

# Einführung in die Künstliche Intelligenz

Paul Lukowicz,

Teil 1: Was ist eigentlich KI und was müssen wir darüber lernen ?





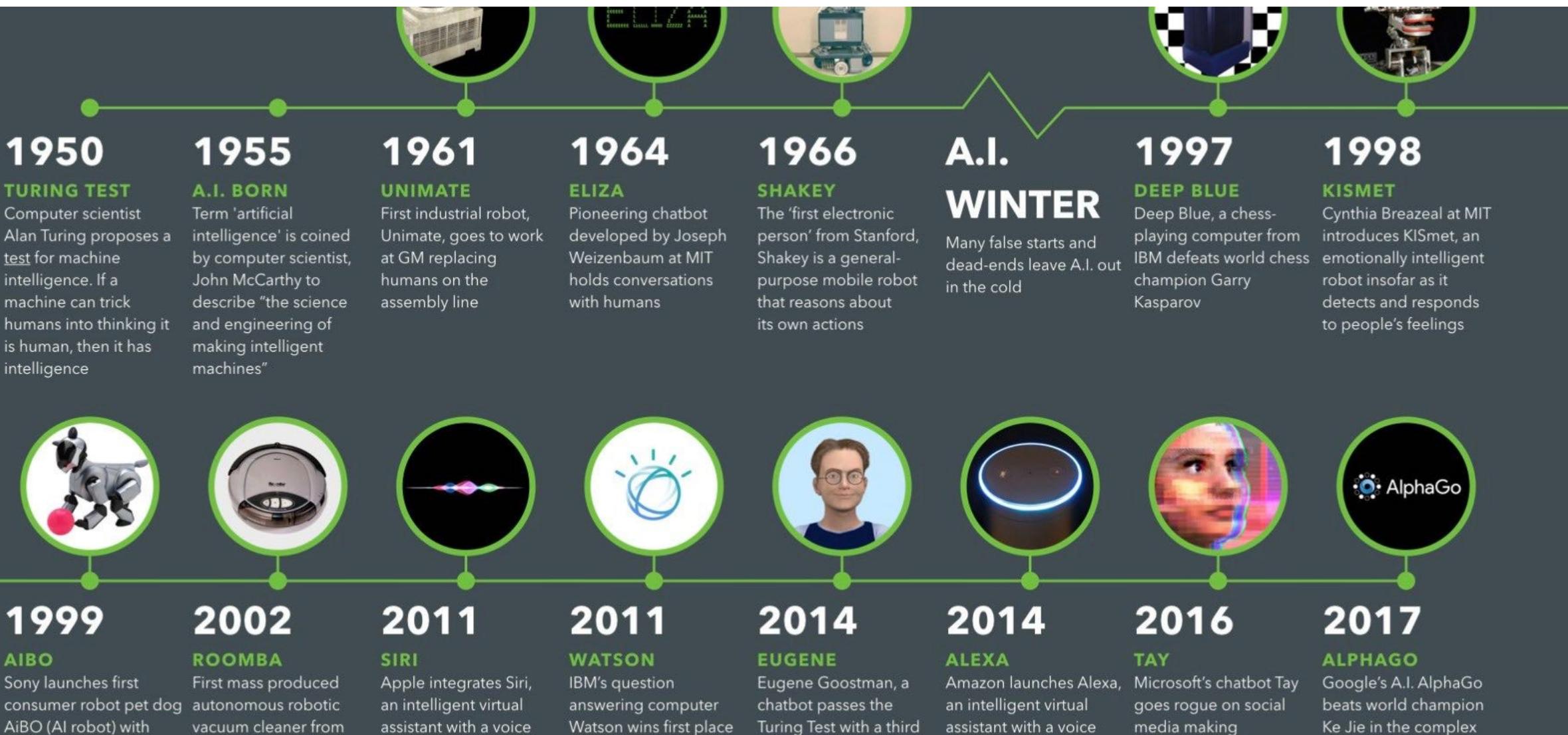
**Growth in computing power, availability of data and progress in algorithms have turned AI into one of the most strategic technologies of the 21st century....The way we approach AI will define the world we live in".**

from: European Commission, 'Communication from the Commission to the European Parliament, the European Council, The Council, the European Economic and Social Committee and the Committee of the Regions: Artificial Intelligence for Europe' (25 April 2018) {COM (2018) 237 Final}, 13-14

# AI in the popular imagination



# History of AI



# Some definitions of Artificial Intelligence

The exciting new effort to make  
computers think ...  
*machines with minds,*  
in the full literal sense.

Haugeland, 1985

A field of study that seeks to explain and  
emulate intelligent behavior in terms of  
computational processes.

Schalkoff, 1990

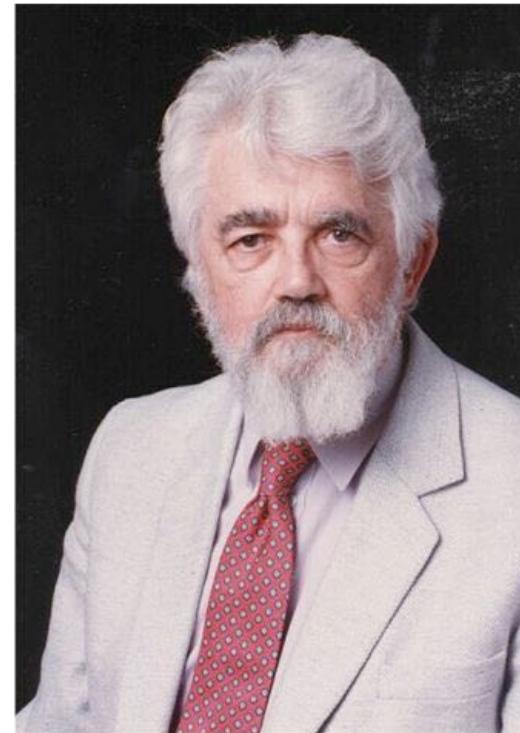
The study of how to make computers do  
things at which, at the moment, people are  
better. Rich & Knight, 1991



# Some definitions of Artificial Intelligence

## AI Definition by John McCarthy

- “Getting a computer to do things which, when done by people, are said to involve intelligence”
- Finesses the idea of whether a computer has consciousness, whether they have rights, etc



# What is Artificial Intelligence?

## (John McCarthy, Stanford University)



- What is artificial intelligence?

It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.

- Yes, but what is intelligence?

Intelligence is the computational part of the ability to achieve goals in the world. Varying kinds and degrees of intelligence occur in people, many animals and some machines.

- Isn't there a solid definition of intelligence that doesn't depend on relating it to human intelligence?

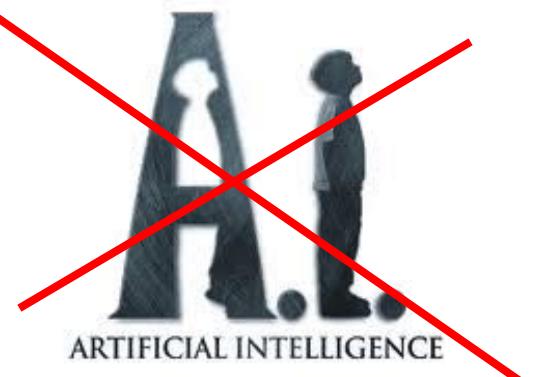
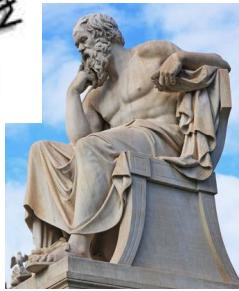
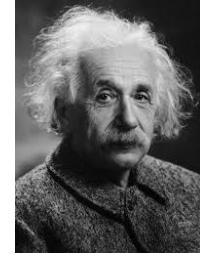
Not yet. The problem is that we cannot yet characterize in general what kinds of computational procedures we want to call intelligent. We understand some of the mechanisms of intelligence and not others.

# Intelligence

“The ability to learn, understand, and think about things.” Longman Dictionary or Contemporary English, 2006

“The ability to learn, understand and make judgments or have opinions that are based on reason” Cambridge Advance Learner’s Dictionary, 2006

I think, therefore I am.  
What is reality?  
What is truth?  
Is truth relative?  
What is the meaning of life?



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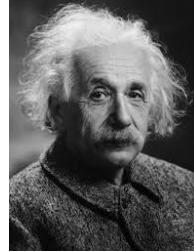
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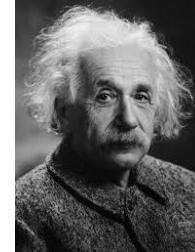
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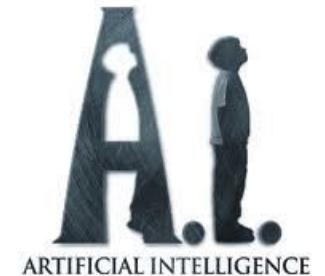
**The ability to perceive and manipulate real world objects and in general „get by“ in complex dynamic environments**

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What is the meaning of life?  
Is truth relative?



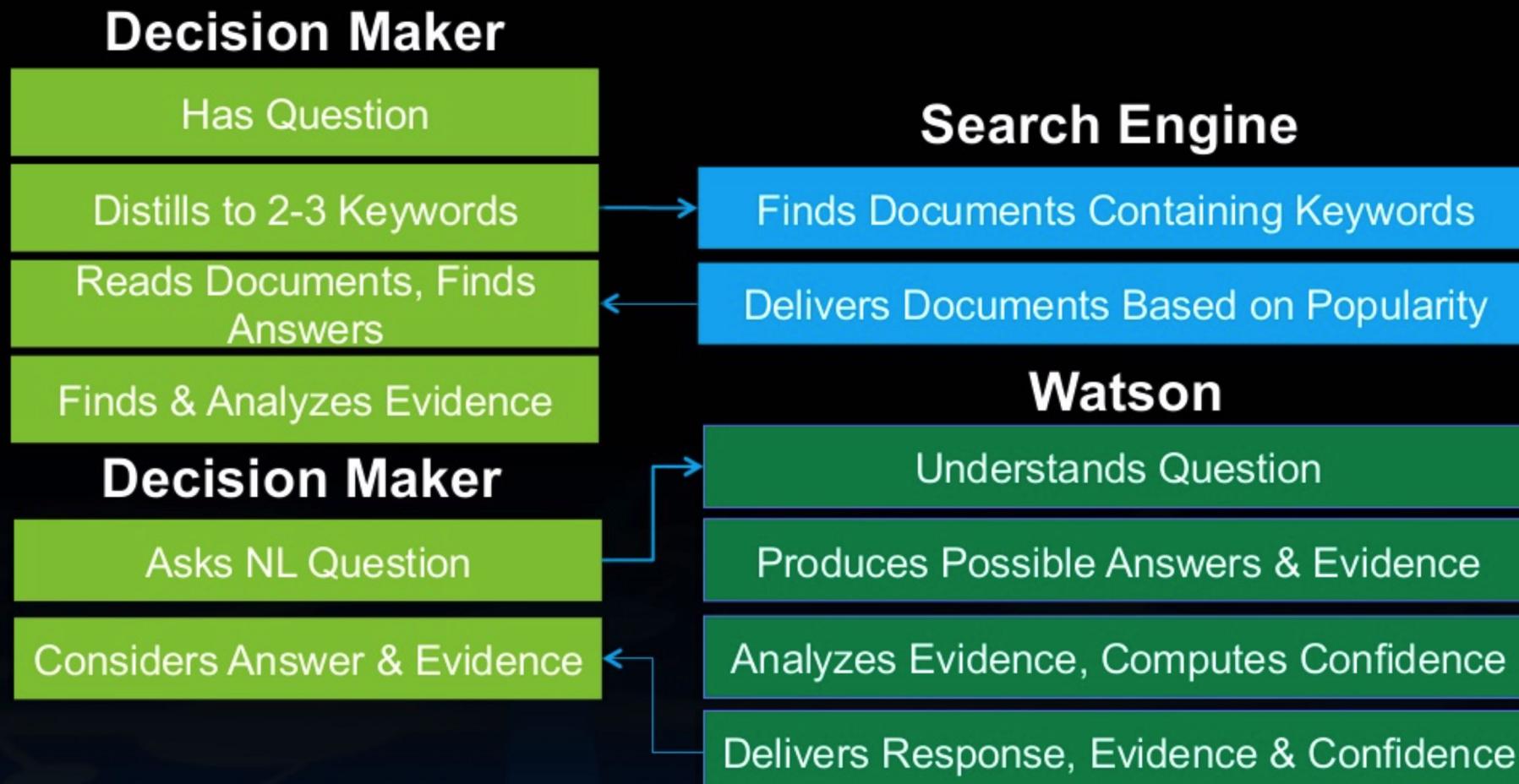
# State of the Art in Artificial Intelligence

The ability to percieve and manipulate real world objects and in general  
„get by“ in complex dynamic environments



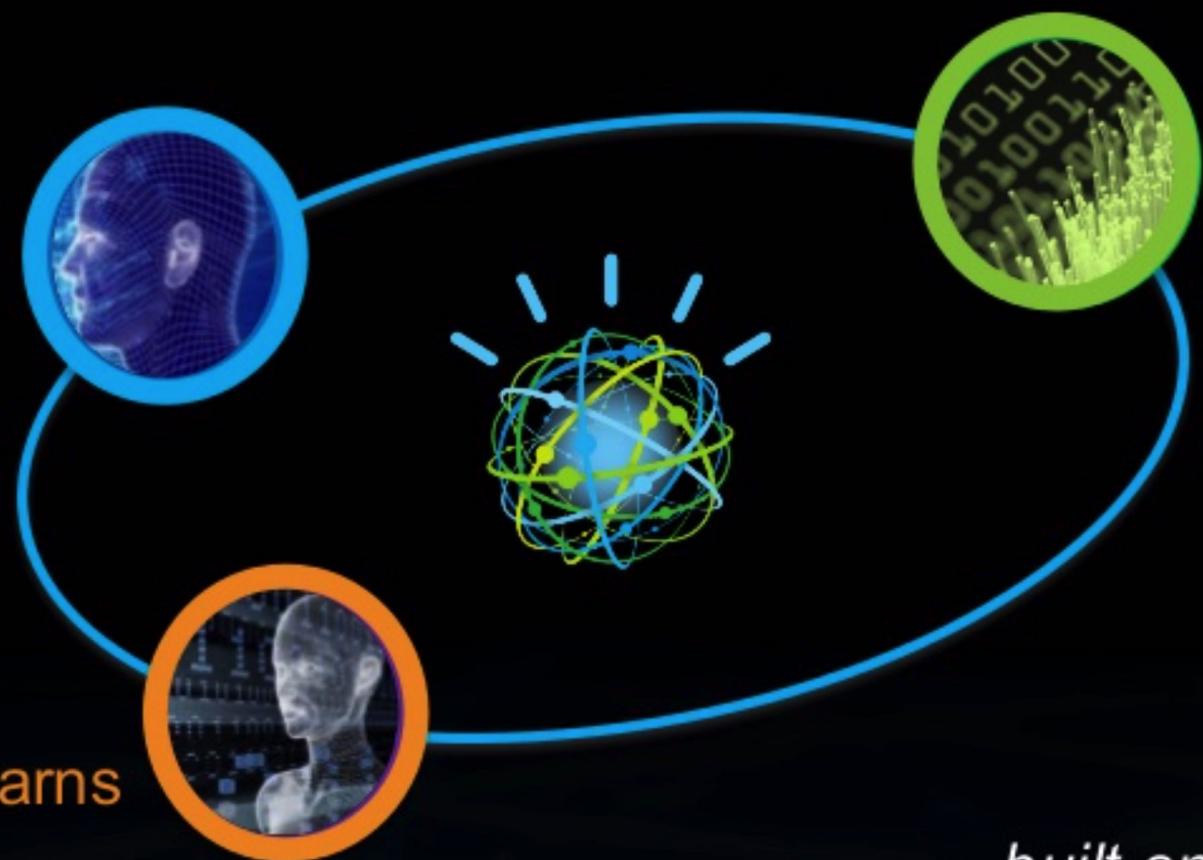


## Informed decision making: search vs. Watson



# IBM Watson combines transformational technologies

1 Understands natural language and human communication



3 Adapts and learns from user selections and responses

2 Generates and evaluates evidence-based hypothesis

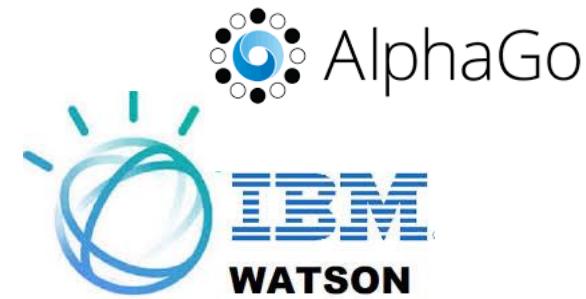
*...built on a massively parallel architecture optimized for IBM POWER7*



# What AI can (should) do



act



think



interact



# What AI can (should) do



how to make computers do  
things at which, at the  
moment, people are better.



think



interact

# How does it work ?



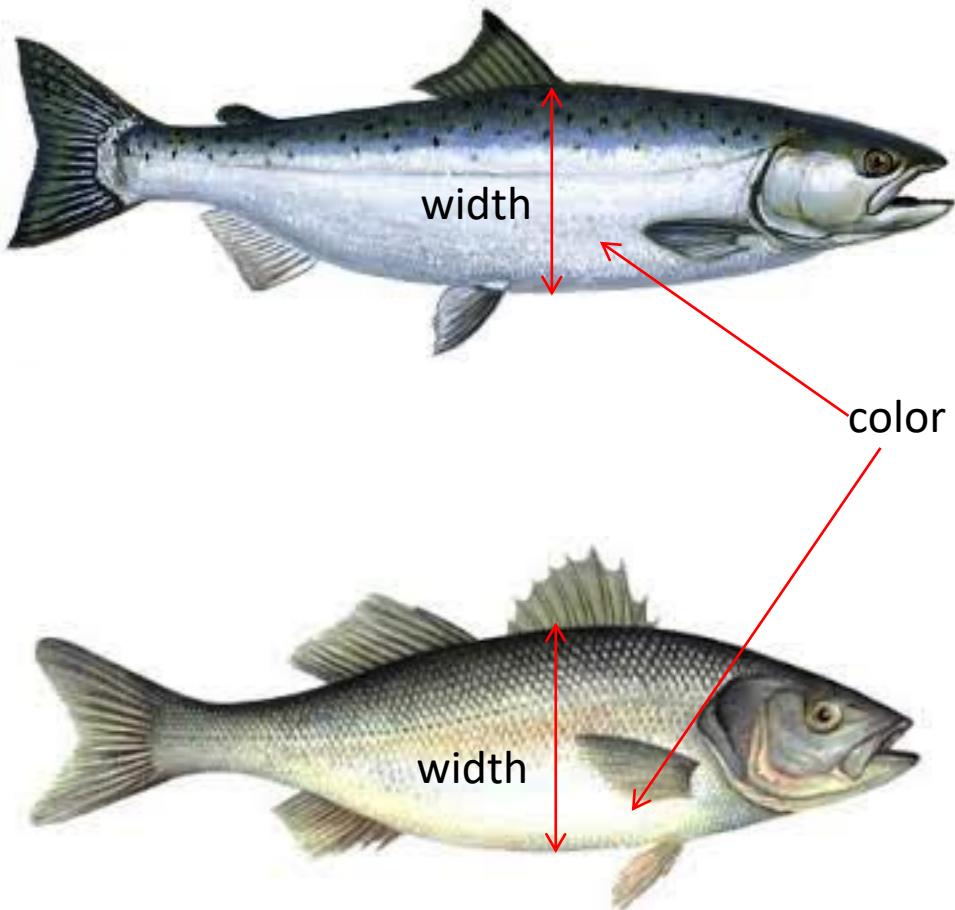
# Example



**How to recognize different types of fish ?**



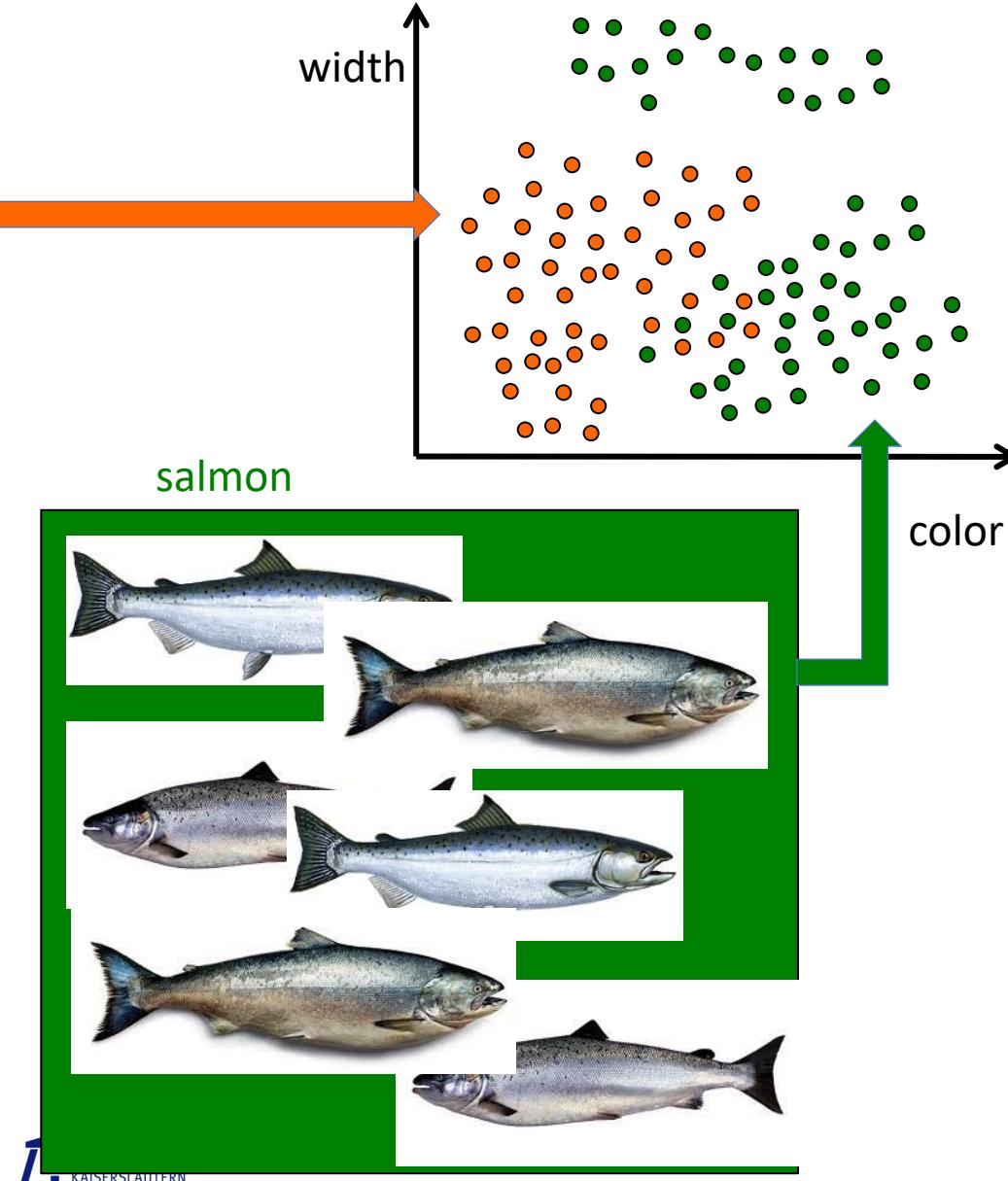
# 1:Find Features



## 2. Catch and measure a lot of fish

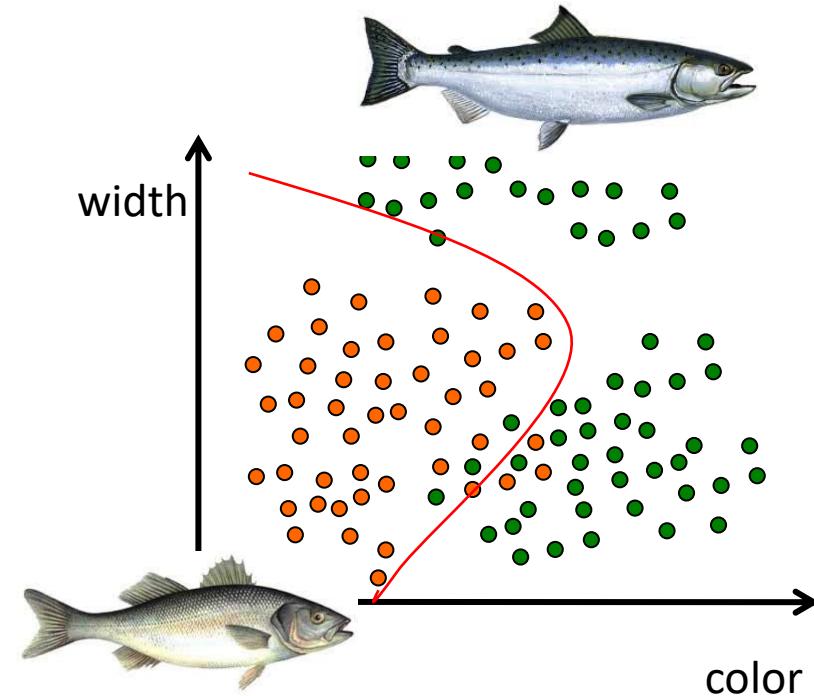


see bass

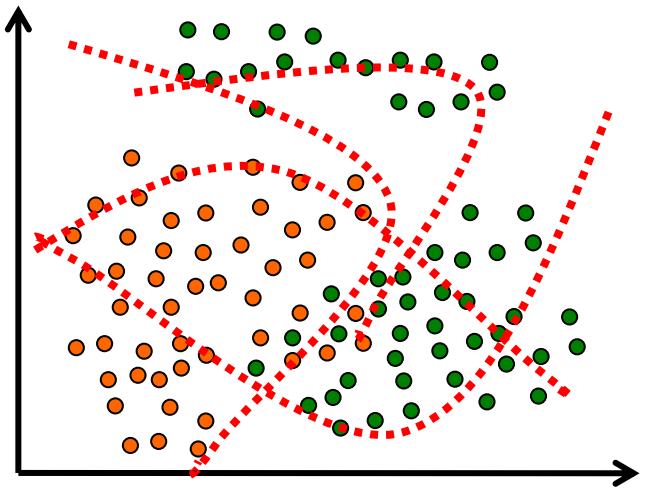


# Do statistics on the data

From statistical analysis a “**separation boundary**” is derived

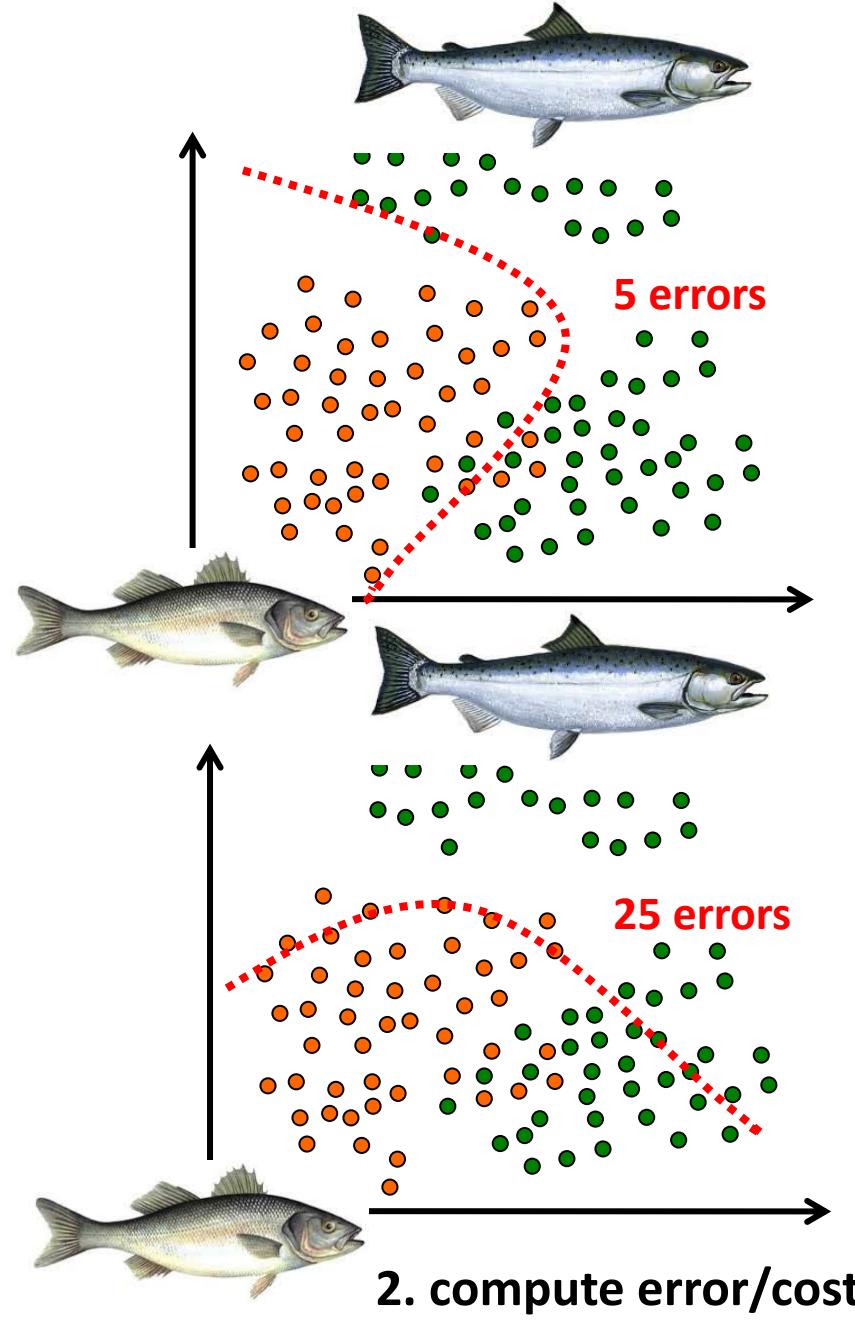
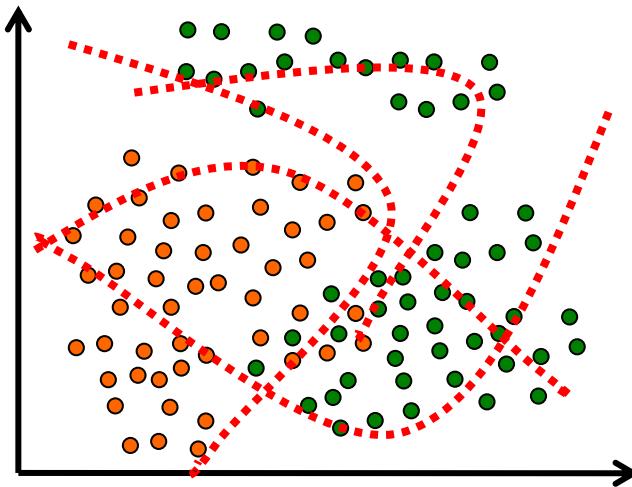


# How it is done

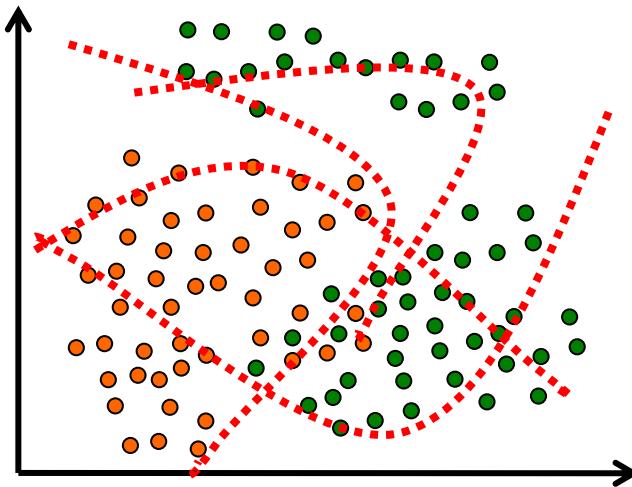


**1. try different shapes**

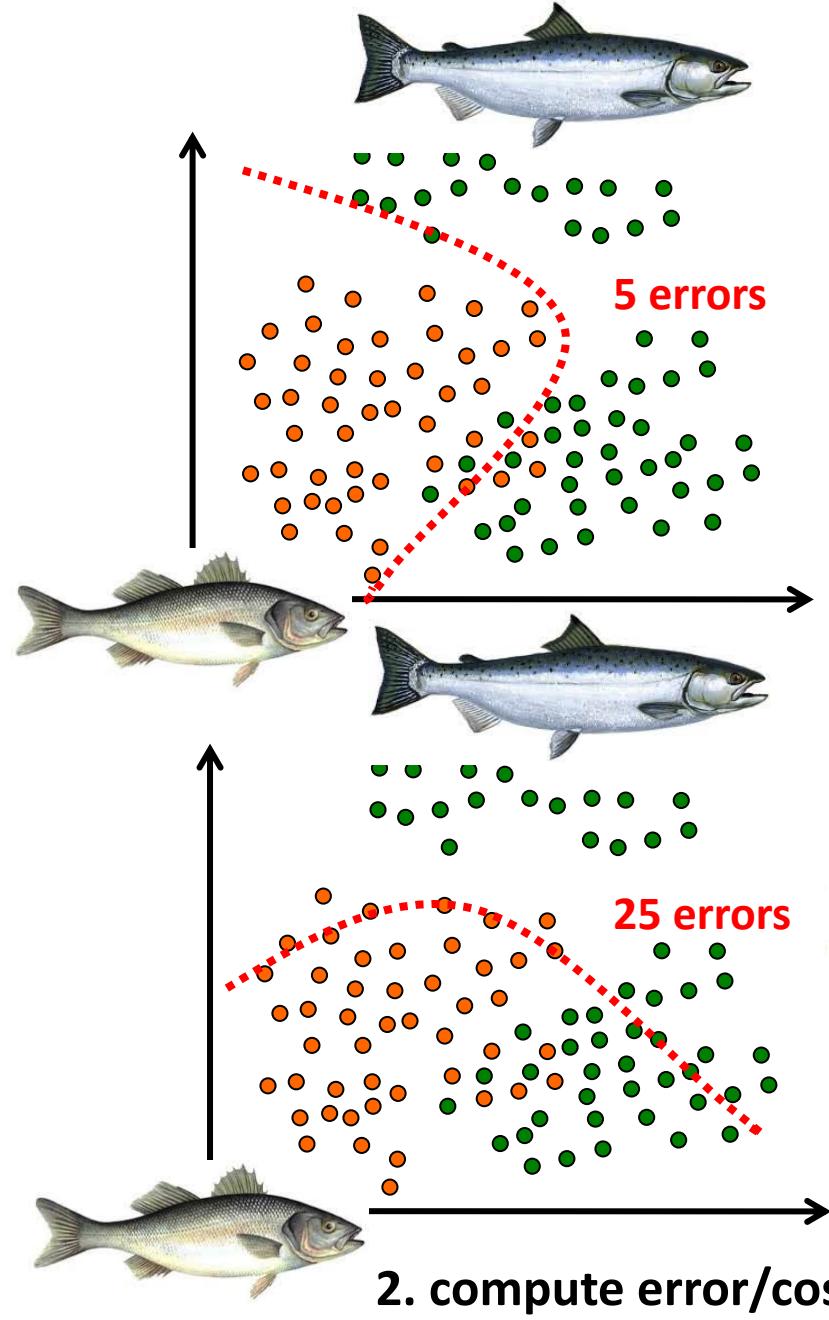
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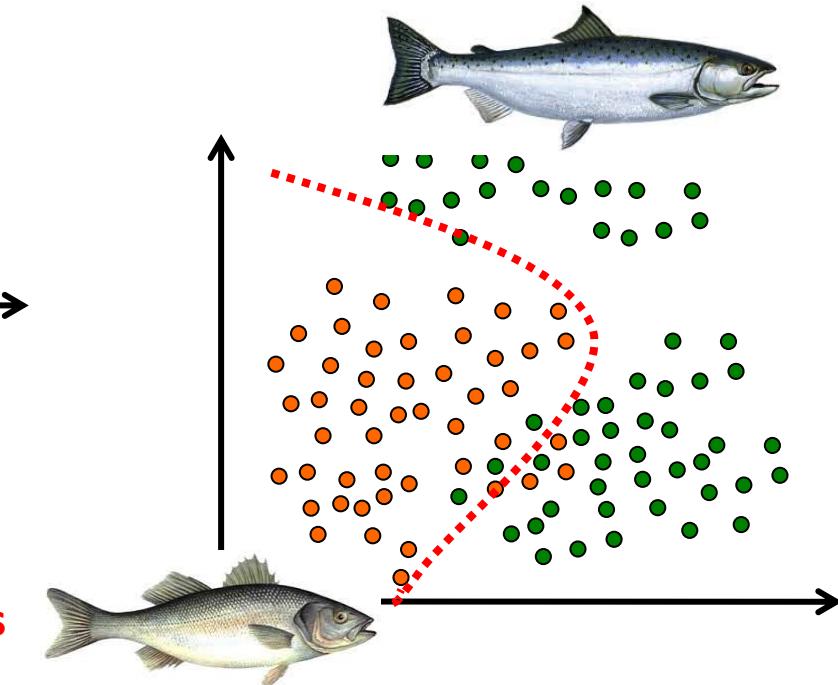
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1. try different shapes

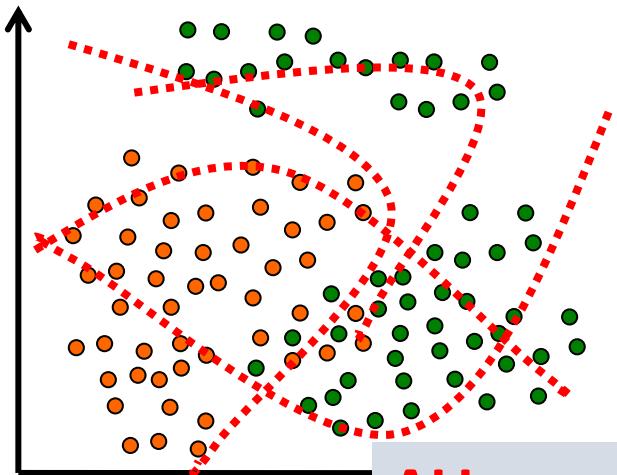


2. compute error/cost

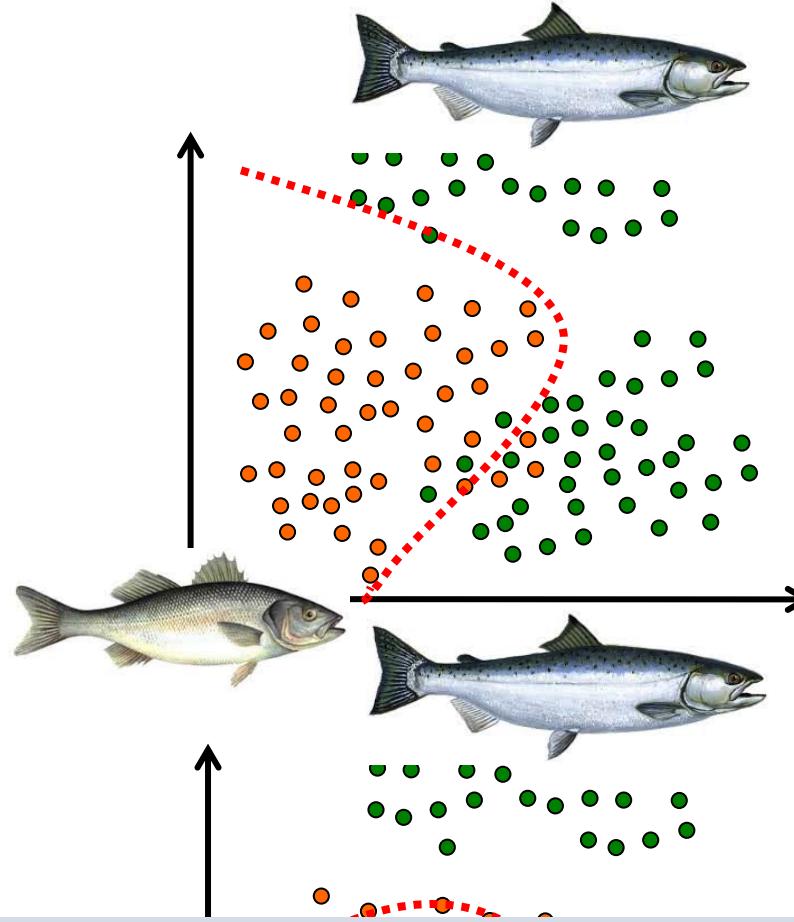


3. select best

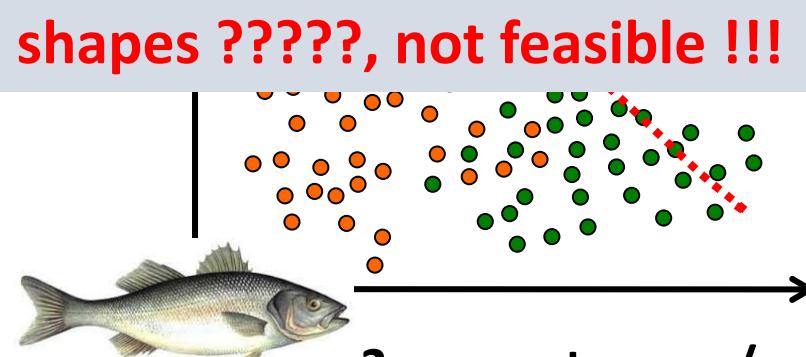
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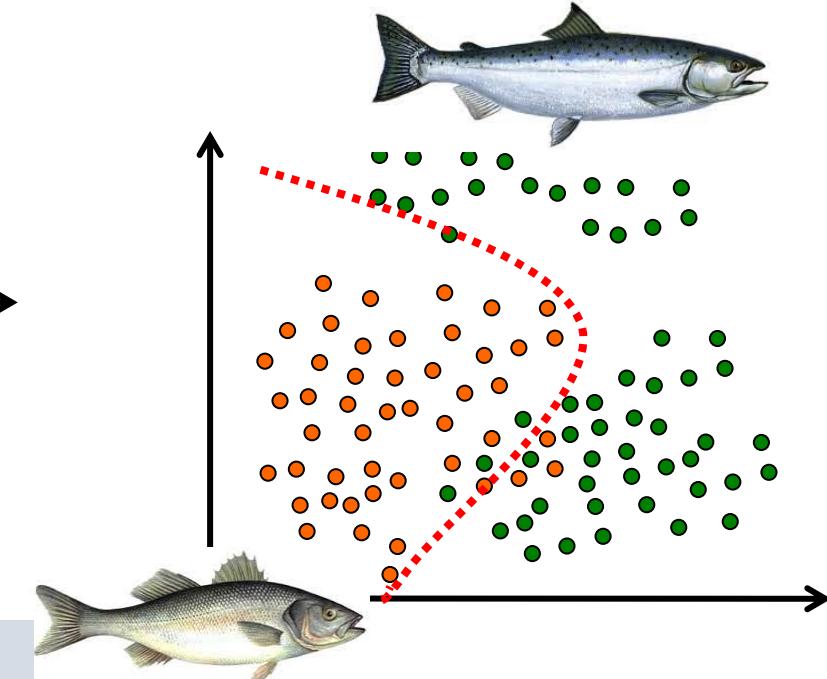
1. try different shapes



**ALL possible shapes ?????, not feasible !!!**

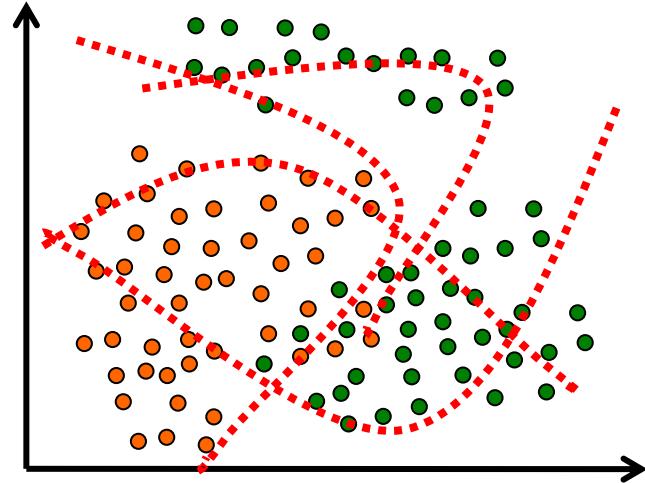


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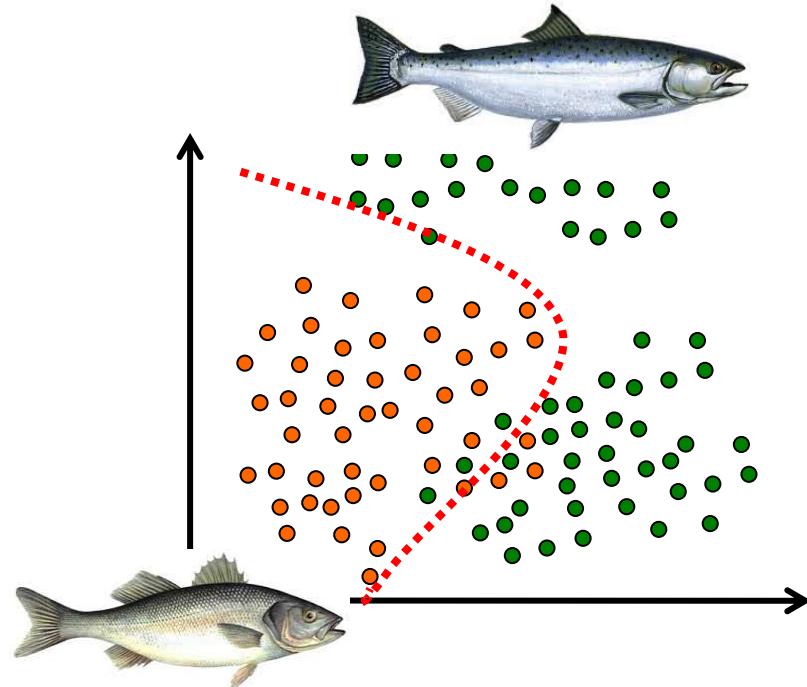


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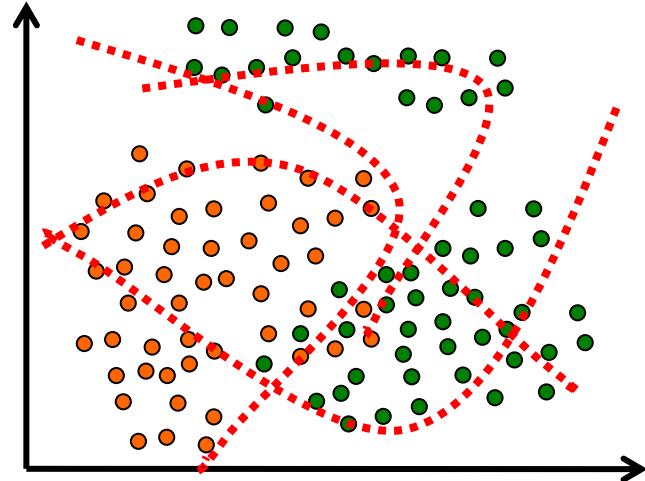
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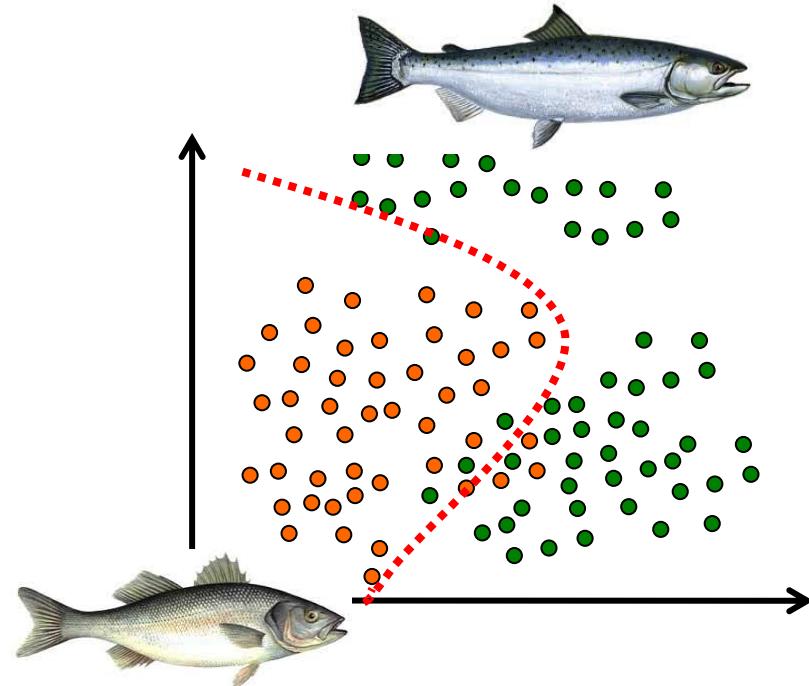
1. describe all possible shapes through  
**parameters** (opening, angle, position,...)



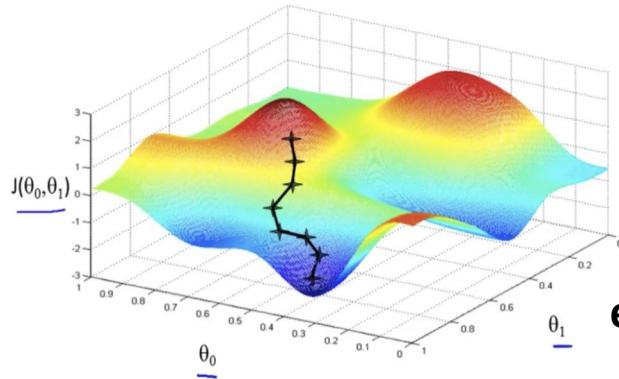
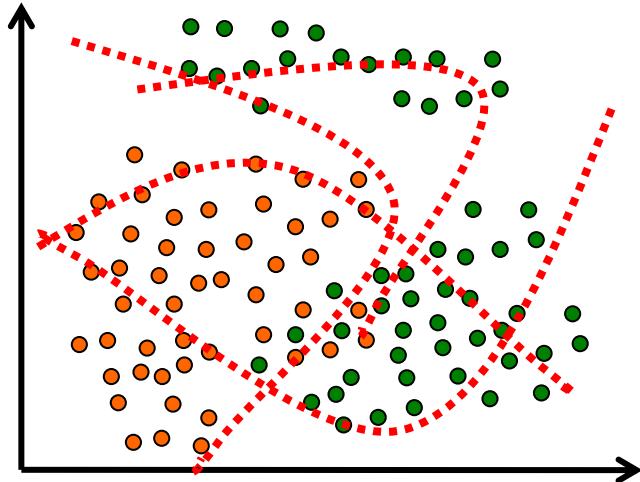
# How it is done



1. describe all possible shapes through **parameters** (opening, angle, position,...)
2. define a function that, given a set of parameters and the training data computes an error value (**error/cost function**)

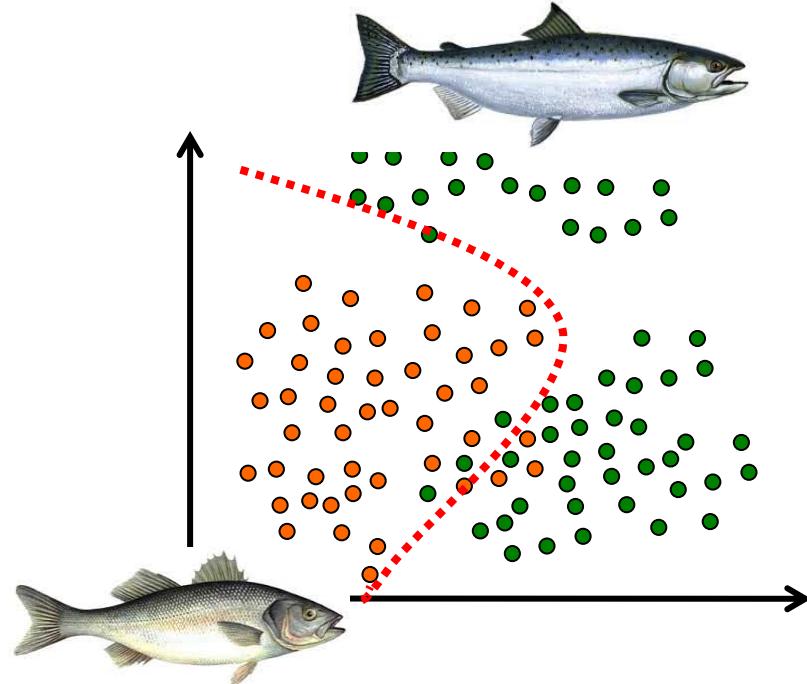


# How it is done



e.g. gradient descent

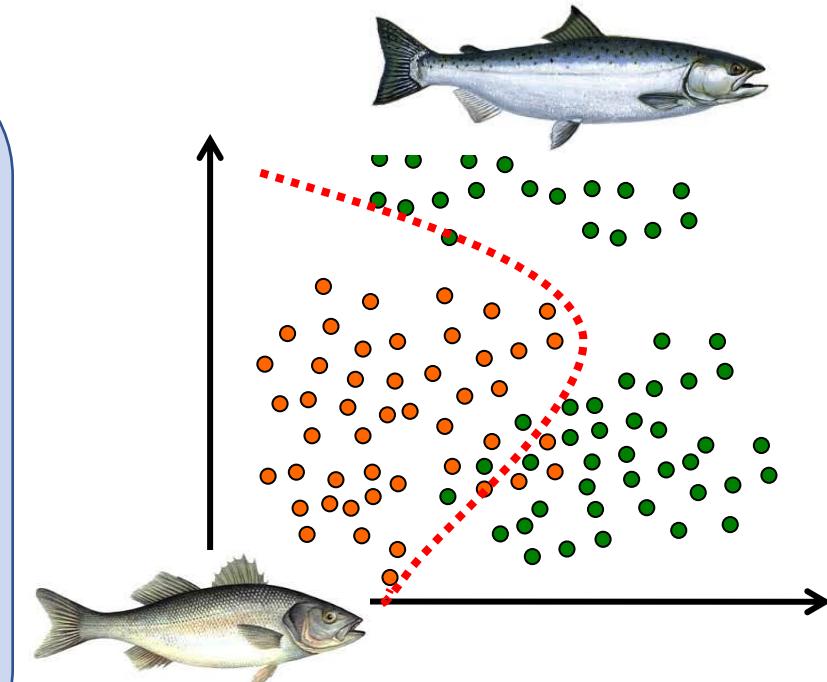
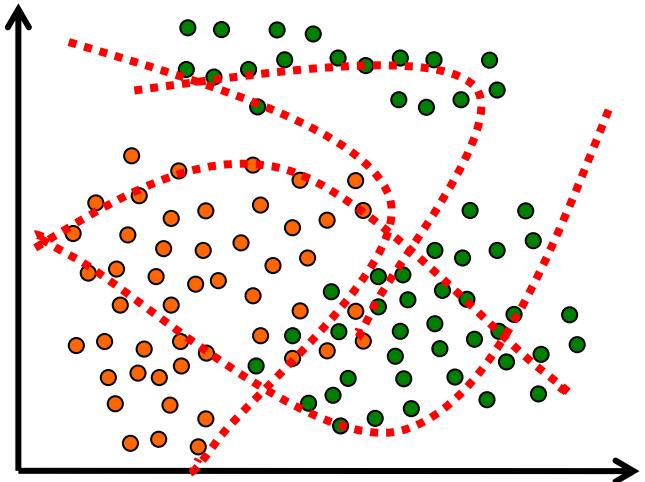
1. describe all possible shapes through **parameters** (opening, angle, position,...)
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3. use an appropriate optimization techniques to find parameter values that **minimize the error function**



# How it is done

## Machine Learning

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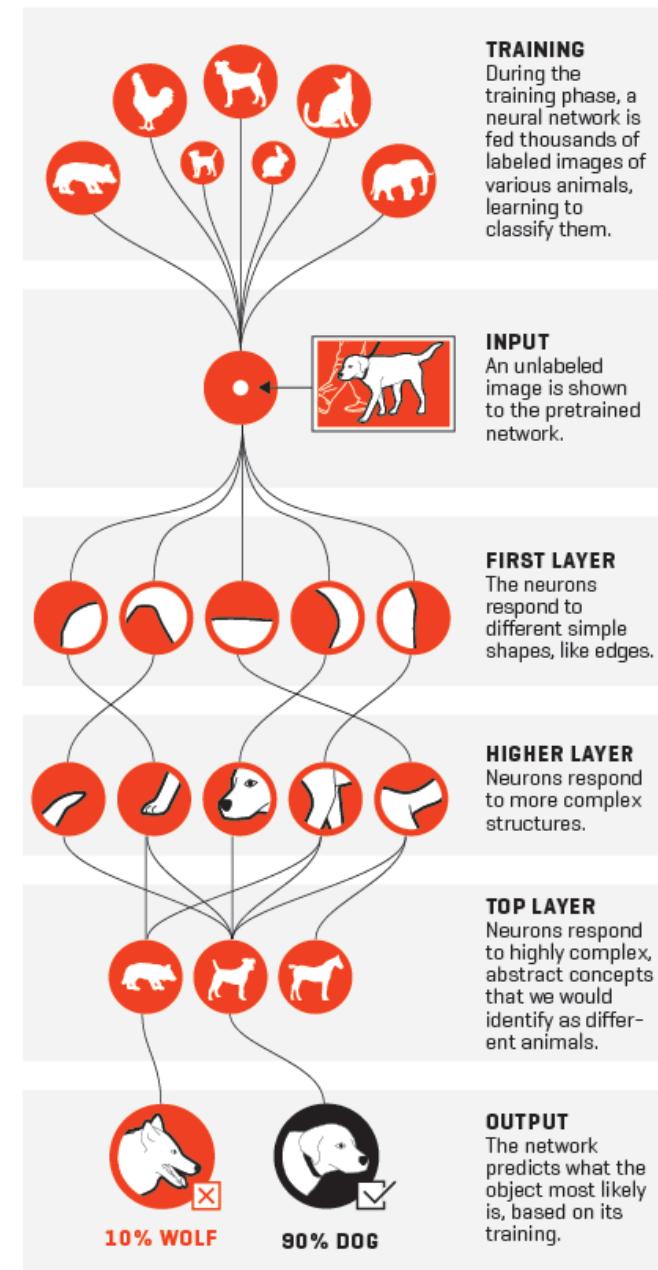
# What about more complex tasks ?



recognize all sorts of  
animals in complex images

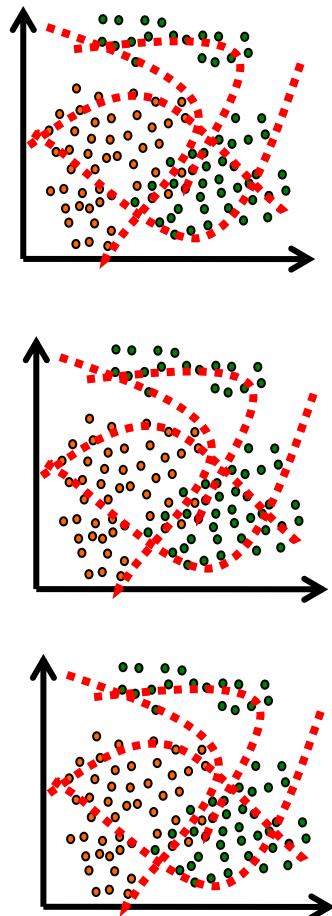
# Deep Learning

HOW NEURAL NETWORKS RECOGNIZE A DOG IN A PHOTO

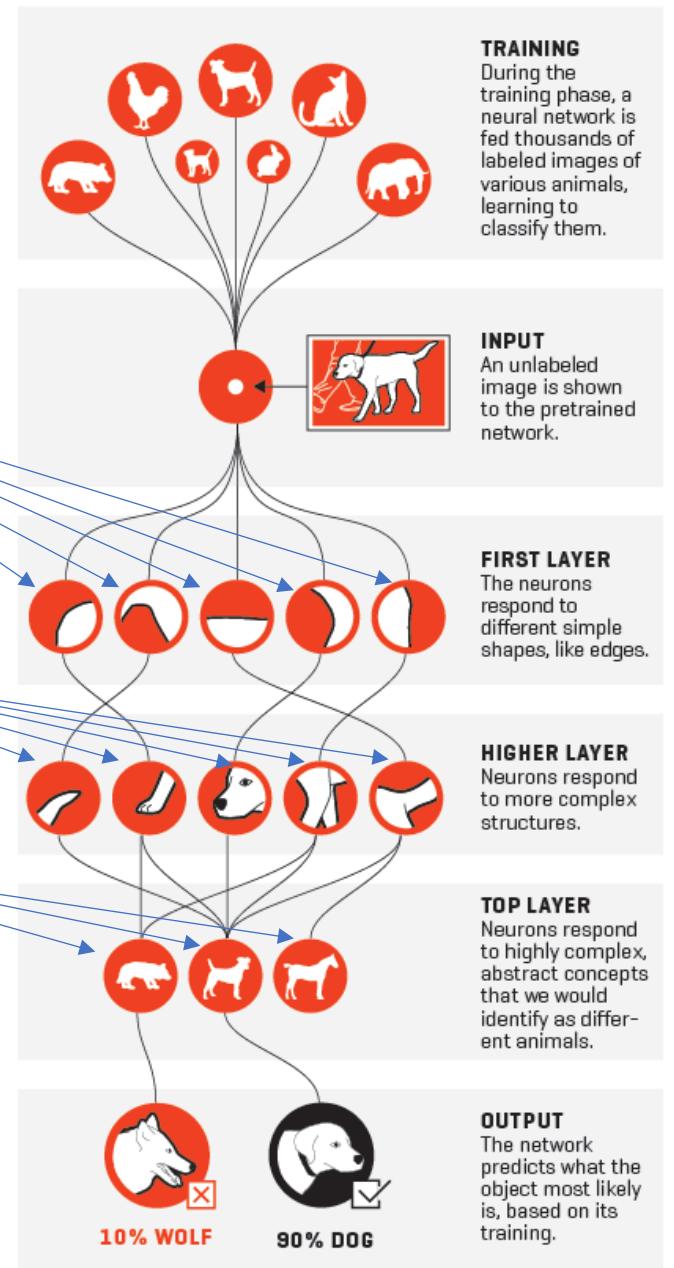


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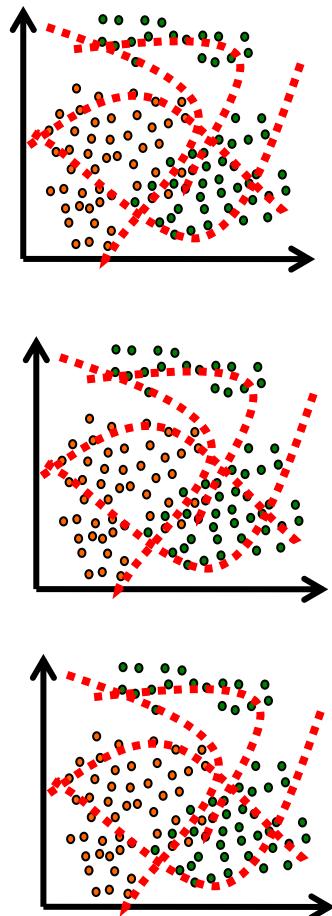
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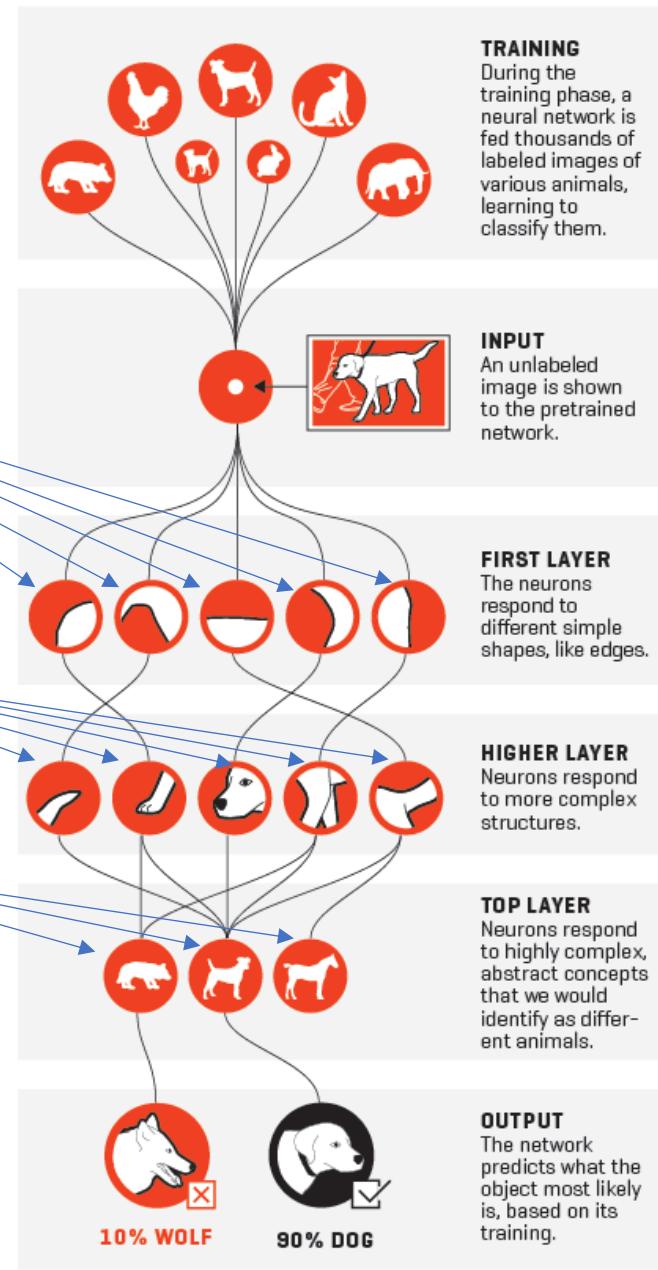
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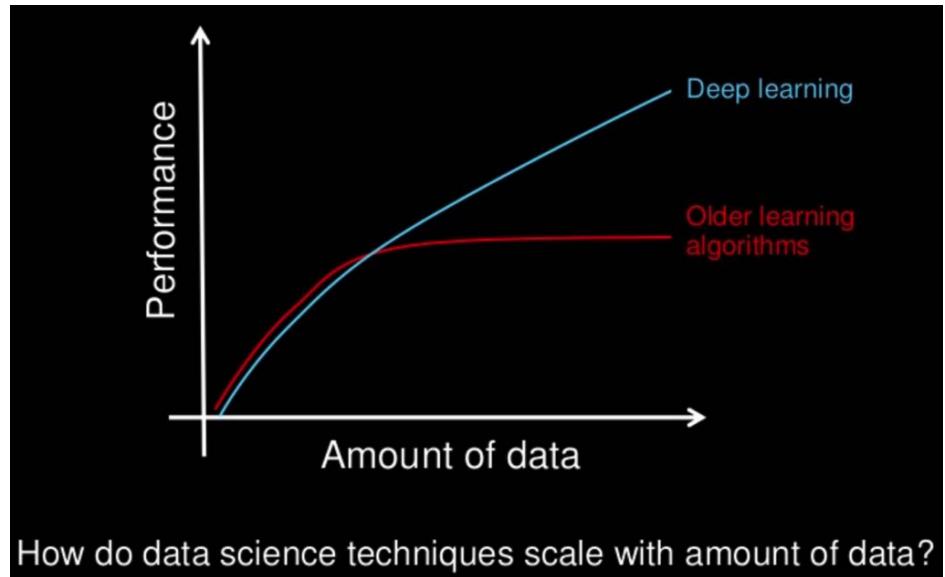
100 of thousands of parameters



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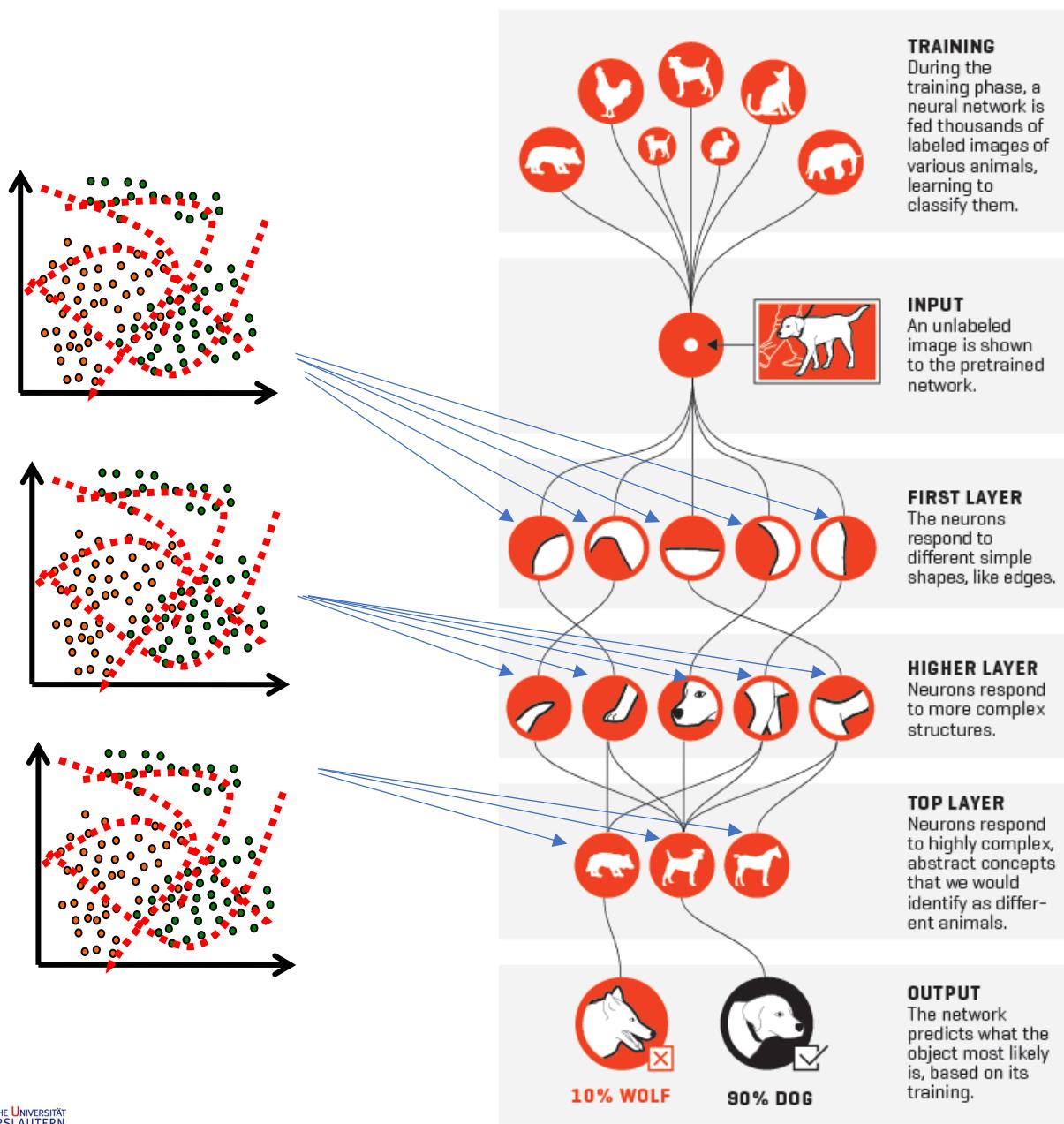
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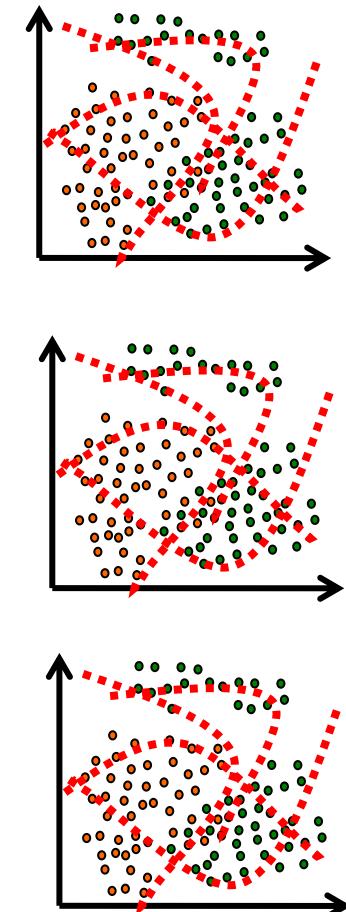
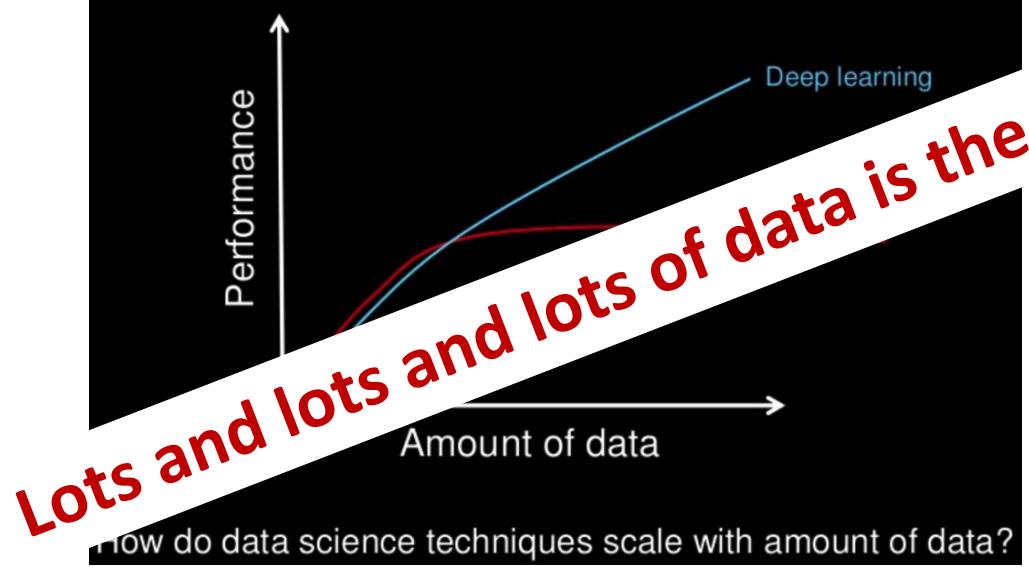
100 of thousands of parameters



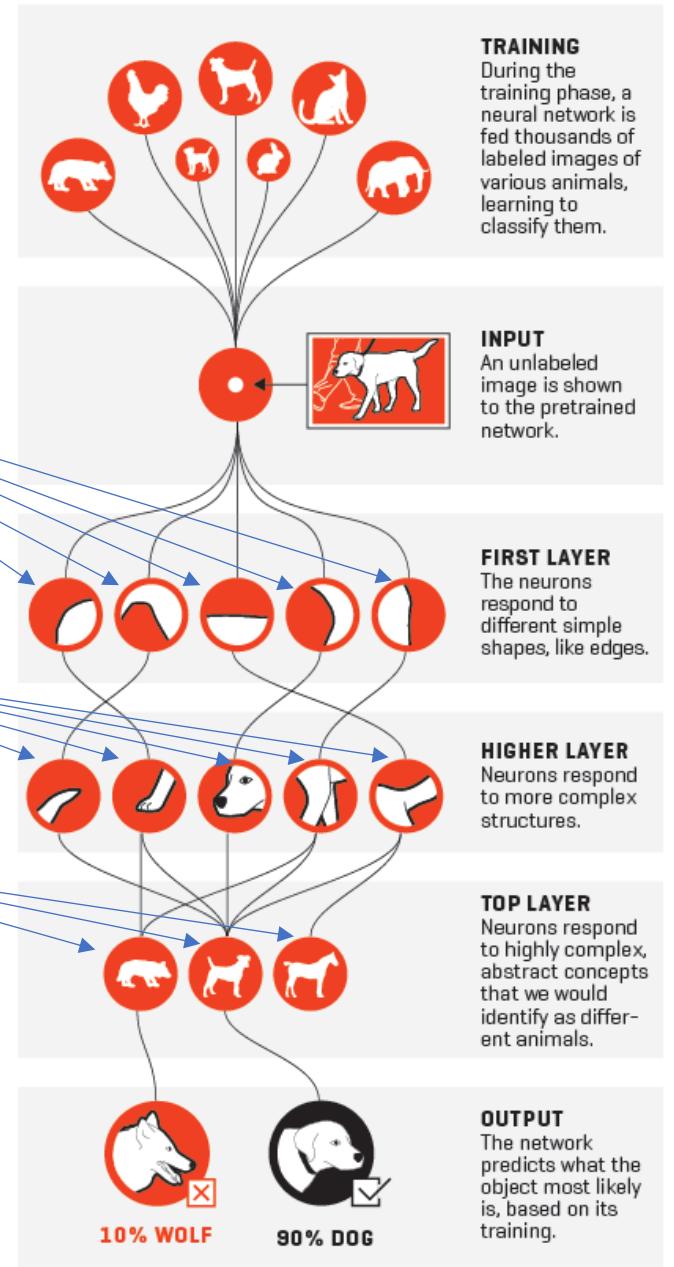
## HOW NEURAL NETWORKS RECOGNIZE A DOG IN A PHOTO



# Deep Learning



## HOW NEURAL NETWORKS RECOGNIZE A DOG IN A PHOTO



# Complex Machine Learning: Image description



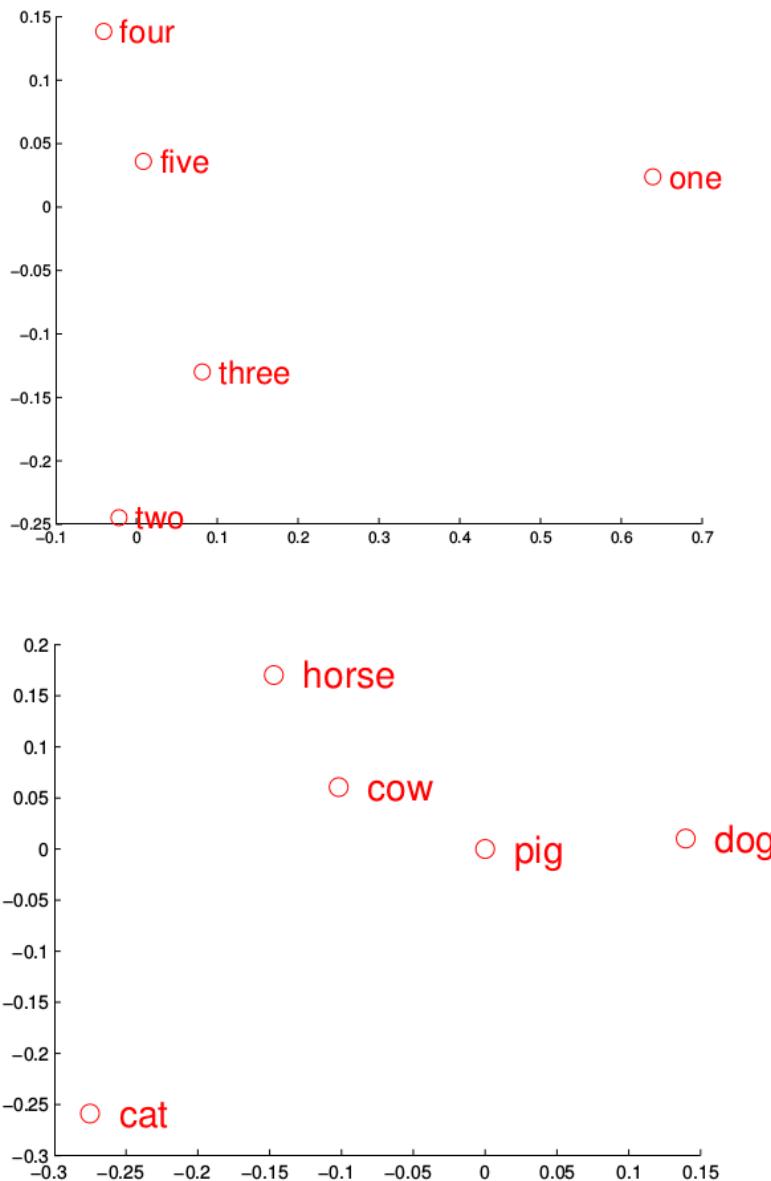
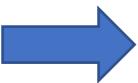
(a)	outdoor, woman, grass
(b)	a woman wearing a blue shirt.
(c)	gorgeous and beautiful as an angel!

(a)	sunglasses, man
(b)	a man wearing sunglasses taking a selfie.
(c)	you look handsome in all shades.

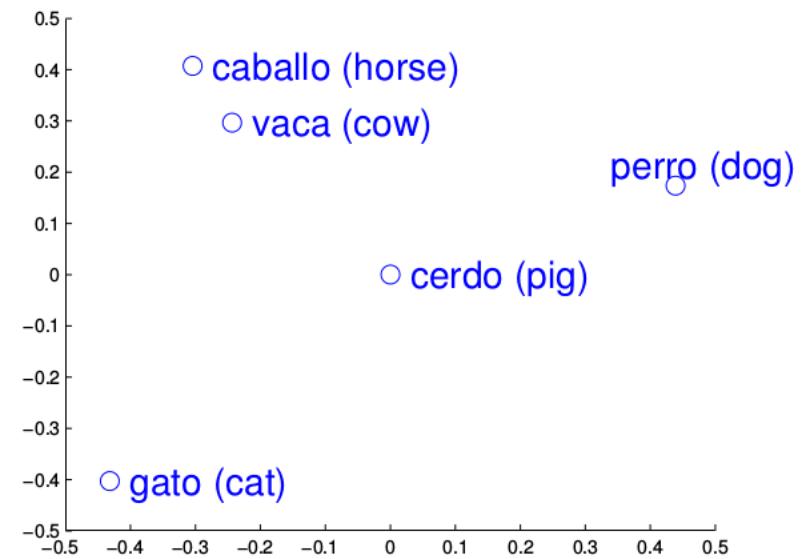
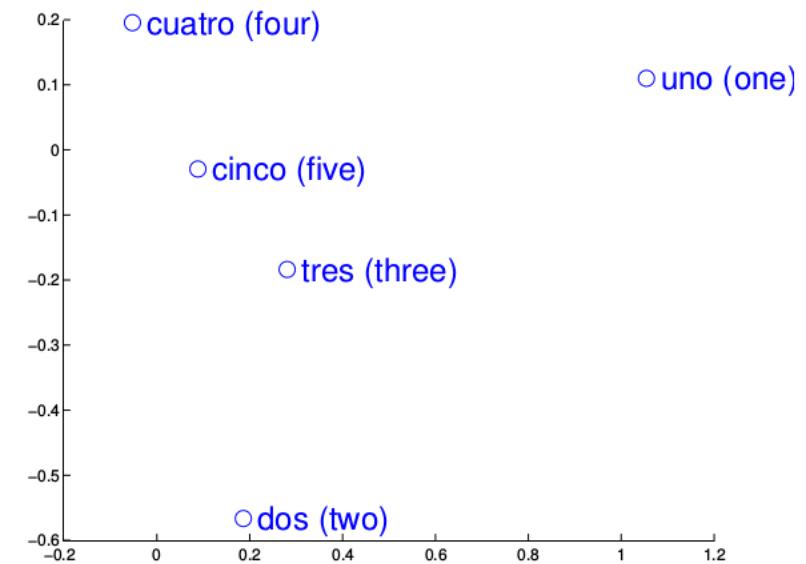
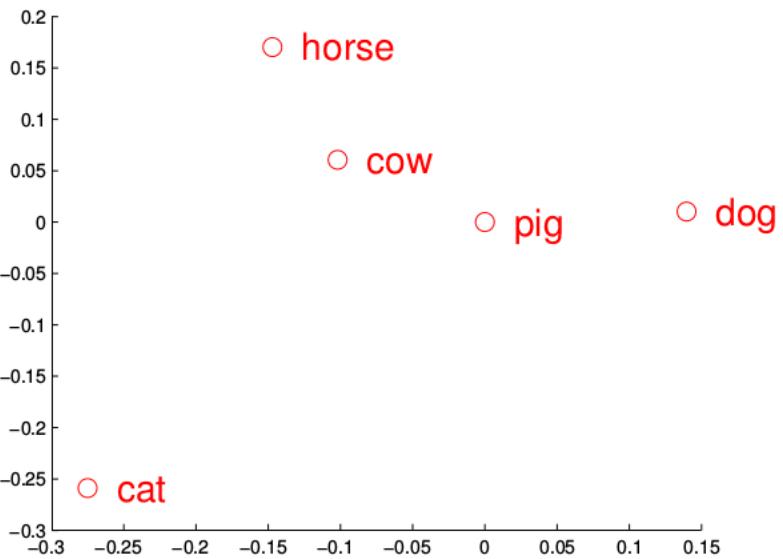
(a)	water, tree, river, boat
(b)	a tree next to a body of water.
(c)	beautiful place looks like you are in the heaven!

*lots and lots and lots of data is the key ! even more then*

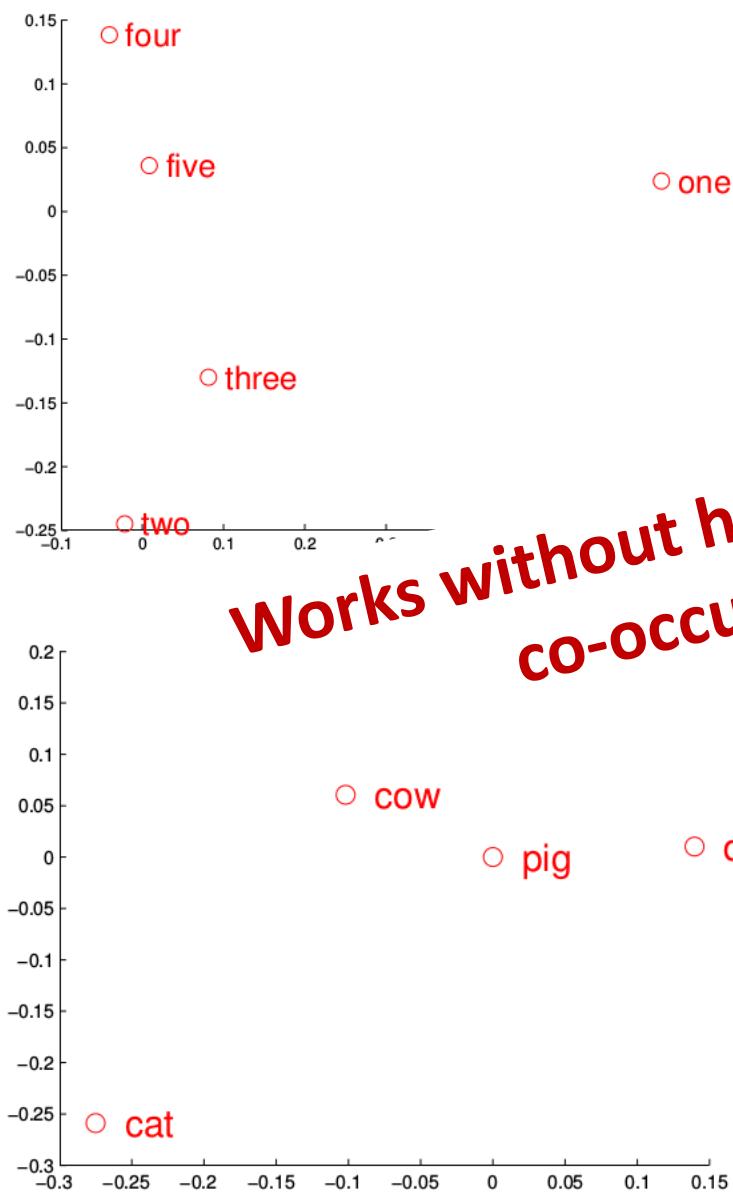
# Word Embeddings



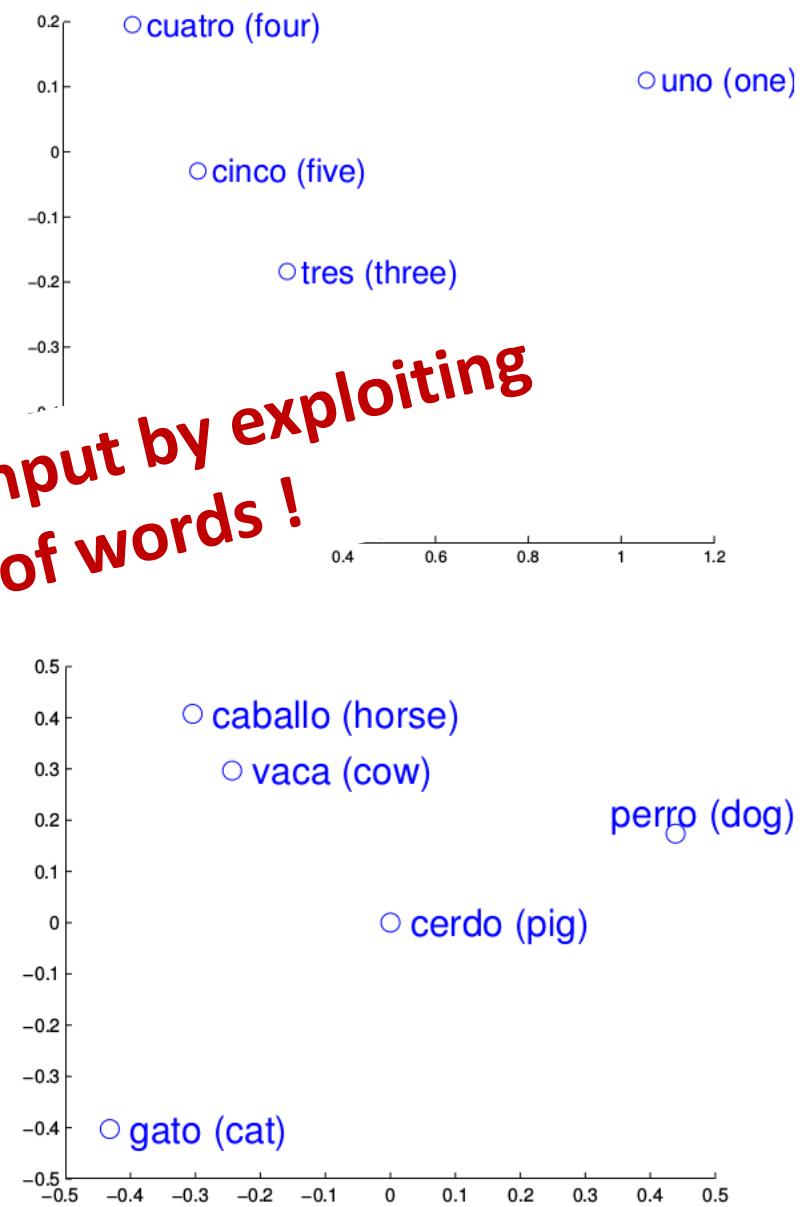
# Word Embeddings



# Word Embeddings



Works without human input by exploiting  
co-occurrences of words !



# Complex Machine Learning



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# Complex Machine Learning



(a) outdoor, woman, grass

(b) a woman wearing a blue shirt.

(c) gorgeous and beautiful as an angel!

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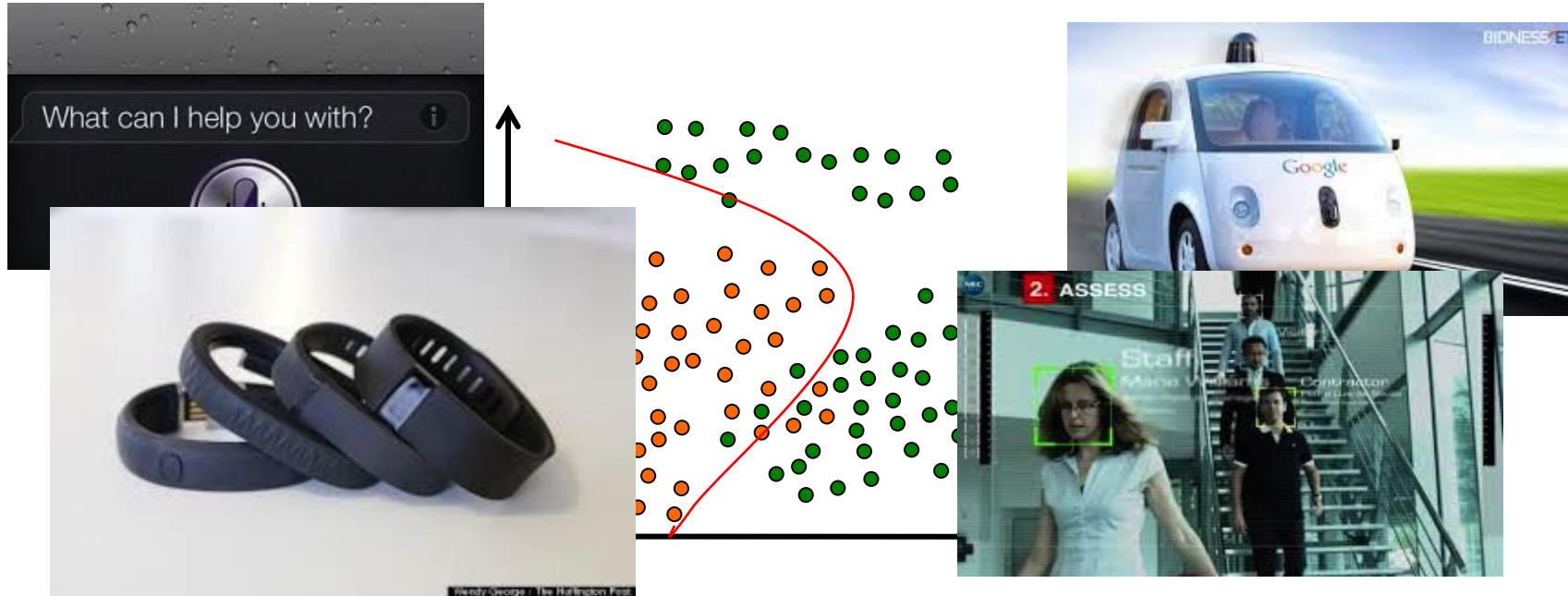
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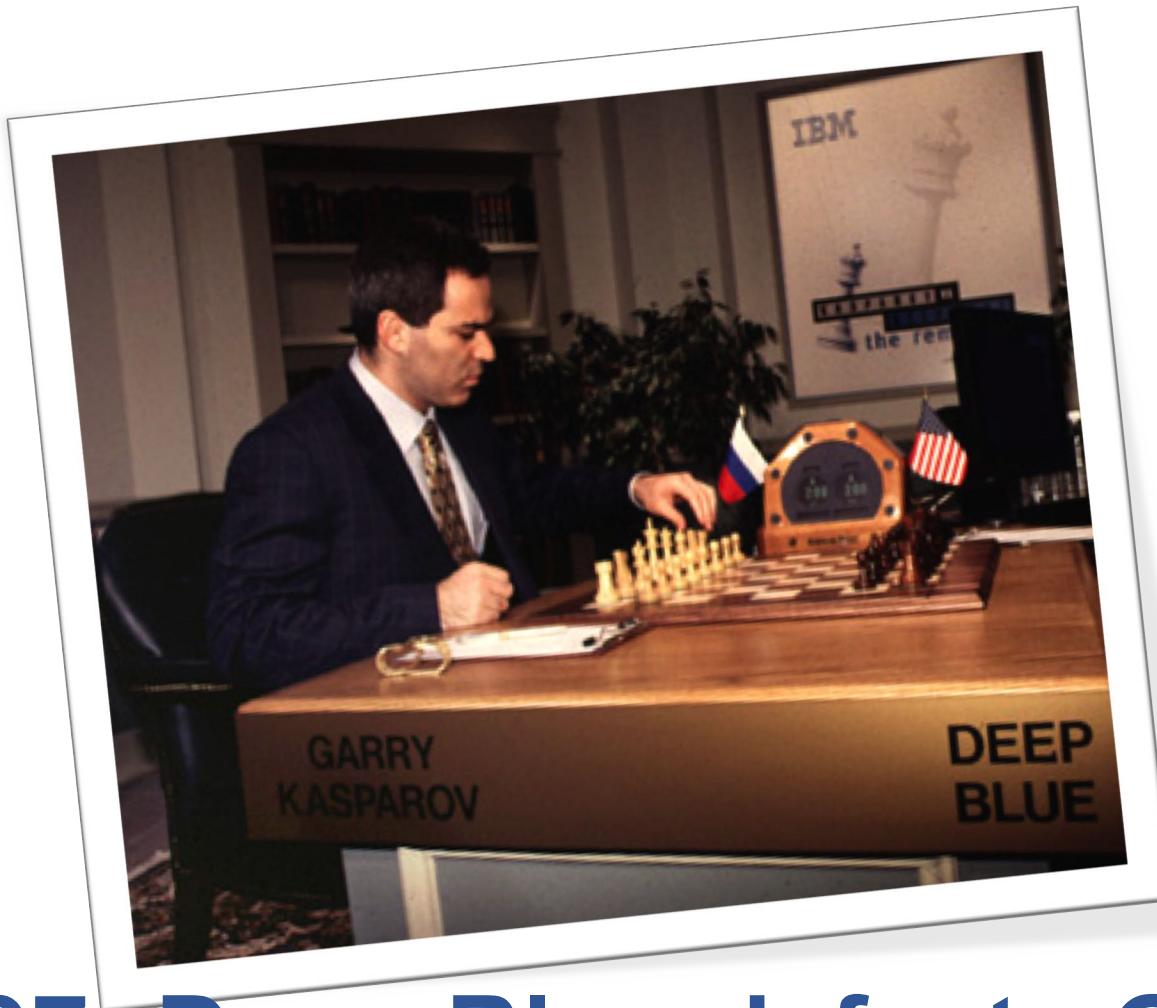
(c) beautiful place looks like you are in the heaven!

# Complex applications simple principle



1. Reduce the real world into simple parameters
2. Record **LOTS** of data
3. Define an errorfunction
4. Optimize the parameters to minimize the error function

# Beyond Machine Learning:



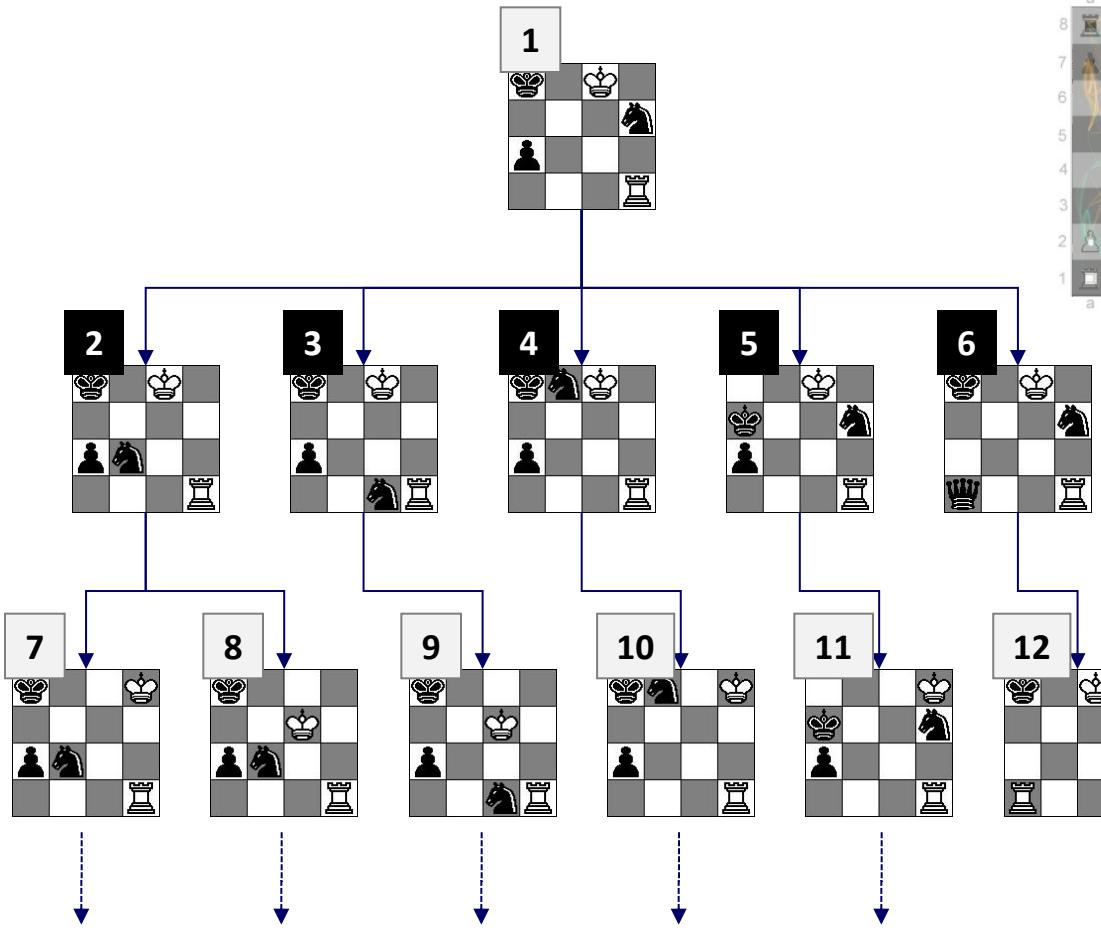
Mai 11, 1997: Deep Blue defeats Garry Kasparov

# Chess is a stupid game...

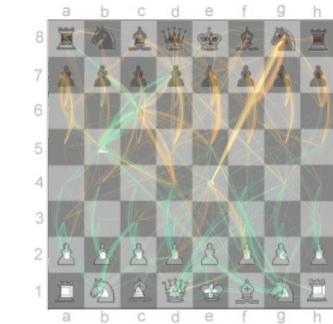
*Current state*

**BLACK:** Computer to move

**WHITE:**  
Potential reaction of human opponent



- One chess game has about  $10^{120}$  realistic game states, making it impossible to establish a complete states space

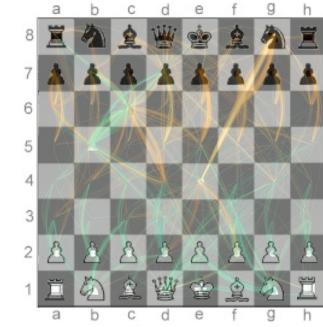


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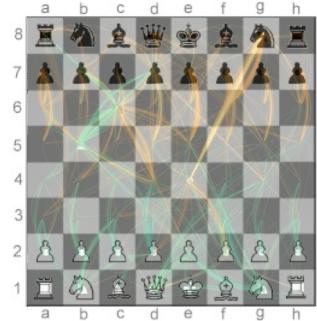
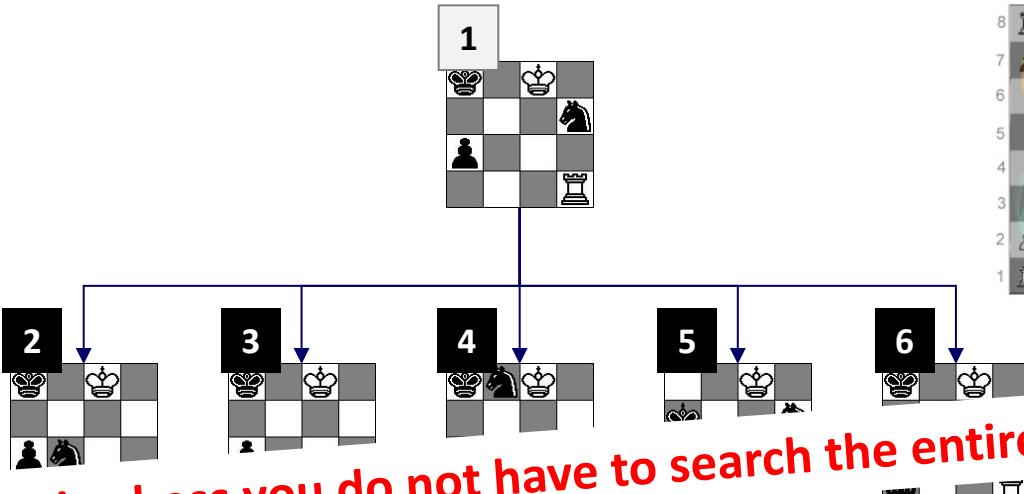


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# Chess is a stupid game...

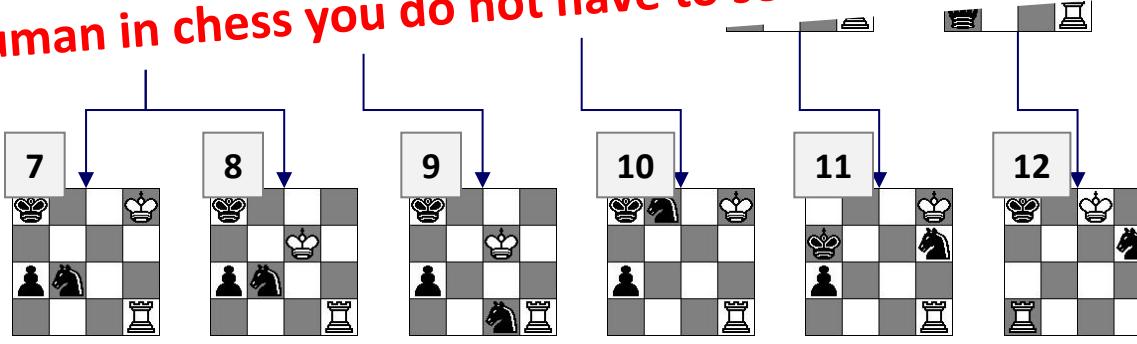
*Current state*

*BLACK: Computer to move*



**To beat a human in chess you do not have to search the entire game !**

*WHITE:  
Potential reaction of  
human opponent*



- One chess game has about  $10^{120}$  realistic game states, making it impossible to establish a complete states space

# Nice comment



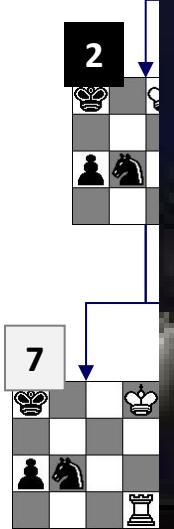
*„A computer beating a chess grandmaster is as fascinating as a bulldozer winning Olympic gold in weight lifting!“* Noam Chomski, MIT

# What about GO ?

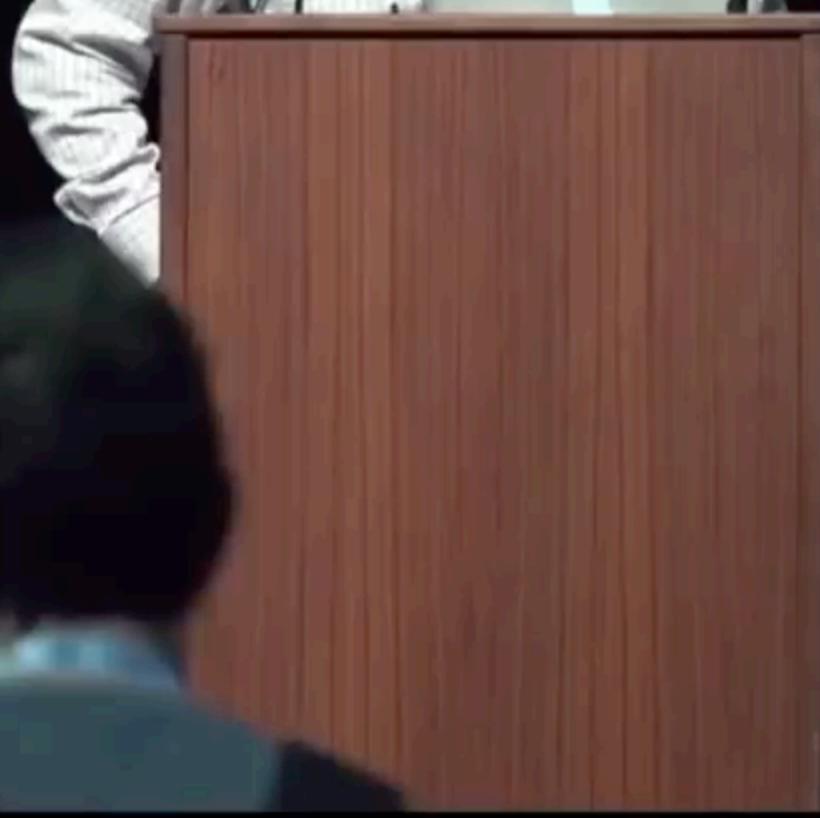
*Current state*

*BLACK:* Computer to move

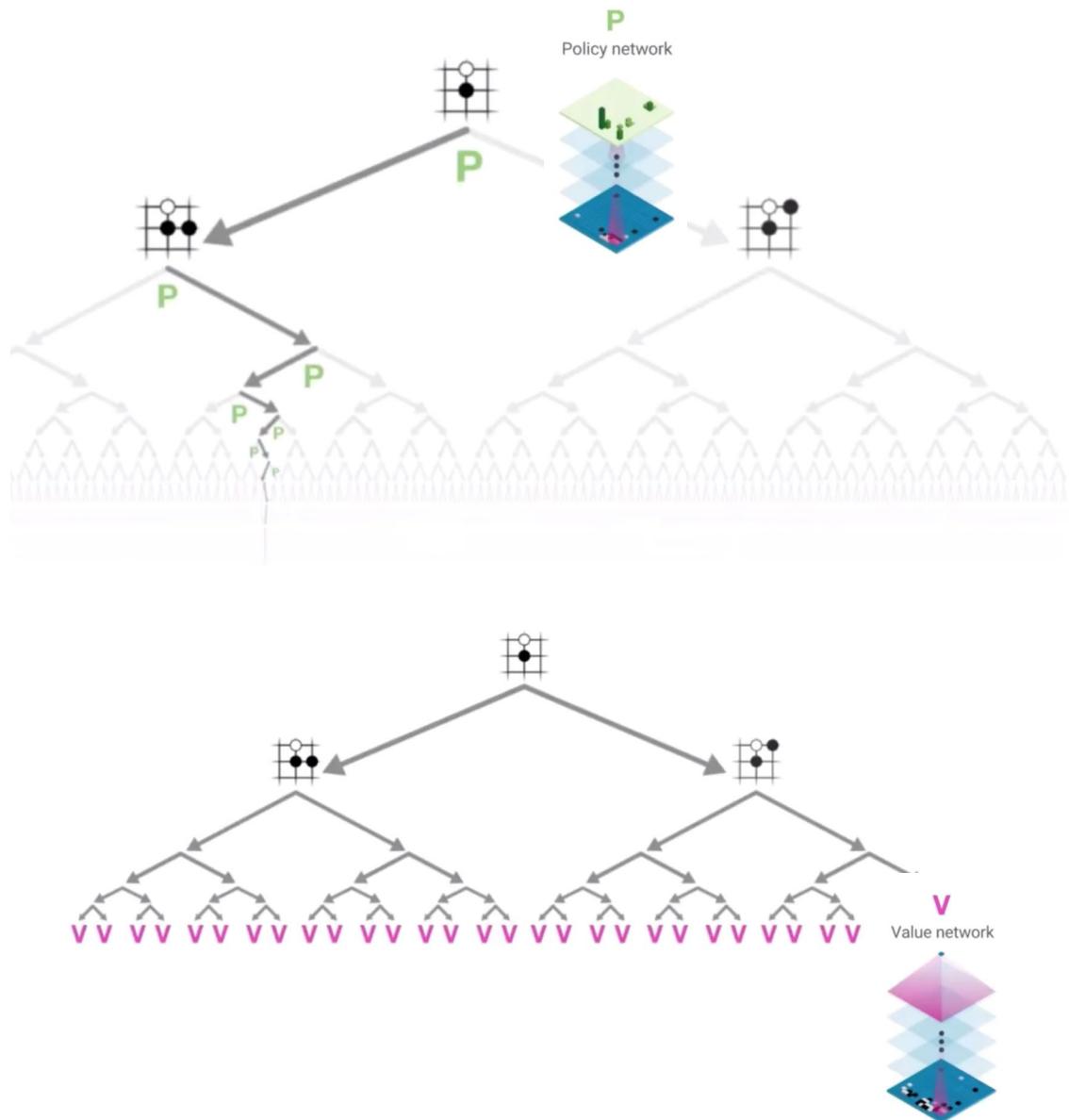
*WHITE:* Potential reaction of human opponent



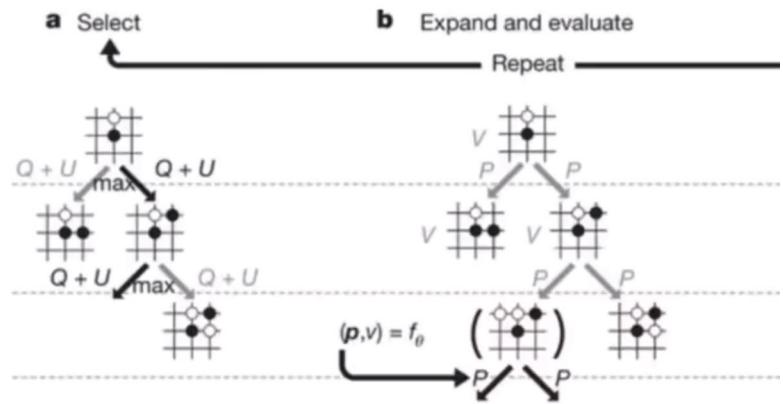
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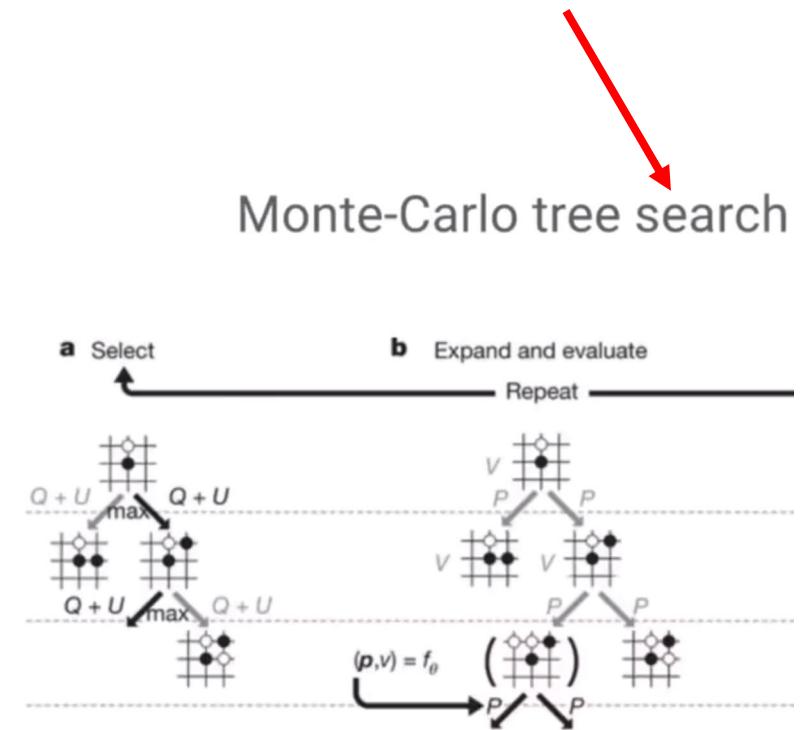
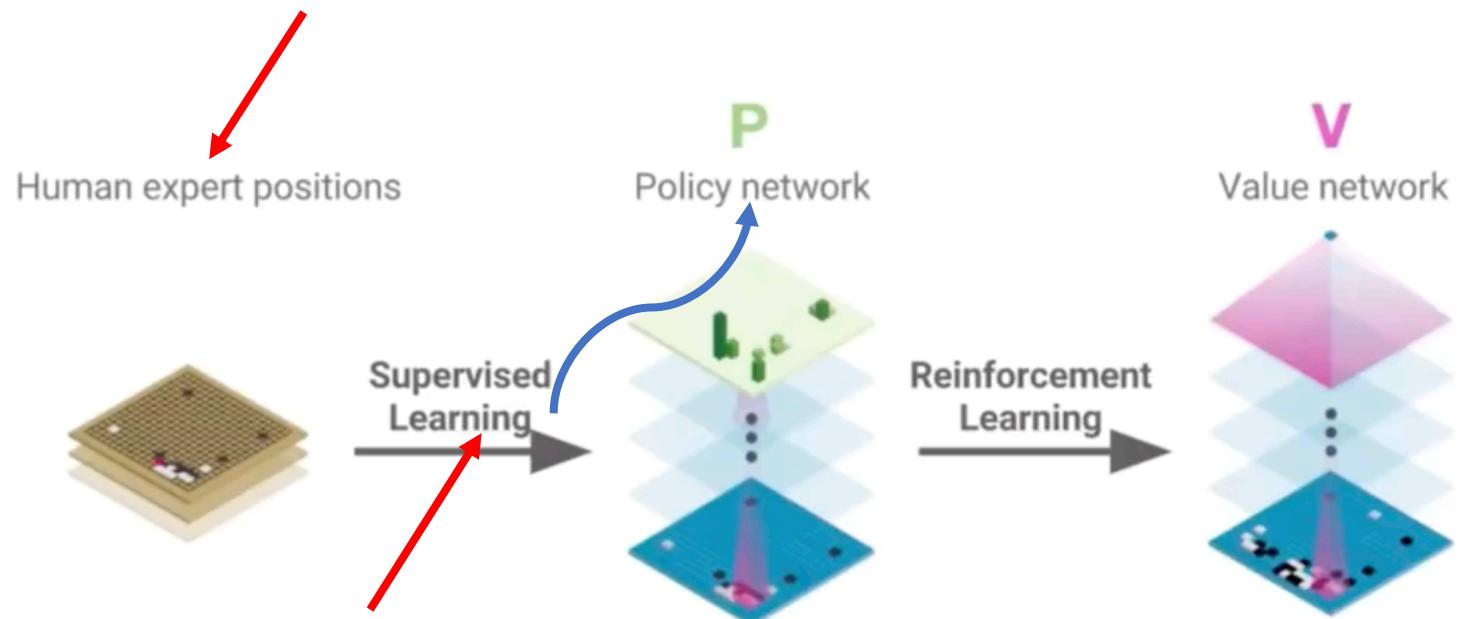
# The core ideas



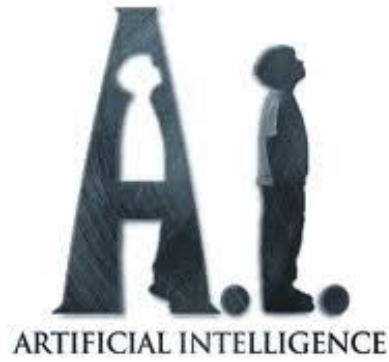
Monte-Carlo tree search



# What is AI ?

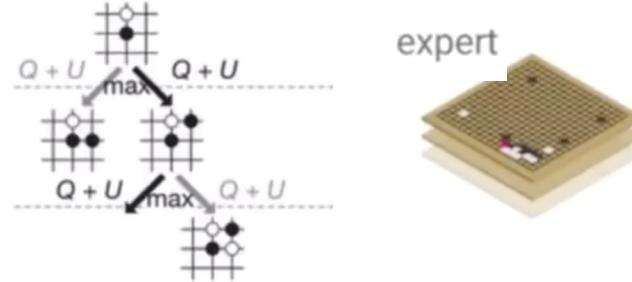


# What is AI ?



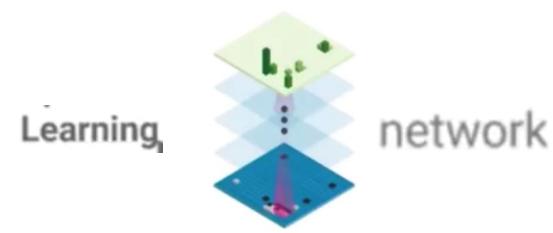
symbolische KI

highly efficient complex **search**  
and **knowledge representation**



expert

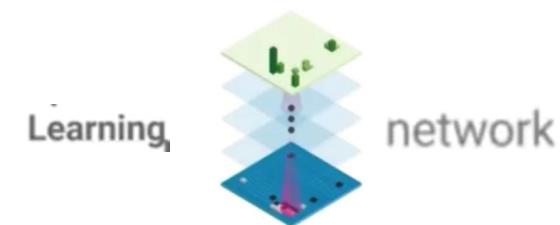
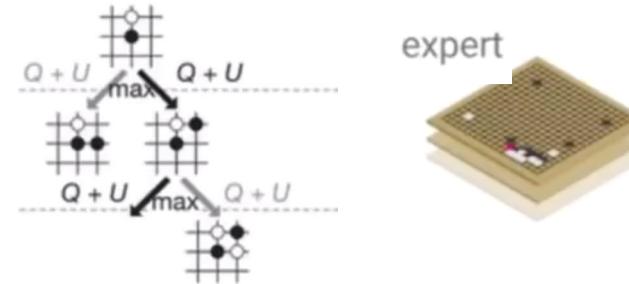
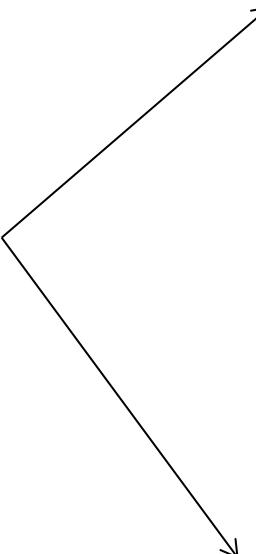
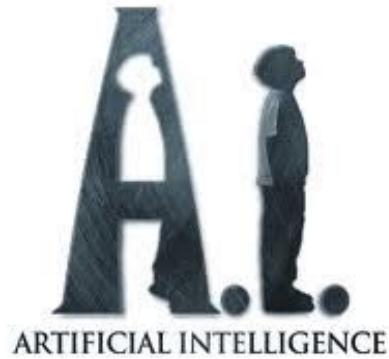
statistische (sub-symbolische) KI



**learning:** statistical analysis and  
optimization

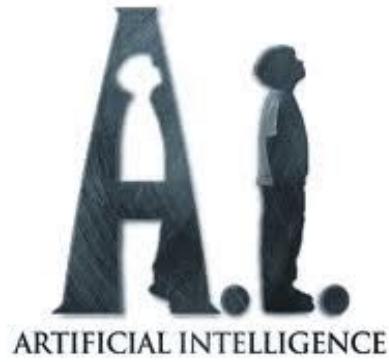
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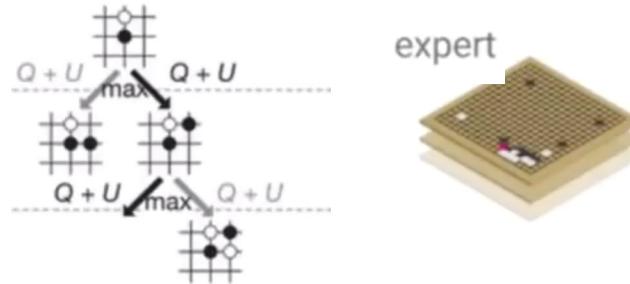
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# What is AI ?



symbolische KI

highly efficient complex **search**  
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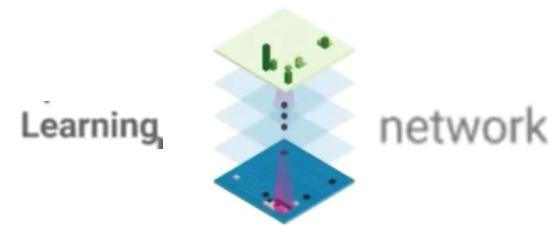


expert



key current research area in AI

statistische (sub-symbolische) KI



**learning:** statistical analysis and  
optimization

If ist no big deal , then why all the fuss ?

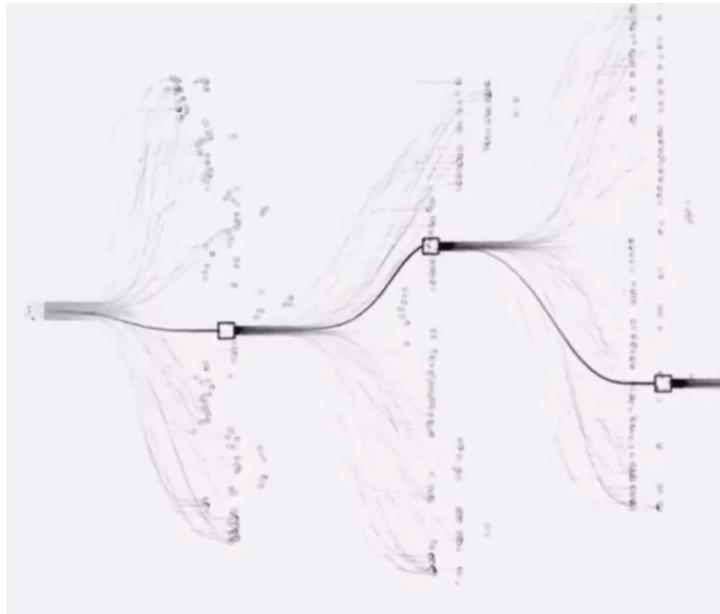


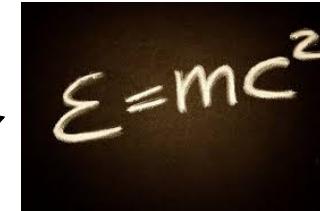
“Growth in computing power, availability of data and progress in algorithms have turned AI into one of the most **strategic technologies** of the 21st century....The way we approach AI will define the world we live in”.

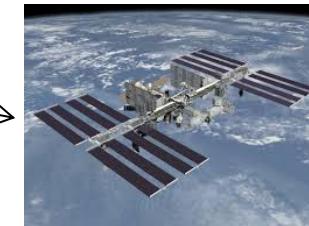
from: European Commission, ‘Communication from the Commission to the European Parliament, the European Council, The Council, the European Economic and Social Committee and the Committee of the Regions: Artificial Intelligence for Europe’ (25 April 2018) {COM (2018) 237 Final}, 13-14

why ?

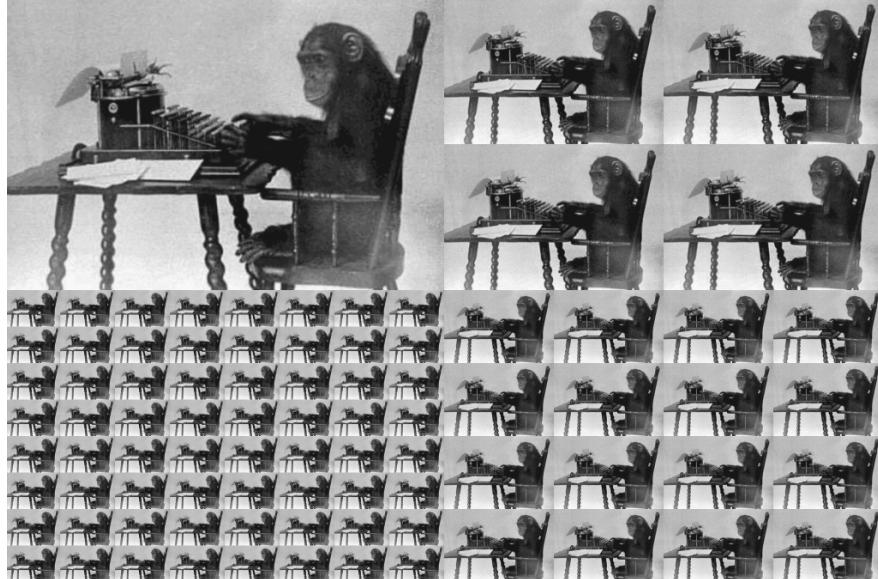
# Everything can be seen as a search problem ;-)



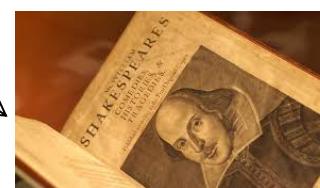
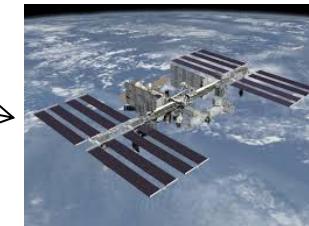

$$E=mc^2$$



# Everything can be seen as a search problem ;-)

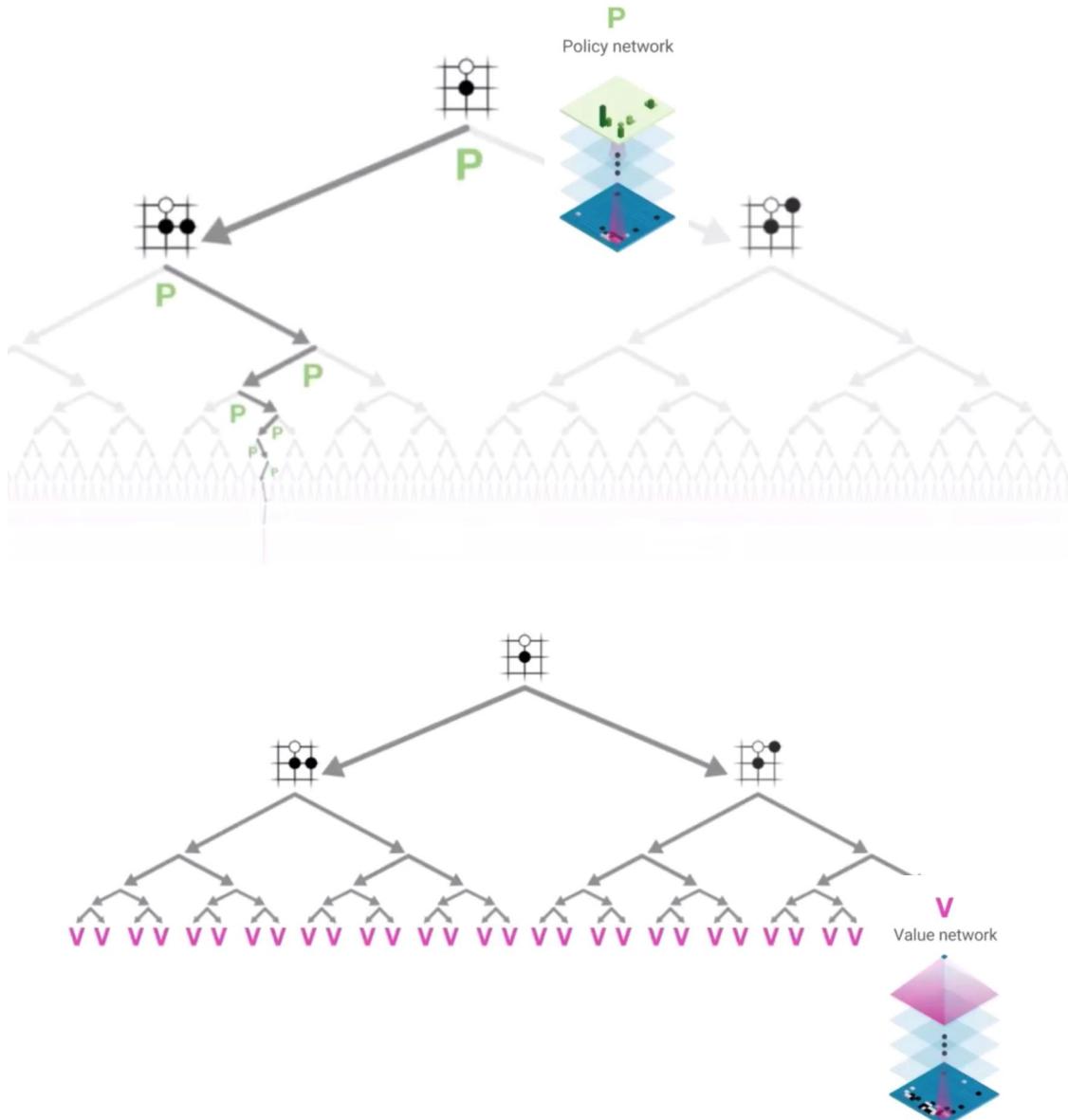


$$E=mc^2$$

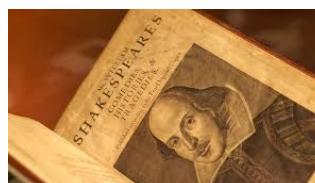


intelligence means solving it without exhaustive search  
(= with limited resources)

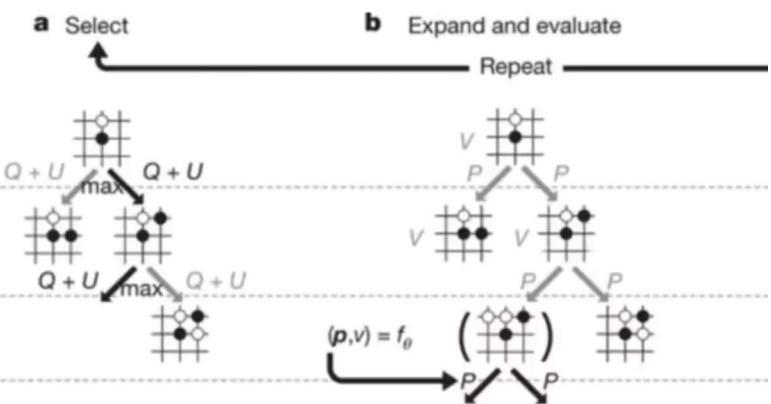
# The core ideas



$$E=mc^2$$



Monte-Carlo tree search



# Complex Machine Learning: Image description



- |     |                                     |
|-----|-------------------------------------|
| (a) | outdoor, woman, grass               |
| (b) | a woman wearing a blue shirt.       |
| (c) | gorgeous and beautiful as an angel! |



- |     |   |
|-----|---|
| (a) | sunglasses, man                           |
| (b) | a man wearing sunglasses taking a selfie. |
| (c) | you look handsome in all shades.          |

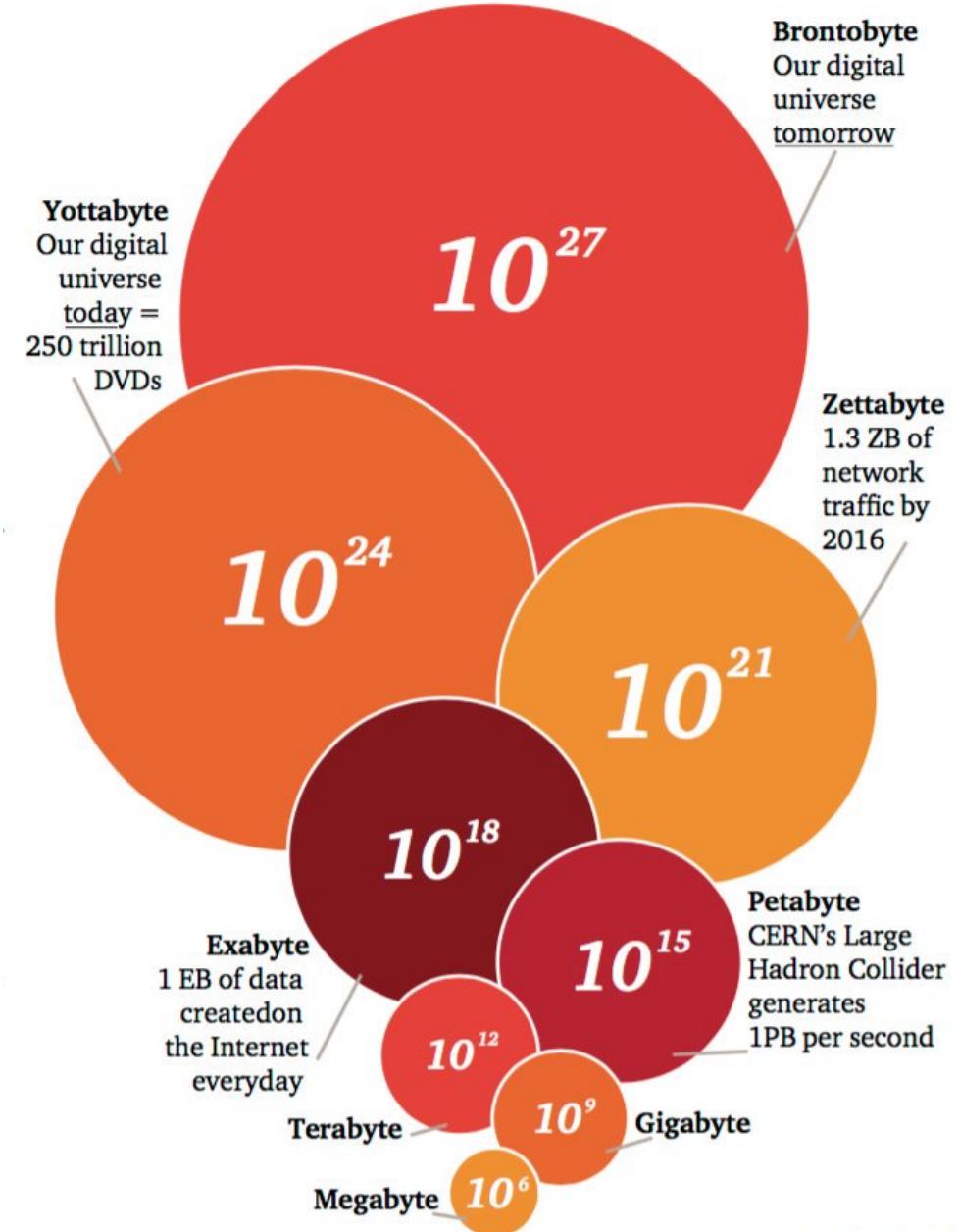


- |     |   |
|-----|---|
| (a) | water, tree, river, boat                          |
| (b) | a tree next to a body of water.                   |
| (c) | beautiful place looks like you are in the heaven! |

*lots and lots and lots of data is the key !  
even more then*

# The age of BigData

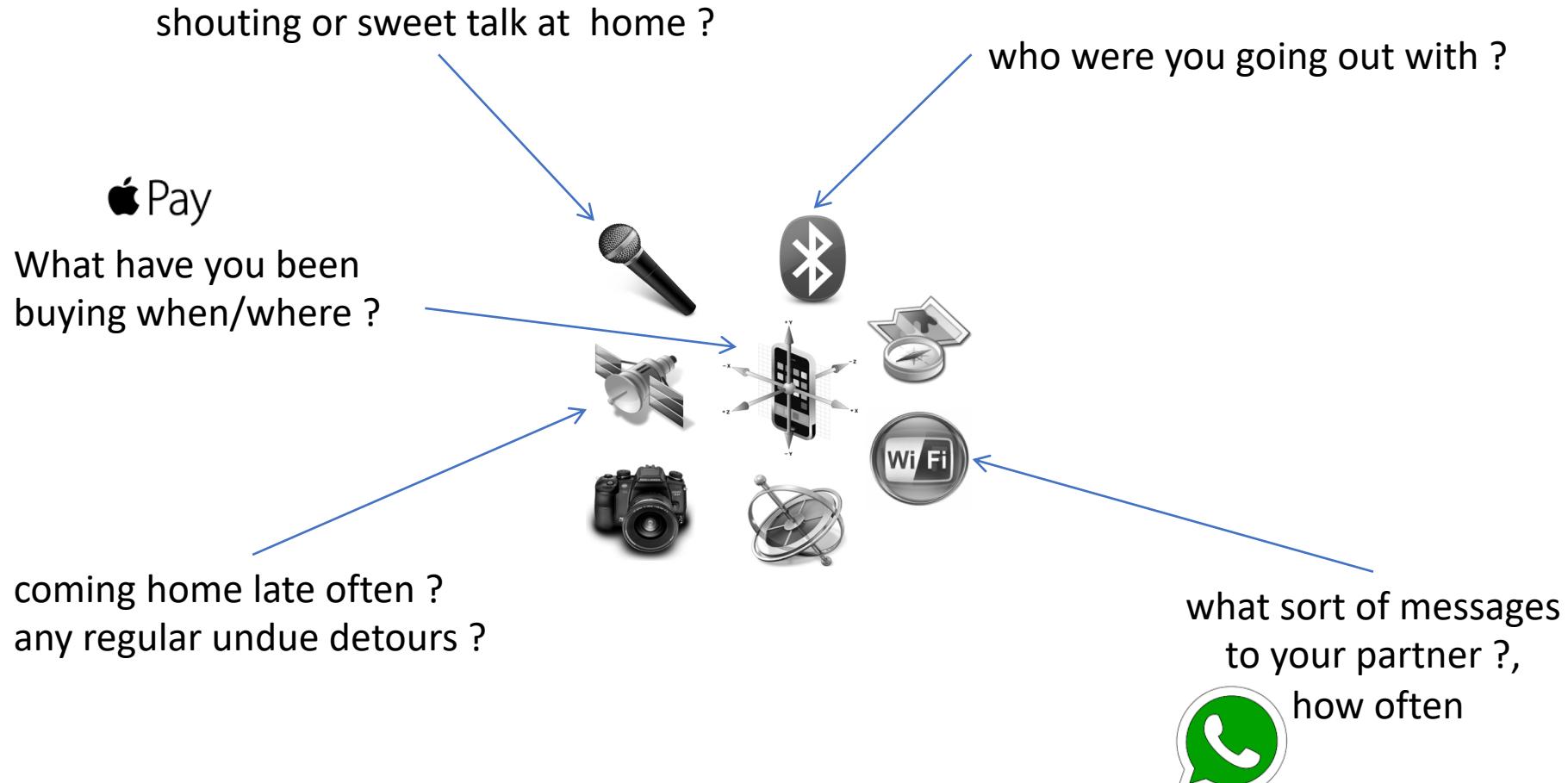
*Information from IoT devices*



# Can your smart phone predict if you will be divorced/married next year



# Can your smart phone predict if you will be divorced/married next year



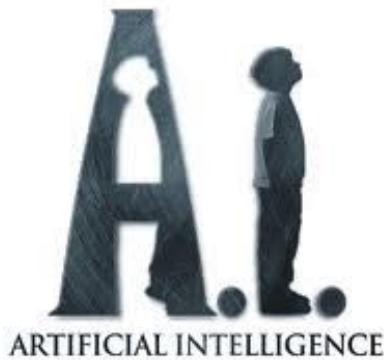
# Biiiiiiiig Data

- The Internet made any piece of digital, **archival knowledge** instantly, globally available
- We are now at the verge of any **real life event becoming, instantly globally connected** to the digital domain



# Biiiiiiiig Data

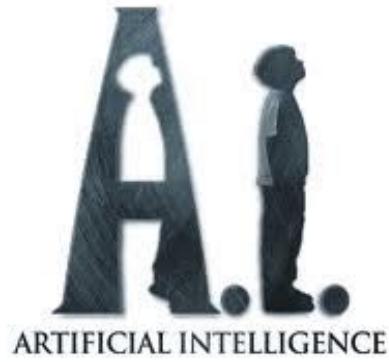
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AI that has that is trained on data  
not of a single human, **but of the  
human race as a whole !**

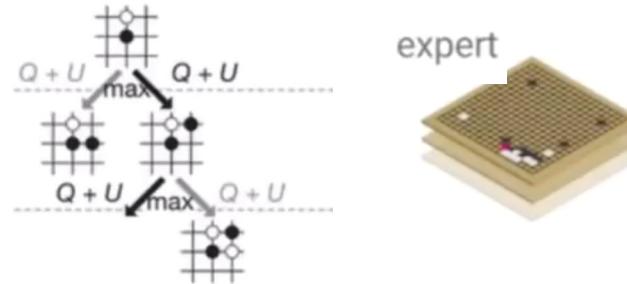


# What is AI ?

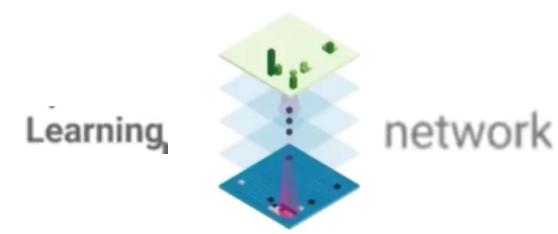


symbolische KI

highly efficient complex search  
and knowledge representation



statistische (sub-symbolische) KI



# Fitness tracking app's map reveals movement patterns on remote military bases



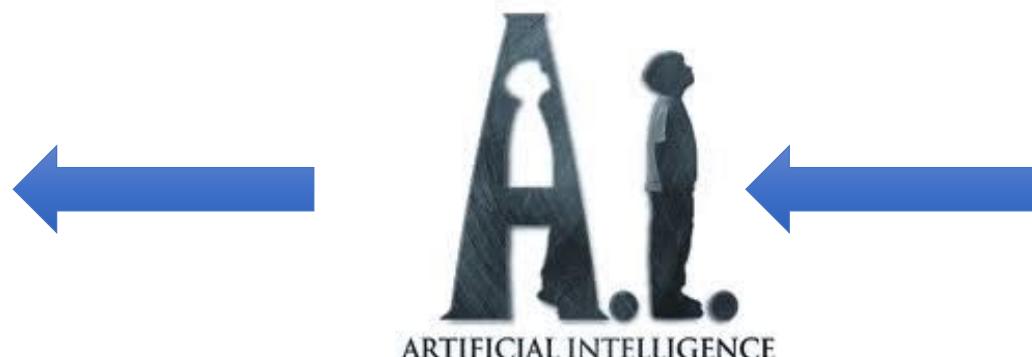
By [Joshua Berlinger](#) and [Maegan Vazquez](#), CNN

Updated 0503 GMT (1303 HKT) January 29, 2018

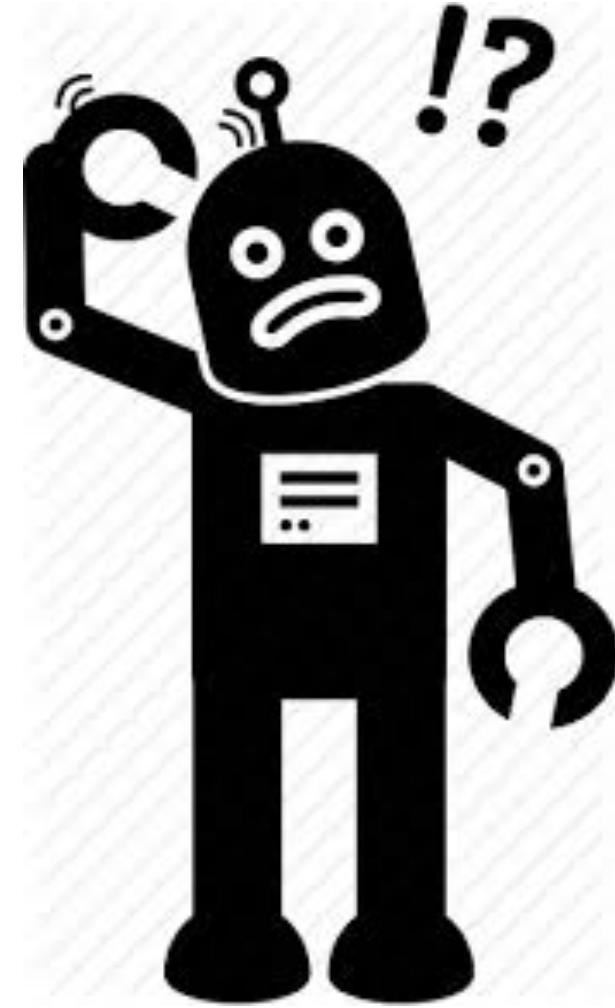


# Biiiiiiiig Data

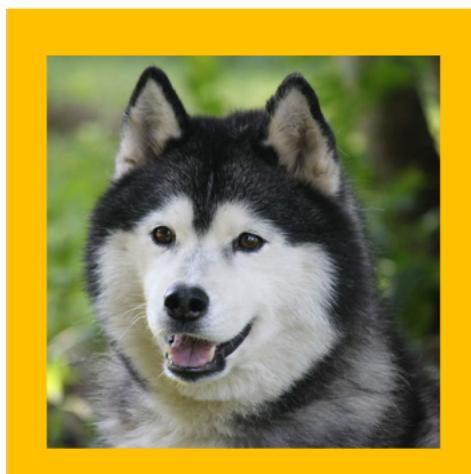
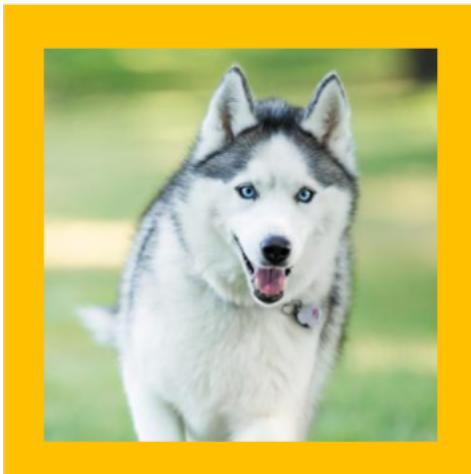
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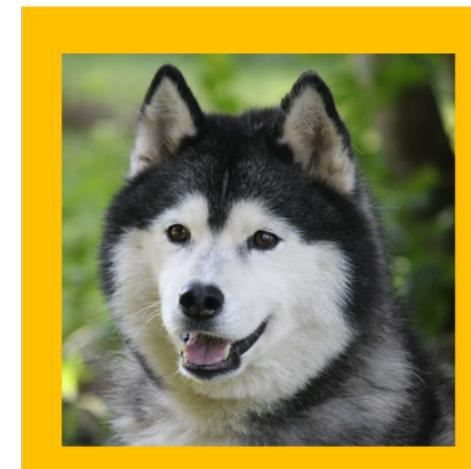
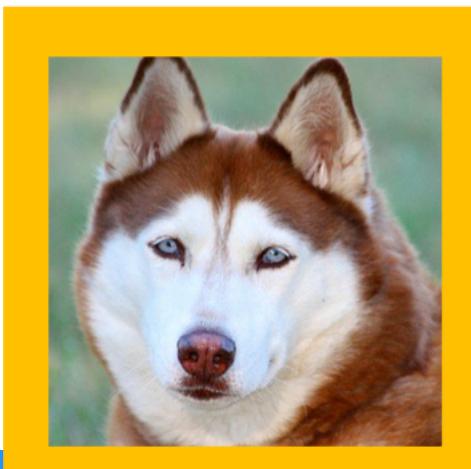
# Limits and problems of AI



# Taking data literally: Husky vs. Wolf



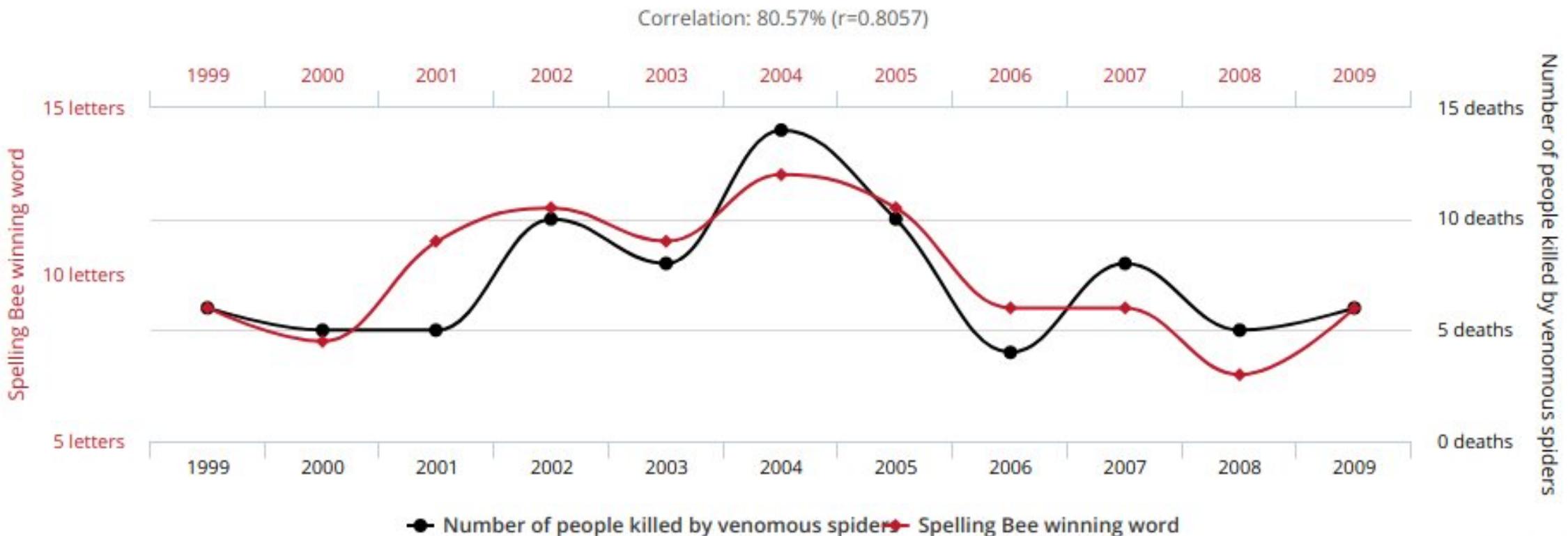
# Taking data literally: Husky vs. Wolf



# ML discovers statistics, not causality

==

**Letters in Winning Word of Scripps National Spelling Bee**  
correlates with  
**Number of people killed by venomous spiders**



tylervigen.com

Data sources: National Spelling Bee and Centers for Disease Control & Prevention



# Where AI still struggles.....



Common  
sense is a  
flower that  
doesn't grow  
in everyone's  
garden.

# Can an AI go beyond its programming ?

NOOOOOOOOOOOOOOO WAY

but

Sufficiently complex analysis /search on sufficiently large amounts of data may lead to results/**behaviors that the designer of the system did not anticipate !**



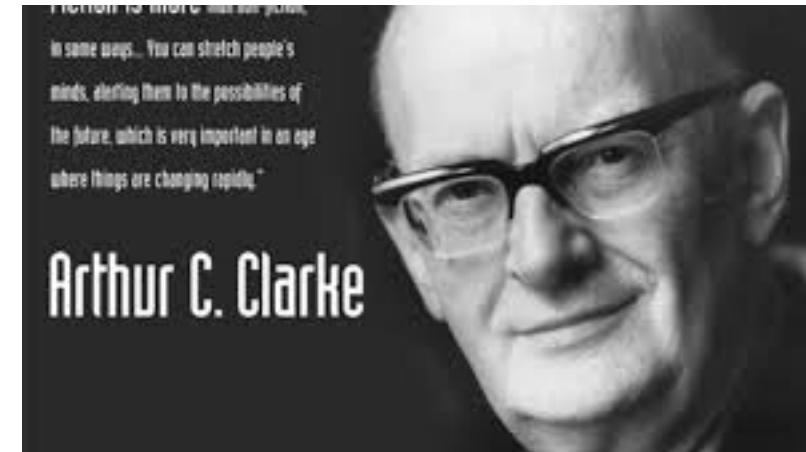
# Can an AI be „responsible“ for its „ethical“ choices



An AI does **not** make ethical choices,  
It **executes** choices and **policies** of its **designers**

# Was künstliche Intelligenz eigentlich mit Intelligenz zu tun hat ?

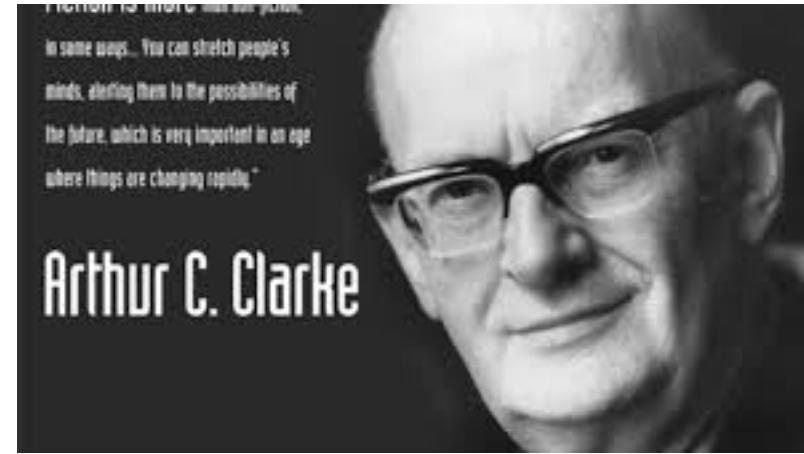
- “Any sufficiently advanced technology is indistinguishable from magic”



# Was künstliche Intelligenz eigentlich mit Intelligenz zu tun hat ?

- “Any sufficiently advanced technology is indistinguishable from magic”

*any sufficiently advanced analysis/search on  
sufficiently large amount of data  
is indistinguishable from intelligence*

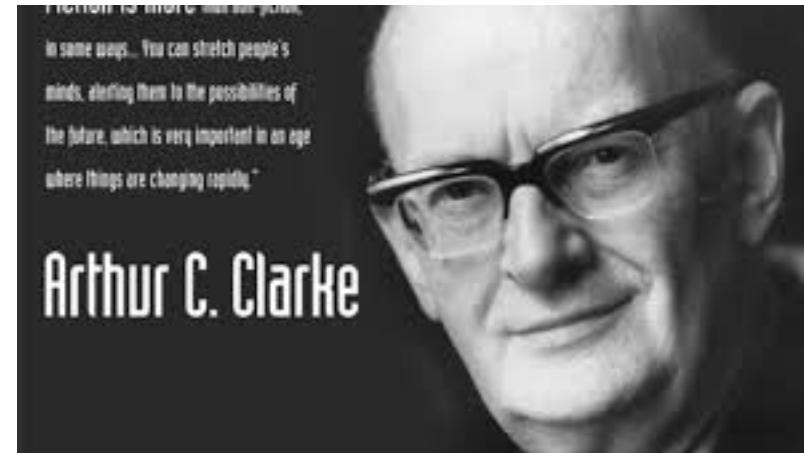


“Technology is often like magic...  
in some ways... You can stretch people's  
minds, alerting them to the possibilities of  
the future, which is very important in an age  
where things are changing rapidly.”

Arthur C. Clarke

# Was künstliche Intelligenz eigentlich mit Intelligenz zu tun hat ?

- “Any sufficiently advanced technology is **indistinguishable** from magic”

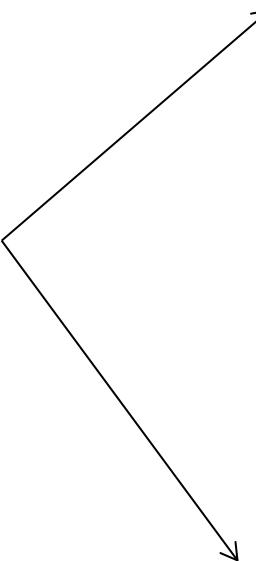
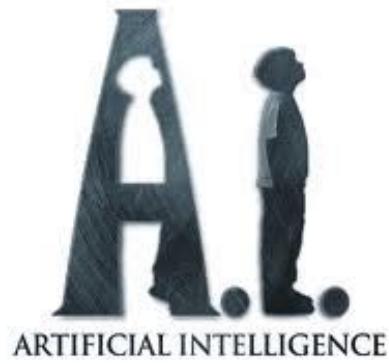


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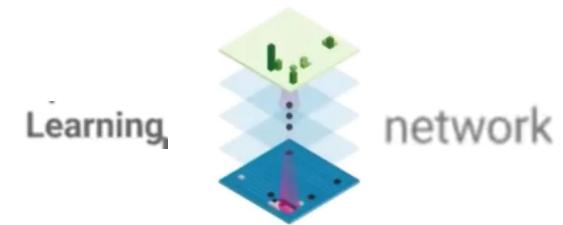
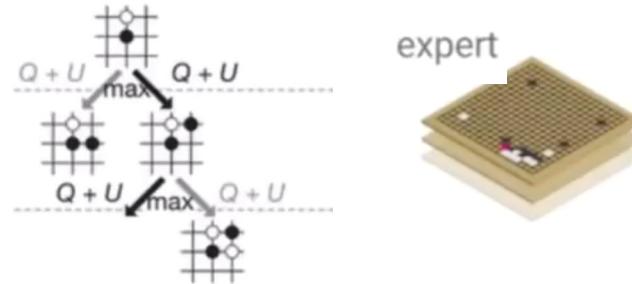
Arthur C. Clarke

*any sufficiently advanced technology  
sufficiently large amount of data  
is indistinguishable from intelligence  
until you understand it !!!*

# Themen der Vorlesung



highly efficient complex (1) search  
and (2) knowledge representation



(3) learning: statistical analysis and  
optimization