

# TFIP-AI - Machine Learning

Unit 1 – Introduction to Artificial Intelligence and Machine Learning



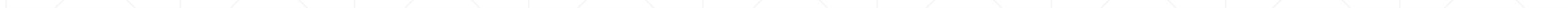
# Textbooks

- None!
- Recommended References:
  - Machine Learning by Tom Mitchell
  - Pattern Recognition and Machine Learning by C.Bishop
  - Artificial intelligence: A modern Approach by Russell and Norvig



# Outline

- Unit 1 – Introduction to Artificial Intelligence and Machine Learning
- Unit 2 – Data Preprocessing Techniques
- Unit 3 – Logical and Reasoning Systems
- Unit 4 – K-Nearest Neighbor Algorithm
- Unit 5 – Linear Regression Algorithms
- Unit 6 – Gradient Descent Algorithms
- Unit 7 – Logistic Regression
- Unit 8 – Graphical Models
- Unit 9 -- Naïve Bayes Classifier



# What is "AI"?



# Some classic definitions

Building computers that

<p><b>Think like a human</b></p> <ul style="list-style-type: none"><li>- Cognitive science / neuroscience</li><li>- Can't there be intelligence without humans?</li></ul>	<p><b>Think rationally</b></p> <ul style="list-style-type: none"><li>- Logic and automated reasoning</li><li>- But, not all problems can be solved just by reasoning</li></ul>
<p><b>Act like a human</b></p> <ul style="list-style-type: none"><li>- Turing test</li><li>- ELIZA, Loebner prize</li><li>- “What is <math>1228 \times 5873</math>? ... “I don’t know, I’m just a human”</li></ul>	<p><b>Act rationally</b></p> <ul style="list-style-type: none"><li>- Basis for intelligence agents framework</li><li>- Unclear if this captures the current scope of AI research</li></ul>

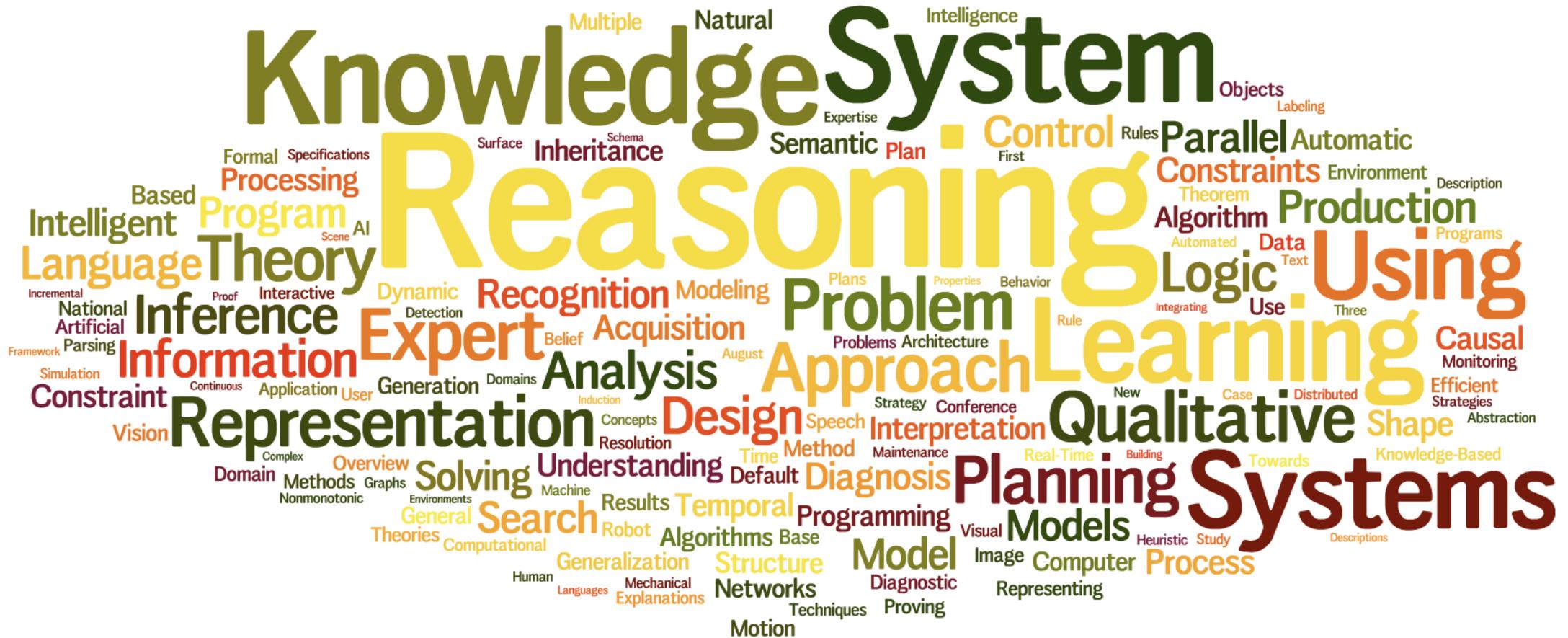
# The Pragmatist's View

“AI is that which appears in academic conferences on AI”

(Let's ignore the possibility of "AI" from other sources)

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# Paper Titles in AAAI



1980s

# Paper Titles in AAAI cont...



1990s

# Paper Titles in AAAI cont...



2000s

# Paper Titles in AAAI cont...

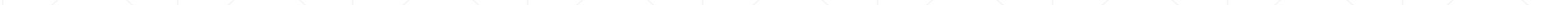


2010s

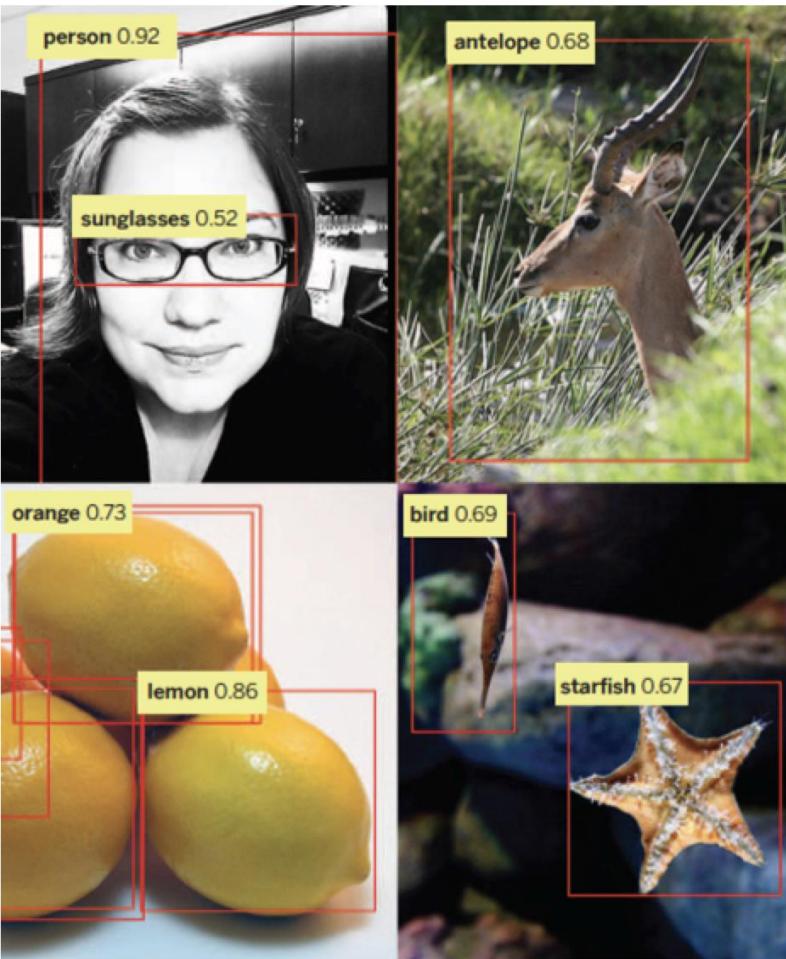
# A Broader Definition

We won't worry too much about definitions. One explanation could be this one:

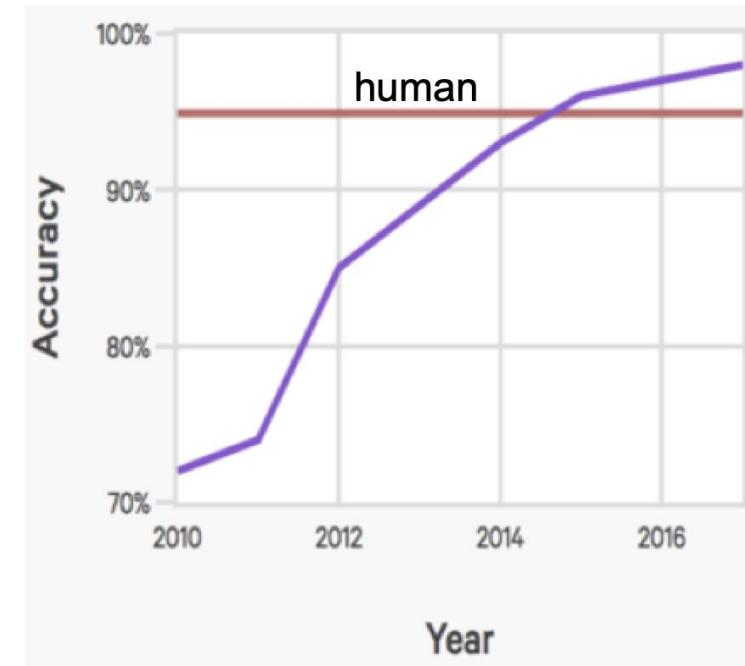
Artificial intelligence is the development and study of computer systems to address problems typically associated with some form of intelligence



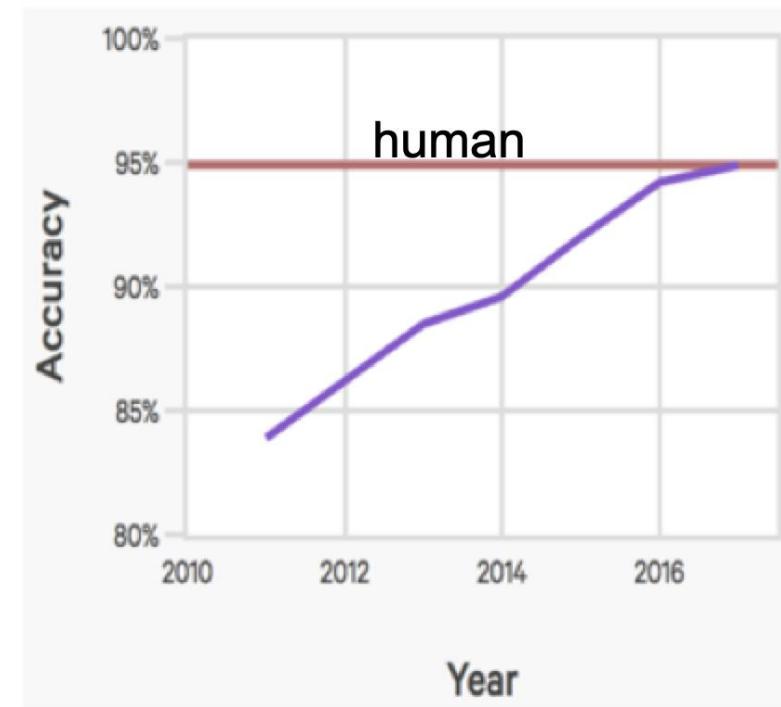
# Computer Vision



Imagenet Visual Recognition Challenge



# Speech Recognition



# Robots

## Factories, Land, Air, Sea, Mines, Homes

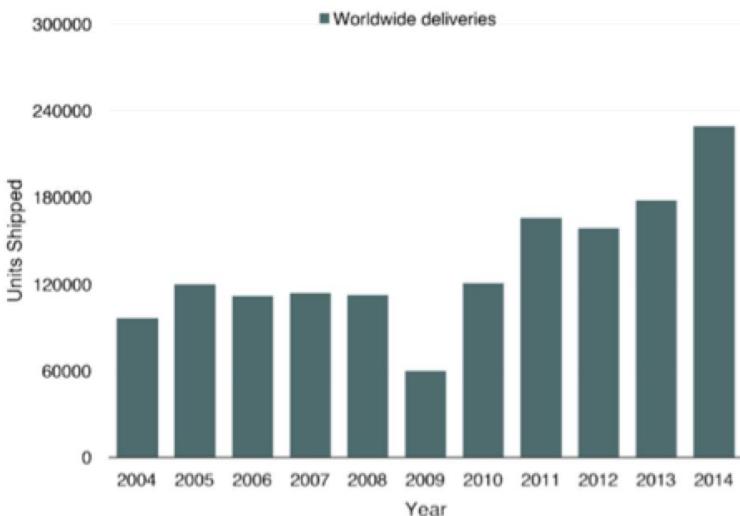


FIGURE 2.4 Worldwide shipping of robots over time. SOURCE: International Federation of Robotics, 2015.

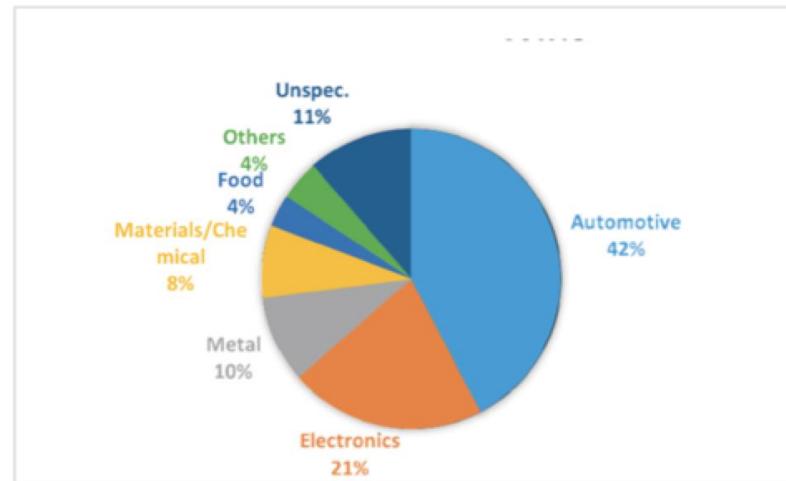
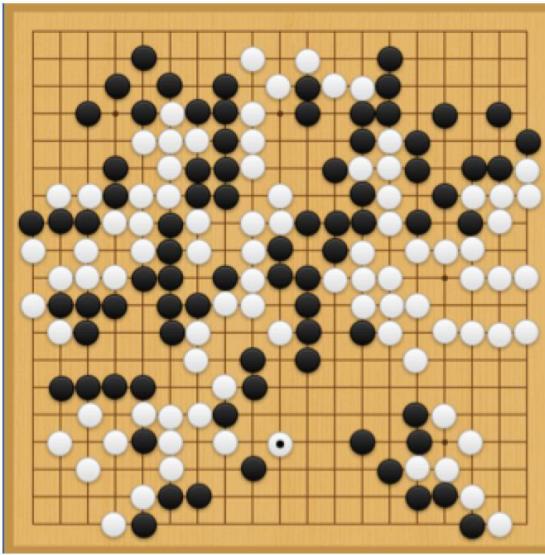


FIGURE 2.5 Robot application areas in 2015. SOURCE: Data from International Federation of Robotics, 2015.

# Games and reasoning



Chess



Go



Jeopardy

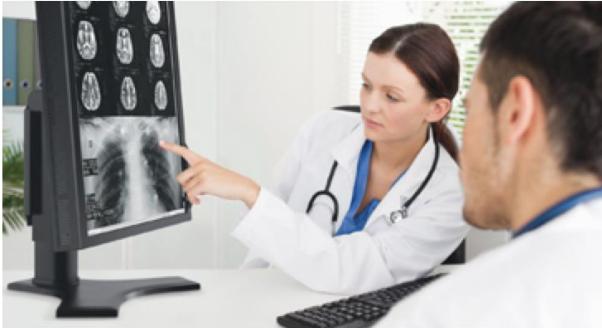


Poker

# The key: Machine Learning



conversational agents



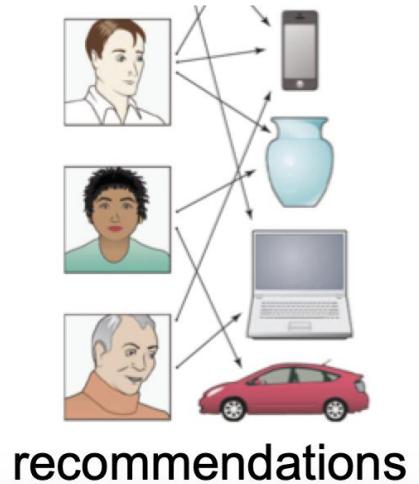
medical diagnosis



fraud detection

A screenshot of a translation application. On the left, under "English - detected", the text "Can AI help solve the skills shortage?" is displayed. On the right, under "French", the translated text "L'AI peut-elle aider à résoudre la pénurie de compétences?" is shown. The interface includes standard translation controls like microphone, speaker, and text input fields.

translation



recommendations

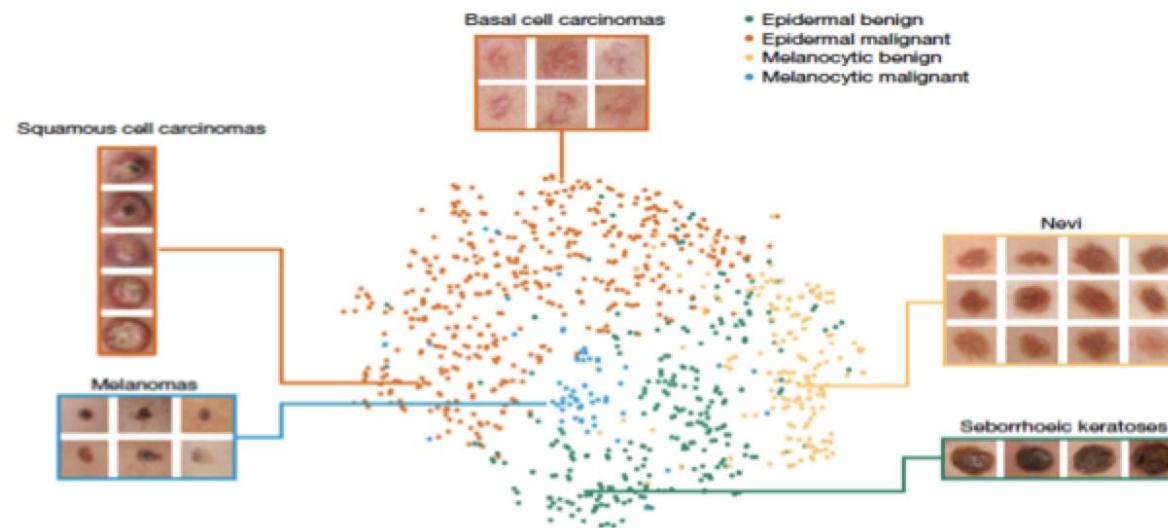
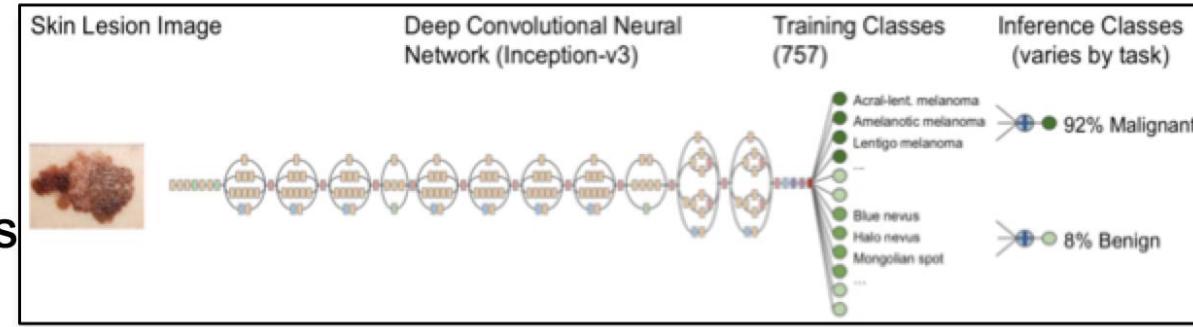
Many algorithms:

- Deep neural networks
- Bayesian networks
- Hidden Markov models
- Support Vector Machines
- Gaussian mixture model
- Expectation maximization

# Skin Cancer Diagnosis

[Esteva et al., *Nature* 2017]

Trained on 129,450 skin images  
plus 1.4 million standard photographs  
Deep net Inception v3 architecture  
Outperforms doctors



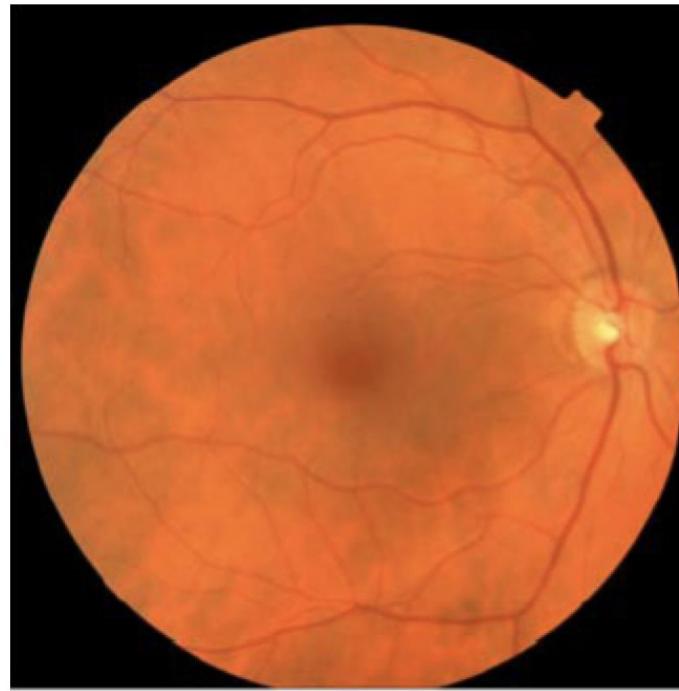
t-SNE visualization of final hidden layer

# Predict Cardiovascular Risk from Retinal Photographs

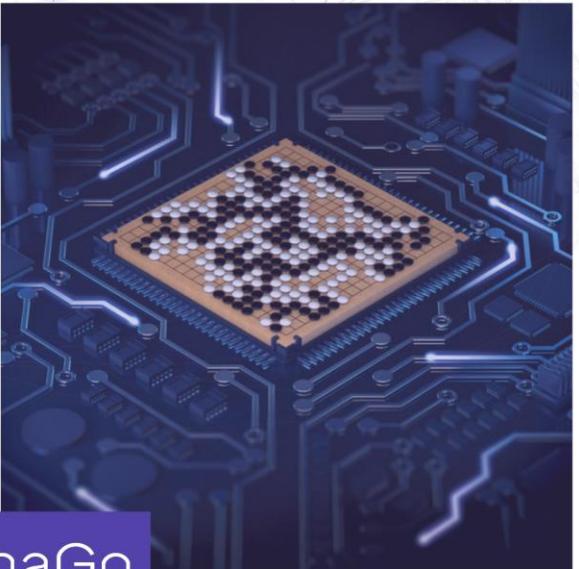
[Poplin et al., *Nature Biomed Eng.* 2018]

Trained deep net on 284,335 retinal images

New approach to detecting risk factors and biometrics



	Accuracy
Age	within 3.26 years on average
Smoker?	71%
Systolic blood pressure	within 11 mmHg on average
Gender	97%
Major cardiac event within past 5 years?	70%



AlphaGo

AlphaGo  
Google Deepmind

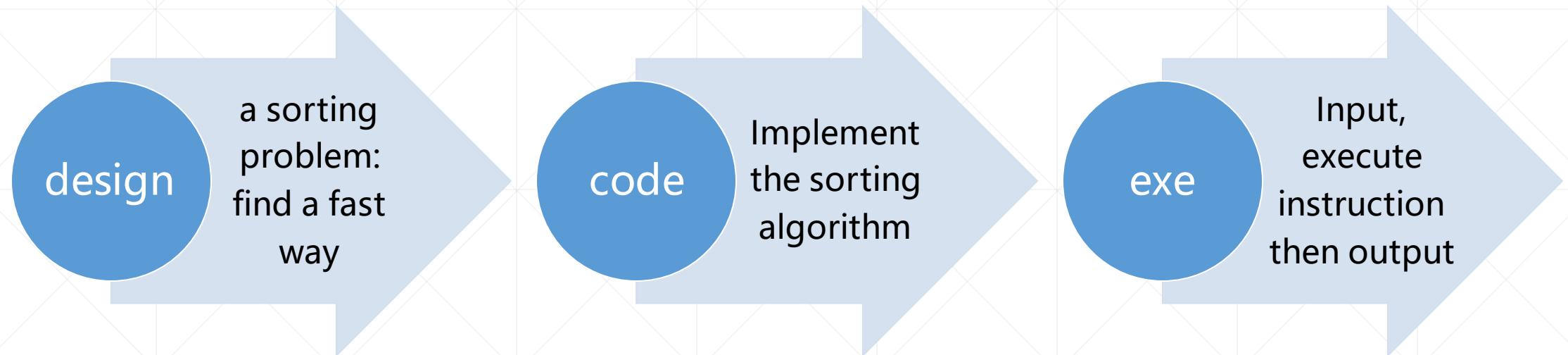


Watson  
IBM



Cortana, Siri, Google Now

# Traditional Programming - sorting



# A real world problem – Will he/she be late?

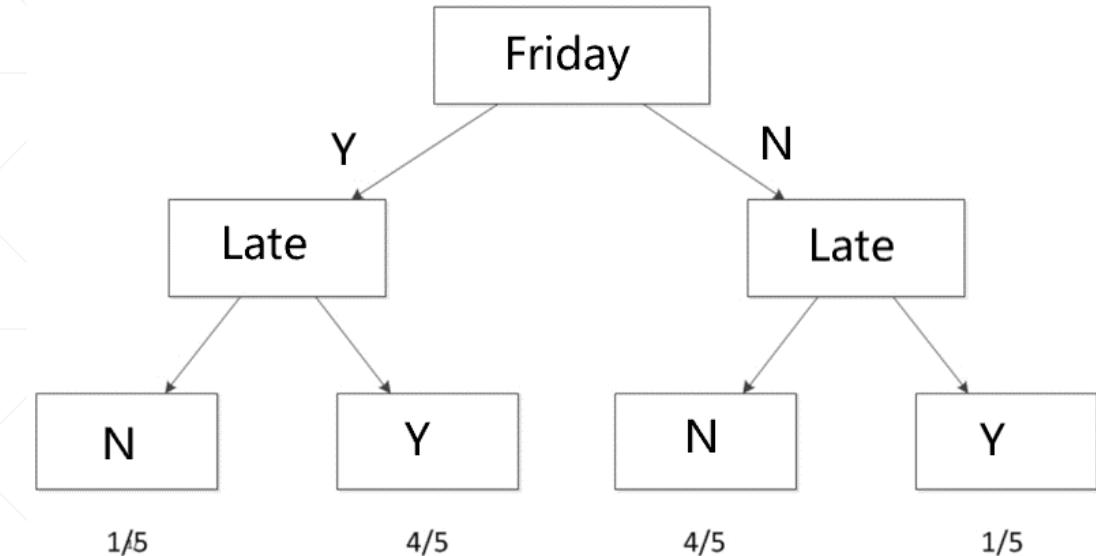


- Call him/her directly
  - Out of service
- Learn from experience
  - 5 times date with him
  - He was late one time, 80%
  - I believe that if it is less than 70%, he will be late this time
  - I assume that he won't be late this time

# Learn from experience/data - induction

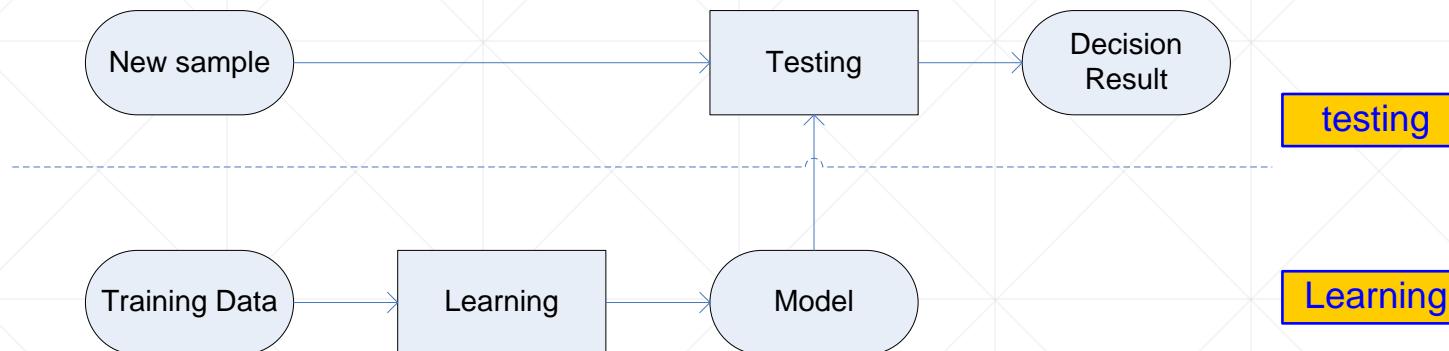
- Let's consider more info

Late?	Day of the week	Weather
Y	Friday	rain
Y	Friday	sunny
N	Thursday	cloudy
.....		

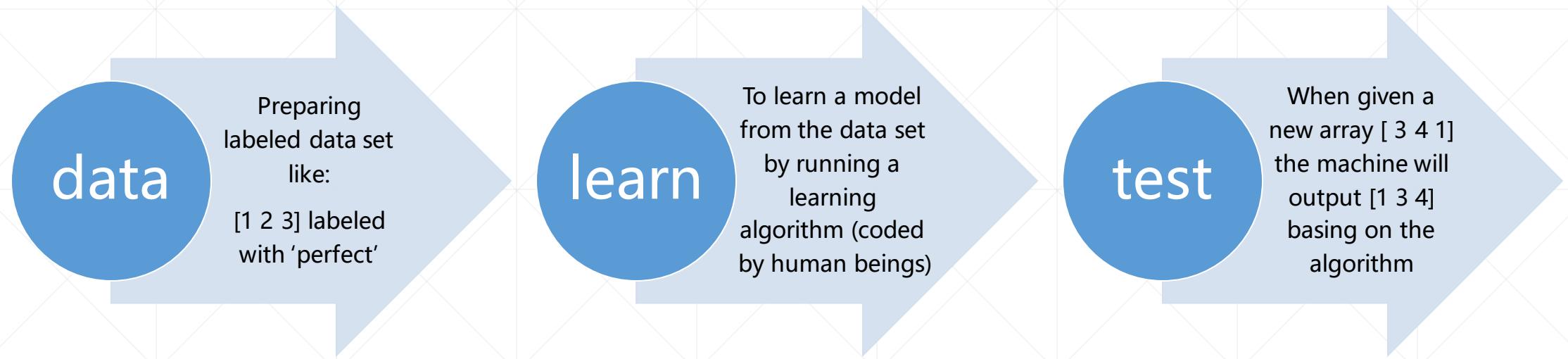


# Machine learning way

- If we consider more info: holiday, the traffic, ...
  - A more complicate model should be learned
- Let the computer has the ability of
  - Step 1: learning from experience/data and creating a computational model
  - Step 2: Using this model to make decision(predict/recognize/classify)

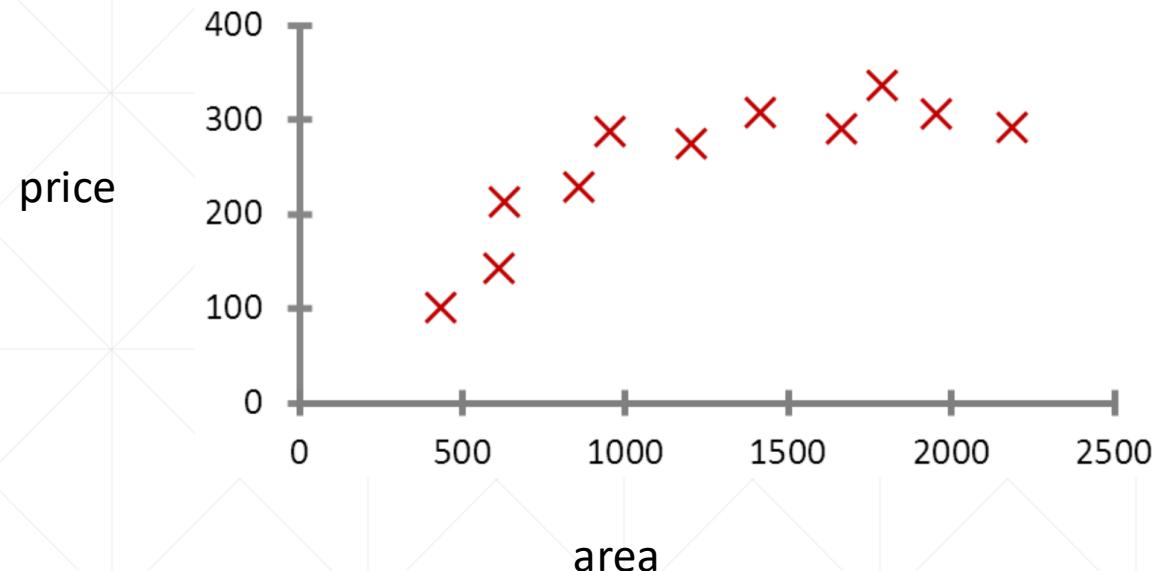


# Machine learning - sorting



Though the sorting is not a typical problem of machine learning, it shows an idea of Machine learning: we tell it which one is the best(objective), and it achieves the goal somehow.

# Price of house



- I have a house with size of 1,000 Sqft
- Estimate the price
  - Compare it with the houses in my neighborhood
  - Collect 11 houses the area + price
  - Is there a pattern/model in them?

Straight line:  $\text{price} = A * \text{area} + B$

.....

A, B are coefficients/parameters

# A Translation System without dictionary

## Italian

L'ente spaziale americano, NASA, ha annunciato che la prossima missione sulla Luna non sarà limitata a orbitare intorno al satellite, ma che includerà anche il lancio di due veicoli spaziali che raggiungeranno la superficie lunare per mezzo di un atterraggio con schianto.

Il Lunar Reconnaissance Orbiter (LRO), la cui missione principale è quella di esplorare la Luna, invierà una navetta di appoggio e una sonda a impatto verso un cratere situato al polo sud lunare.

Sembra che il cratere sia ricco di idrogeno e forse ghiaccio.

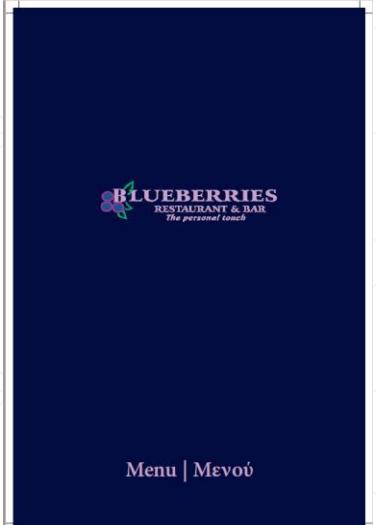
## English

The American space agency, NASA, announced that the next mission to the Moon will not be limited to orbit around the satellite, but also include the launch of two spacecraft that will reach the lunar surface by means of a crash landing.

The Lunar Reconnaissance Orbiter (LRO), whose mission is to explore the Moon, will send a shuttle to and support a probe into an impact crater located on the south lunar pole.

It seems that the crater is full of hydrogen and possibly ice.

# English - Greek



## Salad Starters

- 18. GREEK SALAD / ΕΛΛΗΝΙΚΗ ΣΑΛΑΤΑ(V) 5.50**

Tomatoes, cucumber, onion, feta cheese and olives / Ντομάτα, αγγούρι, κρεμμύδι, φέτα και ελιές

- 19. CAESAR SALAD / ΣΑΛΑΤΑ ΤΟΥ ΚΑΙΣΑΡΑ 5.50**

Romaine lettuce, grated parmesan cheese, croutons and caesar dressing / Μαρούλι, παρμεζάνα, κρουτόνς και σωσ του καίσαρα

- 20. CHERRY TOMATOES & MIX LETTUCE SALAD / NTOMATINIA KAI ΣΑΛΑΤΑ ΜΑΡΟΥΛΙ (V) 5.50**

Ruccula, cherry tomatoes salad with rocket and croutons / Ρουκούλλα, ντοματίνια και σαλάτα μαρούλι

- 21. TOMATOES, ONION, FETTA & FRESH PARSLEY SALAD / NTOMATA, ΚΡΕΜΜΥΔΙ, ΦΕΤΑ & ΜΑΪΝΤΑΝΟΣ(V) 5.90**

Sliced tomatoes & chopped onion with feta cheese, parsley & olive oil / Ντομάτα, κρεμμύδι, φέτα, μαϊντανός και ελαιόλαδο

**18. GREEK SALAD / ΕΛΛΗΝΙΚΗ ΣΑΛΑΤΑ(V)**

**19. CAESAR SALAD / ΣΑΛΑΤΑ ΤΟΥ ΚΑΙΣΑΡΑ**

**20. CHERRY TOMATOES & MIX LETTUCE SALAD /  
ΝΤΟΜΑΤΙΝΙΑ ΚΑΙ ΣΑΛΑΤΑ ΜΑΡΟΥΛΙ (V)**

**21. TOMATOES, ONION, FETTA & FRESH PARSLEY SALAD /  
ΝΤΟΜΑΤΑ, ΚΡΕΜΜΥΔΙ, ΦΕΤΑ & ΜΑΪΝΤΑΝΟΣ(V)**

	English	Greek
18	GREEK SALAD	ΕΛΛΗΝΙΚΗ ΣΑΛΑΤΑ
19	CAESAR SALAD	ΣΑΛΑΤΑ ΤΟΥ ΚΑΙΣΑΡΑ
20	CHERRY TOMATOES MIX LETTUCE SALAD	ΝΤΟΜΑΤΙΝΙΑ ΚΑΙ ΣΑΛΑΤΑ ΜΑΡΟΥΛΙ
21	TOMATOES ONION FETTA FRESH PARSLEY SALAD	ΝΤΟΜΑΤΑ, ΚΡΕΜΜΥΔΙ, ΦΕΤΑ & ΜΑΪΝΤΑΝΟΣ

	English	Greek
46	GRILLED CHICKEN BREAST	ΚΟΤΟΠΟΥΛΟ ΣΤΗ ΣΧΑΡΑ
46	Succulent chicken breast <b>grilled</b> to perfection	Στήθος στη σχάρα με μπαχαρικά
45	Succulent chicken breast <b>grilled</b> with our special seasoning topped with melted cheese & sauté onions & mushrooms	Στήθος στη σχάρα με μπαχαρικά, τυρί, κρεμμύδια & μανιτάρια



### Training

Grilled



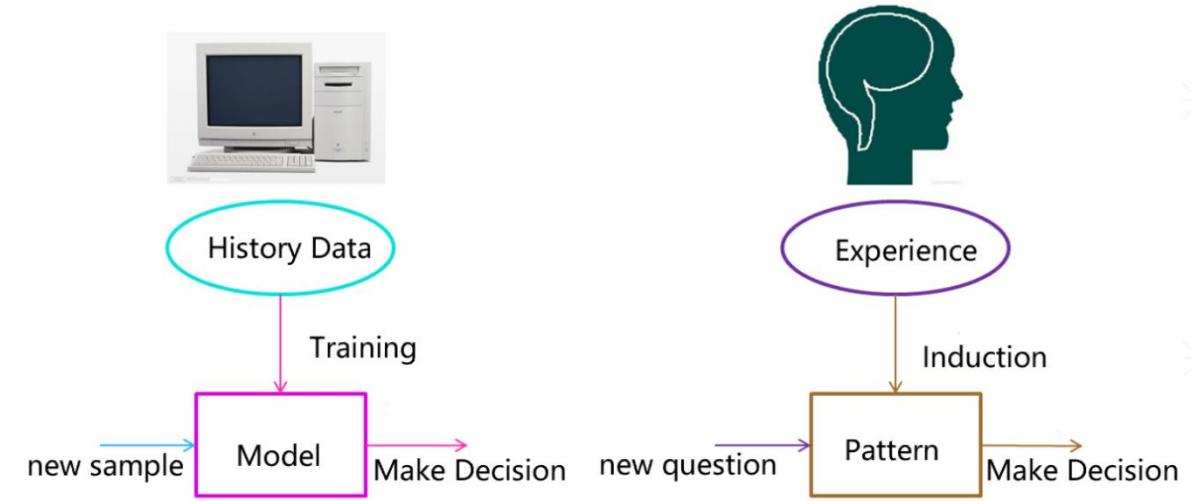
Candidate words Corresponding to GRILLED	Occurrences
ΚΟΤΟΠΟΥΛΟ	1
ΣΤΗ	3
ΣΧΑΡΑ	3
Στήθος	2
Με	2
Μπαχαρικά	2
Τυρί	1
Κρεμμύδια	1
Μανιτάρια	1



στη σχάρα

### Testing

# Machine vs. human

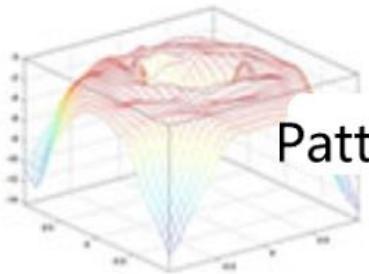


- The form of the model should be given in advance
  - Different forms can be applied: straight line, curve ....
- More data help the model consider different situations, thus make the model more generative

# Scope

Machine Learning





Pattern Recognition



Computer Vision



Data Mining



Machine Learning



Speech Recognition



Statistical  
Learning

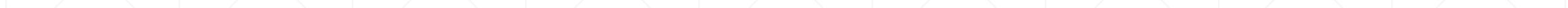


Natural  
Language  
Processing

# Machine learning = Pattern Recognition

- Pattern recognition has its origins in engineering, whereas machine learning grew out of computer science. However, these activities can be viewed as two facets of the same field, and together they have undergone substantial development over the past ten years.

----- Bishop 《 Pattern Recognition And Machine Learning》



# Statistical learning ≈ Machine learning

- Statistical learning is an area which is highly overlapped with machine learning.
- Most machine learning methods are from statistical learning.
  - Clustering
- The difference
  - Statistical learning focus on the development and optimization of statistical models
  - Machine learning focus on models applying



# Computer Vision = Machine learning + Image Processing

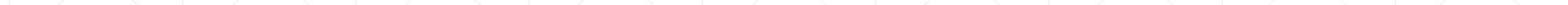
- Image or video means large amount of data (pixels)
- Features are extracted from pixels to help improve the recognition efficiency and effective
- Image processing is used in feature extraction

A person riding a motorcycle on a dirt road



# Speech Recognition = Machine learning + Speech Processing + NLP

- Similar to Computer Vision, features of audio signal first needs to be extracted and then feed to machine learning algorithm
- The objective of introducing Natural Language Processing is to let machine really understand what we are speaking of. Study of Linguistics models could be helpful in this area.



# Methods

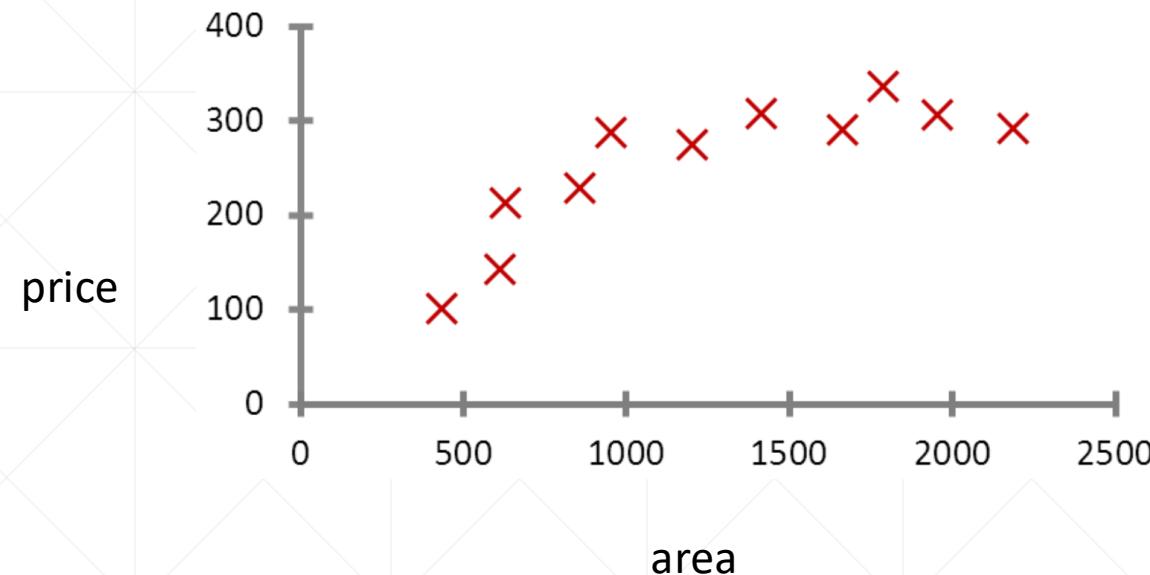
Machine Learning



# 3 types of learning

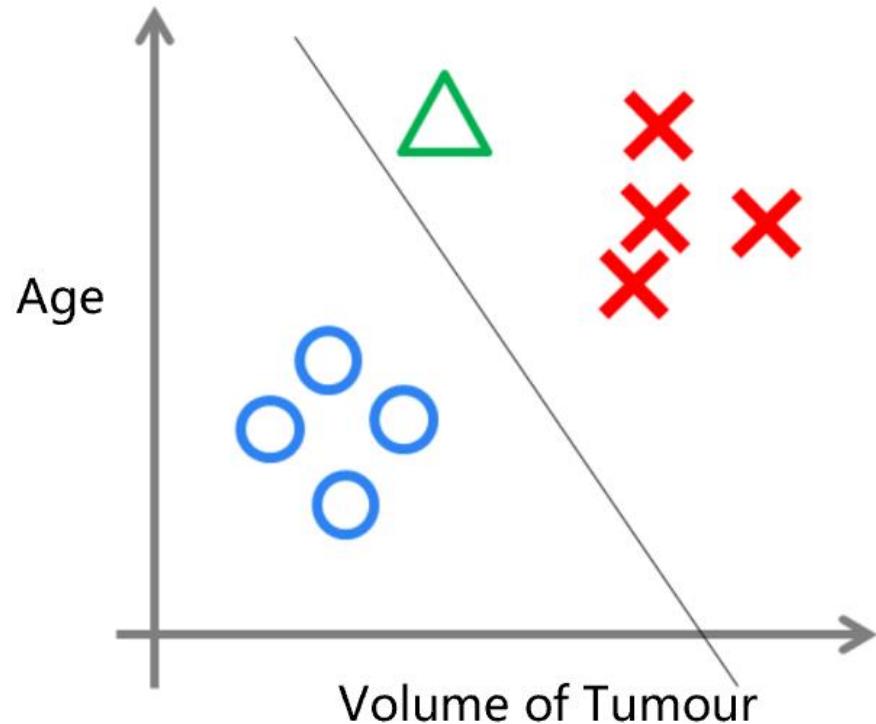
- Supervised
    - in which the training data is labelled with the correct answers.
  - Unsupervised
    - in which we are given a collection of unlabelled data, which we wish to analyse and discover patterns within.
  - Reinforcement
    - in which an agent seeks to learn the optimal actions to take basing on the reward of past actions.
-

# Regression



supervised

# Logistic Regression



Data

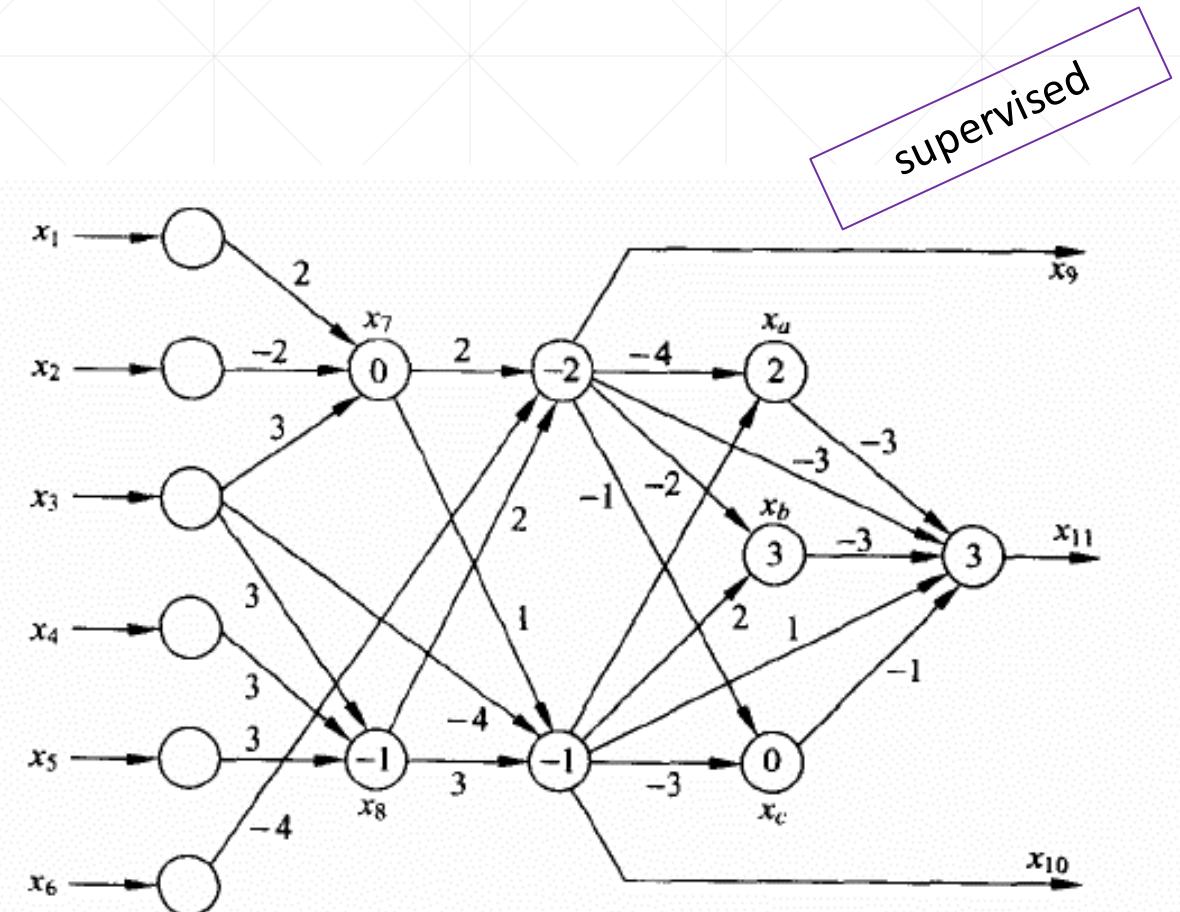
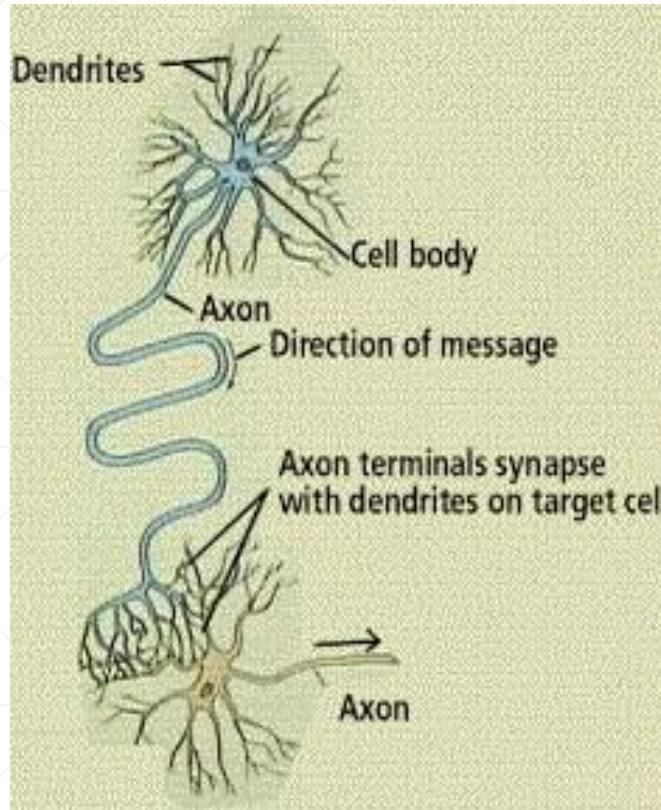
Age of Patient

Size of Tumour

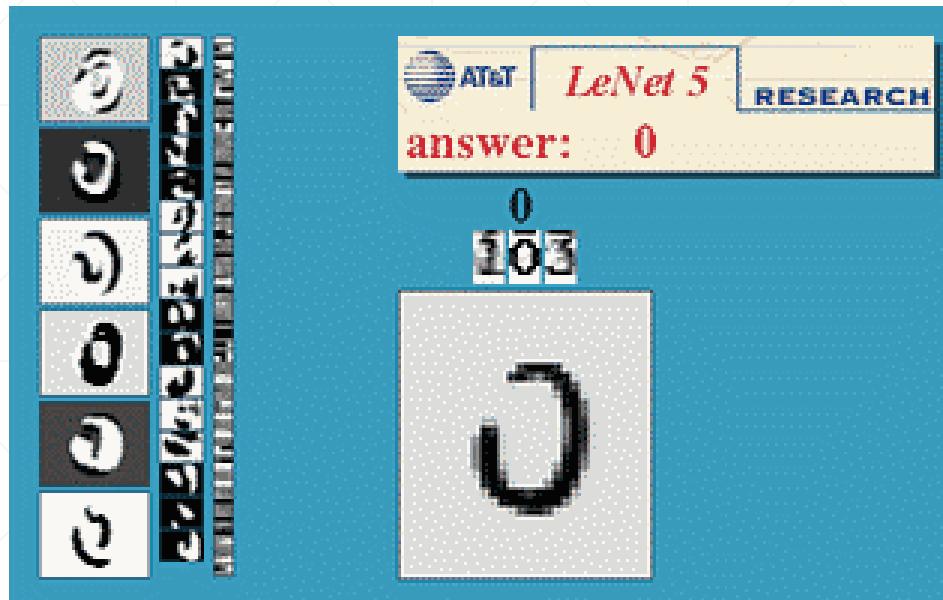
Benign/Cancer

supervised

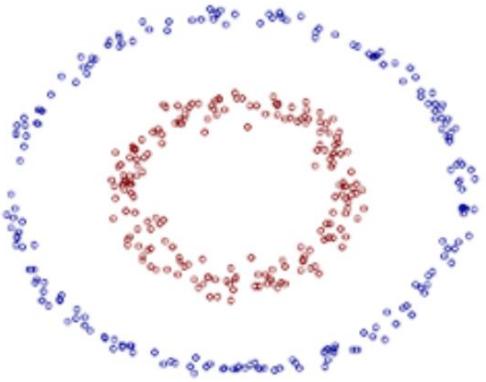
# Neural Network



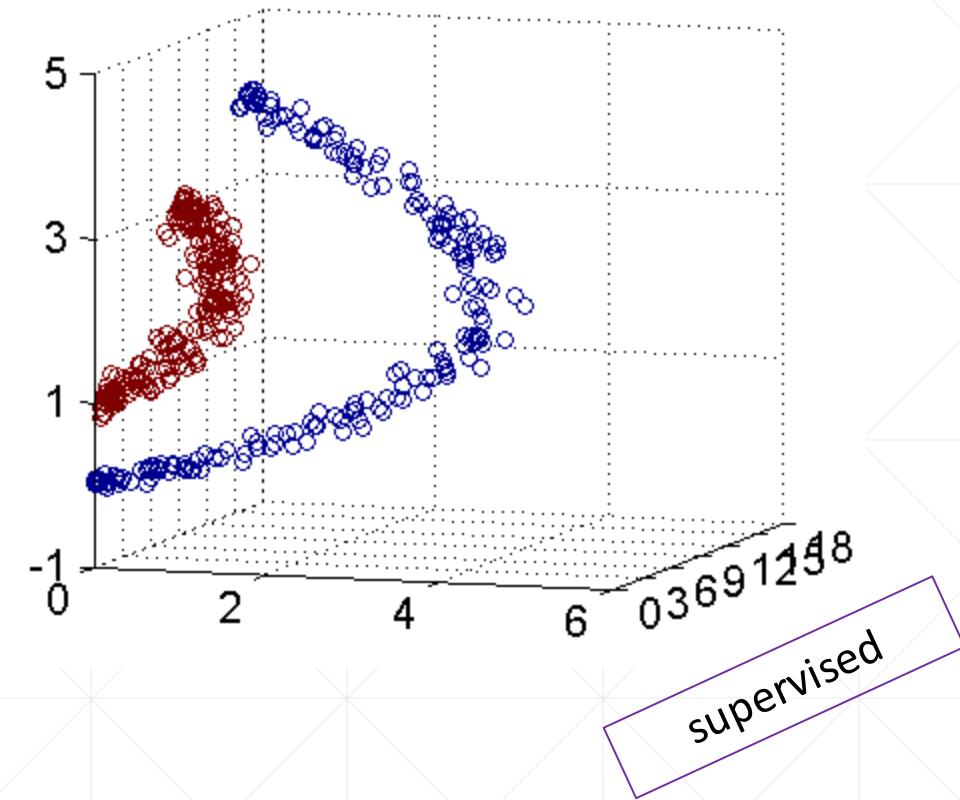
# Neural Network - LeNet



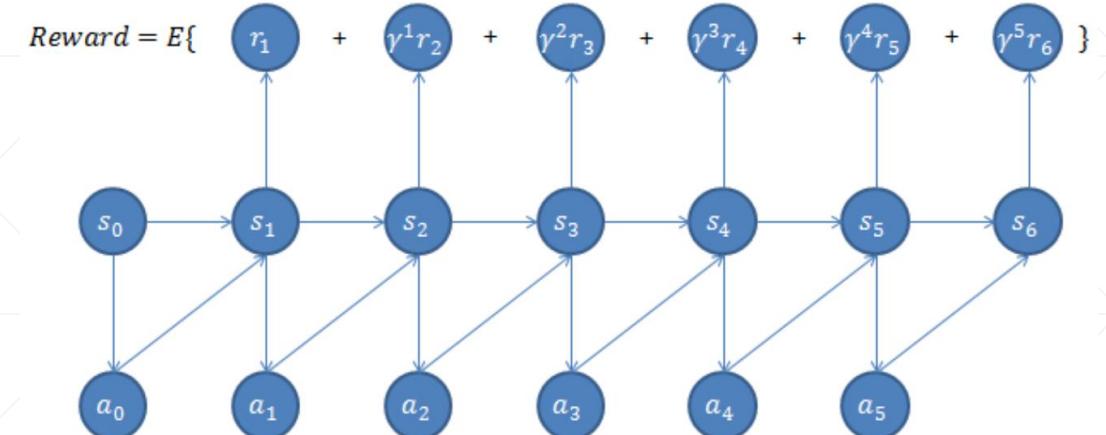
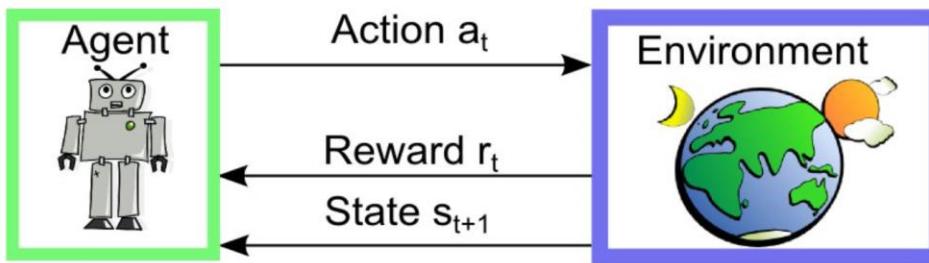
# Support Vector Machine with kernel



2D → 3D



# Reinforcement Learning



# Others

- Clustering – unsupervised learning
- Bayes Network
- Decision Tree
- Recommendation algorithm
- .....



# Linear Regression

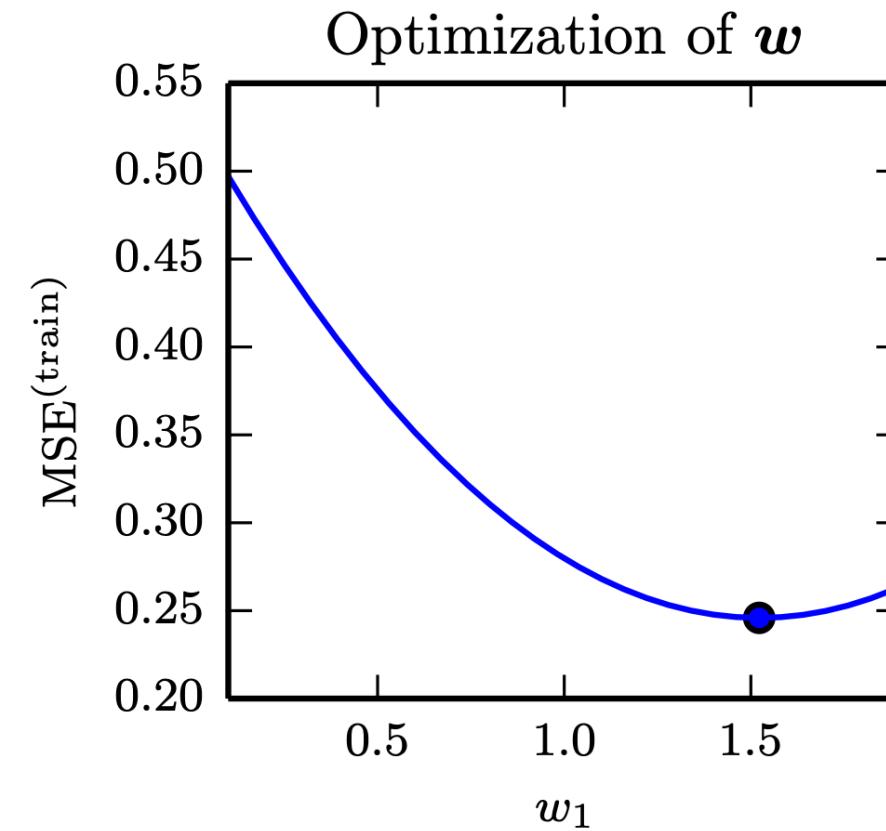
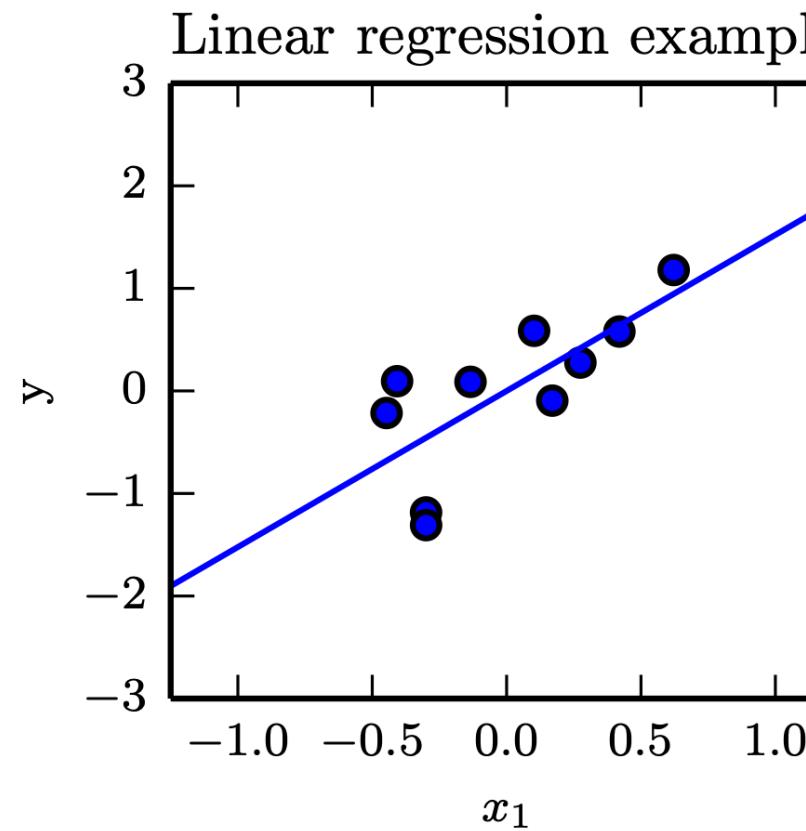


Figure 5.1

# Underfitting and Overfitting in Polynomial Estimation

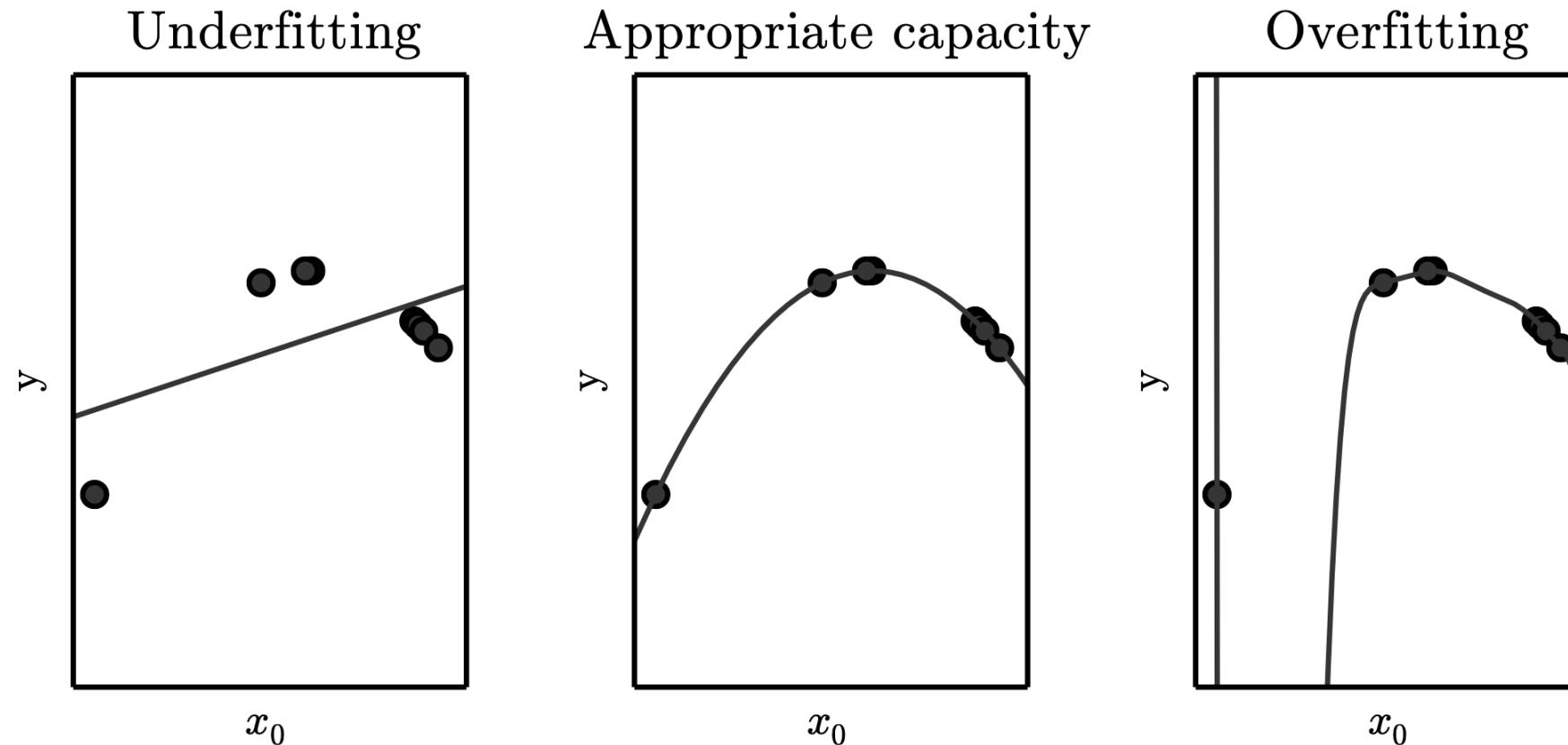


Figure 5.2

# Generalization and Capacity

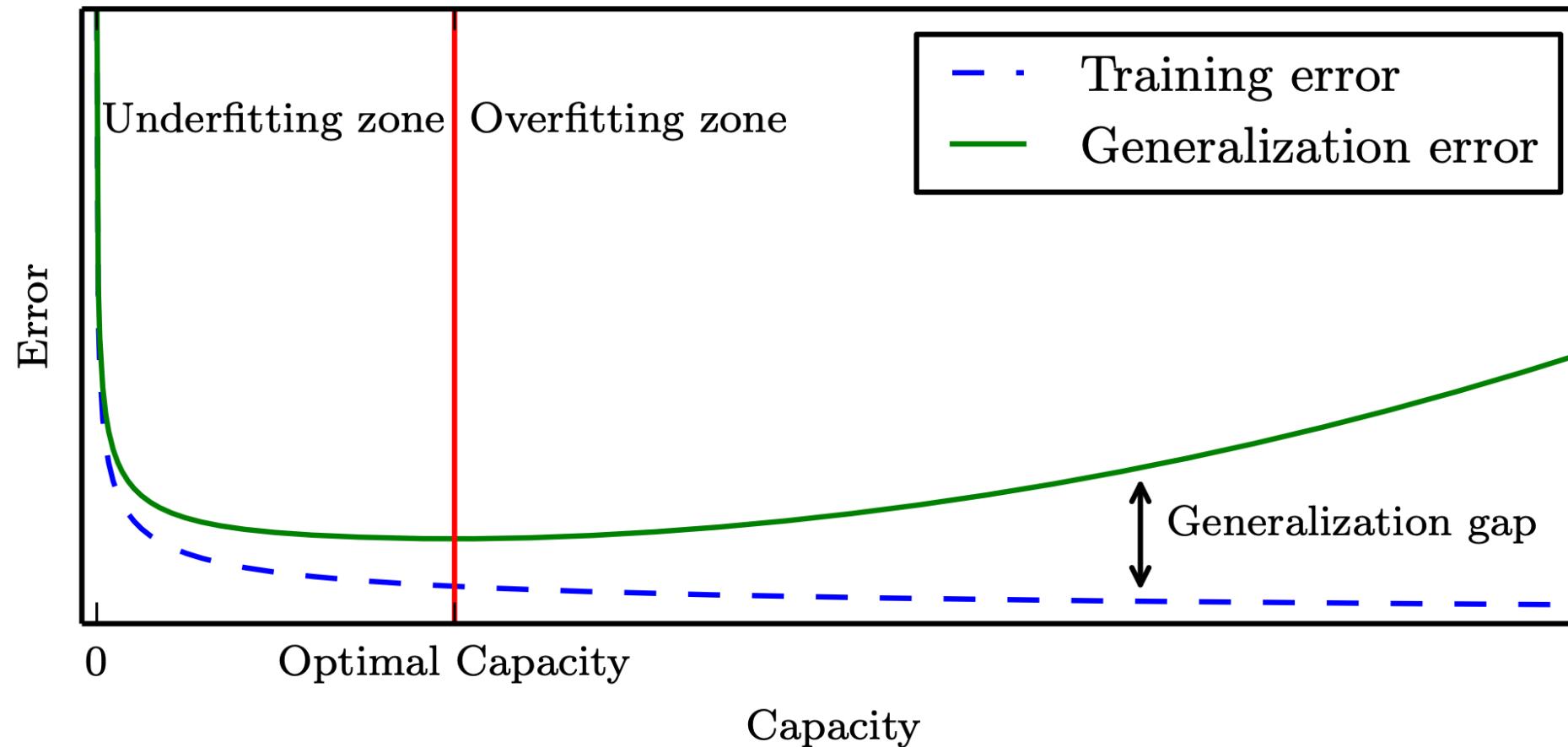


Figure 5.3

# Training Set Size

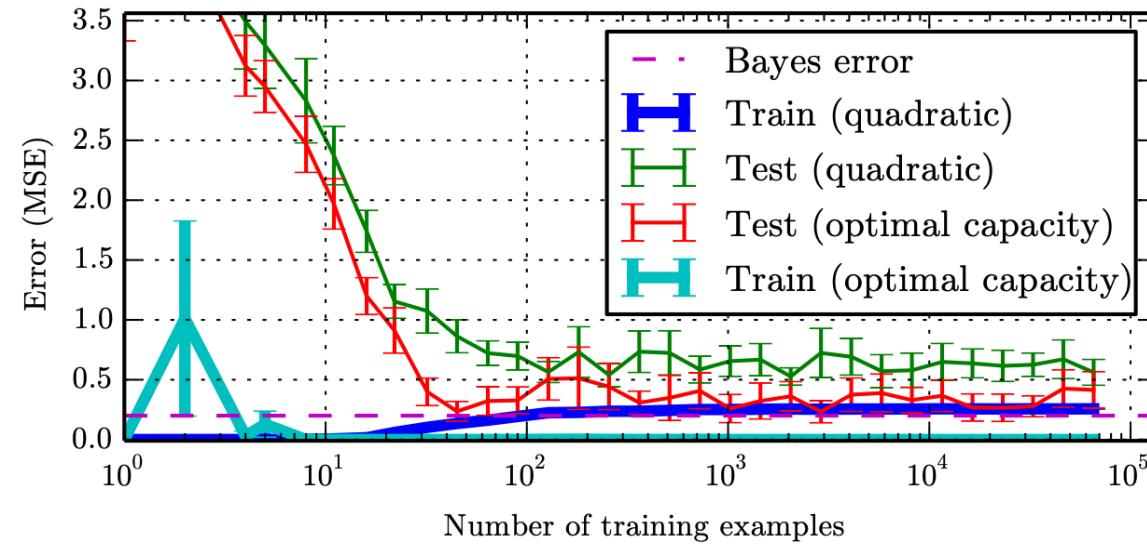
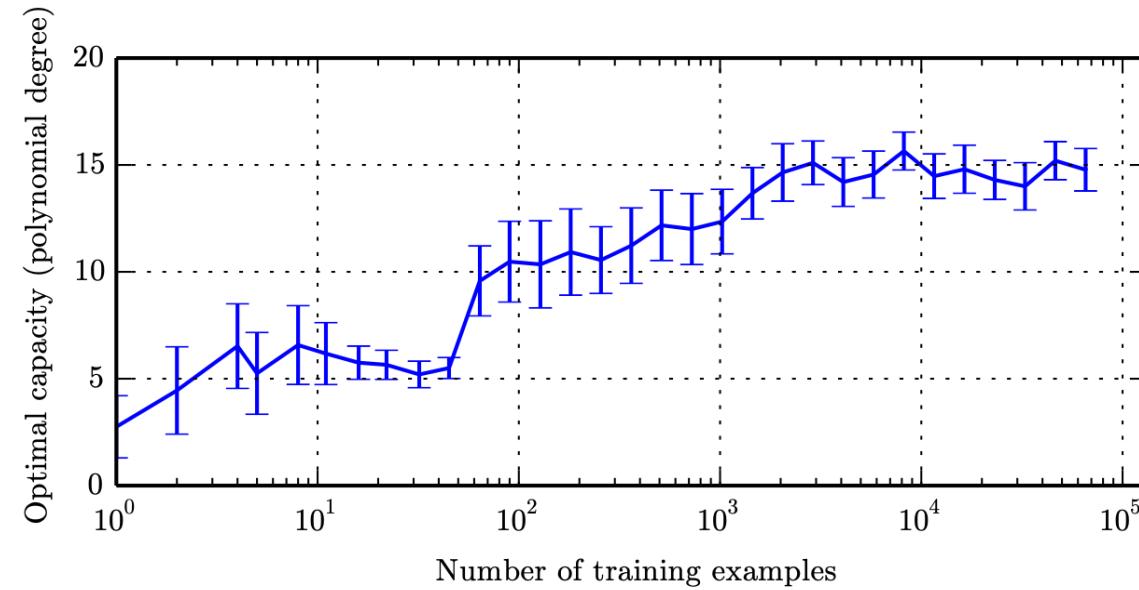


Figure 5.4



# Weight Decay

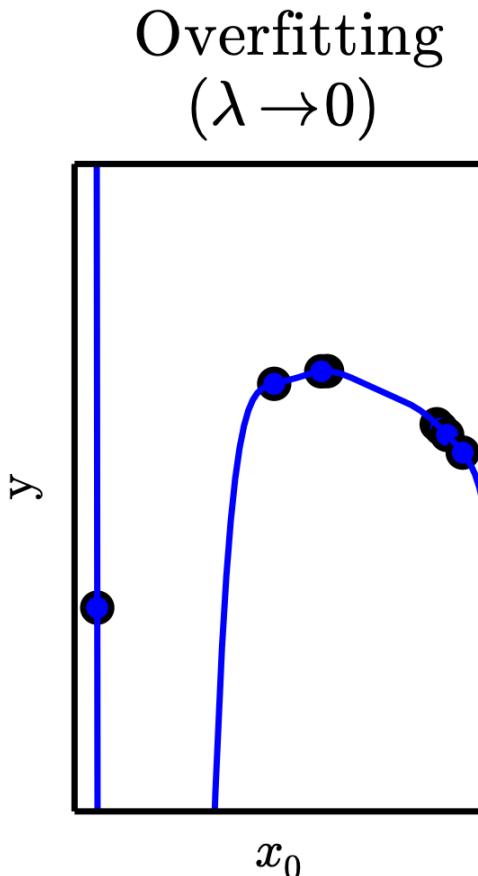
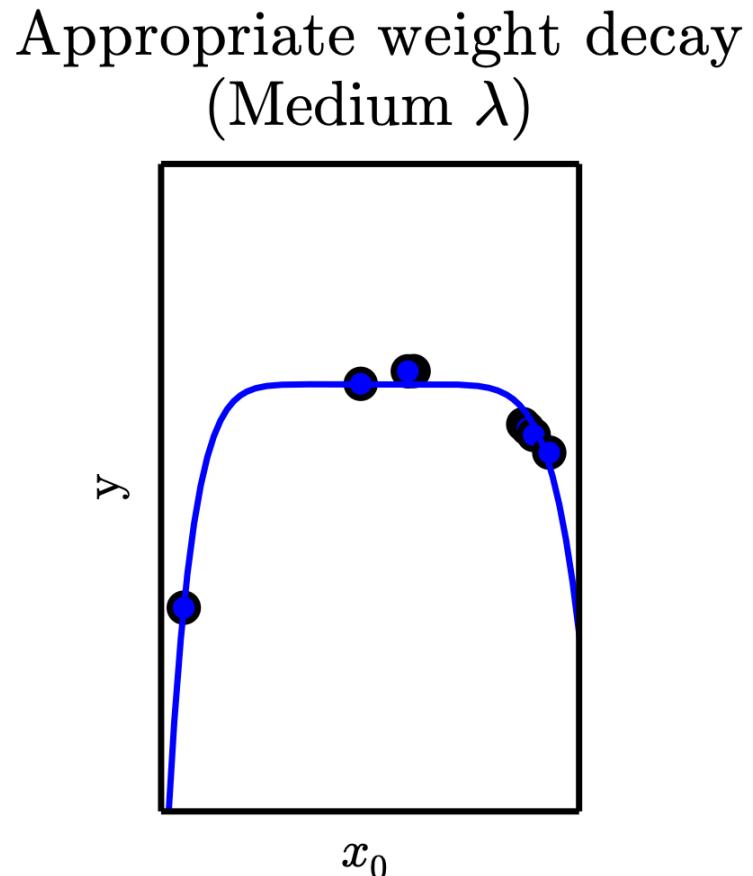
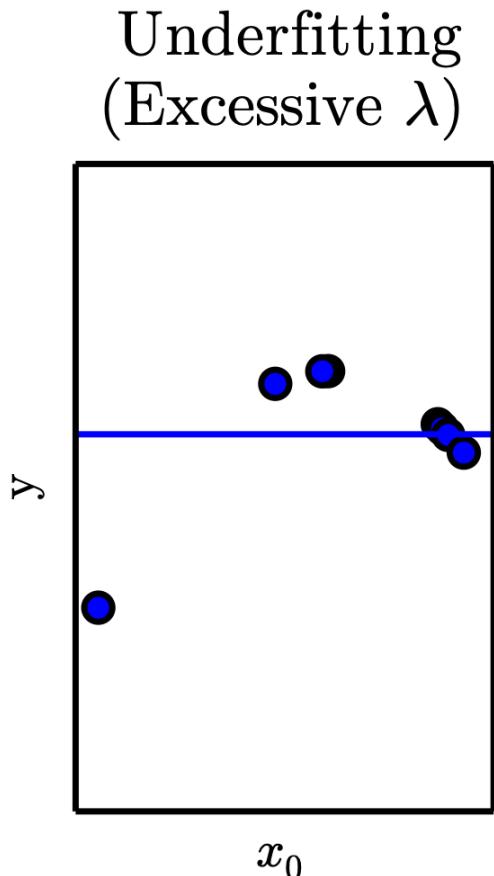


Figure 5.5

# Bias and Variance

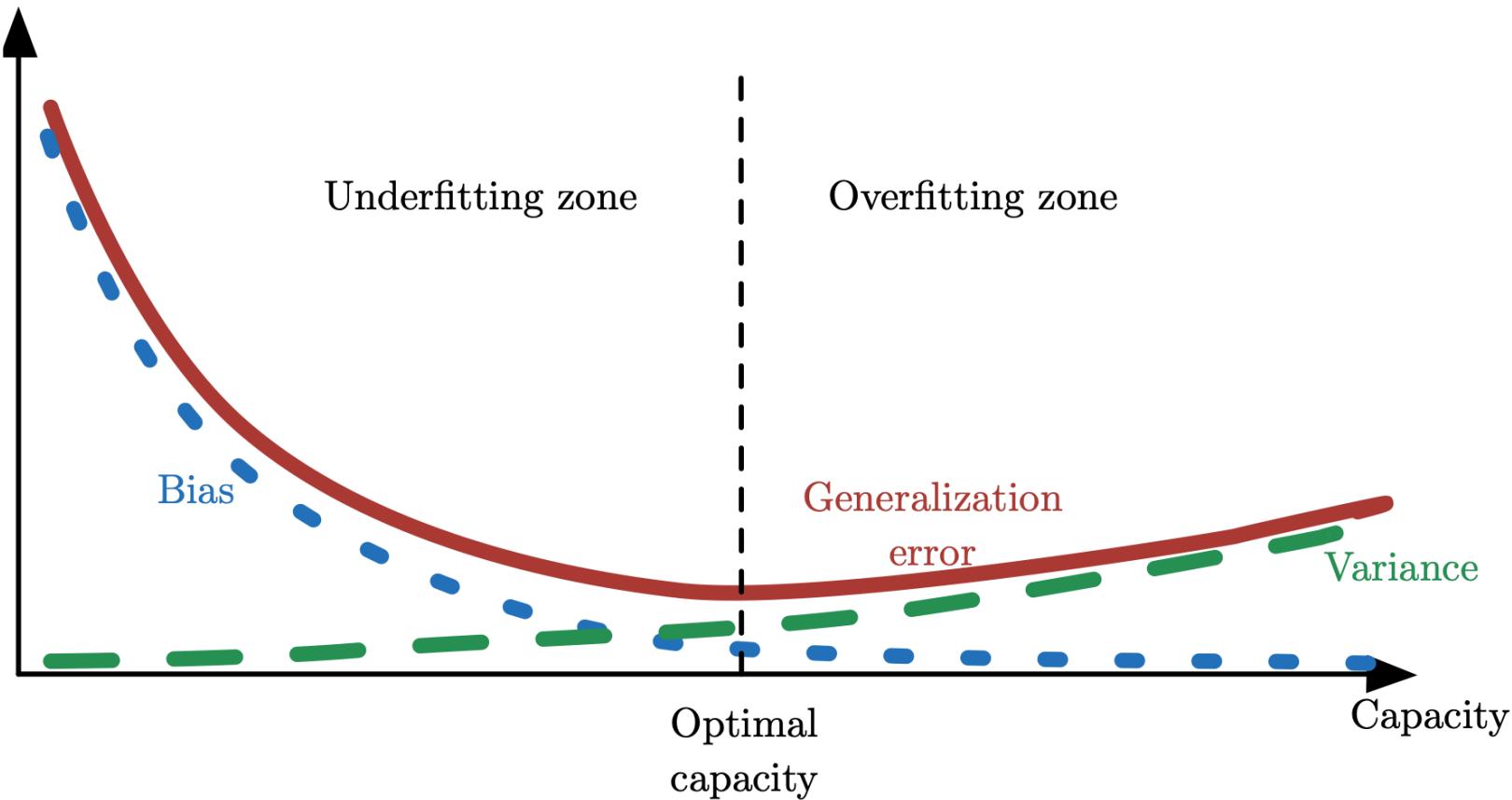


Figure 5.6