

**TDA232 / DIT381**  
**Algorithms for machine  
learning and inference**

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# People

- Lectures: Morteza Haghiri Chehreghani
- Course Assistants:
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  - Yuchong Zhang: [yuchong@chalmers.se](mailto:yuchong@chalmers.se)

# Resources

- Course Canvas page:

<https://chalmers.instructure.com/courses/9318>

- Textbook, slides and other reading on the course page

S. Rogers and M. Girolami, A First Course in Machine Learning, 2nd edition , Chapman & Hall/CRC 2016, ISBN: 9781498738484.

# Evaluation

- Five homework assignments (see course page for detail),
- Build your groups soon!
- Take home 24 hour exam during the exam week (date to be fixed soon).
- The final grade will be a combination of assignments and the exam. More detail will be announced soon.

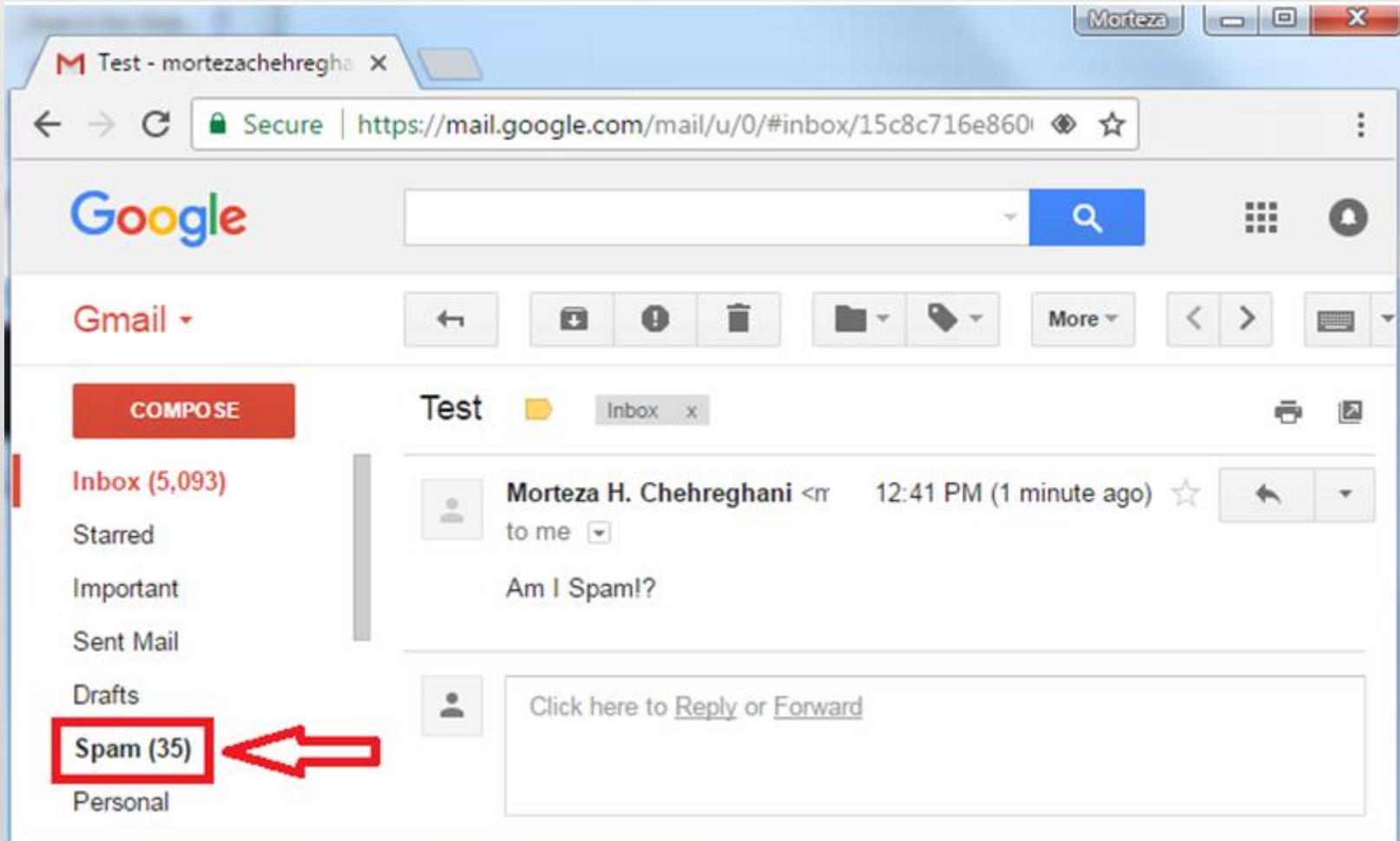
# Contact

- Contact me for questions/suggestions about the lectures, concepts, topics, etc.  
[morteza.chehreghani@chalmers.se](mailto:morteza.chehreghani@chalmers.se)
- There will be a responsible TA for each assignment.
- Contact the responsible TAs about the specific assignments.

# Student representatives

To be selected soon!







Google Translate

DETECT LANGUAGE

SWEDISH

PERSIAN

ENGLISH



SWEDISH

ENGLISH

PERSIAN



I like learning about artificial intelligence

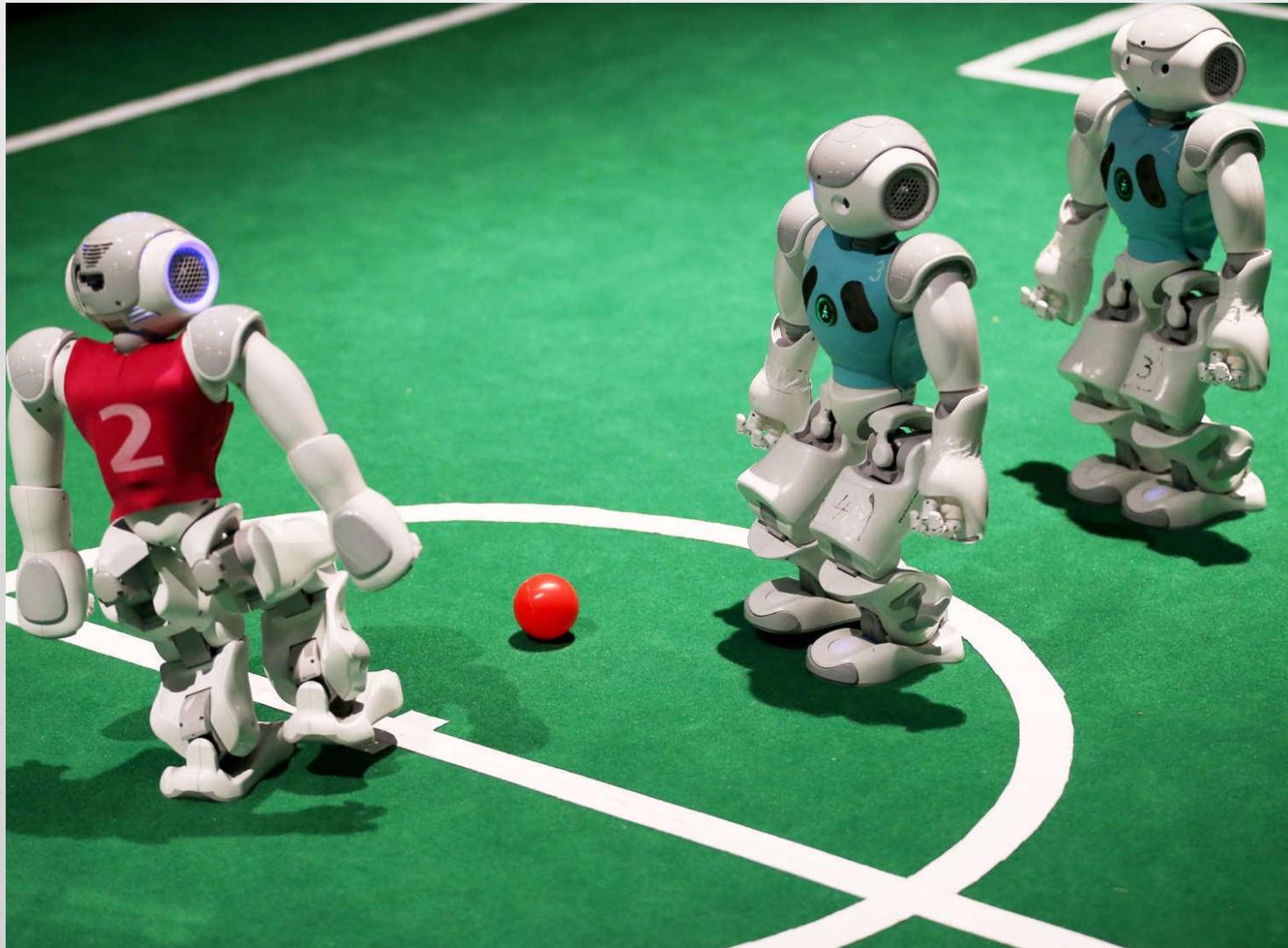


45/5000



Jag gillar att lära mig om artificiell intelligens







# AI: the New Electricity

“AI is the new electricity.  
Just as electricity transformed  
industry after industry 100 years ago,  
I think AI will do the same.”



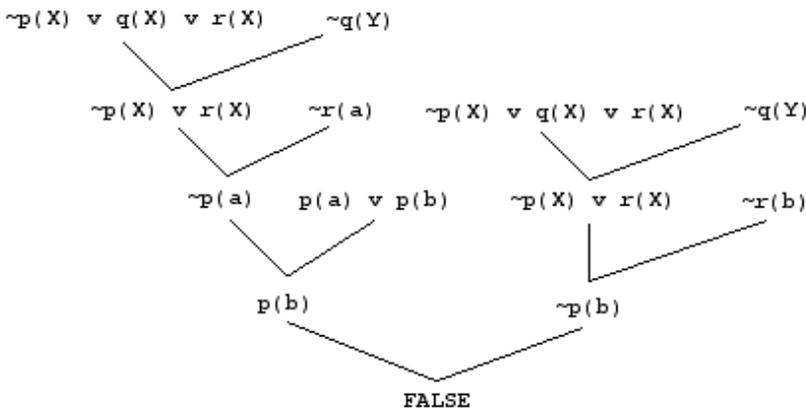
Andrew Ng, Stanford, Baidu, Coursera



- “I believe that at the end of the century the use of words and general educated opinion will have altered so much that one will be able to speak of **machines thinking** without expecting to be contradicted.”  
— **Alan Turing**,  
*Computing Machinery and Intelligence* (1950)

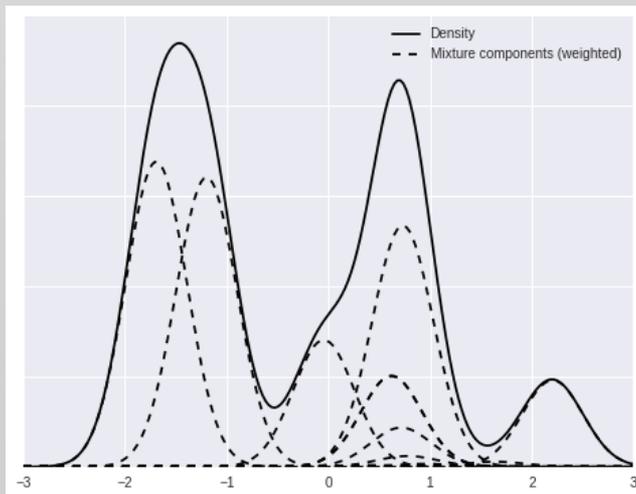
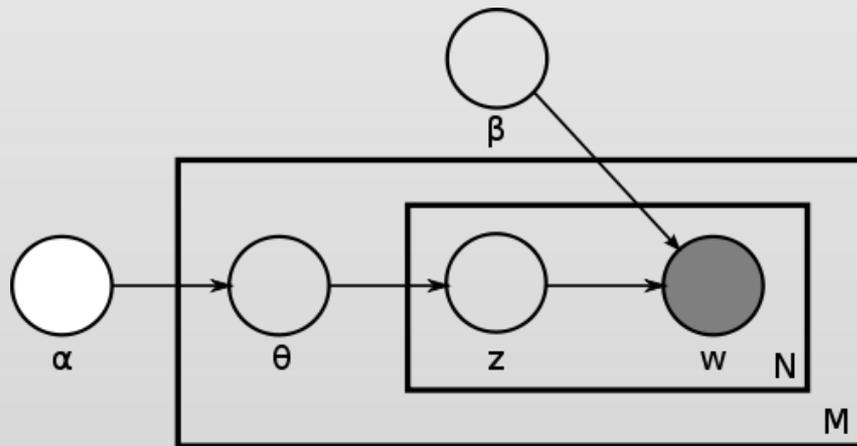
# History: logic-based AI (1960-90)

- Knowledge Representation
- First Order Logic and Theorem Proving



- at(restaurant,Alice)
- at(restaurant,Bob)
- at(restaurant,Carol)
- works\_at(restaurant,Carol)
- has\_job(restaurant,waitress,Carol)
- orders(Bob,pizza)
- orders(Alice,sushi)
- forall X,Y,Z. orders(X,Y) and has\_job(restaurant,waitress,Z) -> serves(Z,X,Y)
- serves(Carol,Bob,pizza)
- serves(Carol,Alice,sushi)

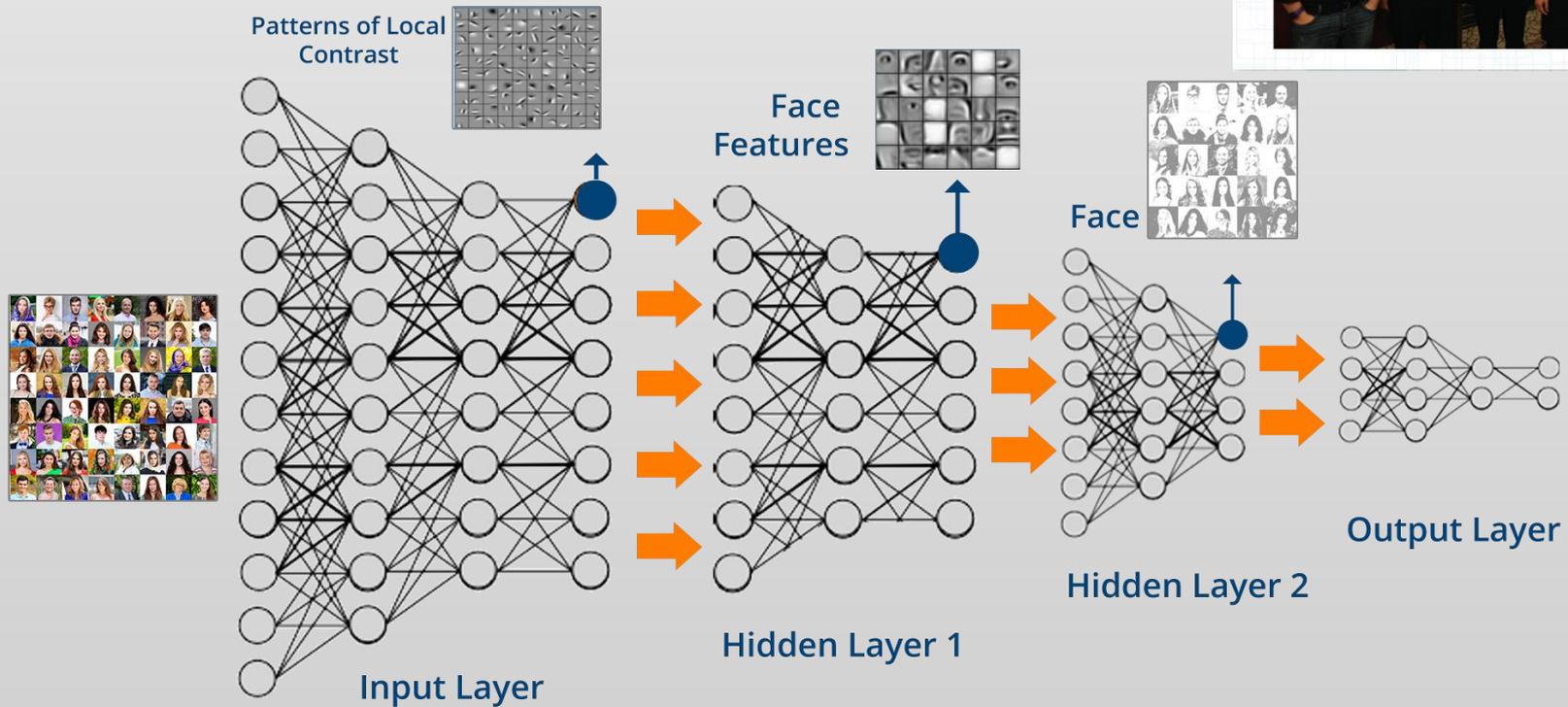
# Machine Learning 1990-



- Data driven  
(no hardcoded rules)  
[e.g., to estimate the parameters of the model]
- Probabilistic models
- Statistical learning and inference

# Deep Learning 2005-

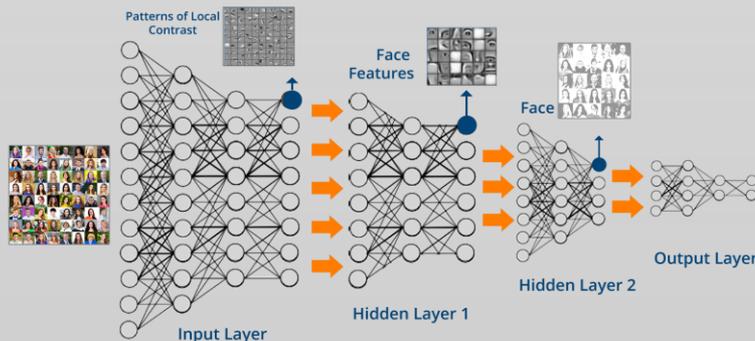
People Behind It :  
LeCun, Hinton, Bengio & Ng



# Why Now?

## Convergence of Technologies

- Data sensing, acquisition revolution
- Rapid increase in computing power
- Novel algorithms
- Software frameworks





**Computing  
Power**



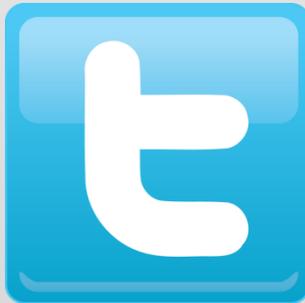
**Machine  
Learning**



**Data-based  
Decisions**

# How much data?

**12+ TBs**  
of tweet data  
every day



**25+ TBs** of  
log data  
every day



**4.6 billion**  
camera phones  
worldwide



**100s of millions**  
of **GPS enabled**  
devices sold  
annually

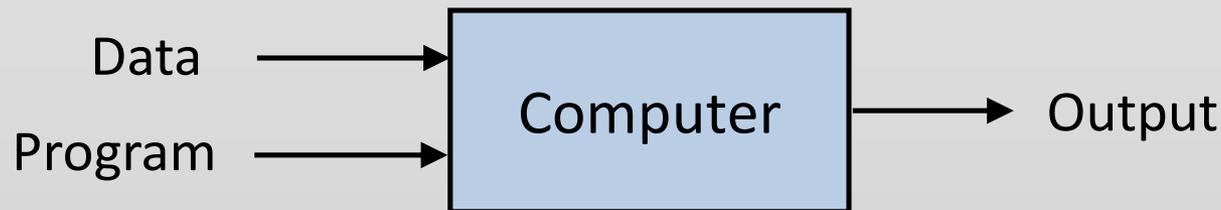


**3.5+ billion**  
people on the Web

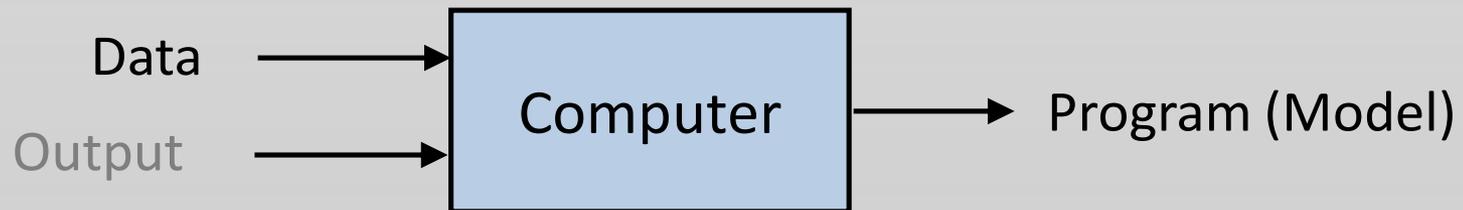
# Machine learning definition (1)

- Arthur Samuel (1959): Field of study that gives **computers** the ability to **learn** without being explicitly **programmed**.

## Programming

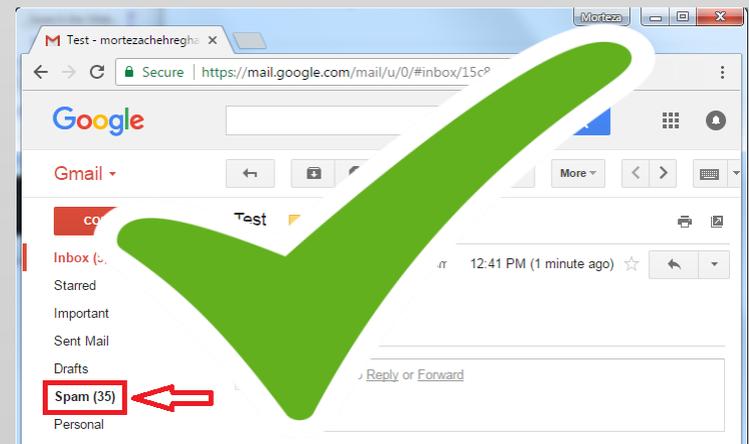
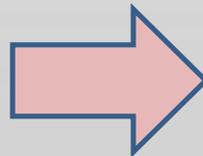


## Machine Learning



# Machine learning definition (2)

- Herbert A. Simon (1957): Learning is any process by which a system improves performance from experience.
- Tom Mitchell (1997): A **computer program** is said to **learn** from **experiences** with respect to some class of **tasks** and **performance measures**, if its performance at the tasks improves with the experiences.





# Types of learning

## ❑ Supervised learning

- Learning in presence of training (labeled) data

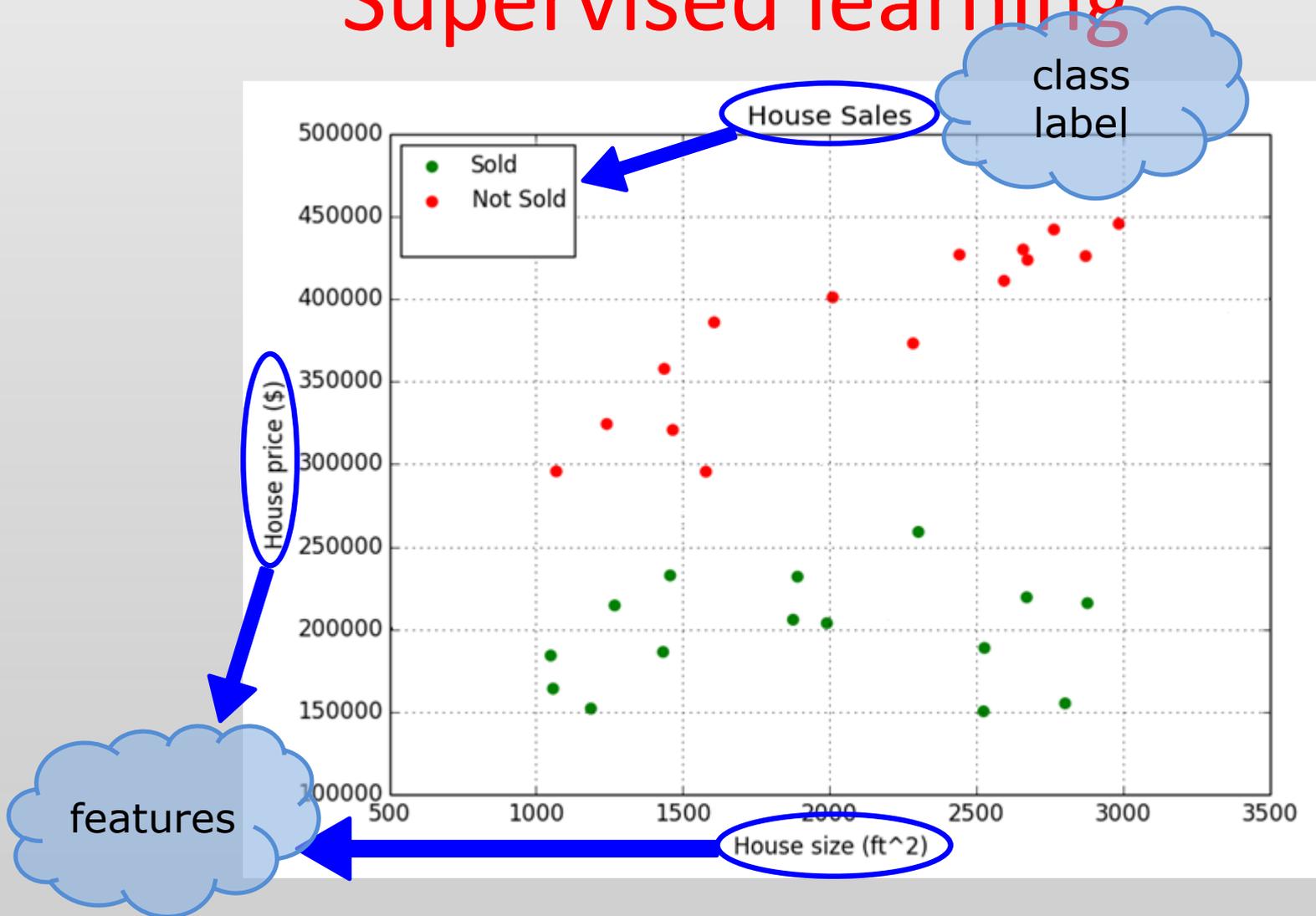
## ❑ Unsupervised learning

- Learning when no training data is available

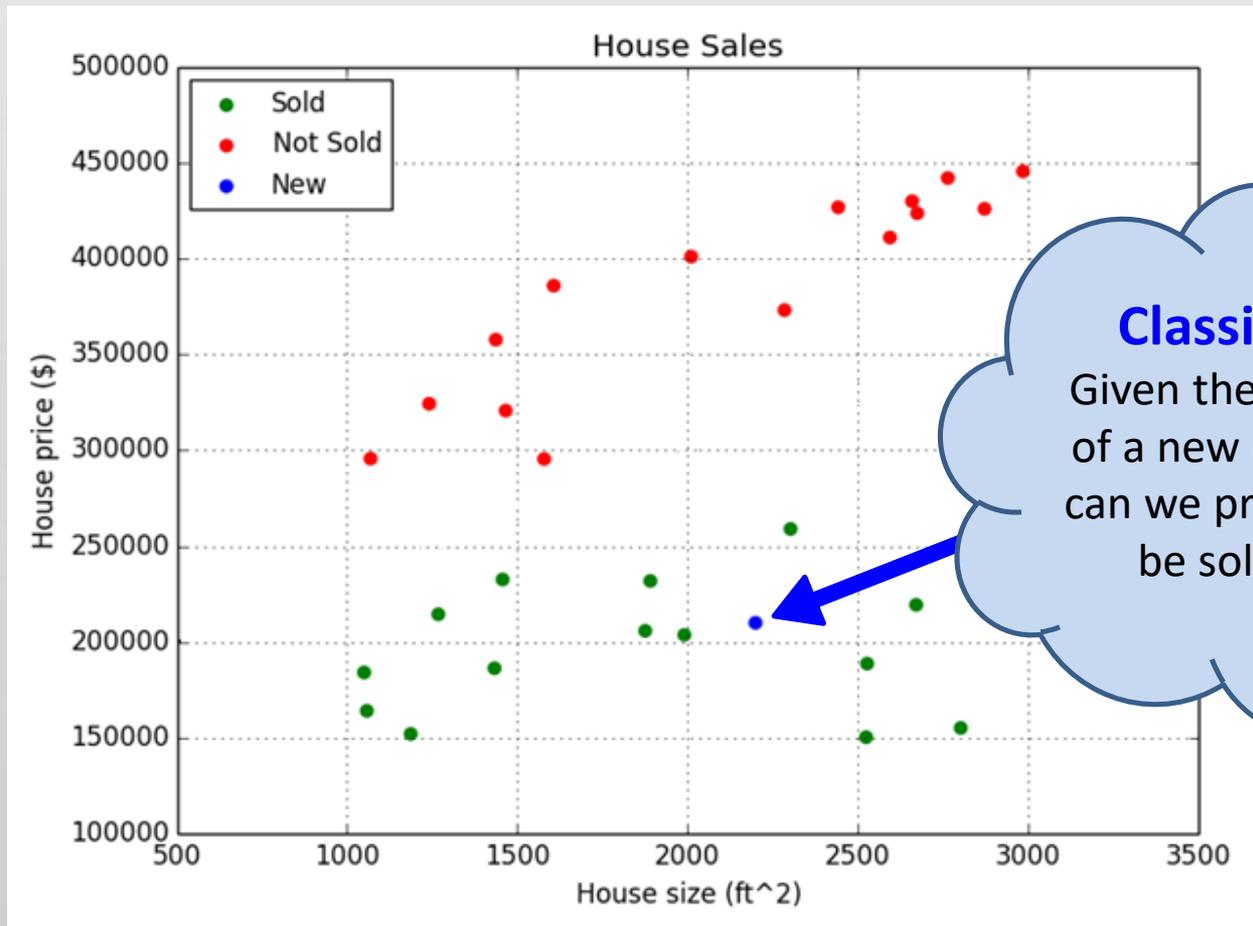
## ❑ Reinforcement learning

- Interactive learning in an environment

# Supervised learning



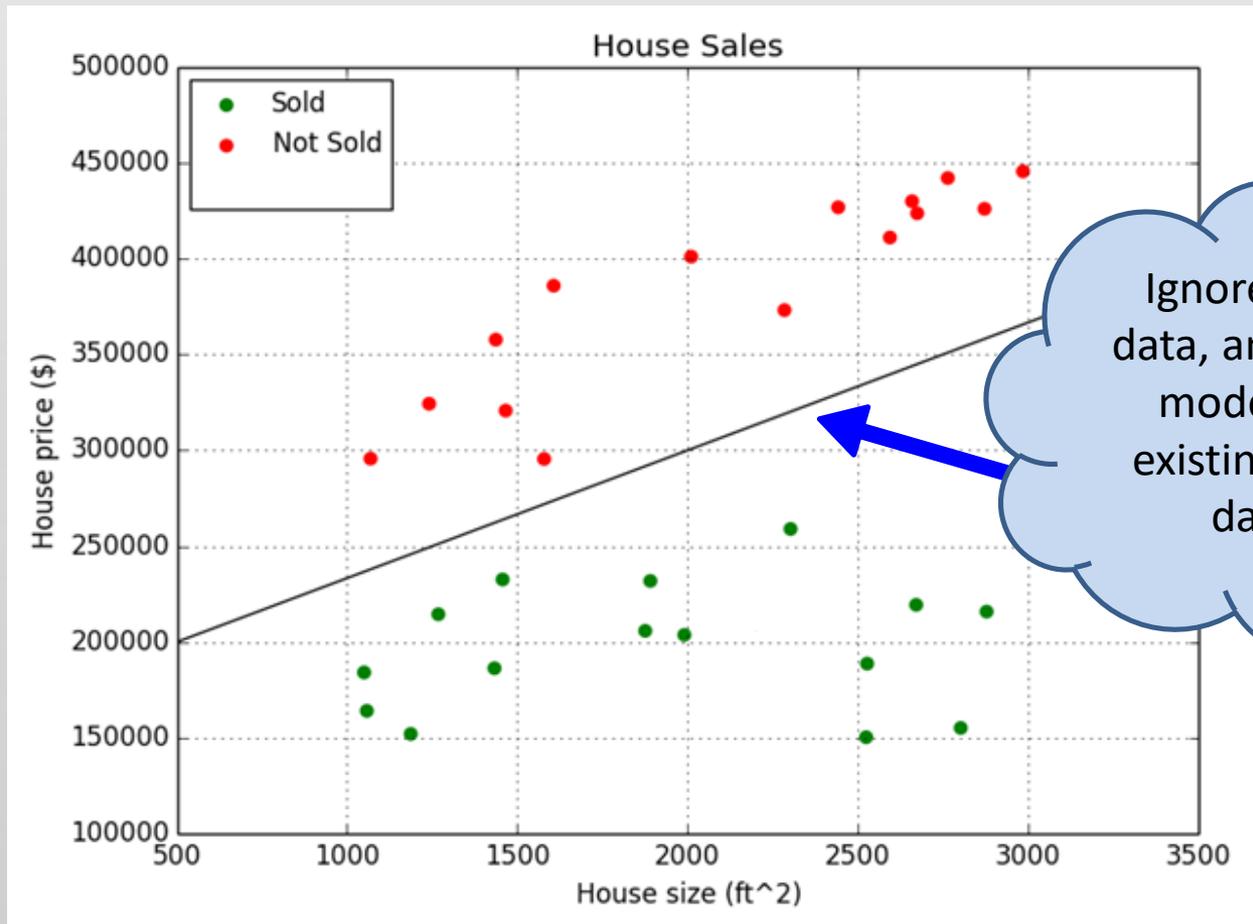
# Supervised learning



## Classification:

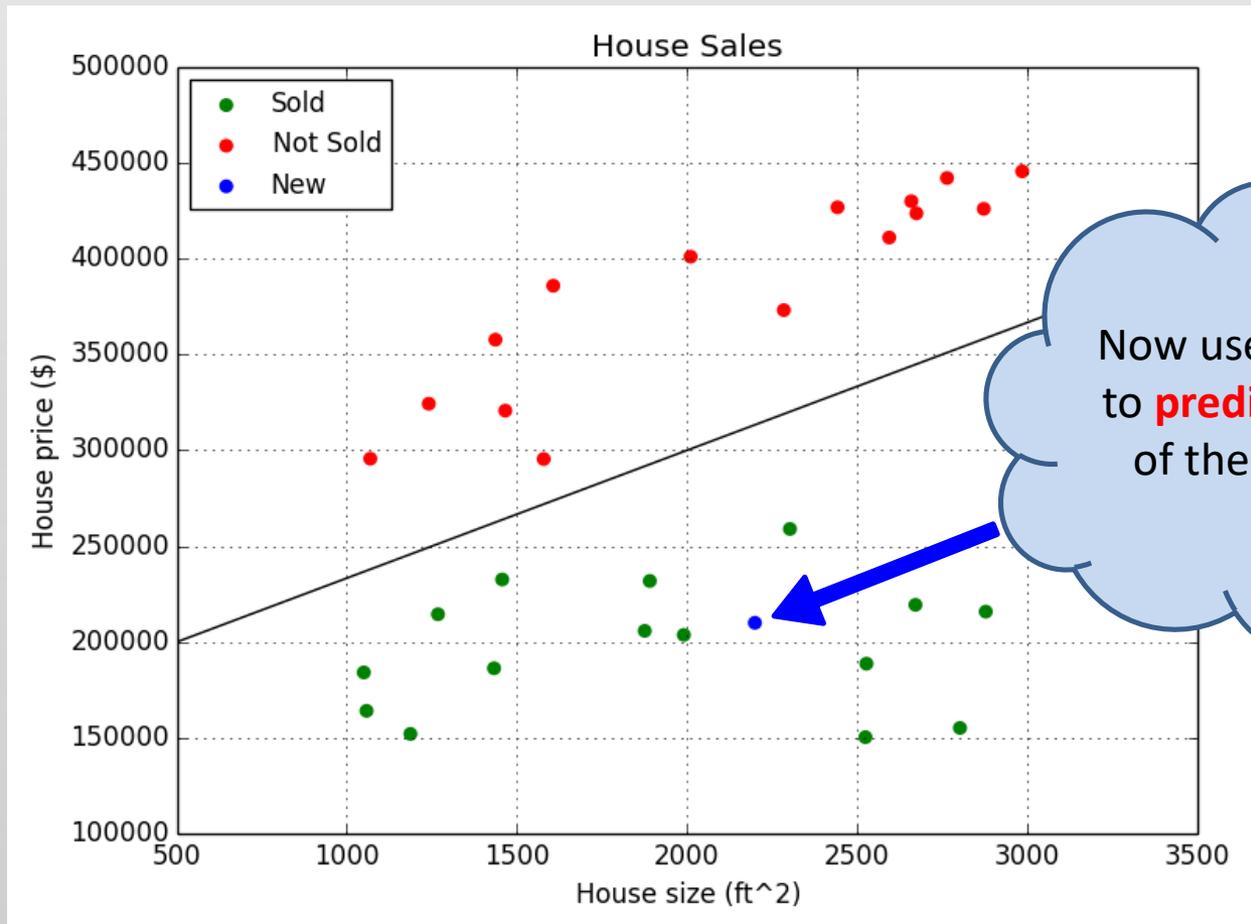
Given the information of a new (**test**) house, can we predict if it will be sold or not?

# Supervised learning

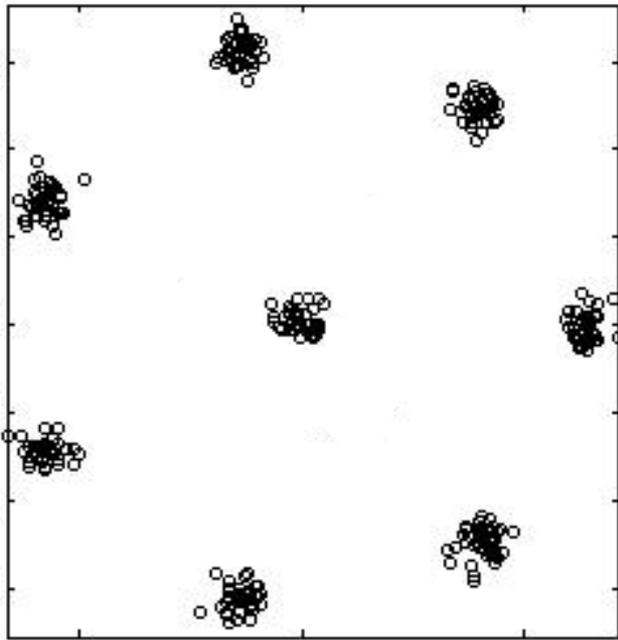


Ignore the **test** data, and obtain a model on the existing **training** dataset.

# Supervised learning



# Unsupervised learning

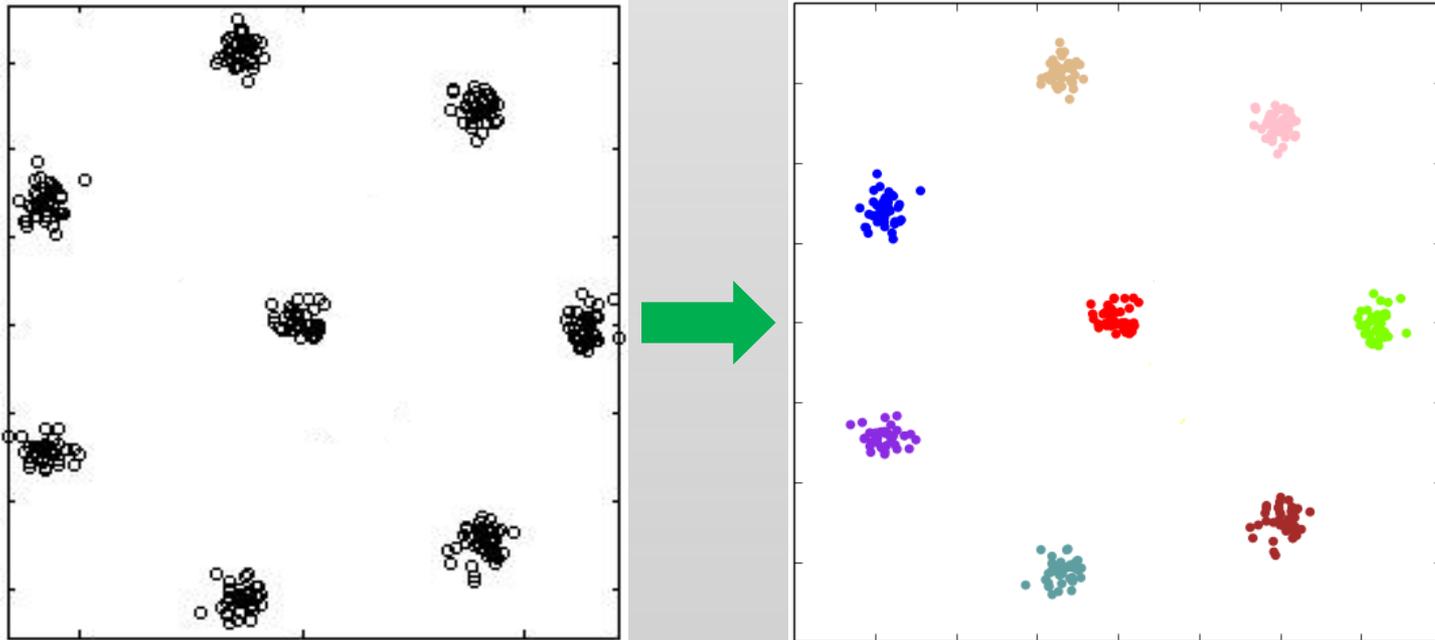


No **training** data  
is available!



# Unsupervised learning

**Clustering:** Partition the data into groups of similar objects.



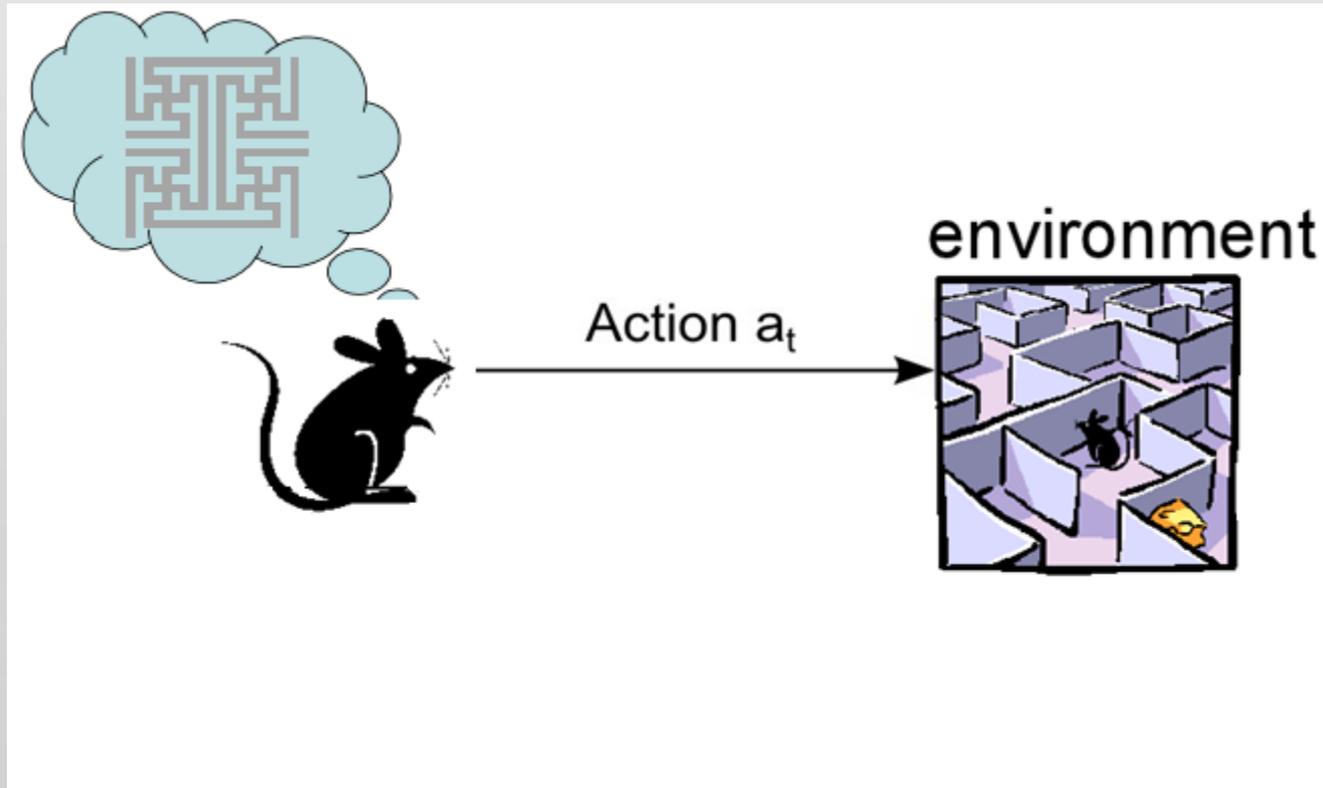
# Reinforcement learning



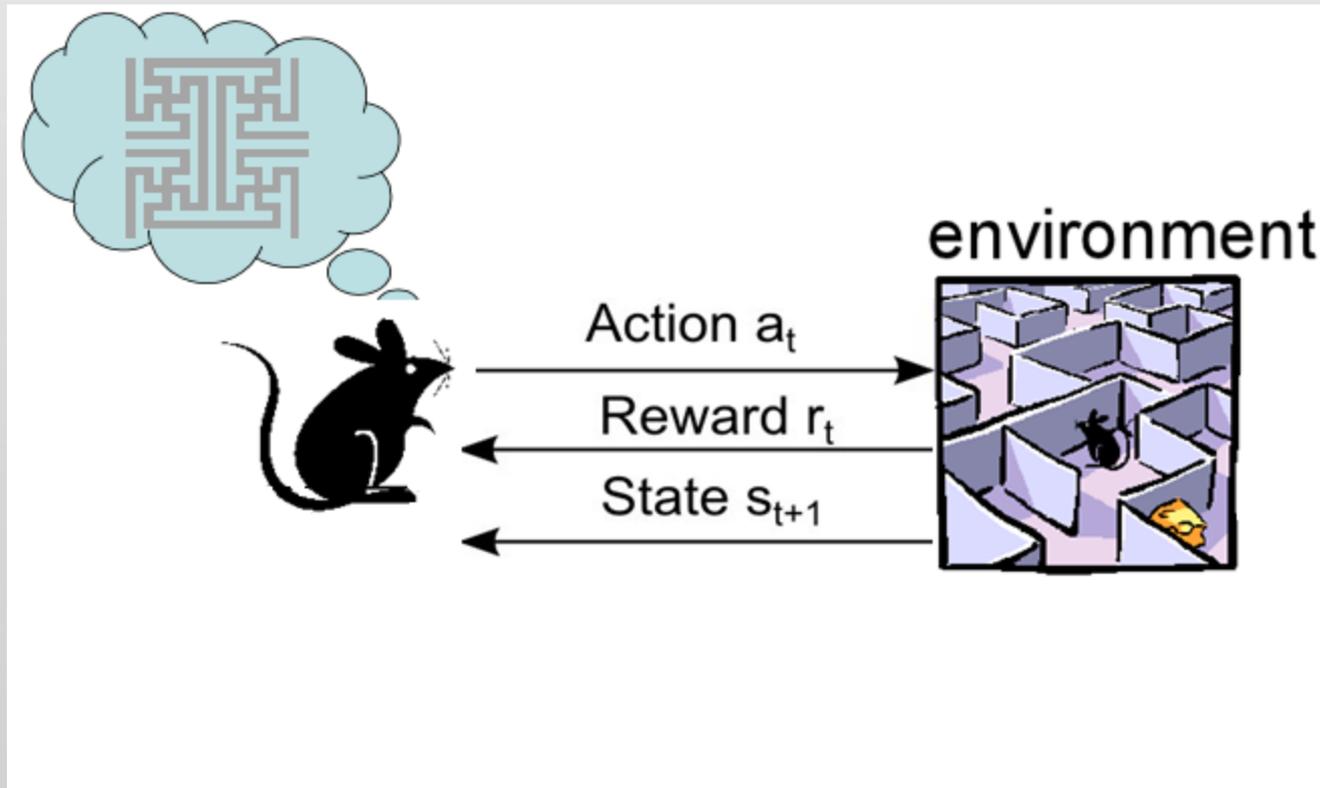
environment



# Reinforcement learning



# Reinforcement learning



■ **"Pure" Reinforcement Learning (cherry)**

- ▶ The machine predicts a scalar reward given once in a while.
- ▶ **A few bits for some samples**

■ **Supervised Learning (icing)**

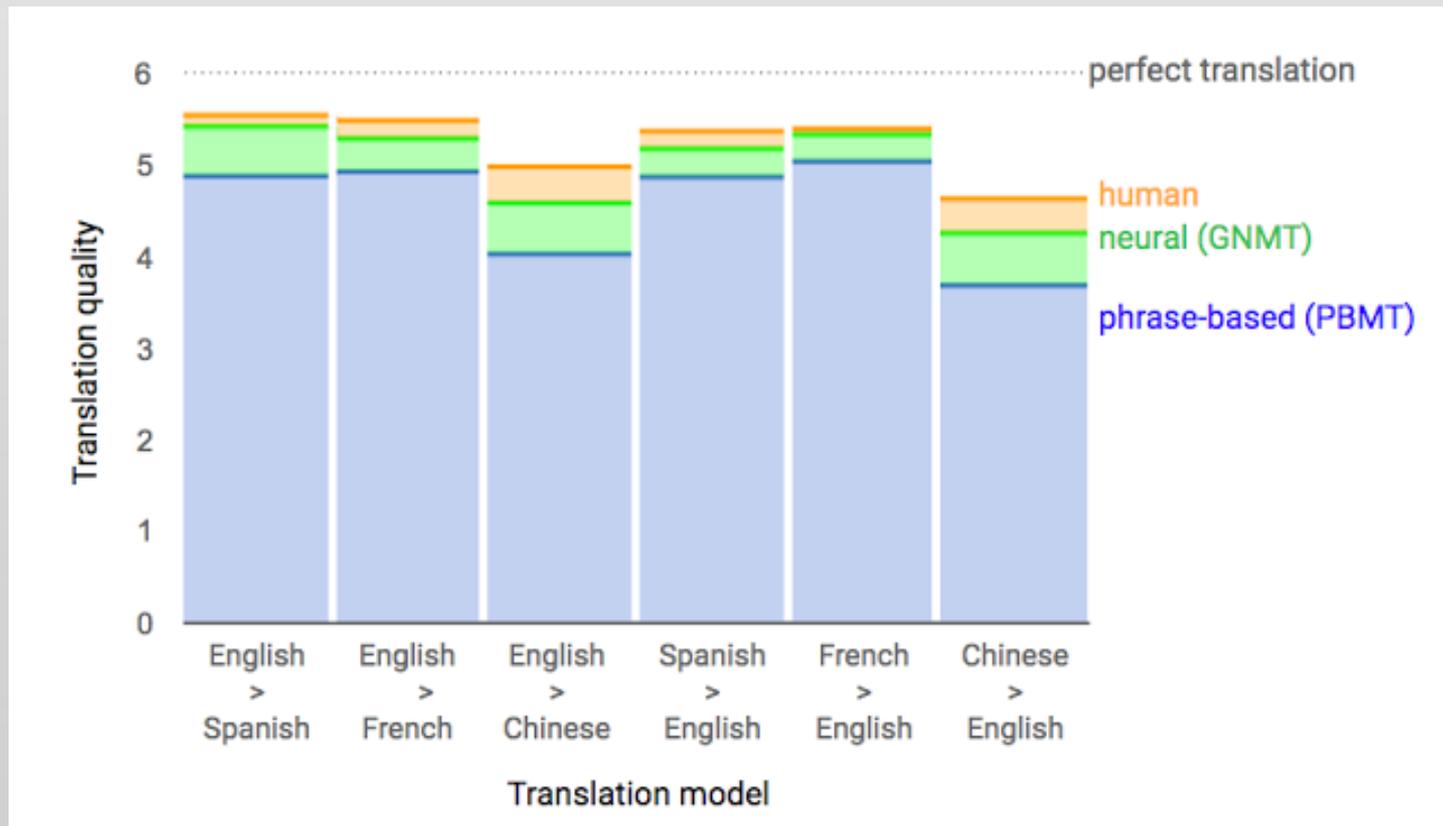
- ▶ The machine predicts a category or a few numbers for each input
- ▶ Predicting human-supplied data
- ▶ **10→10,000 bits per sample**

■ **Unsupervised/Predictive Learning (cake)**

- ▶ The machine predicts any part of its input for any observed part.
- ▶ Predicts future frames in videos
- ▶ **Millions of bits per sample**



# AI Revolution in NLP

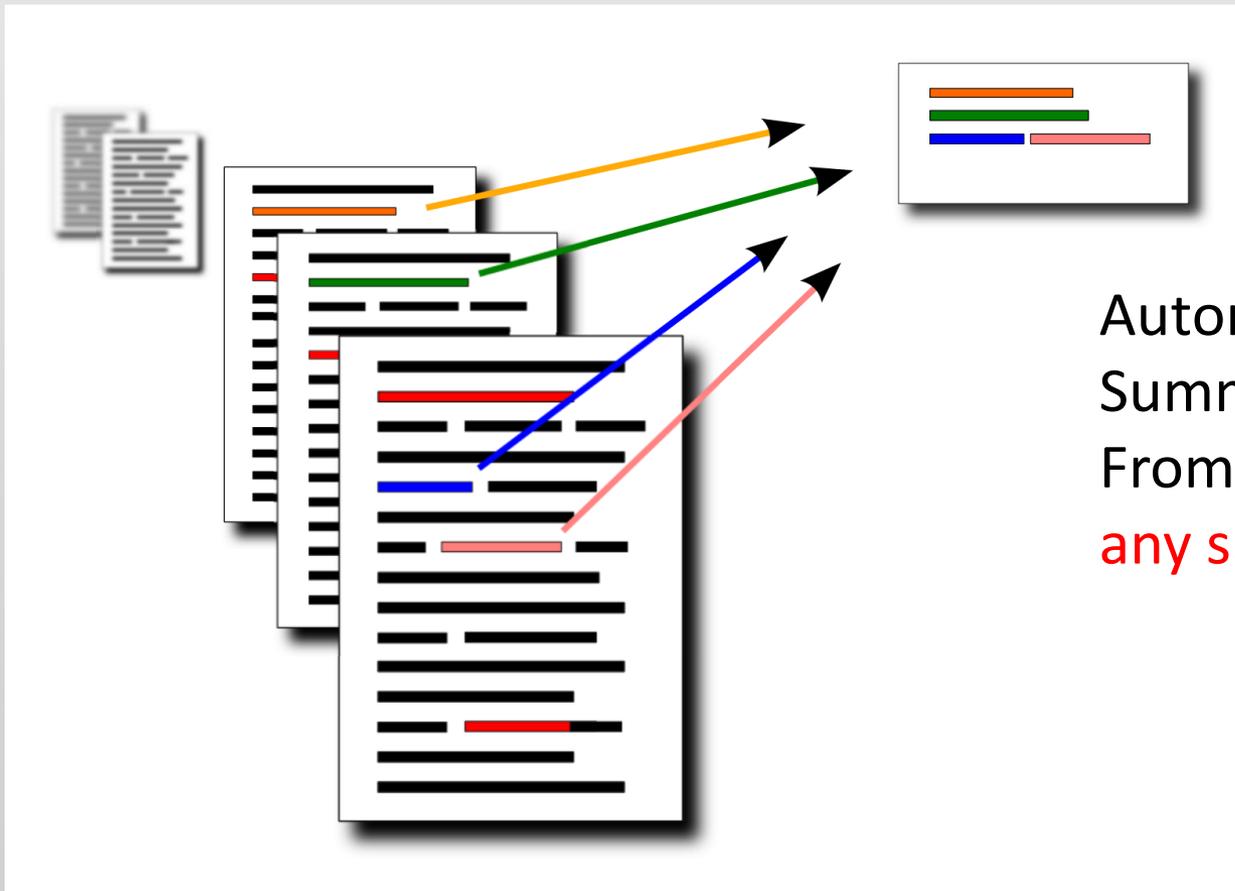


# Google Translate

<i>Input sentence:</i>	<i>Translation (PBMT):</i>	<i>Translation (GNMT):</i>	<i>Translation (human):</i>
<p>李克強此行將啟動中加總理年度對話機制，與加拿大總理杜魯多舉行兩國總理首次年度對話。</p>	<p>Li Keqiang premier added this line to start the annual dialogue mechanism with the Canadian Prime Minister Trudeau two prime ministers held its first annual session.</p>	<p>Li Keqiang will start the annual dialogue mechanism with Prime Minister Trudeau of Canada and hold the first annual dialogue between the two premiers.</p>	<p>Li Keqiang will initiate the annual dialogue mechanism between premiers of China and Canada during this visit, and hold the first annual dialogue with Premier Trudeau of Canada.</p>



# Document summarization



Automatically extract a  
Summary of documents  
From raw text **without**  
**any supervision.**

# Document Summarization

## Summaries

(Approx. 40 words)

### [Multiple Kernel Learning]

The report said Andreas Lubitz repeatedly set the plane for an unauthorised descent earlier that day. He had locked the flight captain out of the cockpit. Five minutes on the Duesseldorf-Barcelona flight 07:21:10 - Plane told to descend to 21,000ft

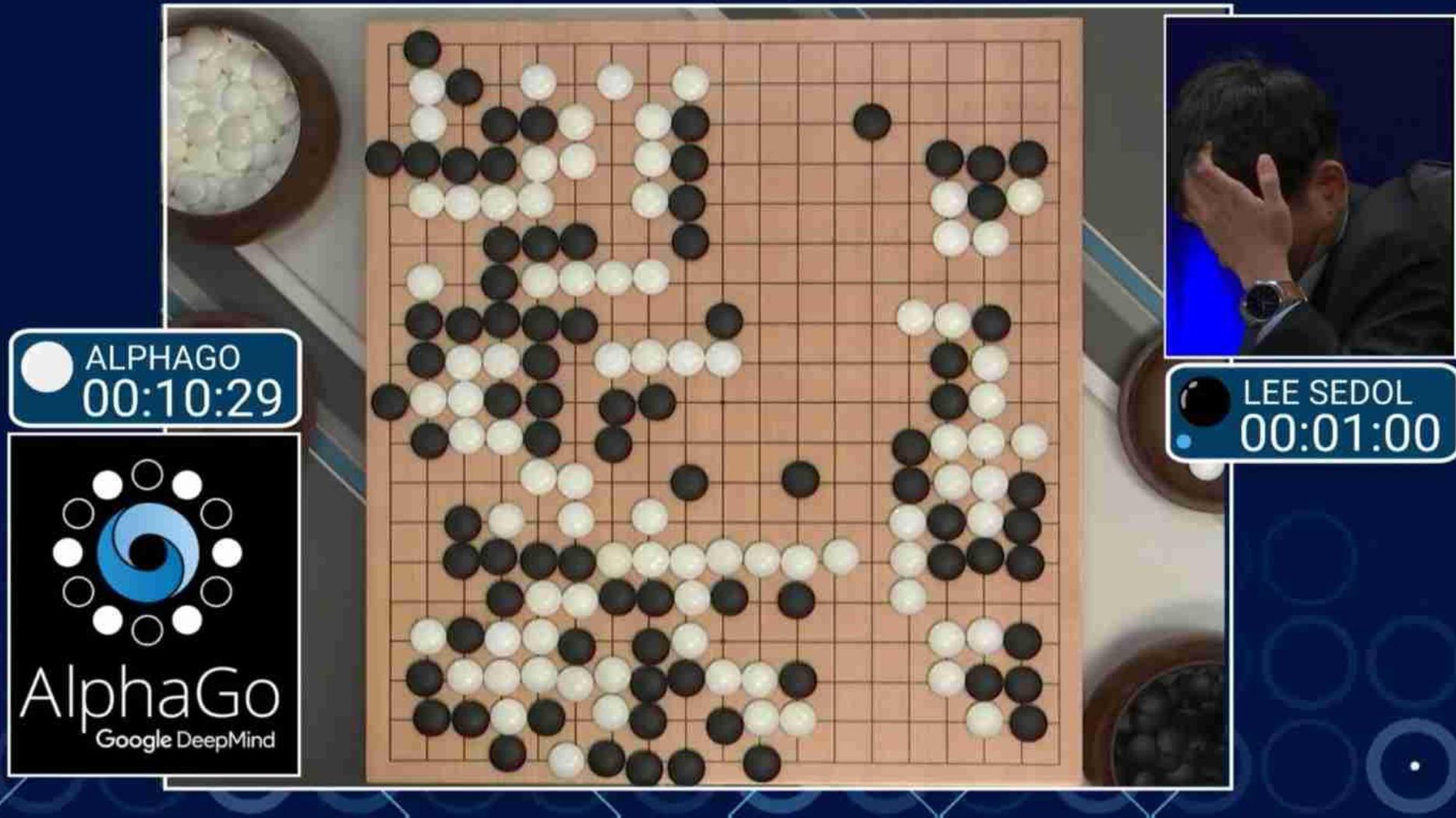
### [TextRank]

The co-pilot of the Germanwings plane that

## Original Text

ness Tech Science Magazine Entertainment & Arts Health In Pictures World selected Africa Asia Australia Europe selected Latin America Middle East US & Canada [Germanwings crash: Co-pilot Lubitz 'practised rapid descent'] 21 minutes ago From the section Europe [Germanwings co-pilot Andreas Lubitz is known to have suffered depression in the past] [Alps plane crash] What drives people to murder-suicide? The victims of the Germanwings plane crash Germanwings: Unanswered questions Flight 4U 9525: The final 30 minutes [[The co-pilot of the Germanwings plane that crashed in the French Alps in March appears to have practised a rapid descent on a previous flight, a report by French investigators says.]] [The report said Andreas Lubitz repeatedly set the plane for an unauthorised descent earlier that day.] Lubitz is suspected of deliberately crashing the Airbus 320, killing all 150 people on board. [[He had locked the flight captain out of the cockpit]] The plane had

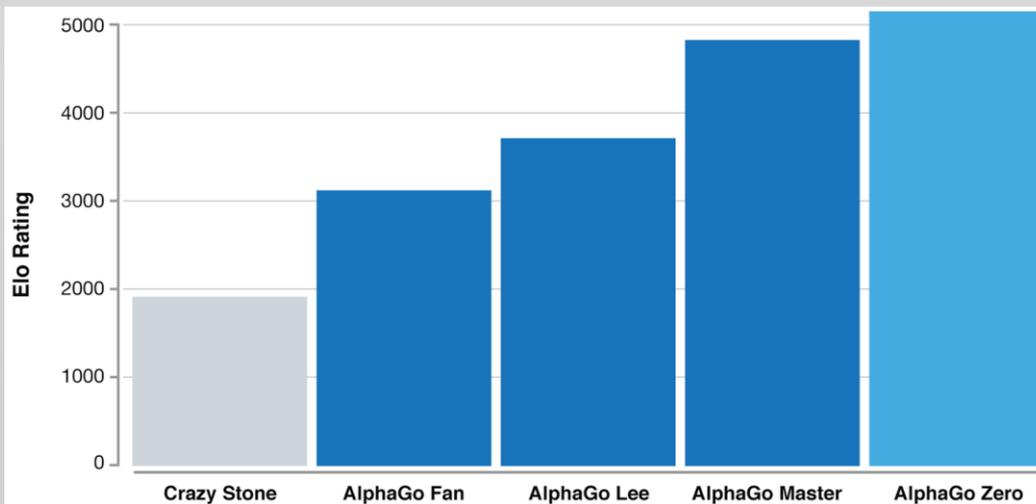
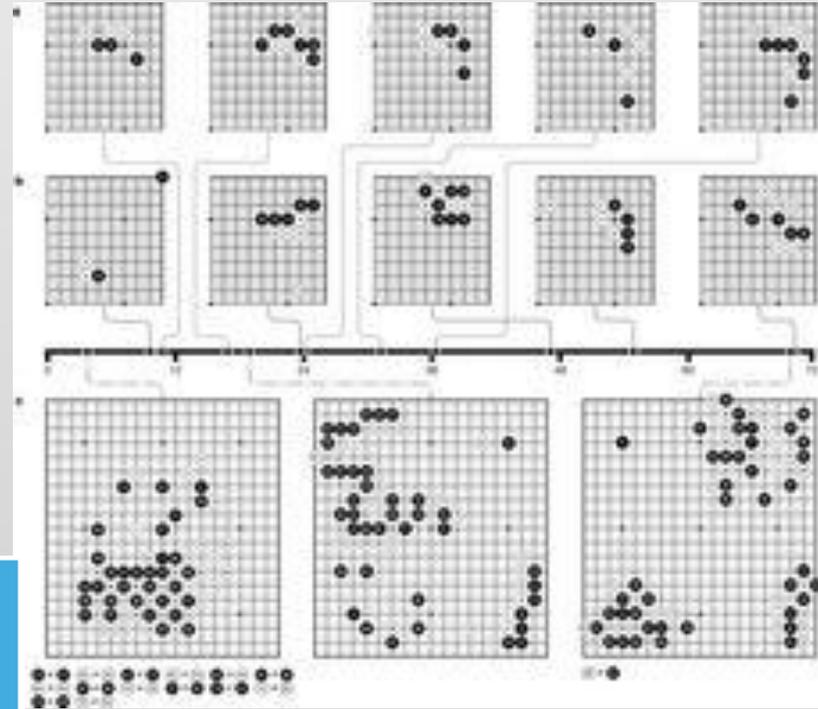
# Reinforcement Learning



A recent documentary:

<https://www.youtube.com/watch?v=WXuK6gekU1Y>

# AlphaGoZero



Trained from scratch **without any Human input** only for 36 hours and beat the previous version 100-0!



# Easy to Use and Improve



PYTORCH



- AI will contribute as much as **\$15.7 trillion** to the world economy by 2030 (PwC)
- \$6.6 trillion from **increased productivity** as businesses automate processes and augment with new AI technology, and \$9.1 trillion from consumption side-effects as shoppers snap up **personalized and higher-quality goods**



**TIME**

SPECIAL EDITION

# Artificial Intelligence

The Future of  
Humankind

