jupyter notebook method:
  - ✓ polyglot environment, mixing source code, markdown test and formulas (LaTeX),
  - ✓ interactive/explorativt/trial-and-error environment,
    - ÷ not good at source-code level debugging.
- ▶ Other IDE's:
  - ▶ Spyder (Anaconda),
  - ▶ VSCode (Microsoft),
  - ▶ and many others...

# Scikit-learn Introduction

- ▶ Scikit-learn: a framework (API + website) for machine Learning in python.
- ▶ <http://scikit-learn.org>
- ▶ <git@github.com:scikit-learn/scikit-learn.git>

The screenshot shows the official scikit-learn website. At the top, there's a navigation bar with links for 'Install', 'User Guide', 'API', 'Examples', and 'More'. Below the header, the main title 'scikit-learn' is displayed in large letters, followed by the subtitle 'Machine Learning in Python'. A search bar and a 'Go' button are on the right. Below the title, there are three buttons: 'Getting Started', 'What's New in 0.22.1', and 'GitHub'. To the right, there's a list of bullet points highlighting the project's features:

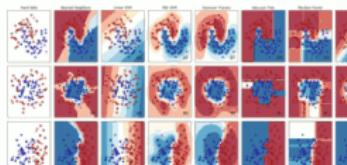
- Simple and efficient tools for predictive data analysis
- Accessible to everybody, and reusable in various contexts
- Built on NumPy, SciPy, and matplotlib
- Open source, commercially usable - BSD license

## Classification

Identifying which category an object belongs to.

**Applications:** Spam detection, image recognition.

**Algorithms:** SVM, nearest neighbors, random forest, and more...

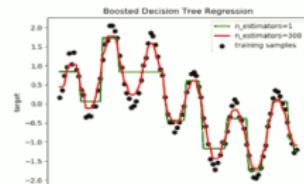


## Regression

Predicting a continuous-valued attribute associated with an object.

**Applications:** Drug response, Stock prices.

**Algorithms:** SVR, nearest neighbors, random forest, and more...

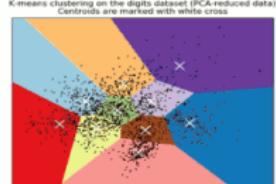


## Clustering

Automatic grouping of similar objects into sets.

**Applications:** Customer segmentation, Grouping experiment outcomes

**Algorithms:** K-Means, spectral clustering, mean-shift, and more...



# Vores videnskabelige framework

Sat sammen...



Gode hjælpe og dokumentations-systemer..

Alternativer kunne være...



# Anaconda and Jupyter Demo

The screenshot shows a Jupyter Notebook interface with the following details:

- Title Bar:** localhost:8888/notebooks/itmala/L01/demo.ipynb
- Toolbar:** Includes File, Edit, View, Insert, Cell, Kernel, Widgets, Help, Trusted, Python 3, and various file operations like Open, Save, and Run.
- Header:** Jupyter demo (autosaved), Logout, Python logo.
- Section Header:** L01
- Section Title:** Mini Python Demo
- Revisions:**

2019-0128	CEF, Initial.
2019-0806	CEF, E19 ITMAL update.
- Section Title:** Mini Python/Jupyter notebook demo
- Description:** Build-in python array an Numpy arrays...
- Code Cell:** In [79]:

```
# import clause, imports numpy as the name 'np'
import numpy as np

# python build-in array
x = [[1, 2, 3], [4, 5, 6]]

# print using print-f-syntax, prefeed againts say print('x =
print(f'x = {x}')
print()
```

# Anaconda and Jupyter Demo: Highlights...

- ▶ Polyglot miljø:
  - ▶ lidt ala Matlab IDE,
  - ▶ markdown (HTML+LaTeX)-og-Python-i-een = polyglot,
  - ▶ alt kører i browser, lokalt eller på server.
- ▶ Quickstart:
  - ▶ åbn via `http://localhost:8888` (efter launch),
  - ▶ ENTER på celle: editer celle,
  - ▶ CTRL+ENTER: kør celle,
  - ▶ SHIFT+TAB: hjælp på funktion,
  - ▶ TAB: tab-completion.
- ▶ Magics:
  - ▶ nulstil vars: `%reset -f`,
  - ▶ inline plots: `%matplotlib inline`.
- ▶ Hints:
  - ▶ Pas på globale vars (igen scopes ml. `.ipynb` celler),
  - ▶ Brug menu 'Help' og  
find shortcuts i 'open command palette'n,
  - ▶ Hvis du er C++ haj: alt er anderledes!

# Q: L01/modules\_and\_classes.ipynb

## Modules and Packages...

The screenshot shows a Jupyter Notebook interface with the following content:

### ITMAL Exercise

#### REVISIONS

2018-1219	CEF, initial.
2018-0206	CEF, updated and spell checked.
2018-0207	CEF, made Qh optional.
2018-0208	CEF, added PYTHONPATH for windows.
2018-0212	CEF, small mod in itmutils/utils.
2019-0820	CEF, updated.

### Python Basics

#### Modules and Packages in Python

Reuse of code in Jupyter notebooks can be done by either including a raw python source as a magic command

```
%load filename.py
```

but this just pastes the source into the notebook and creates all kinds of pains regarding code maintenance.

A better way is to use a python **module**. A module consists simply (and pythonic) of a directory with a module init file in it (possibly empty)

```
lbitmal/_init_.py
```

# Q: L01/modules\_and\_classes.ipynb

## Python classes...

The screenshot shows a Jupyter Notebook interface with the following content:

### Classes in Python

Good news: Python got classes. Bad news: they are somewhat obscure compared to C++ classes.

Though we will not use object-oriented programming in Python intensively, we still need some basic understanding of Python classes. Let's just dig into a class-demo, here is `MyClass` in Python

```
class MyClass:  
    myvar = "blah"  
  
    def myfun(self):  
        print("This is a message inside the class.")  
  
myobjectx = MyClass()
```

**Q: Extend the class with some public and private functions and member variables**

How are private function and member variables represented in python classes?

What is the meaning of `self` in python classes?

What happens to a function inside a class if you forget `self` in the parameter list, like `def myfun():` instead of `def myfun(self):`?

[OPTIONAL] What does 'class' and 'instance variables' in python correspond to in C++? Maybe you can figure it out, I did not really get it reading, say this tutorial

<https://www.digitalocean.com/community/tutorials/understanding-class-and-instance-variables-in-python-3>

In [ ]: # TODO: Qe...

END Python intro/BEGIN ML intro



# Klassisk maskinlæring årgang 1992

Pattern recognition, machine vision, neural networks...

612 Recognition and Interpretation

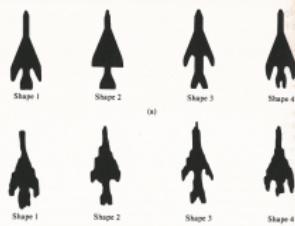


Figure 9.18. (a) Reference shapes and (b) typical noisy shapes used in training the neural network of Fig. 9.19. (From Gopas et al. [1990].)

Pattern vectors were generated by computing the normalized signatures of the shapes (see Section 8.1.3) and then obtaining 48 uniformly spaced samples of each signature. The resulting 48 48-dimensional vectors were the inputs to the three-layer feedforward neural network shown in Fig. 9.19. The number of neuron nodes in the first layer was chosen to be 48, which corresponds to the dimensionality of the input pattern vectors. The 4 neurons in the third (output) layer correspond to the number of pattern classes, and the number of neurons in the middle layer was heuristically specified as 26 ( $\approx$  the average of the number of neurons in the input and output layers). There are no known rules for specifying the number of neurons in the internal layers of a neural network, so this number generally is based either on experience or simply chosen arbitrarily and then refined by testing. In the output layer, the neurons from top to bottom in this case represent classes  $a_{i,j} = 1, 2, 3$ , and 4, respectively. After the network structure has been set, activation functions have to be selected for each unit and layer. All activation functions were selected to satisfy Eq. (9.3-50) so that, according to the earlier discussion, Eqs. (9.3-72) and (9.3-73) apply.

The training process was divided in two parts. In the first part, the weights were initialized to small random values with zero mean, and the network was

9.3 Decision-Theoretic Methods 613

then trained with pattern vectors corresponding to noise-free samples like the shapes shown in Fig. 9.18(a). The output nodes were monitored during training. The network was said to have learned the shapes for all four classes if, given, for any training pattern from class  $a_{i,j}$ , the elements of the output layer yielded  $O_j \geq 0.95$  and  $O_q \leq 0.05$ , for  $q = 1, 2, \dots, N_Q$ ,  $q \neq i$ . In other words, for any pattern of class  $a_{i,j}$ , the output unit corresponding to that class had to be high ( $\approx 0.95$ ) while, simultaneously, the output of all other nodes had to be low ( $\approx 0.05$ ).

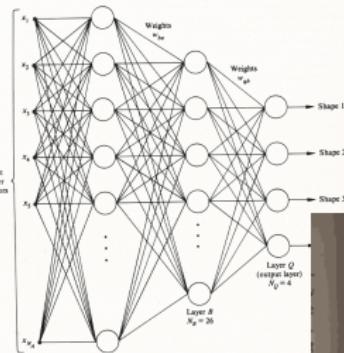
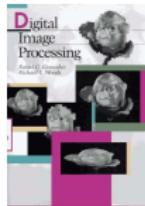


Figure 9.19. Three-layer neural network used to recognize the shapes in Fig. 9.18.

- ▶ Indeholder allerede det 'meste' ML,
- ▶ ML "vintre og somre":  
90'erne=sommer,  
00'erne=vinter



Digital Image Processing,  
Gonzalez and Woods,  
1992

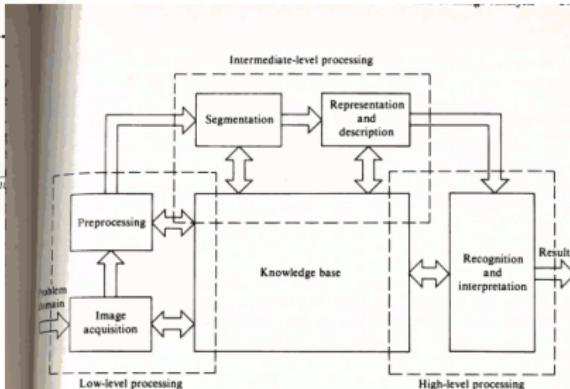
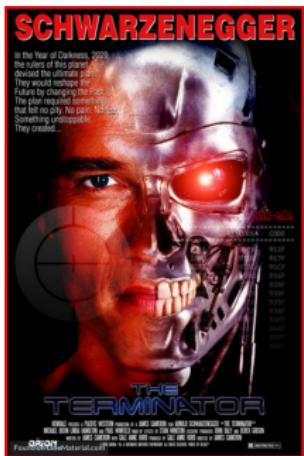


Figure 9.1. Elements of image analysis.

dark theater from bright sunlight. The (intelligent) process of finding an unoccupied seat cannot begin until a suitable image is available. The process

# Moderne maskinlæring, renæssancen

SciFi:



Real:



## Apple's Siri



## *IBM's Watson*



## Tesla's selvkørende bil

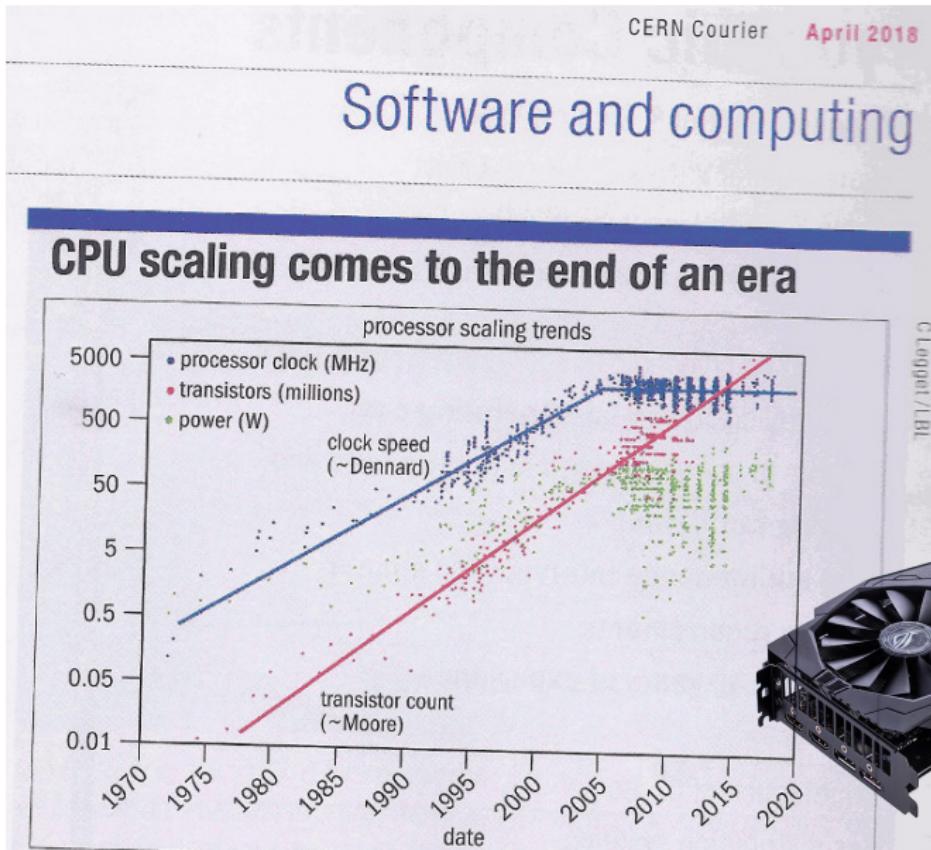
# Moderne maskinlæring

Diskussion: hvad er ML for Jer?

- ▶ hvad kender I af ML systemer?
- ▶ hvilke ML systemer anvender I allerede nu?
- ▶ ...og andre ML relaterede kommentarer!

# Moderne maskinlæring

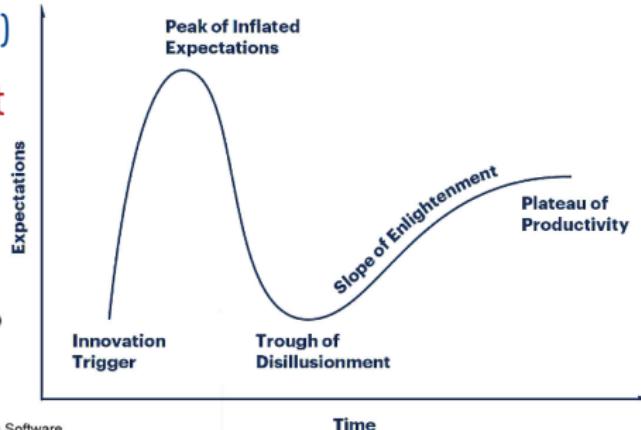
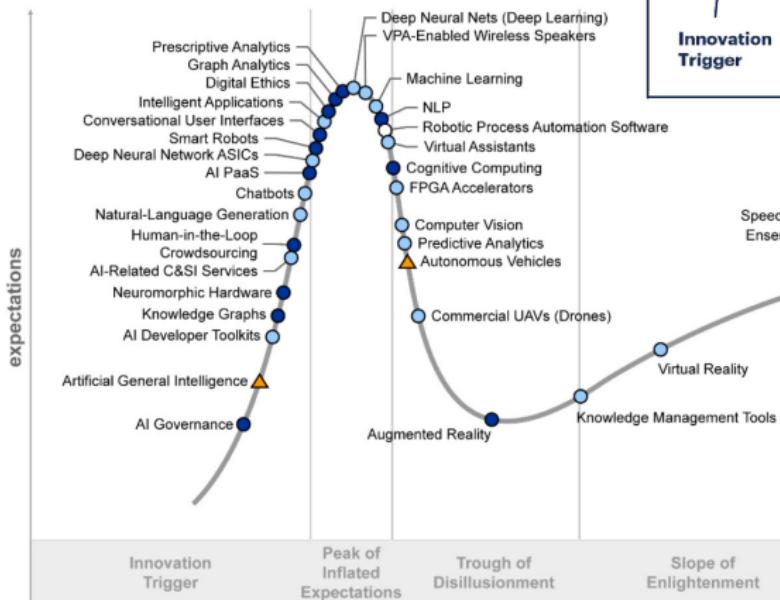
## Eksponentiel udvikling og Moore's Lov



# Moderne maskinlæring

Forskelse på ML og AI (artificial intelligence)

- ▶ Er det skrevet i **PowerPoint**  
så er det **AI**.
- ▶ Er det skrevet i **Python**  
så er det **ML**.



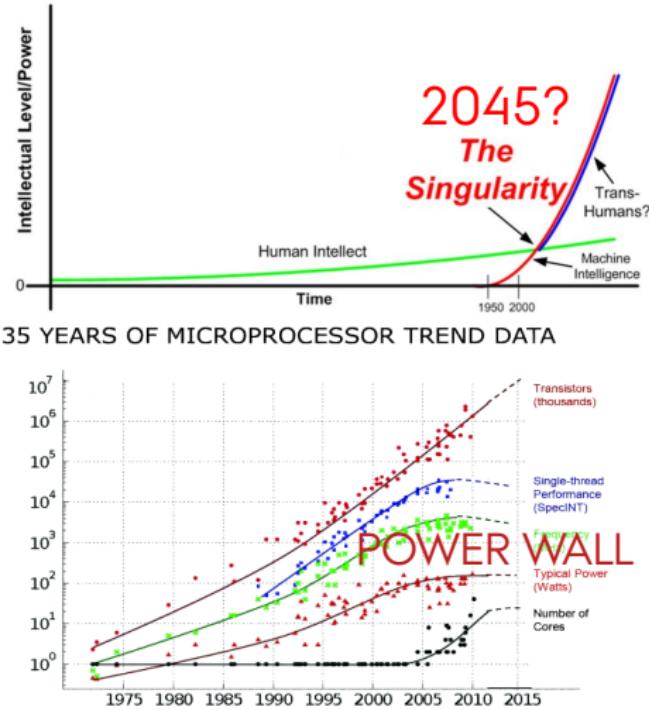
*Data is not information,  
information is not knowledge,  
knowledge is not understanding,  
understanding is not wisdom*  
- Cliff Stoll

As of July 2018

# Moderne maskinlæring

## Forskelse på Sci-Fi og Science

- ▶ Har seks årtiers forskning i AI led til ingenting?
- ▶ Forstår vi hjernen, cognition, menneskelig intelligens?
- ▶ Vil eksponentiel udvikling give os ægte AI?  
(Ray Kurzweil, Singularity)
- ▶ Hvor er alle android, cyborg eller HAL-9000'erne i vores hverdag?



Original data collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond and C. Batten  
Dotted line extrapolations by C. Moore

Sci: Dette kursus handler om Hands-on ML+python—ikke om Sci-Fi.

# Moderne maskinlæring

ALLE AI OVERSKRIFTER  
HAVDE MODALVERBER I  
NUTID (*skal give*),

MEN SÅ KOM DENNE...

The image shows a screenshot of the ING/VERSION2 website. The main header reads "ING/VERSION2" with "ING" in white and "VERSION2" in bold black. Below the header are navigation links: NYHEDER, BLOGS, DEBAT, JOB SEKTIONER, MERE, IT-TALENT, and INFOS. A sub-header on the left says "Sådan GAV ML resultater i det danske sundhedsvæsen". The main text of the article says "Sådan skal AI give resultater i det danske sundhedsvæsen". At the bottom right, there is a small illustration of a doctor's hands on a laptop keyboard, with the caption "Illustration: Andrei\_R, BigStock". A note at the bottom right states: "Masser af signaturprojekter skal anvende kunstig intelligens på sundhedsområdet. AI-forbedret diagnostik dominerer blandt de 25 projekter."

## BREAKING NEWS

Første AI artikel i datid: 'Sådan gav ML resultater.'

# Fra klassisk til moderne maskinlæring

Stadig pattern recognition, machine vision, neural networks...

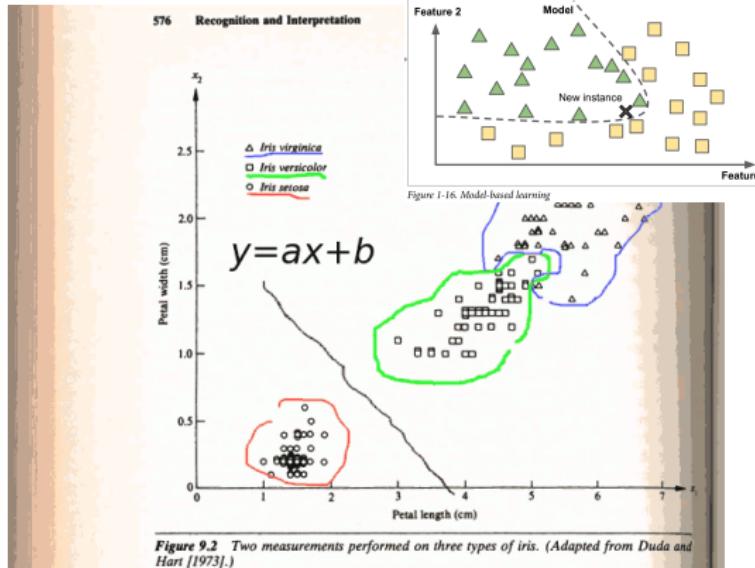
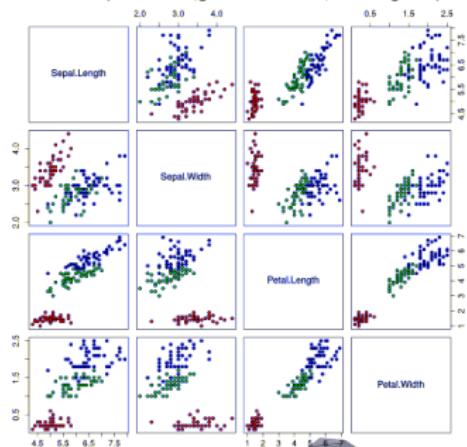


Figure 9.2 Two measurements performed on three types of iris. (Adapted from Duda and Hart [1973].)

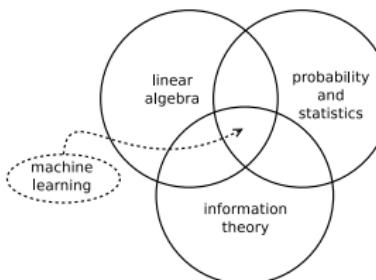


- ▶ ikke-nyt<sub>1</sub>: matematik,
- ▶ ikke-nyt<sub>2</sub>: algoritmer,
- ▶ nyt<sub>1</sub>: meget mere data og flere dimensioner, f.eks. 4D til 784D,
- ▶ nyt<sub>2</sub>: hurtigere hardware (og parallelitet).



# Machine learning baggrund

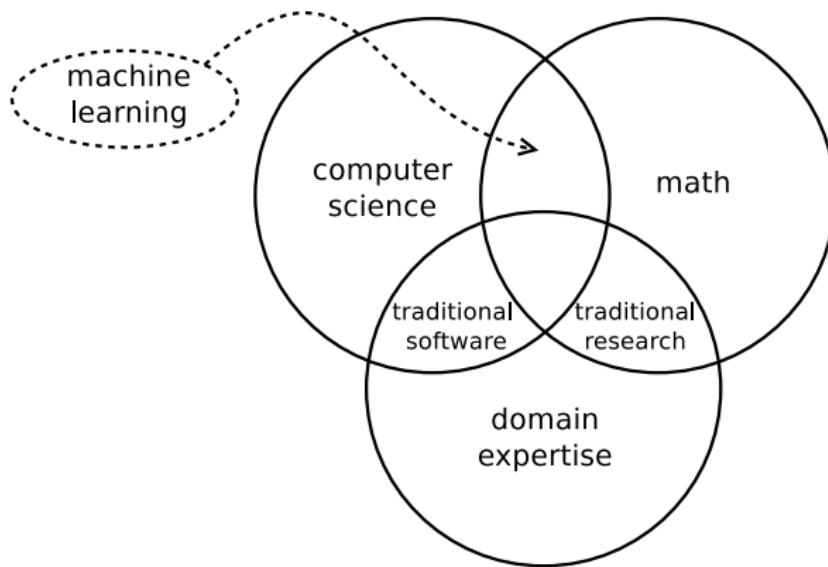
## Machine learning: matematisk baggrund



- ▶ Lineær algebra, læs løbende op:
  - ▶ norm (afstand),
  - ▶ matrix algebra (mest multiplikation),
  - ▶ least-square closed solution,  $(\mathbf{X}^T \mathbf{X})^{-1} \mathbf{X}^T \mathbf{y}$ ,
  - ▶ nabla operator,  $\nabla_{\mathbf{w}} = [\frac{\partial}{\partial w_1}, \frac{\partial}{\partial w_2} \dots]$ .
- ▶ Sandsynlighedsregning, læs løbende op:
  - ▶ multivariate mean, variance,
  - ▶ multivariate Gaussisk distribution,
  - ▶ (Bayes',)
- ▶ Informationsteori: vi navigere (mest) udenom entropi og andre informations-teori elementer i dette kursus.

# Machine learning baggrund

## Machine learning: ekspertise



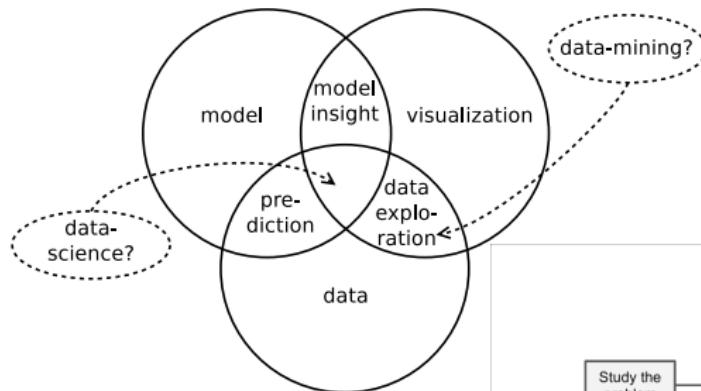
- ▶ ML ekspert er computer science og matematik ekspert.
- ▶ ML ekspert er IKKE (nødvendigvis) domæne ekspert!

### NOTE:

[\[https://imarticus.org/what-are-the-skills-you-need-to-become-a-machine-learning-engineer/\]](https://imarticus.org/what-are-the-skills-you-need-to-become-a-machine-learning-engineer/)

# Machine learning baggrund

Machine learning: data science ekspert



- ▶ fra white-box domæne ekspert til black-box ML data scientist,
- ▶ stadig polytekniker:
  - ▶ math- og computer science,
  - ▶ pattern-recognition,
  - ▶ neurocomputation,
  - ▶ datamining,
  - ▶ visualization,
  - ▶ etc..

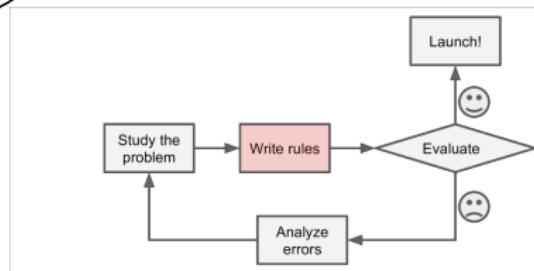


Figure 1-1. The traditional approach

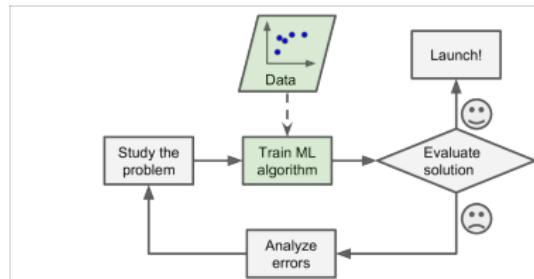
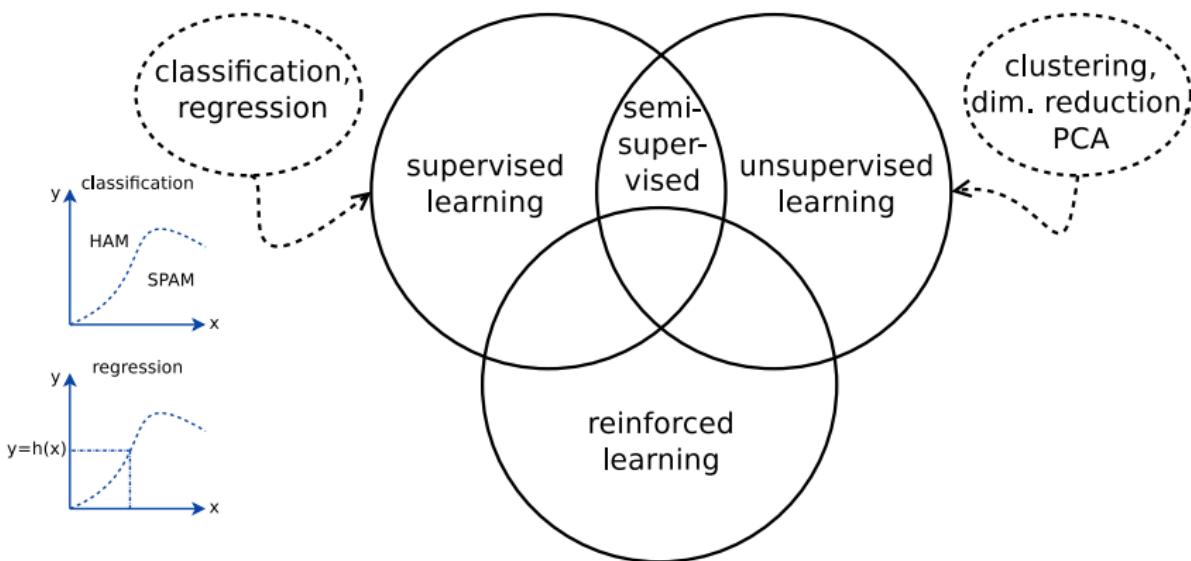


Figure 1-2. Machine Learning approach

# Machine learning taksonomi

## Machine learning læringstyper



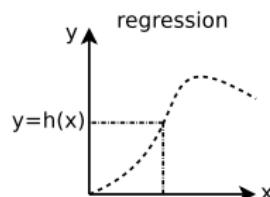
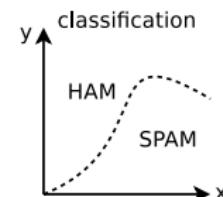
- ▶ I dette kursus:

**kun om supervised- og unsupervised-learning.**

# Et ML end-to-end projekt

Emner fra [HOML] §2 'End-to-end Machine Learning'

- ▶ Læringstyper:
  - ▶ supervised (mest om dette i ITMAL),
  - ▶ unsupervised, [semisupervised], [reinforced learning].
- ▶ Output klasser:
  - ▶ classification (ham/spam),
  - ▶ regression ( $h(x) = y$ ).
- ▶ Læring via data:
  - ▶ batch læring (al data),
  - ▶ [inkrementel læring (on-the-fly)].
- ▶ Prediktions/generaliserings model:
  - ▶ model-based (pattern-detection, byg intern model),
  - ▶ [instance-based (lær al data udenad)],
- ▶ Typiske ML fejl klasser:
  - ▶ for lidt trænings data (small-data, brug cross-validation),
  - ▶ sampling noise, sampling bias (ved manglende stratificering),
  - ▶ outliers og dårlig data (i big-data),
  - ▶ model og algoritme fejl: underfitting/overfitting.



# Machine learning terminologi

$\mathbf{X}, \mathbf{x}$ : input data matrix og vektor,

$\mathbf{y}, y$ : output data vektor og skalar,

$\theta$  or  $w$ : model parametre,

$h$ : hypothesis funktion; typer af ML algos:

Bayes classifier, k-Nearest Neighbors, Linear Reg., Logistic Reg., SVM, Decision Trees, Random Forest, Neural Networks, k-Means, ...

$y_{true}$ : ground truth, til supervised learning,

$y_{pred}$ : predikteret værdi, aka  $\hat{y}$ ,

attribut: data type, f.eks. salgspris, dog anvendes  
'feature' typisk i stedet for attribut!

$\lambda$ , feature: data attribut plus value, f.eks.  $\lambda_{salgspris} = \$42$ ,

$J, L$ , loss fun.: loss/cost/error/objective funktion, som  
minimeres via fitting, jo lavere jo bedre et fit,

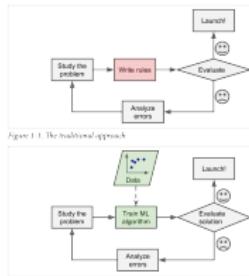
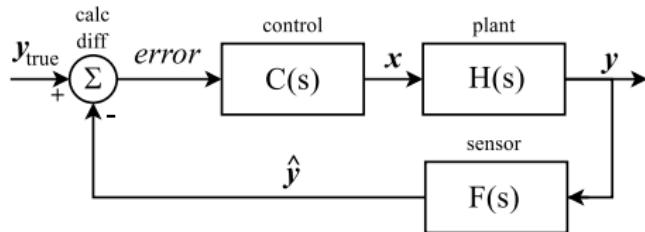
score fun.: score/fitness/goodness funktion, jo højere

performance-  
metric bruges typisk efter fit-minimeringen  
til model inspektion og eftervalidering.

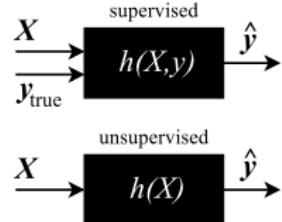
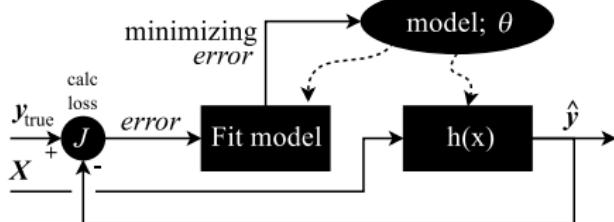
# Supervised learning, blok diagram (SKIP slide!)

Fra white-box til black-box

Almindelig white-box negativt feedback control block diagram, som for lineære og tids-uafhængige funktioner kan Laplace analyseres 'i det uendelige':



Supervised machine learning block diagram:



Valg af: model/hypothesis funktion,  $h$ , that's is!

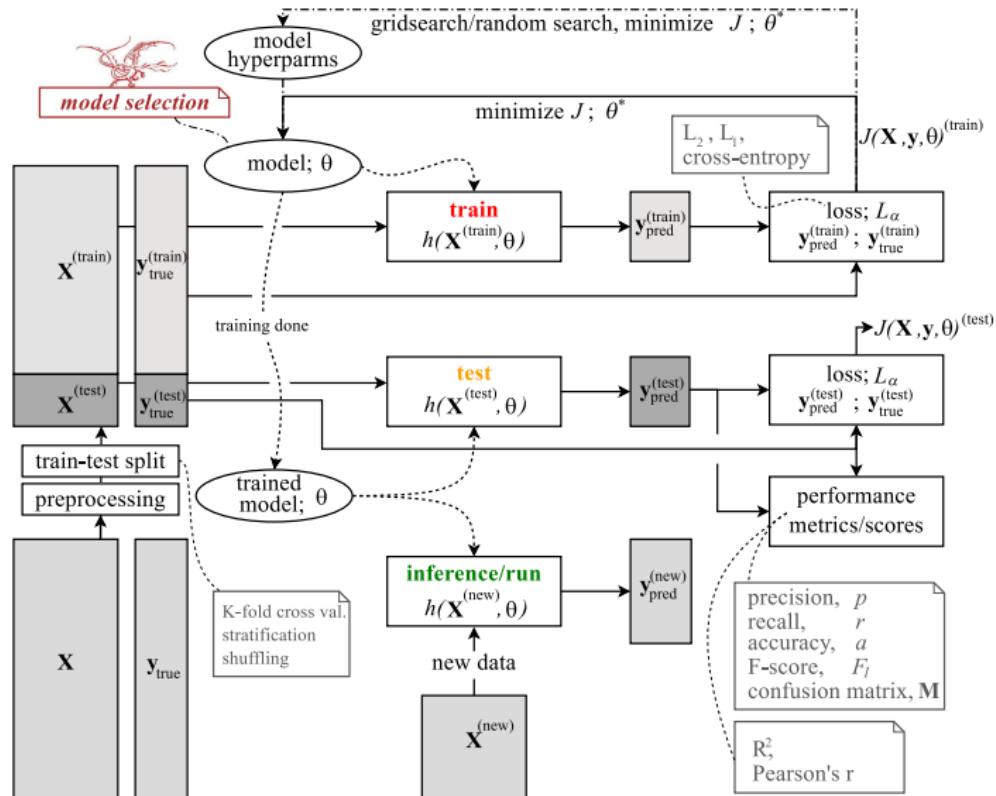
(excl. hyperparametre og valg af loss fun.)

Alt er nu black-box.

Holder ikke, kendskab til  
ML algo osv. nødvendig!

# Supervised learning, blok diagram

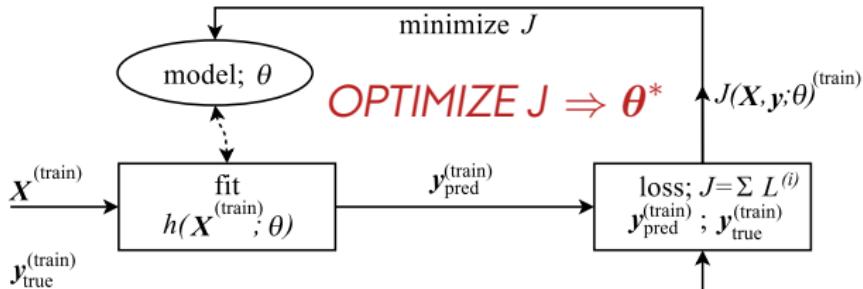
## Sneak-preview af 'the full monty'...



**NOTE:** Kun et preview; vi går igennem detaljerne i figuren i de følgende lektioner.

# Q: L01/intro.ipynb

ML supervised learning data flow model: i) Training (fit).

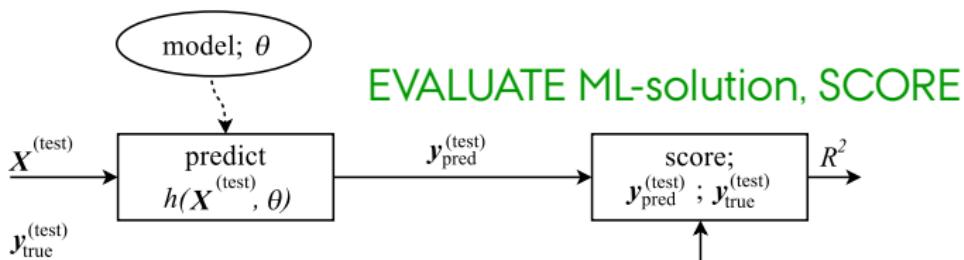


- $\mathbf{X}^{(train)}$  : trænings matrix input data,
- $\mathbf{x}^{(train)}$  : data input vector;  $\mathbf{x} = [x_1, x_2, \dots, x_d]$ ,
- $\mathbf{y}_{true}^{(train)}$  : trænings input ground truth vektor,
- $\mathbf{y}_{pred}^{(train)}$  : predikteret værdi for  $y$ , aka  $\hat{y}$
- $\theta$  : model parametre,
- $h$  : hypothesis funktion, aka. ML algoritmen,
- $L^{(i)}$  : loss funktion (individuel),  $L^{(i)}(y_{pred}^{(i)}, y_{true}^{(i)})$
- $J$  : loss funktion (summeret),  $J = \frac{1}{n} \sum_i L^{(i)}$ .

NOTE: med  $\mathbf{x}$  havende dimensionalitet  $d$ ... mere om denne og loss funktioner i L02.

# Q: L01/intro.ipynb

ML supervised learning data flow model: ii) Testing (predict) + eval (score)



Øvelse:

- ▶ træn en lineær regression model,  
(Scikit-learn fit-predict interface),
- ▶ gå i detaljen med  $R^2$  score funktionen,  
(NOTE: test data er lig train data for denne øvelse),
- ▶ check k-Nearest Neighbors modellen ud på data,  
sammenlign kNN-score med lineær regression-score.
- ▶ prøv en neutralt netværks-model på data  
(NOTE: den performer ekstrem dårligt!).

## Q: L01/intro.ipynb

Opstart med Python, Scikit-learn og lidt matematik...

- ▶ Jupyter notebook: `intro.ipynb` [GITMAL].
- ▶ Scikit-learn `fit-predict` interface
- ▶ ML Algoritmer:
  - ▶ mange forskellige ML algoritmer, vi går pt. ikke i detaljen,
  - ▶ for denne opgave:
$$h(\mathbf{X}, \theta) = \begin{cases} \text{▶ Linear Regression.} \\ \text{▶ k-Nearest Neighbors.} \\ \text{▶ Neural-network (virker dårligt til data!).} \end{cases}$$
  - ▶ fokuserer på det overordnede ML flow.
- ▶ **Loss** og **Scores** funktioner
  - ▶ Loss: funktion, som ML algoritmen forsøger at minimere under `fit`.
  - ▶ Score: funktion, der fortæller noget om hvor godt et `predict` er, her afprøver vi  $R^2$  (Coefficient of determination).