

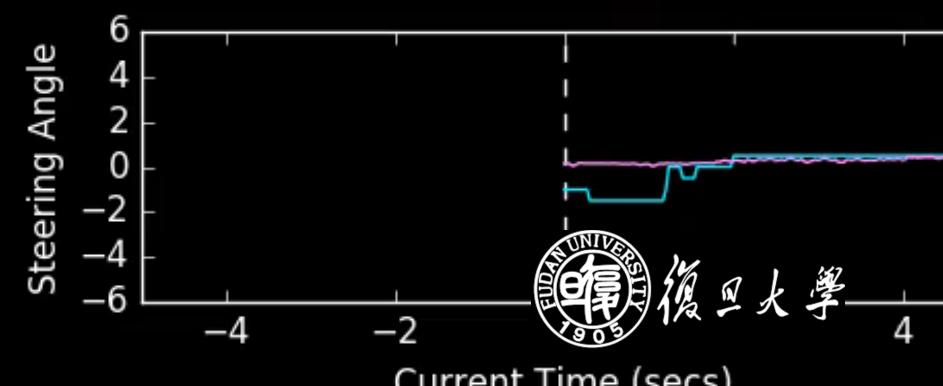
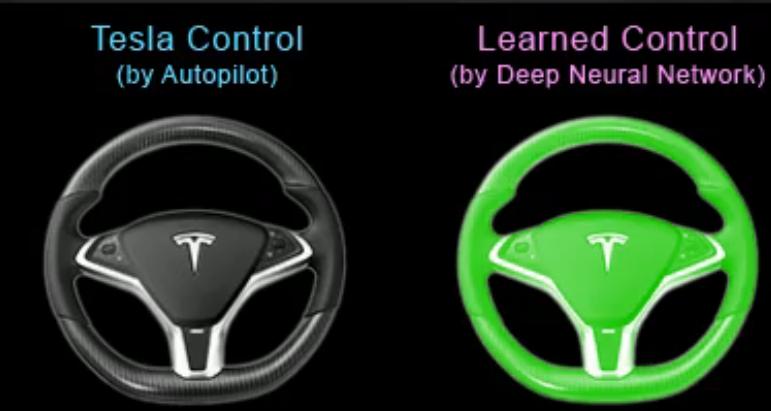
数据驱动的人工智能（1）概述

Data Driven Artificial Intelligence

邬学宁 SAP 硅谷创新中心

2017 / 02

工程硕士系列课程



復旦大學
1905

数据驱动的人工智能（1）概述

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工程硕士系列课程



“2013: Atari 爆发



训练**10**分钟后



训练**120**分钟后



训练**240**分钟后

“人工智能 (Artificial Intelligence) 霸屏”



The New York Times Magazine

The Great A.I. Awakening

How Google used artificial intelligence to transform Google Translate, one of its more popular services — and how machine learning is poised to reinvent computing itself.

BY GIDEON LEWIS-KRAUS DEC. 14, 2016

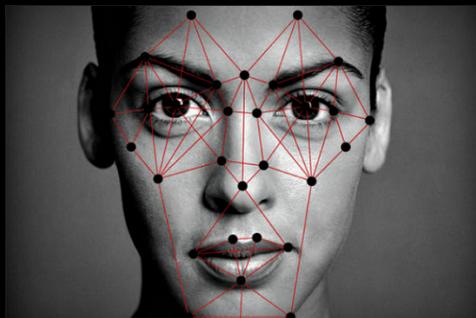
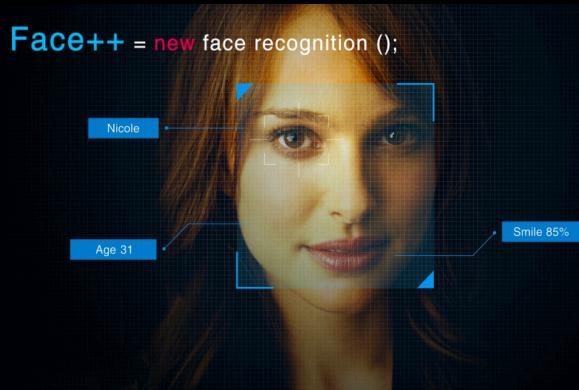


“强化学习目前的弱点

- 定义一个良好的Reward函数不容易... **Coast Runners**: 发现局部高Reward的Pocket, 而忽略了“隐含”的完成比赛的大目标。
- 此外, 定义无人驾驶汽车的reward函数, 可能会导致伦理道德问题...



“人工智能应用(Computer Vision)



Wu Xiaolin, Zhang Xi 2016

Accuracy	False Positive Rate	False Negative Rate
80.23%	21.05%	19.65%

“人工智能应用(Autonomous Vehicle)



	Miles	Diseng	Miles/D	Road type
BMW	638	1	638.0	Likely Highway
Bosch	983	1442	0.7	Interstates/Freeways
GM/Cruise	9 776	181	54.0	Urban
Delphi	3 125	178	17.6	Highway/Urban/Suburban
Ford	590	3	196.7	Highway
Google/Waymo	635 868	124	5128.0	Mostly suburban
Mercedes	673	336	2.0	Urban
Nissan	4 099	28	146.4	Highway/Urban/Suburban
Tesla	550	182	3.0	Highway/Suburban/Unknown

The figure shows a screenshot of the DeepTraffic web application. At the top, there's a header "DeepTraffic" with a subtitle "Americans spend 8 billion hours stuck in traffic every year. Deep neural networks can help!". Below the header is a code editor containing Python code for a reinforcement learning environment. The code defines variables like laneSize, patchesAhead, patchesBehind, trainIterations, and numActions. It also includes logic for calculating num_inputs based on lane size and the number of patches ahead and behind. Buttons at the bottom of the code editor allow users to apply changes, save the code, load a file, or submit the model to a competition.

Code Editor:

```
3 //---[CODE]---  
4 // x The things don't have var in front of them - they update already  
5 // existing variables the game needs  
6 laneSize = 1; //1 / 3  
7 patchesAhead = 1; //1 / 3;  
8 patchesBehind = 0; //1 / 3;  
9 trainIterations = 100000;  
10  
11 // begin from convertJ example  
12 var num_inputs = (laneSize - 2 + 1) * (patchesAhead + patchesBehind);  
13 var num_actions = 2;  
14 var temporal_window = 3; //1 // amount of temporal memory. 0 = agent lives  
15 // in-the-moment  
16 var network_size = num_inputs * temporal_window * num_actions *
```

Buttons:

- Apply Code/Reset Net
- Save Code/Net to File
- Load Code/Net from File
- Submit Model to Competition

Below the code editor is a visualization of a traffic simulation. It shows a grid of cars on a road with a red light at an intersection. A progress bar indicates the simulation has run for 290 steps. On the left, there are sliders for "Speed" (set to 80 mph), "Cars Passed:" (set to 290), and "Lane Overlay:" (set to "None").

Below the visualization is a chart titled "Start Evaluation Run". The chart plots "Value Function Approximating Neural Network" against "Input(135)". It shows four series: "fc1(10)", "relu(fc1(10))fc2(5)", "regression(5)", and "Input(135)". Each series is represented by a different colored bar chart.

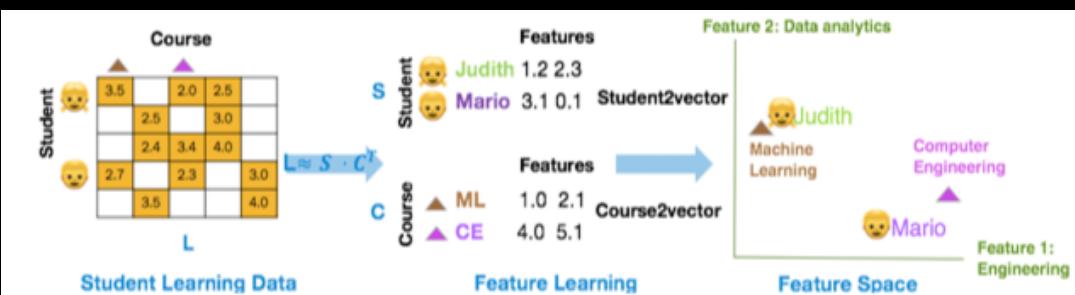
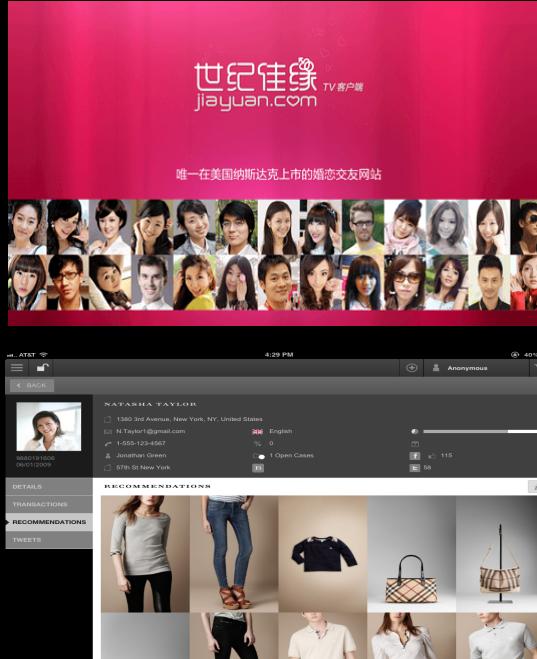
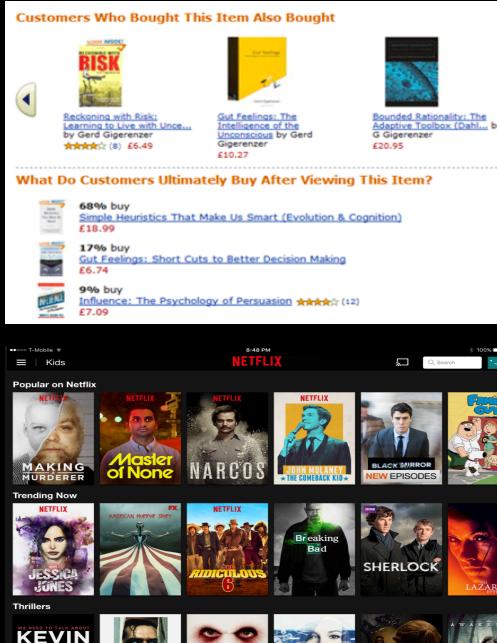


ALVINN, Dean Pomerleau, 1989, CMU

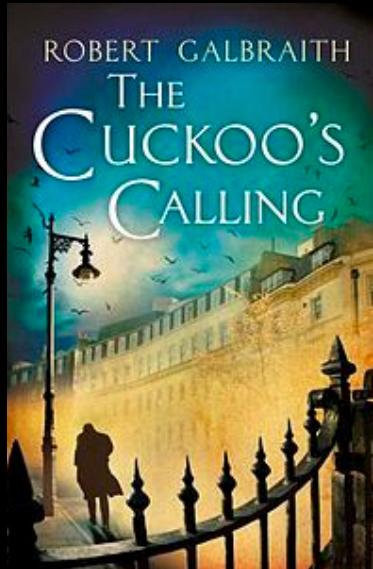
- 本课程获MIT无人驾驶课程授权
 - Courtesy to Lex Fridman and MIT6.S094 TAs



“人工智能应用(Recommendation System)



“人工智能应用(Natural Language Processing)



Hi, I'm Cortana.



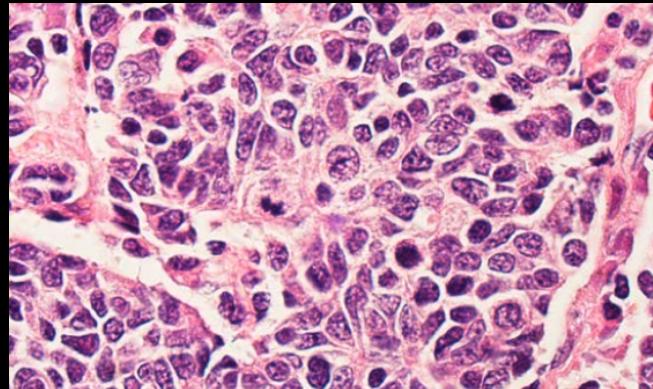
Alexa



Palantir

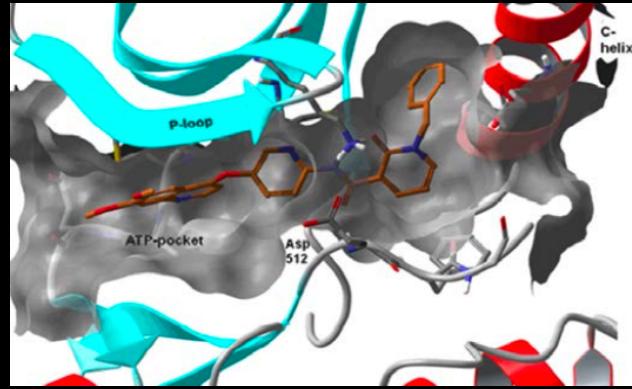


“人工智能应用(Personalized Medicine)



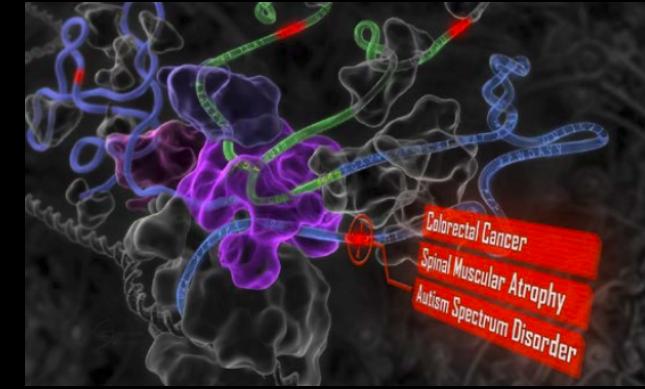
乳腺癌细胞有丝分裂侦测

- IDSIA



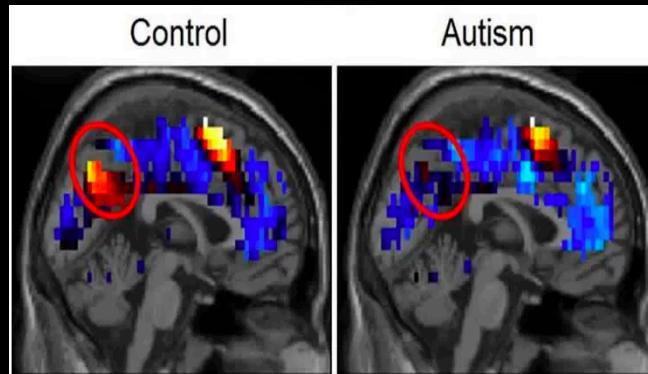
预测新药物的毒性

- Johannes Kepler University

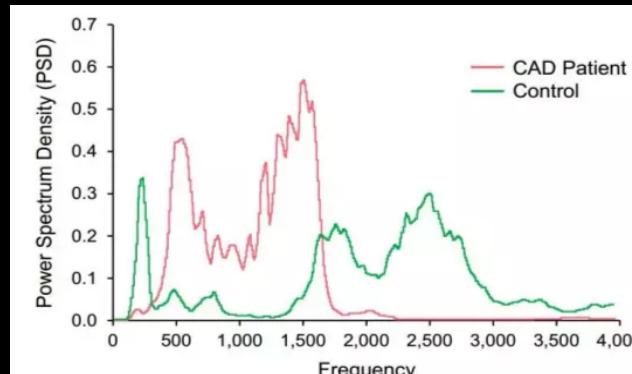


理解基因突变预防疾病

- University of Toronto



Credit: Carnegie Mellon University



语音冠心病诊断

- Beyond Verbal



“人工智能应用(Robot)



斯坦福无人直升机



復旦大學



“人工智能应用(Assistant or Killer?)

Story #1

► Denny's Corporation on Monday reported first-quarter profit of 8.5 million dollars. The Spartanburg, South Carolina-based company said it had profit of 10 cents per share. The results beat Wall Street expectations. The average estimate of four analysts surveyed by Zacks Investment Research was for earnings of 9 cents per share. The restaurant operator posted revenue of \$120.2 million in the period, also beating Street forecasts. Three analysts surveyed by Zacks expected \$117.1 million. Denny's shares have risen nearly 6 percent since the beginning of the year. In the final minutes of trading on Monday, shares hit \$10.90, a climb of 61 percent in the last 12 months.

Story #2

► Denny's Corporation notched a grand slam of its own in the first quarter, earning a better-than-expected ten cents a share, as restaurant sales jumped by more than 7-percent. Operating revenues topped \$120 million. Adjusted net income jumped 36 percent to \$8.7 million. Denny's is one of the nation's largest full-service restaurant chains. The growth in sales suggests consumers are opening their pocketbooks for pancakes, eggs, and hash browns. Earnings were also helped by lower costs for raw materials. Denny's results were also helped by the re-opening of the high-volume location inside the Las Vegas Casino Royale restaurant. After sales grew faster than expected in the first three months of the year, managers raised their sales forecast for the remainder of 2015.



Machine Intelligence

Source: Automated Insight
Credit: Quoctrung Bui / NPR

Scott Horsley V.S. Wordsmith



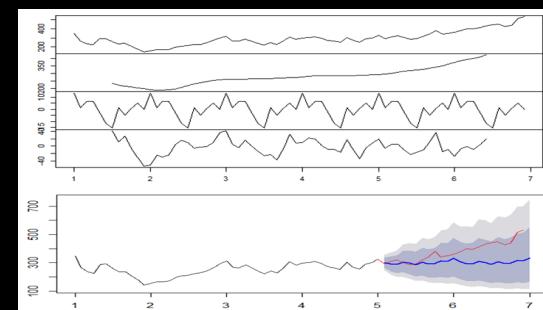
“人工智能应用(Finance)



个性化保险政策



信用卡反欺诈

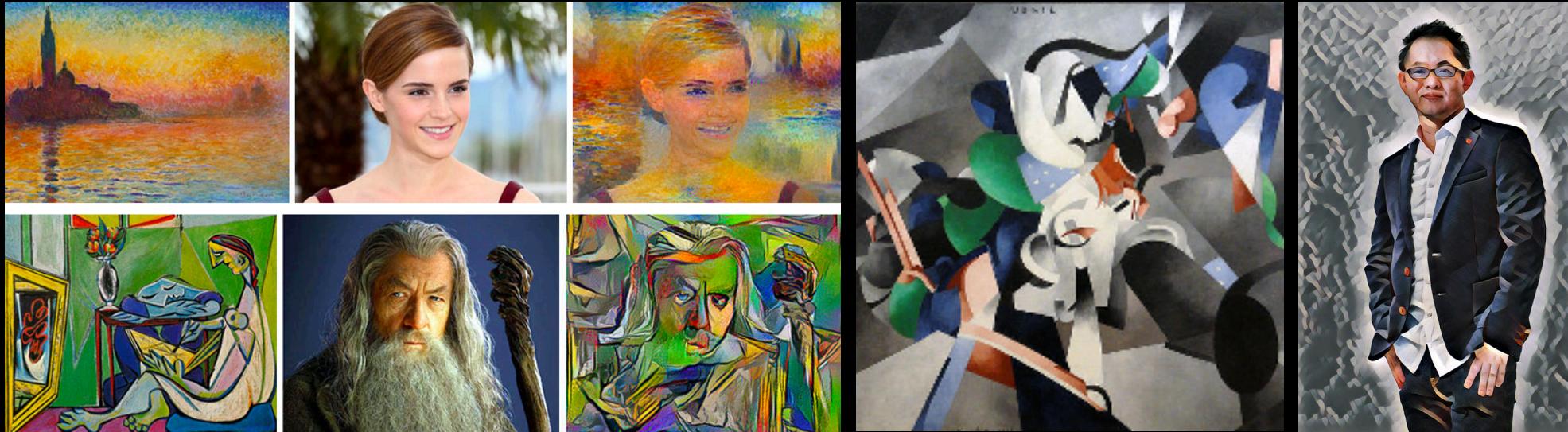


Google股价预测

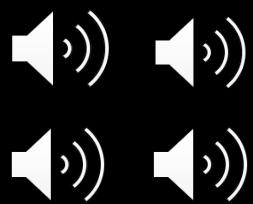
Oct. 3, 2008 — *Rachel Getting Married* opens: BRK.A up .44%
Jan. 5, 2009 — *Bride Wars* opens: BRK.A up 2.61%
Feb. 8, 2010 — *Valentine's Day* opens: BRK.A up 1.01%
March 5, 2010 — *Alice in Wonderland* opens: BRK.A up .74%
Nov. 24, 2010 — *Love and Other Drugs* opens: BRK.A up 1.62%
Nov. 29, 2010 — Anne announced as co-host of the Oscars: BRK.A up .25%

Anne Hathaway / 机器交易

“人工智能应用(Art): When Program becomes Programmer



Leon A. Gatys, Alexander S. Ecker, Matthias Bethge



Michelangelo's 'Creation of Adam' as seen through Google's Deep Dream
Kyle McDonald, Flickr CC-BY-2.0



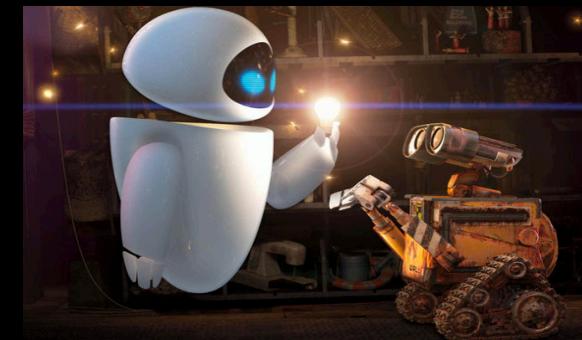
秋雁

一声秋雁连天远，
万里归帆隔水遥，
惆怅旧游零落处，
白头萧瑟满江桥。

Xiaoyuan Yi & Ruoyu Li & Maosong Sun



“什么是人工智能? (Artificial Intelligence)



“课程目录

Lecture 1: Artificial Intelligence Overview

Lecture 2: Machine Learning Foundation

Lecture 3: Deep Learning

Lecture 4: Reinforcement Learning

Lecture 5: Probabilistic Graphic Model

Lecture 6: Natural Language Processing

Lecture 7: Industry 4.0 / Exam



“ 定义人工智能 (AI)

“Intelligence: The ability to learn and solve problems.”

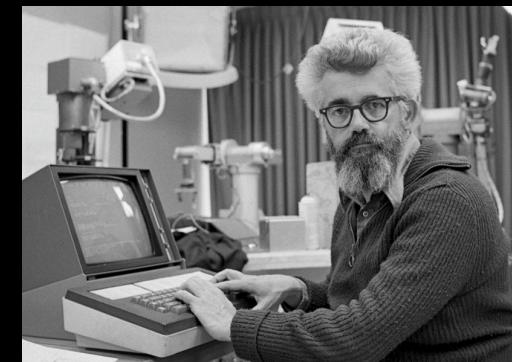
Webster Dictionary

Artificial intelligence: The intelligence exhibited by machine or software.

Wikipedia

Artificial intelligence: It is the science and engineering of making intelligent machines, especially computer programs.

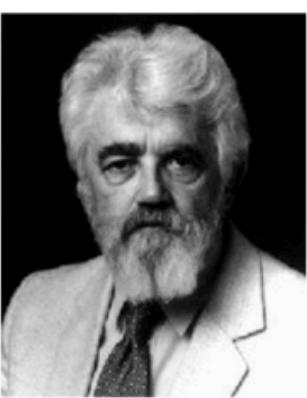
John McCarthy



“人工智能之父：达特茅斯会议

会议联合发起人，神经网络学派先驱 信息论发明者

会议发起人，率先使用
AI作为术语



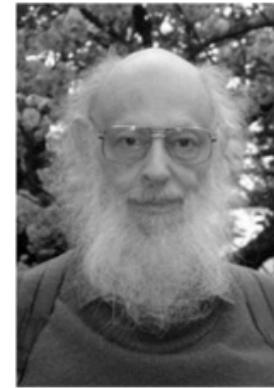
John McCarthy



Marvin Minsky



Claude Shannon



Ray Solomonoff

致力于使用概率方法实现AI



Alan Newell



Herbert Simon



Arthur Samuel

And three others...

Oliver Selfridge
(Pandemonium theory)

Nathaniel Rochester
(IBM, designed 701)

Trenchard More
(Natural Deduction)

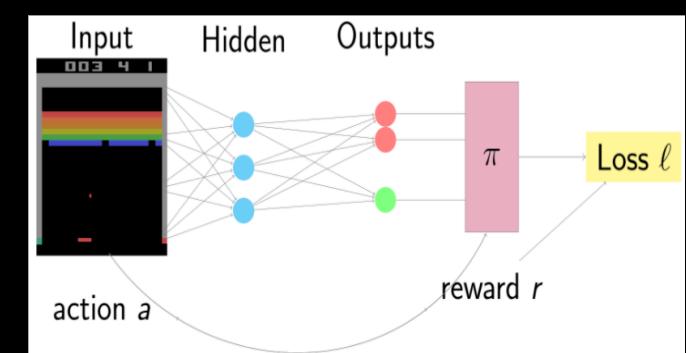
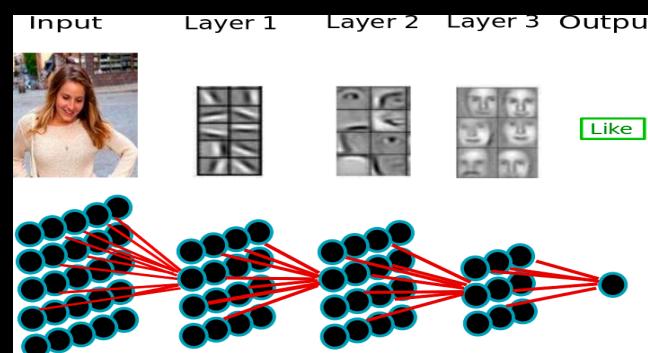
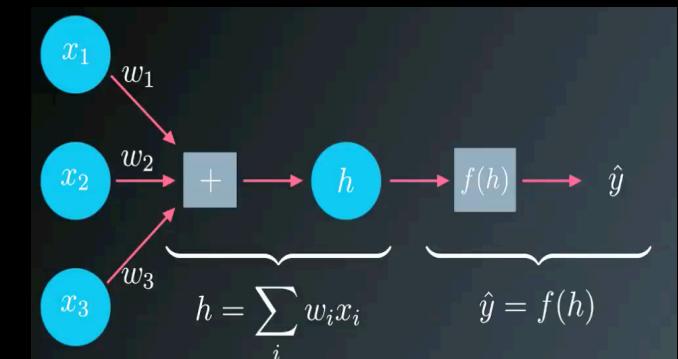
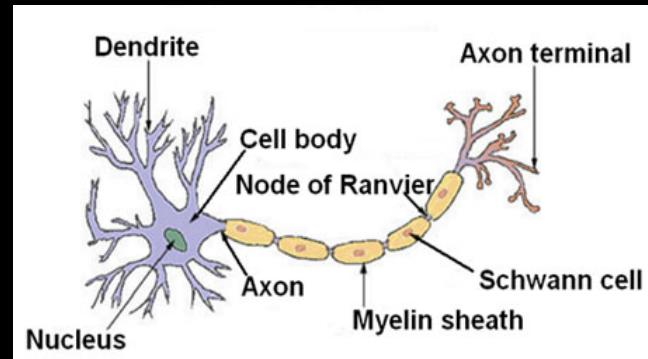
“人工智能是交叉学科

- 哲学
 - 450 BC , Socrates 提出使用算法分辨虚伪与不虚伪的人
 - Aristotle 提出逻辑推理的规则
- 数学、统计学（统计力学）
 - 1847年，George Boole引入了进行逻辑推断的形式语言
 - 概率图模型（PGM）
- 经济学
 - 1776年，Adam Smith将经济看为个体（Agent）自身利益最大化的集合
- 神经科学
 - 1861年，Paul Broca 研究大脑如何处理信息
 - 视觉的形成机制
 - 神经元
- 心理学
 - 1879年，Wilhelm Wundt建立首个心理学实验室
- 语言学
 - 1957年，Skinner 使用行为主义的方法来研究语言学习



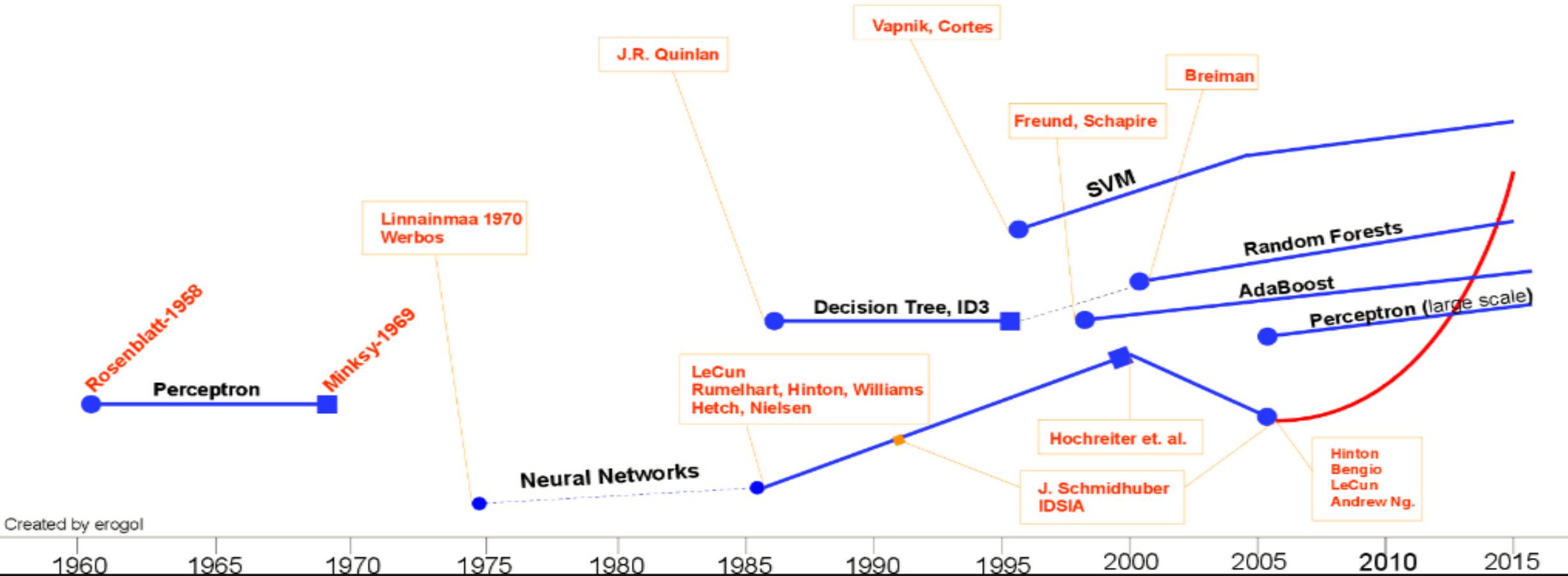
“人工智能简史

- 1940-1950: AI启蒙
 - McCulloch & Pitts
 - 图灵计算机器与智能
- 1950-1970: 首次热潮
 - Samuel 的象棋程序
 - Dartmouth会议
- 1970-1990: 基于知识的AI
 - 专家系统
 - 神经网络回归 (BP)
 - 2次明显的AI冬季
- 1990-现在: 统计方法
 - 概率图模型 (PGM)
 - SVM & Boosting
- 2010-现在 : AI春天
 - 神经网络再次回归 (Deep Learning)
 - 强化学习 : 强人工智能 (AGI) 的拐点



机器学习算法简史

Subjective Popularity



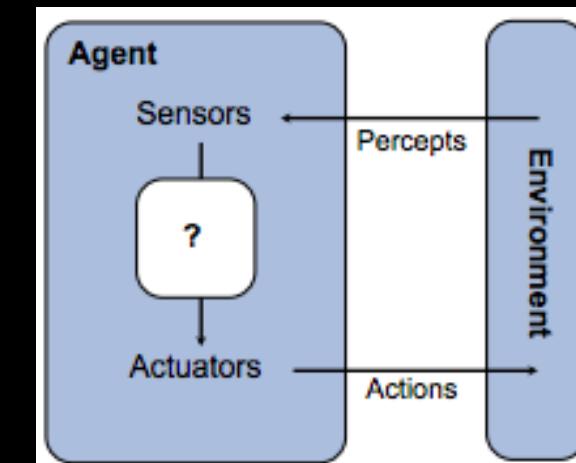
“ 定义人工智能 (AI)

AI是一门科学，使机器能够：

	Human	Rationally
Think	像人一样思考（尚不清楚）	理性思考（正确思考）
Act	像人一样行动（图灵测试）	理性行动 ★★★

关于“理性”的说明：

- 最大化实现预定的目标
- 仅与决策相关（非思考过程）
- 目标以结果的Utility（测量结果的好坏）来表达
- “Being Rational”意味着最大化期望的Utility



An agent is an entity that perceives and acts.

“ 定义人工智能 (AI)

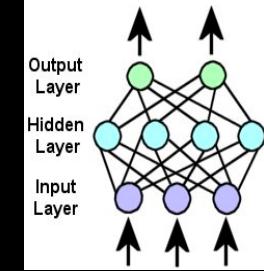
ALGORITHMS enables by
CONSTRAINTS exposed by
REPRESENTATION that support
MODELS targeted at
THINKING, PERCEPTION, ACTION



“人工智能方法分类

Connectionism: represents information in a distributed, less explicit form within a network.

模仿生物学习和解决问题的过程。



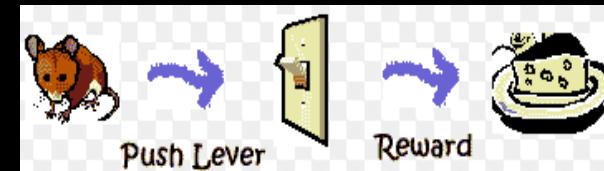
Symbolic: represents information through symbols and their relationship.

通过使用特定的算法来处理符号（symbol），以解决问题或演绎新的知识。



Behaviorism: a systematic approach to the understanding of human and animal behavior.

假定行为的产生是因为环境的刺激所产生的反馈，或是个体的历史所导致的结果，例如控制论和强化学习。



“人工智能方法分类

Evolutionary: inspired by biological evolution and natural selection.



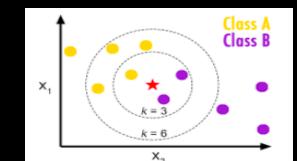
遗传算法等借鉴生物界自然选择和基因突变与遗传搜索最优解的算法。

Bayesian: reasoning under uncertainty with Bayesian philosophy (Adapt posterior with new facts.)

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

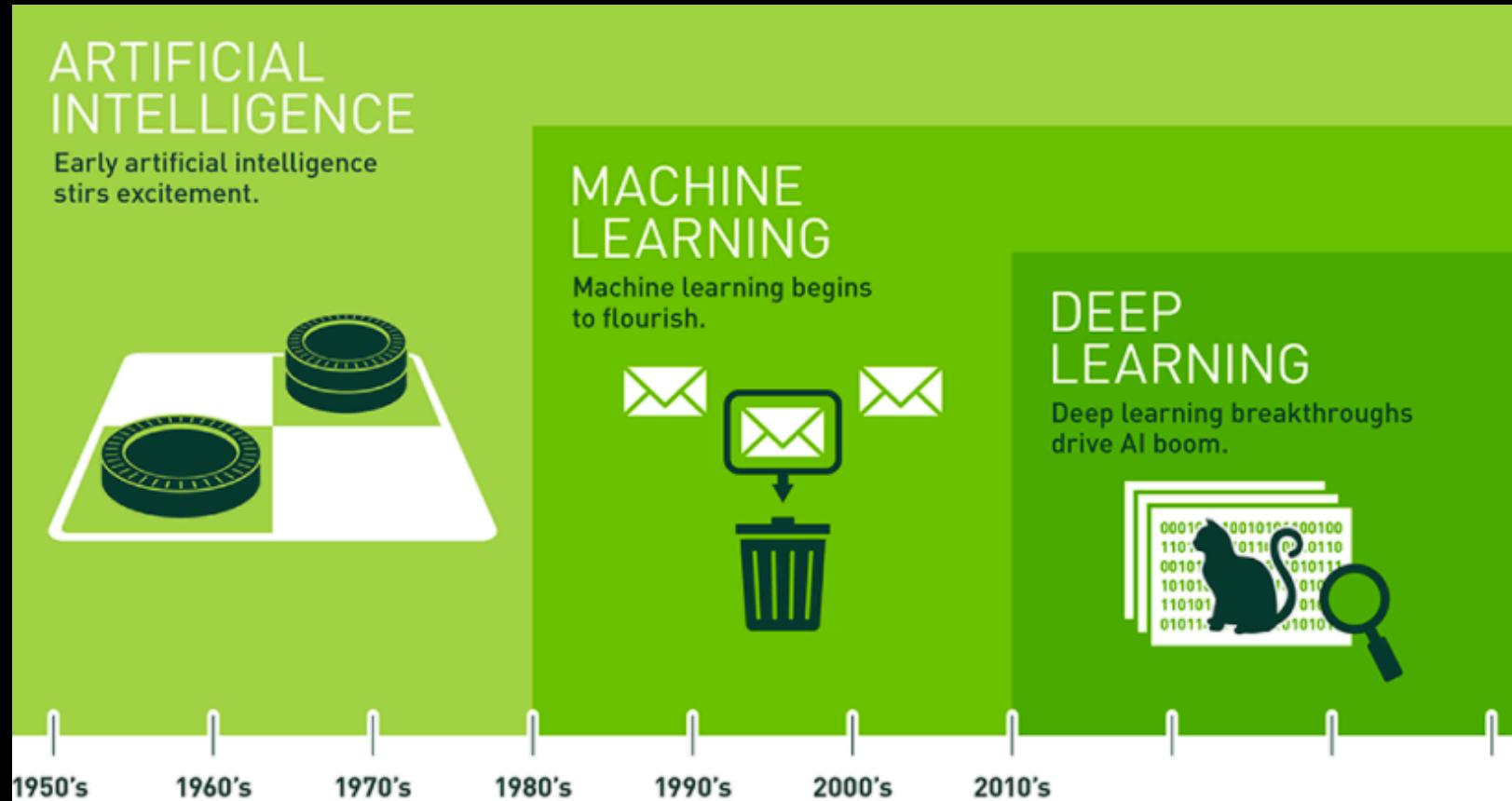
某些AI需要在不确定的环境下进行决策，基于贝叶斯的方法提供了基于小数据进行决策的有效途径。

Analogizer: focuses on techniques to match bits of data to each other.



专注于将某一数据与其他‘最邻近’的数据进行类比，KNN，SVM是这类算法的代表，很多推荐系统（Amazon）也属于该类。

“人工智能 / 机器学习 / 深度学习



Source : Nvidia



“深度学习领导者”



Yann LeCun, Geoff Hinton, Yoshua Bengio, Andrew Ng, at NIPS 2014 (Source : Andrew Ng's Facebook page).

“什么是学习?



Learning is any process by which a system improves performance from experience.

-- Herbert Simon



When Activity were repeated, the connections between those neurons strengthened, this repetition was what led to the formation of memory.

-- Donald Hebb , 1949

“什么是机器学习?

“Field of study that gives computers the ability to learn without being explicitly programmed.”

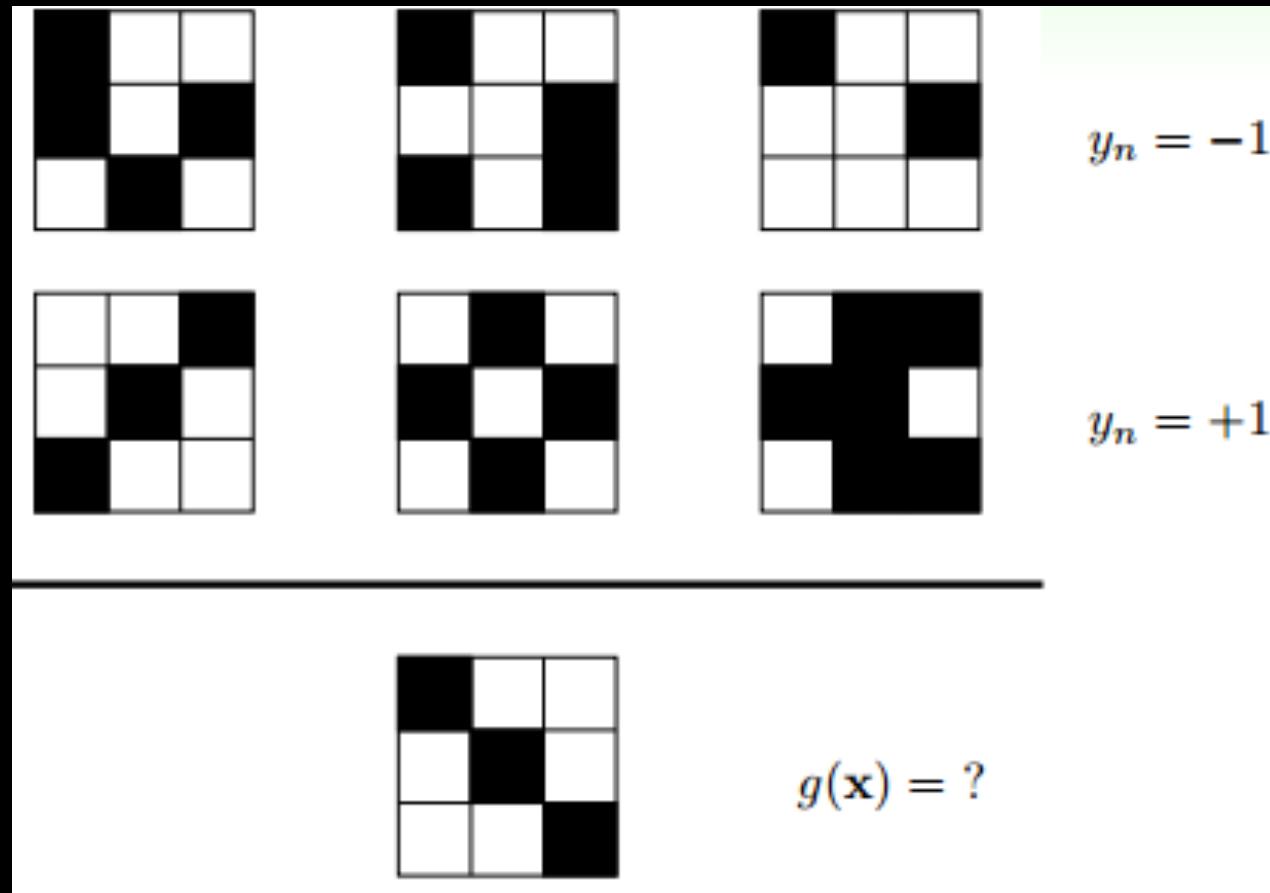
-- Arthur Samuel



“The field of machine learning is concerned with the question of how to construct computer programs that automatically improve with experience.”

-- Tom Mitchell

“绝对的学习是可能的吗?



Source: learn from data, Yaser S. Abu-Mostafa, Malik Magdon-Ismail, Hsuan-Tien Lin

“绝对的学习是可能的吗?

\mathbf{x}_n	$y_n = f(\mathbf{x}_n)$	\mathbf{x}	y	g	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8
000	o	0 0 0	o	o	o	o	o	o	o	o	o	o
001	x	0 0 1	x	x	x	x	x	x	x	x	x	x
010	x	0 1 0	x	x	x	x	x	x	x	x	x	x
011	o	0 1 1	o	o	o	o	o	o	o	o	o	o
100	x	1 0 0	x	x	x	x	x	x	x	x	x	x
		1 0 1	?	o	o	o	o	x	x	x	x	x
		1 1 0	?	o	o	x	x	o	o	x	x	x
		1 1 1	?	o	x	o	x	o	x	o	x	x

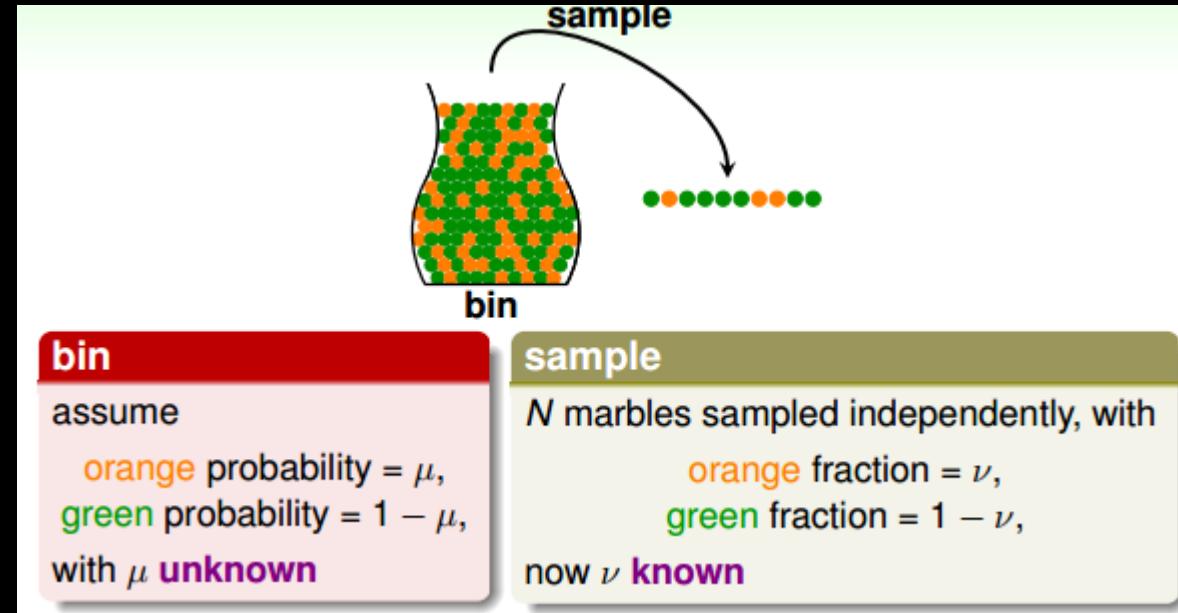
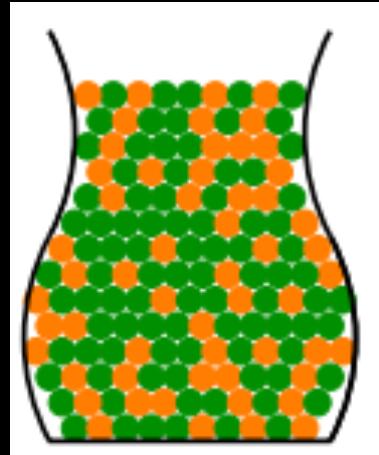
$$(5, 3, 2) \rightarrow 151022, \quad (7, 2, 5) \rightarrow ?$$



Source: learn from data, Yaser S. Abu-Mostafa, Malik Magdon-Ismail, Hsuan-Tien Lin



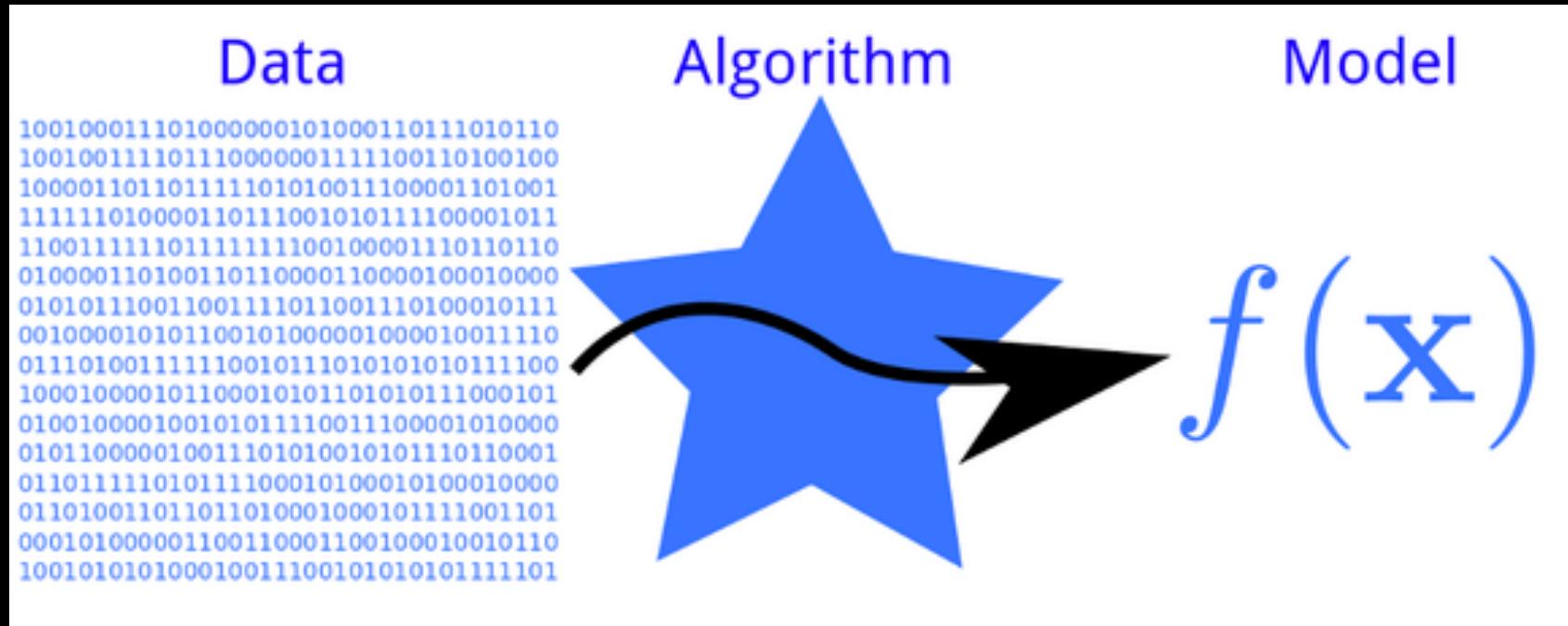
“概率来救场!! (Hoeffding Inequity)



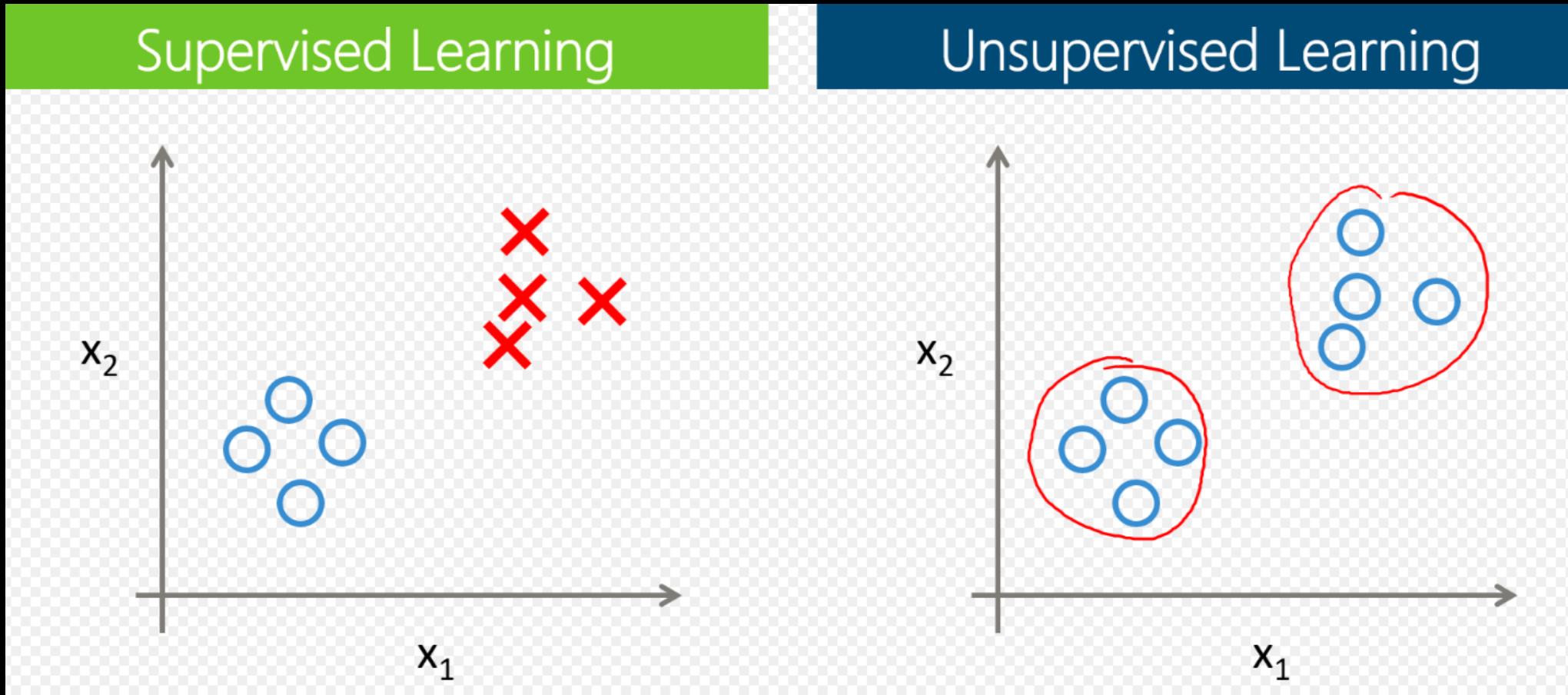
- in big sample (N large), ν is probably close to μ (within ϵ)

$$\mathbb{P} [|\nu - \mu| > \epsilon] \leq 2 \exp(-2\epsilon^2 N)$$

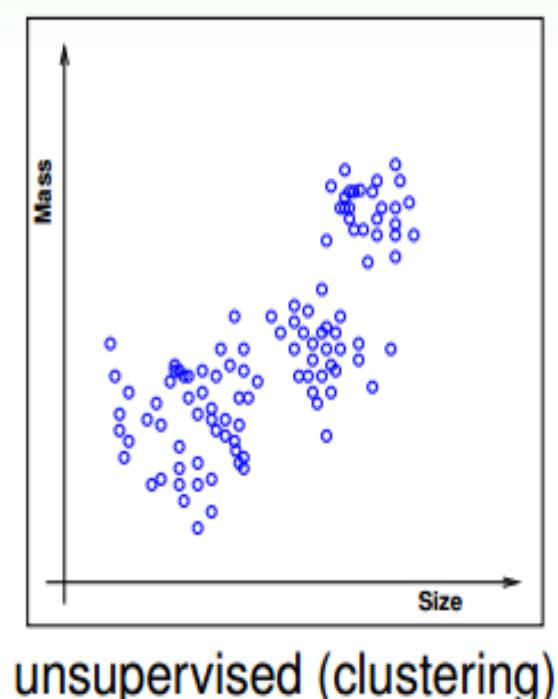
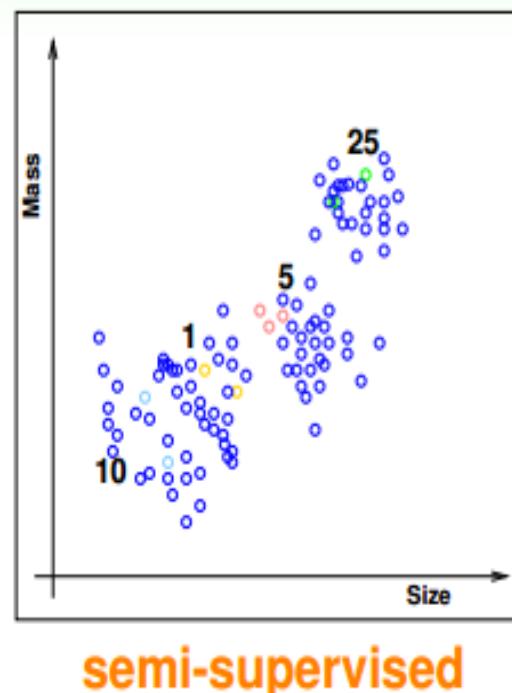
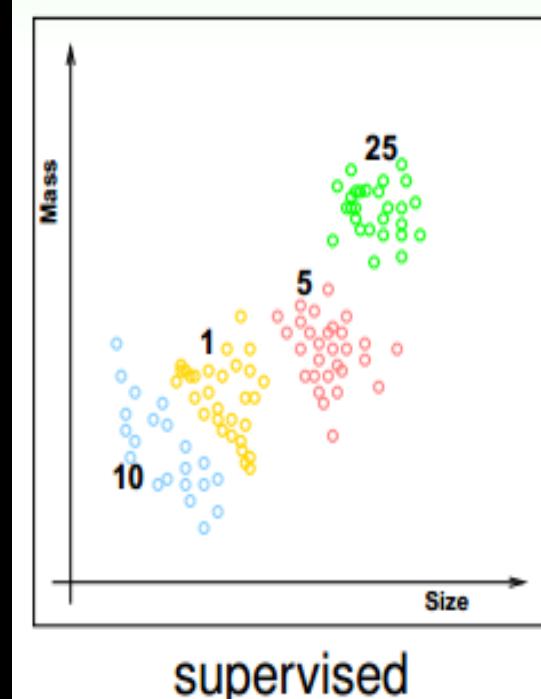
“什么是机器学习？



“机器学习分类：监督式学习与非监督式学习



“半监督学习



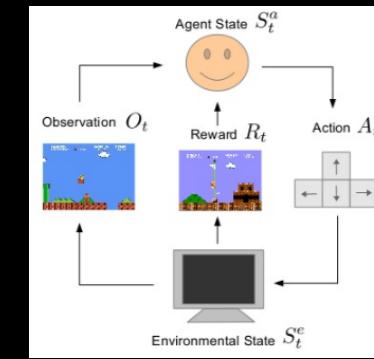
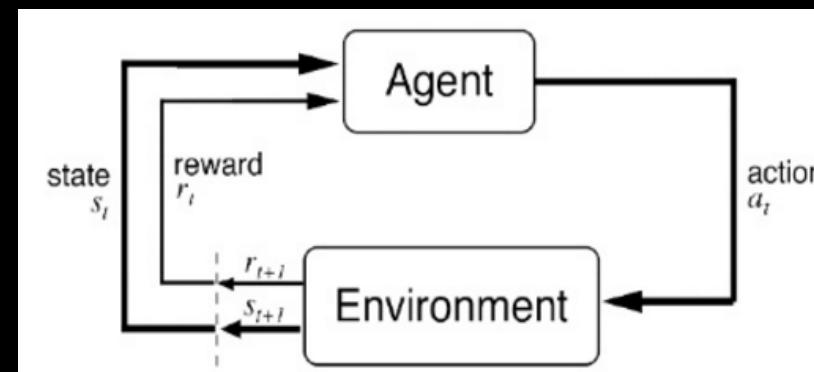
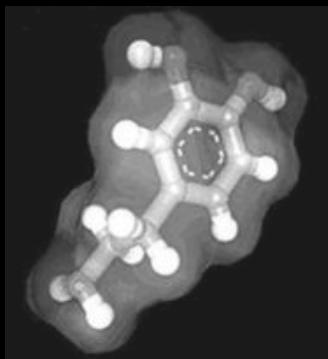
“机器学习分类：强化学习

Supervised learning : 任务驱动 (Classification)

Unsupervised learning : 数据驱动 (Clustering)

Reinforcement learning :

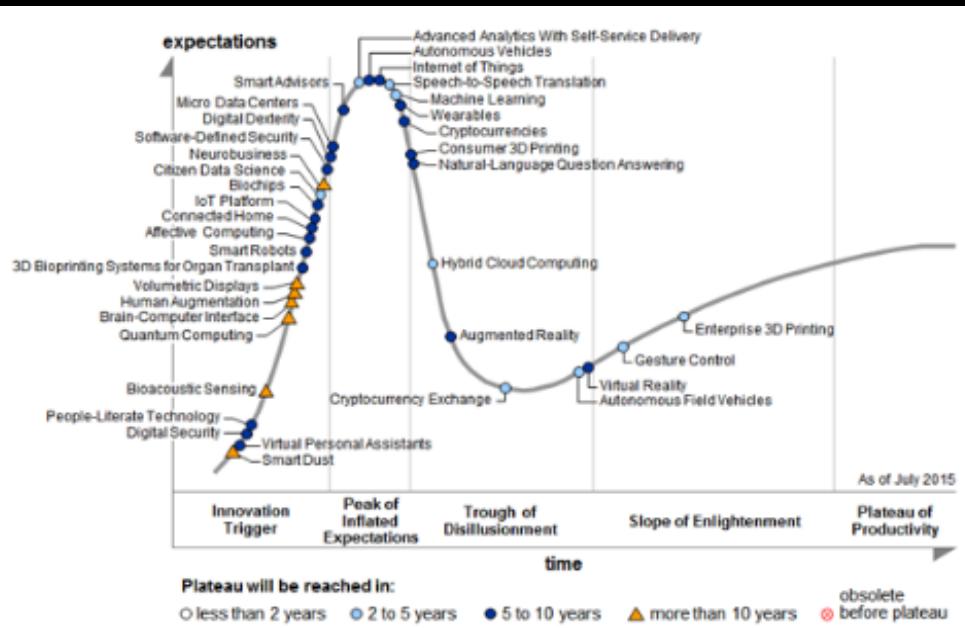
- 更接近人类的学习过程；
- Actions 对环境产生影响，环境产生(延时的) rewards 来更新强化学习算法的参数；
- Agent 通过在动态环境中，通过试错交互来进行行为的学习；
- Agent 通过学习了解如何动作，以最大化reward；
- Temporal Difference (TD学习) : Dopamine



“ Gartner技术曲线：大数据Out, 机器学习In

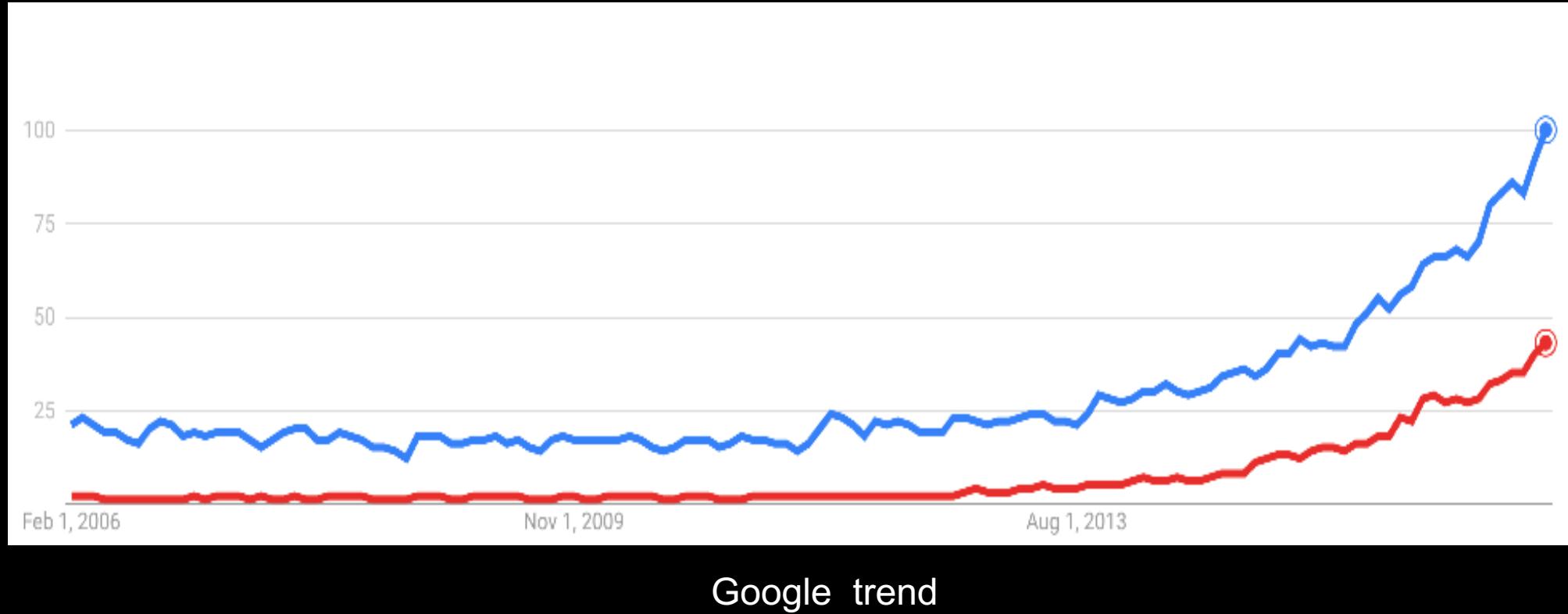


2014



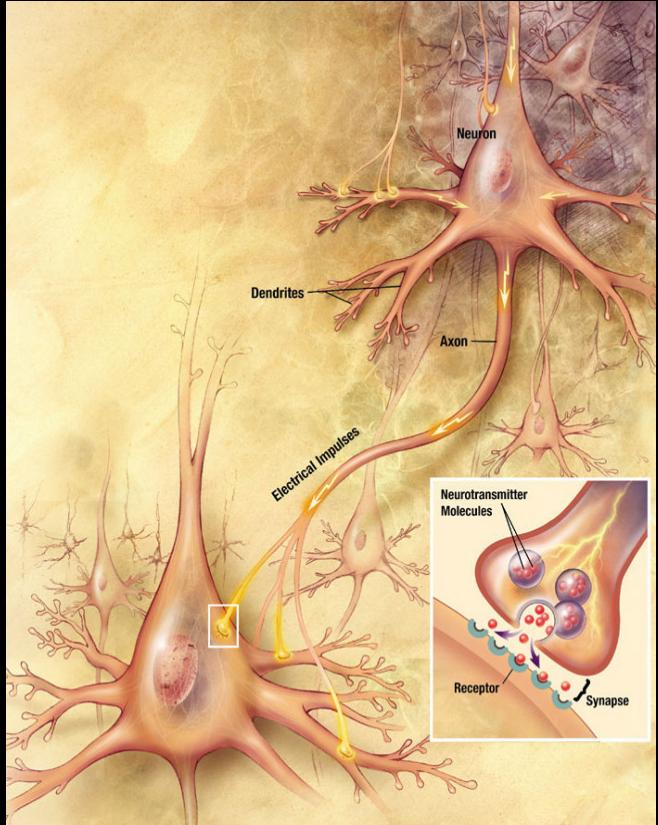
2015

“机器学习 / 深度学习Google搜索趋势

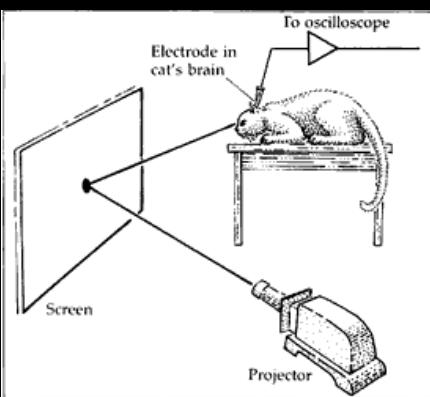
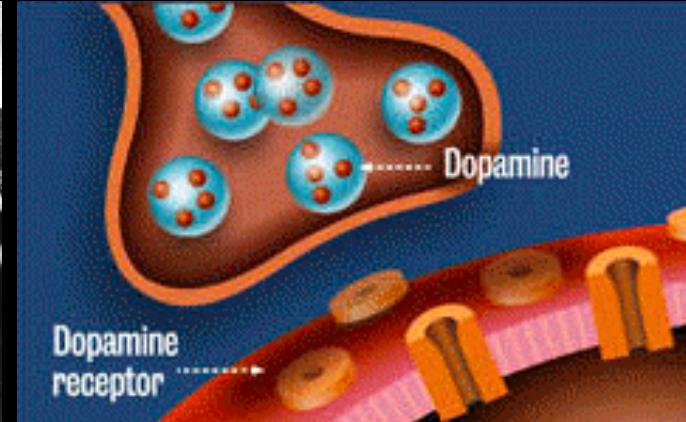


“认知科学发展对AI的影响”

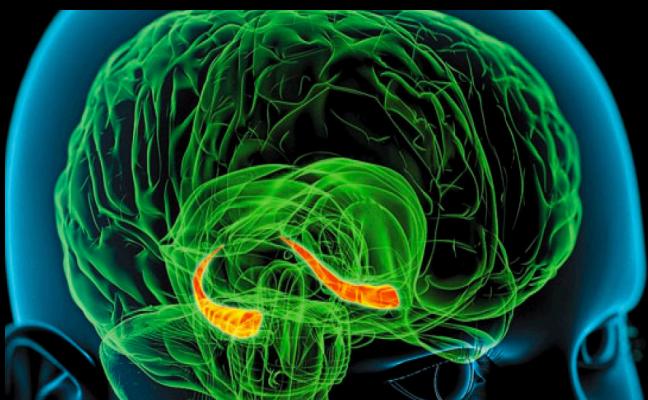
Neuron Dendrites and Axon



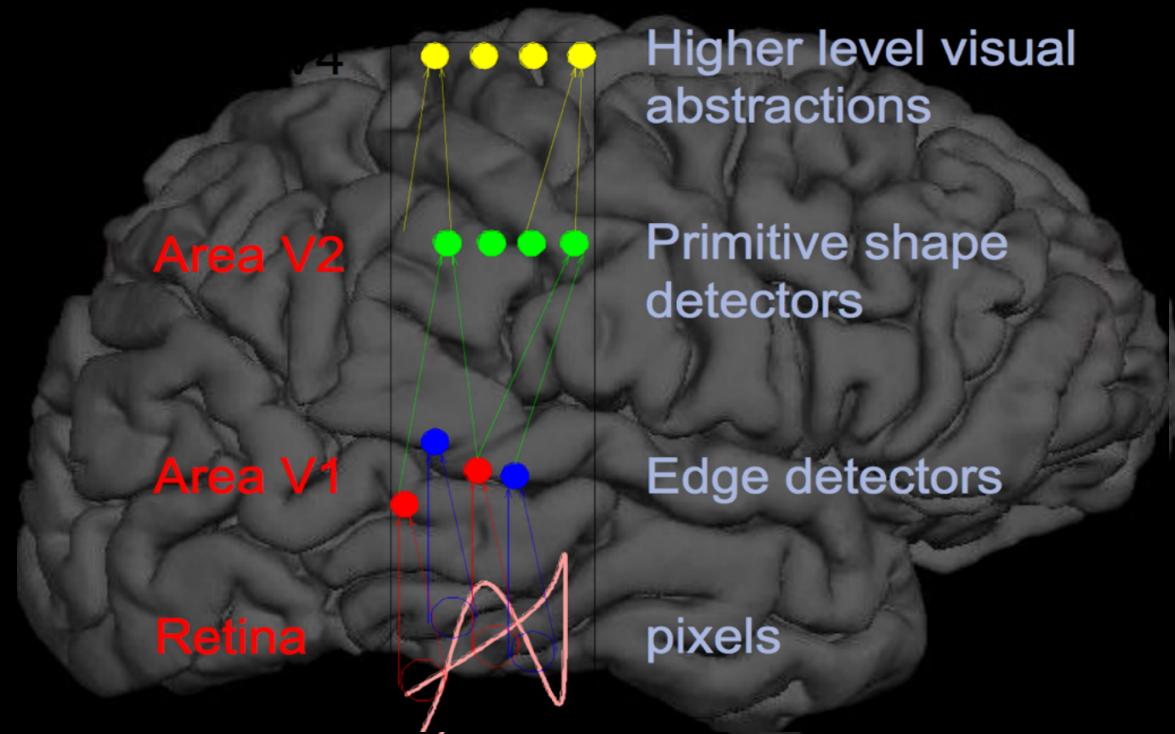
Hubel & Wiesel



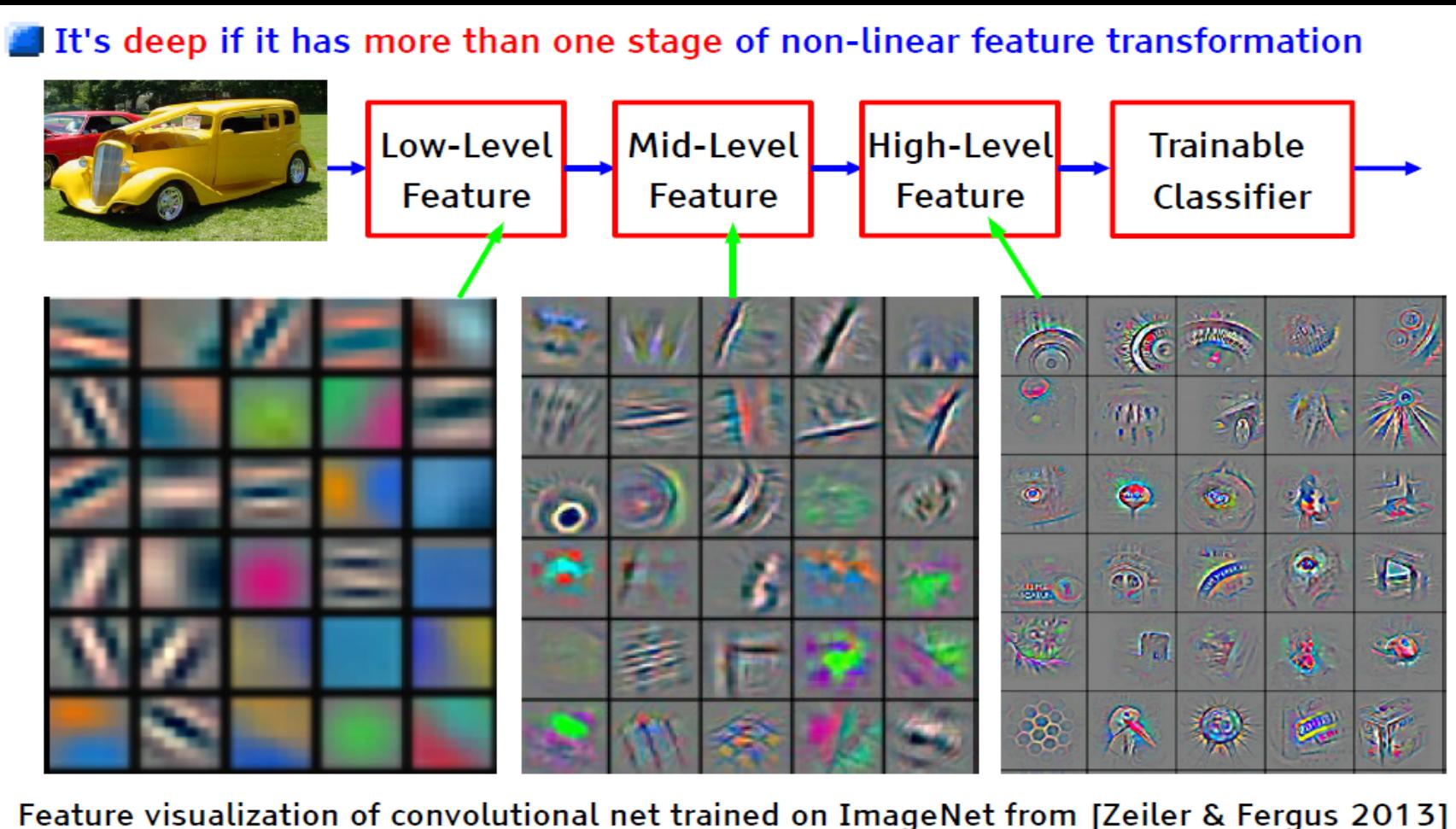
STIMULATION OF RETINA with patterns of light. The eyes of an anesthetized, light-adapted cat (or monkey) focus on a screen onto which various patterns of light are projected. Alternatively, a TV screen is used, with patterns generated by a computer. An electrode records the responses from a single cell in the visual pathway. Light (or shadow) falling onto a restricted area of the screen may accelerate (excite) or slow (inhibit) the signals given by a neuron. By determining the areas on the screen from which a neuron's firing is influenced, one can delineate the receptive field of the cell. The positions of cells in the brain and the tracks of electrode penetrations can be reconstructed histologically after the experiment.



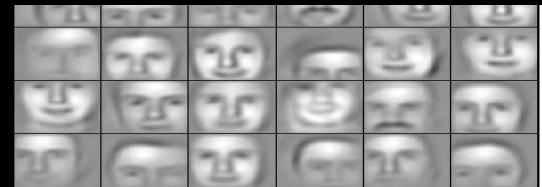
“视觉的形成是分层的



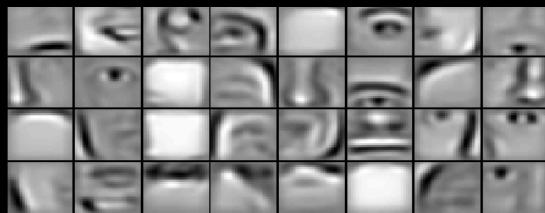
“深度学习 = 学习层次表达



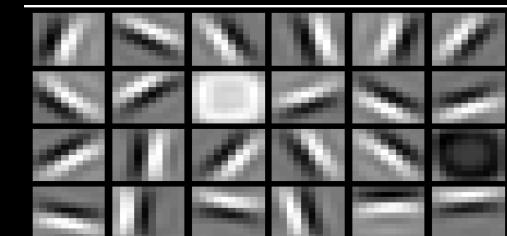
“ 特征层级



object models



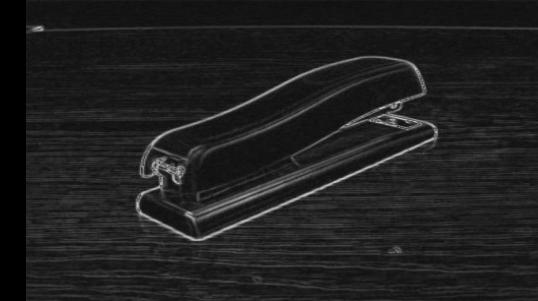
object parts
(combination
of edges)



edges



pixels



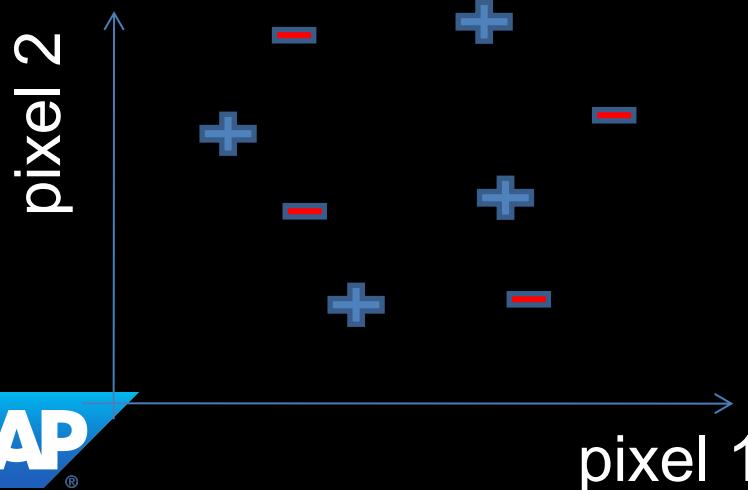
Andrew Ng

“ 机器学习 & 特征表达



Input space

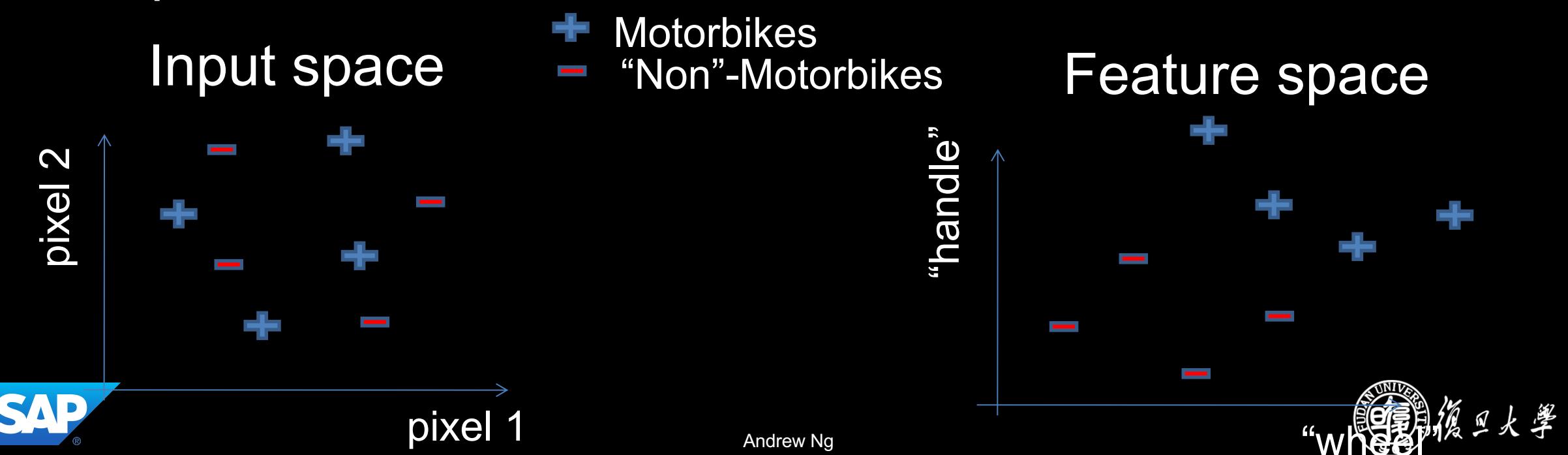
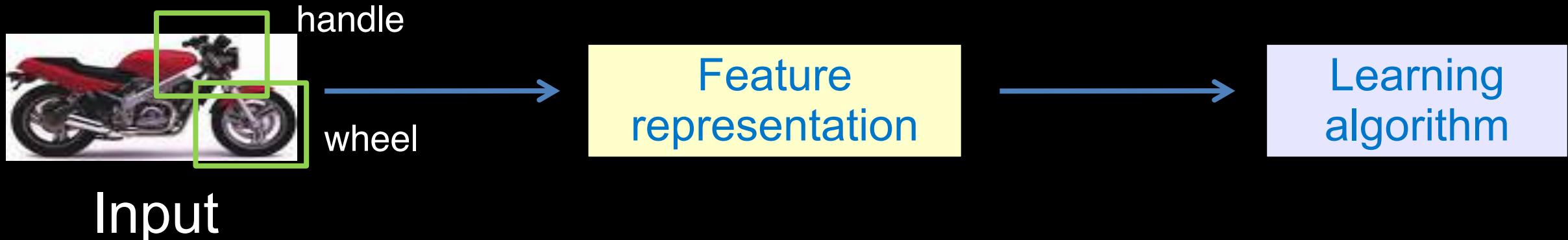
- + Motorbikes
- “Non”-Motorbikes



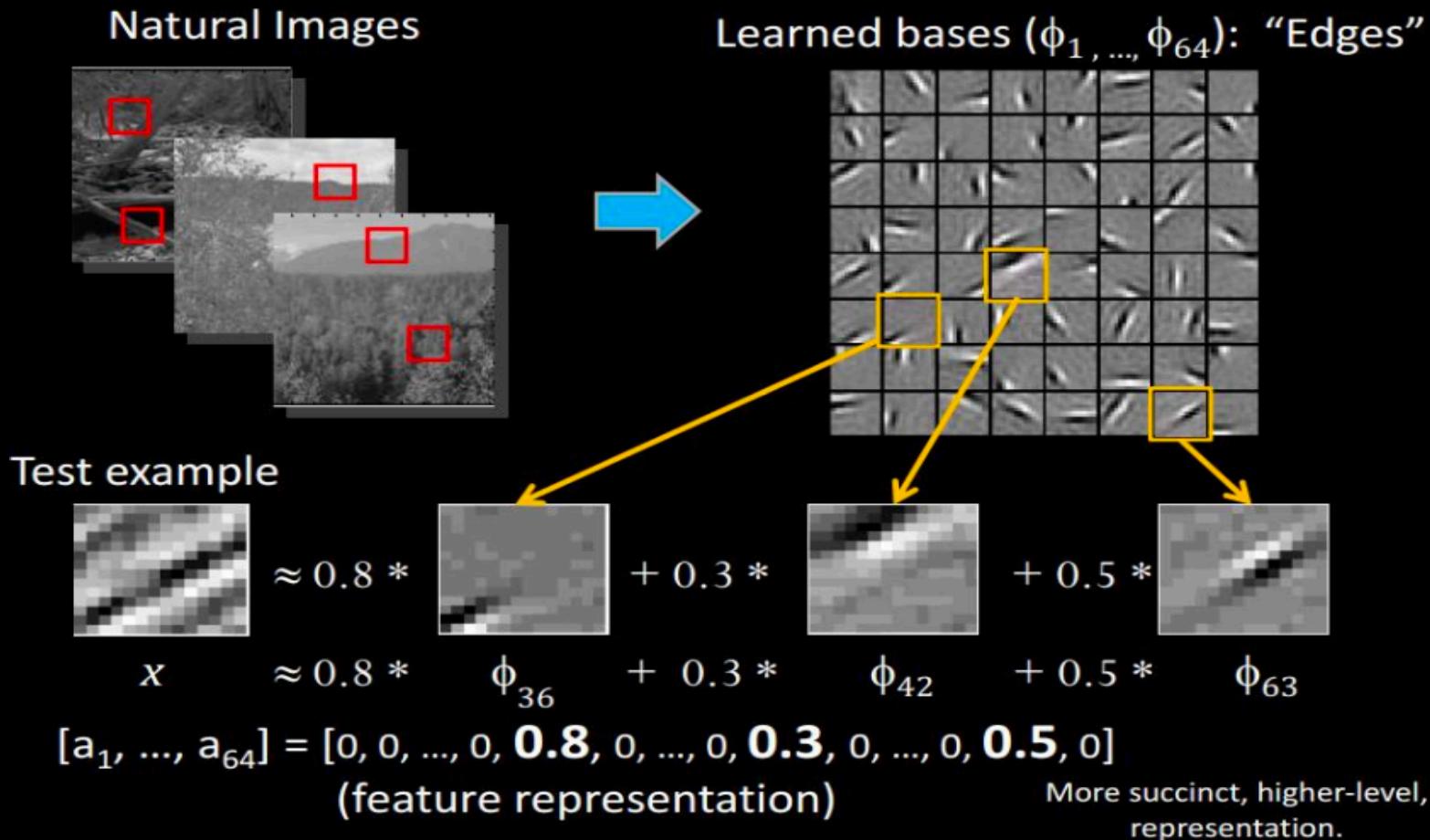
Andrew Ng



“ 机器学习 & 特征表达



“ 使用稀疏编码学习特征



“ 使用稀疏编码学习特征


$$\text{Image} \approx 0.6 * \phi_{15} + 0.8 * \phi_{28} + 0.4 * \phi_{37}$$

Represent as: $[a_{15}=0.6, a_{28}=0.8, a_{37} = 0.4]$.


$$\text{Image} \approx 1.3 * \phi_5 + 0.9 * \phi_{18} + 0.3 * \phi_{29}$$

Represent as: $[a_5=1.3, a_{18}=0.9, a_{29} = 0.3]$.

- Method “invents” edge detection.
- Automatically learns to represent an image in terms of the edges that appear in it. Gives a more succinct, higher-level representation than the raw pixels.
- Quantitatively similar to primary visual cortex (area V1) in brain.

“ 使用稀疏编码学习特征 (细节)

输入: 图像 $x^{(1)}, x^{(2)}, \dots, x^{(m)}$ (each in $R^{n \times n}$)

$$\min_{a, \phi} \sum_{i=1}^m \left(\left\| x^{(i)} - \sum_{j=1}^k a_j^{(i)} \phi_j \right\|^2 + \lambda \sum_{j=1}^k |a_j^{(i)}| \right)$$



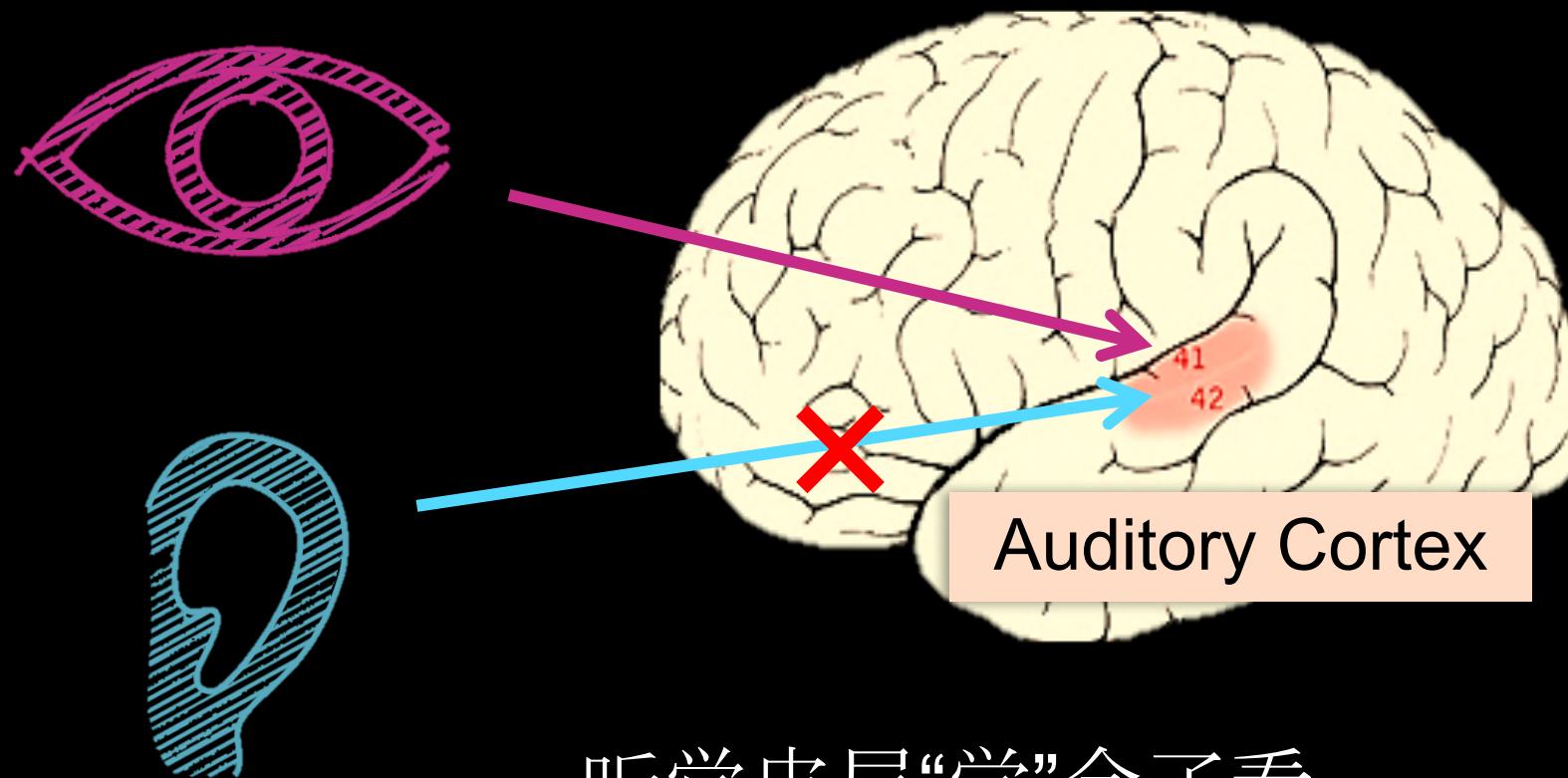
L_1 sparsity term



Andrew Ng



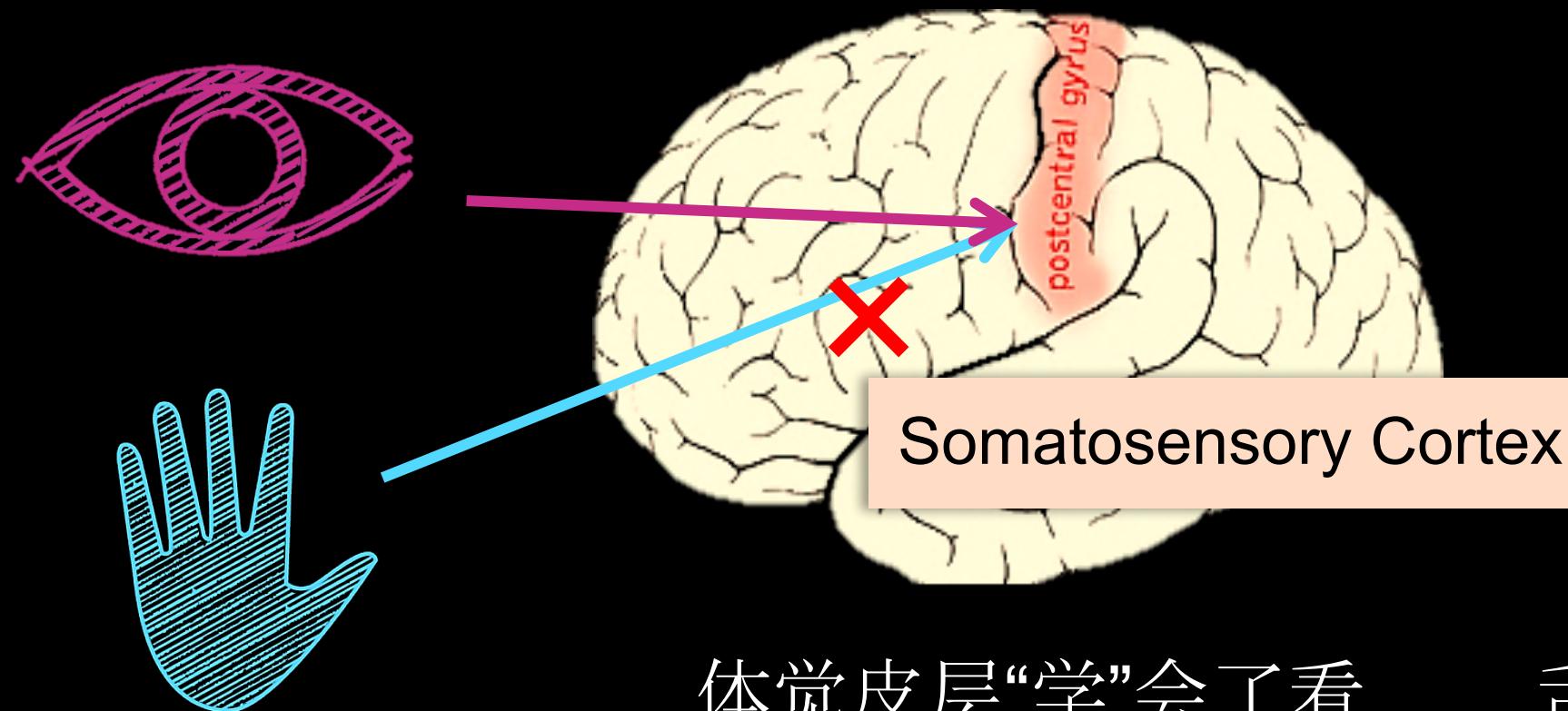
“单一“学习”算法假设



听觉皮层“学”会了看

[Roe et al., 1992]

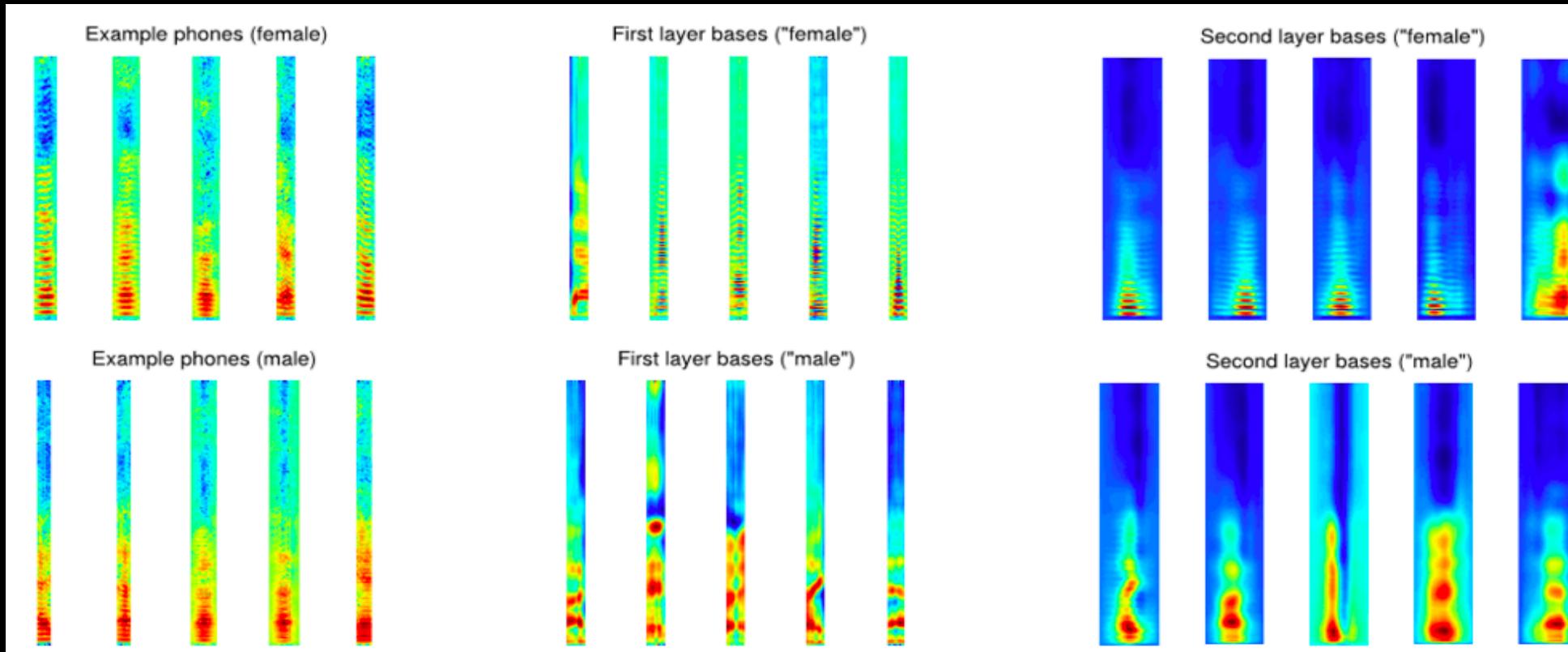
“单一“学习”算法假设



体觉皮层“学”会了看

舌头“学”会了看

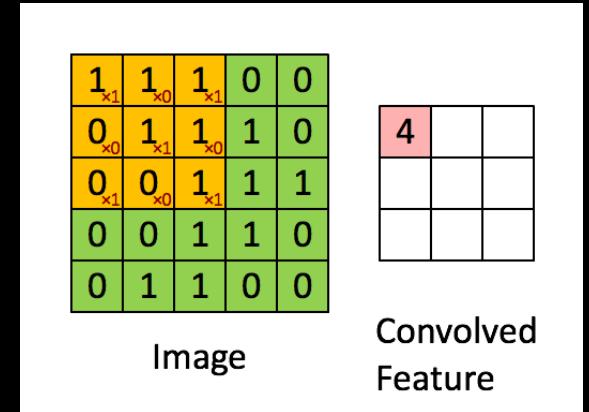
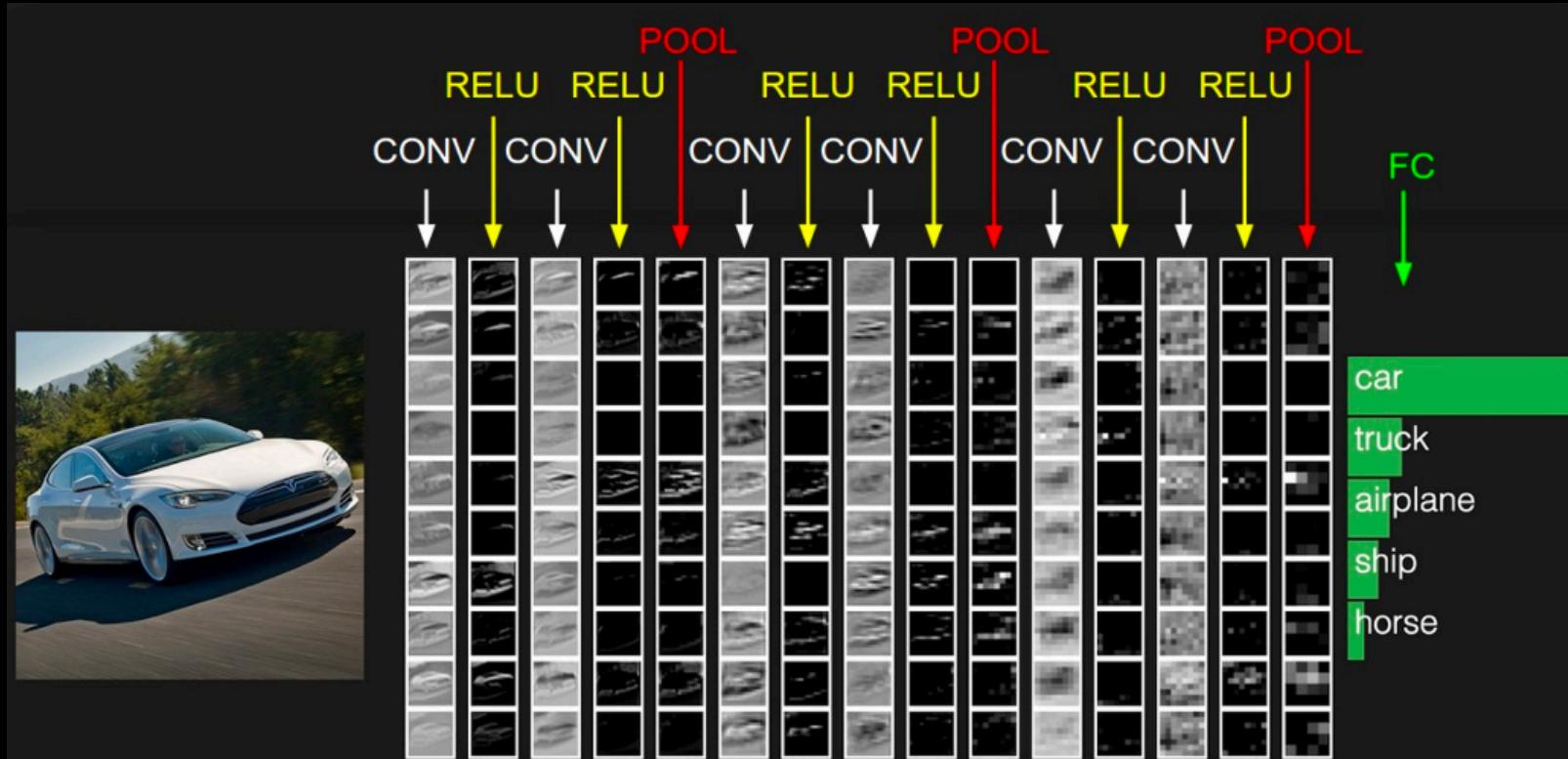
“稀疏编码也可以用于音频识别



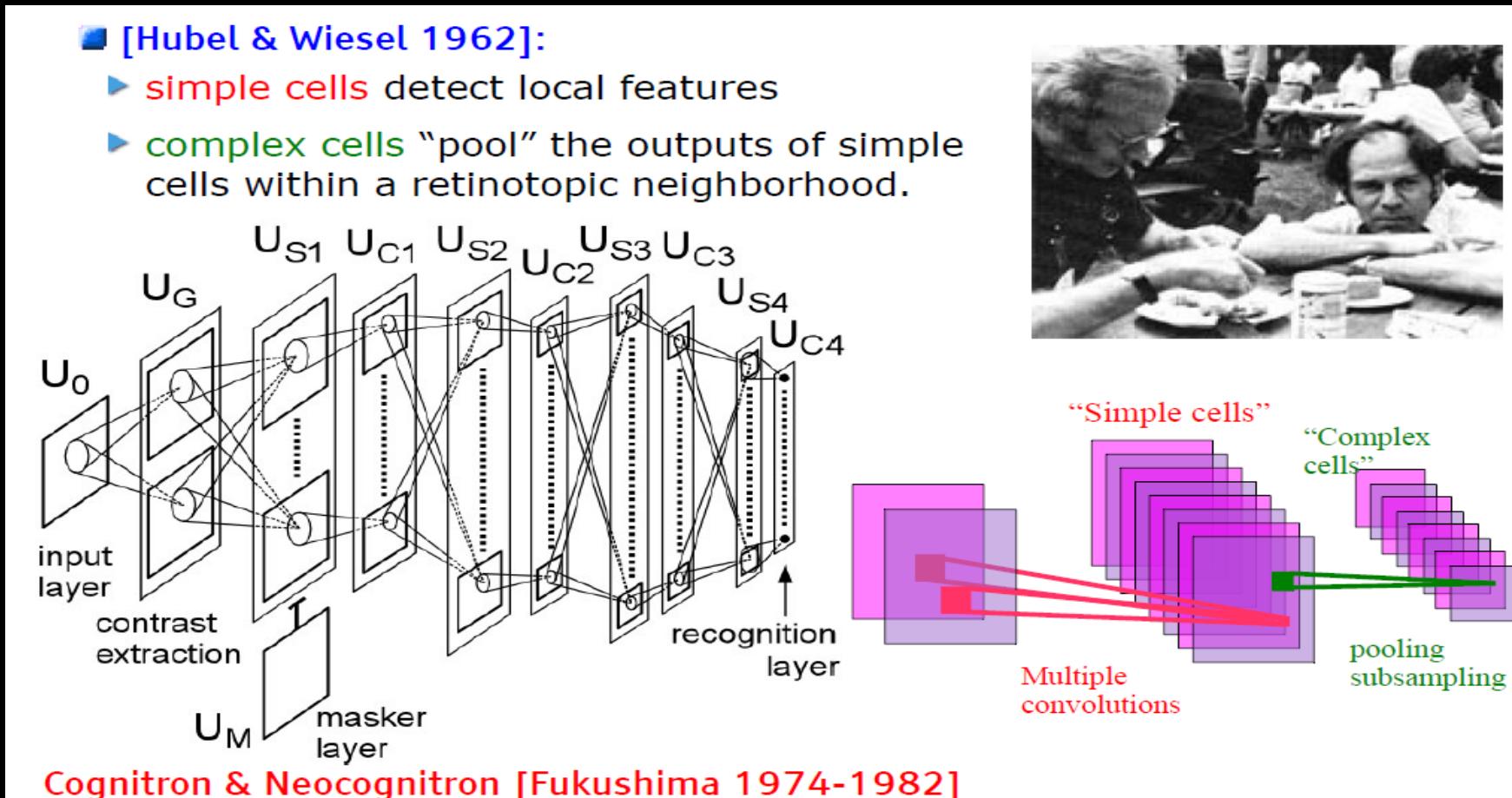
Honglak Lee, Peter T. Pham, Yan Largman, Andrew Y. Ng NIPS 2009



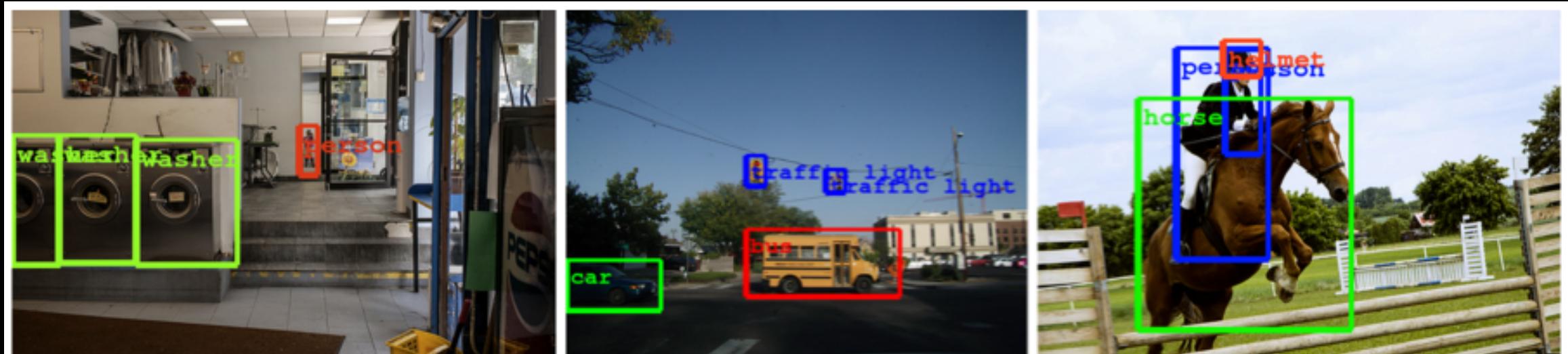
“卷积神经网络 (CNN) ”



“早期针对视觉的层次特征建模



“卷积神经网络：对象识别



数据科学

小测验.

These numbers were found in two tax declarations. One is entirely made up. Which one?

EUR

127,-

2.863,-

10.983,-

694,-

29.309,-

32,-

843,-

119.846,-

18.744,-

1.946,-

275,-

EUR

937,-

82.654,-

18.465,-

725,-

98.832,-

7.363,-

4.538,-

38,-

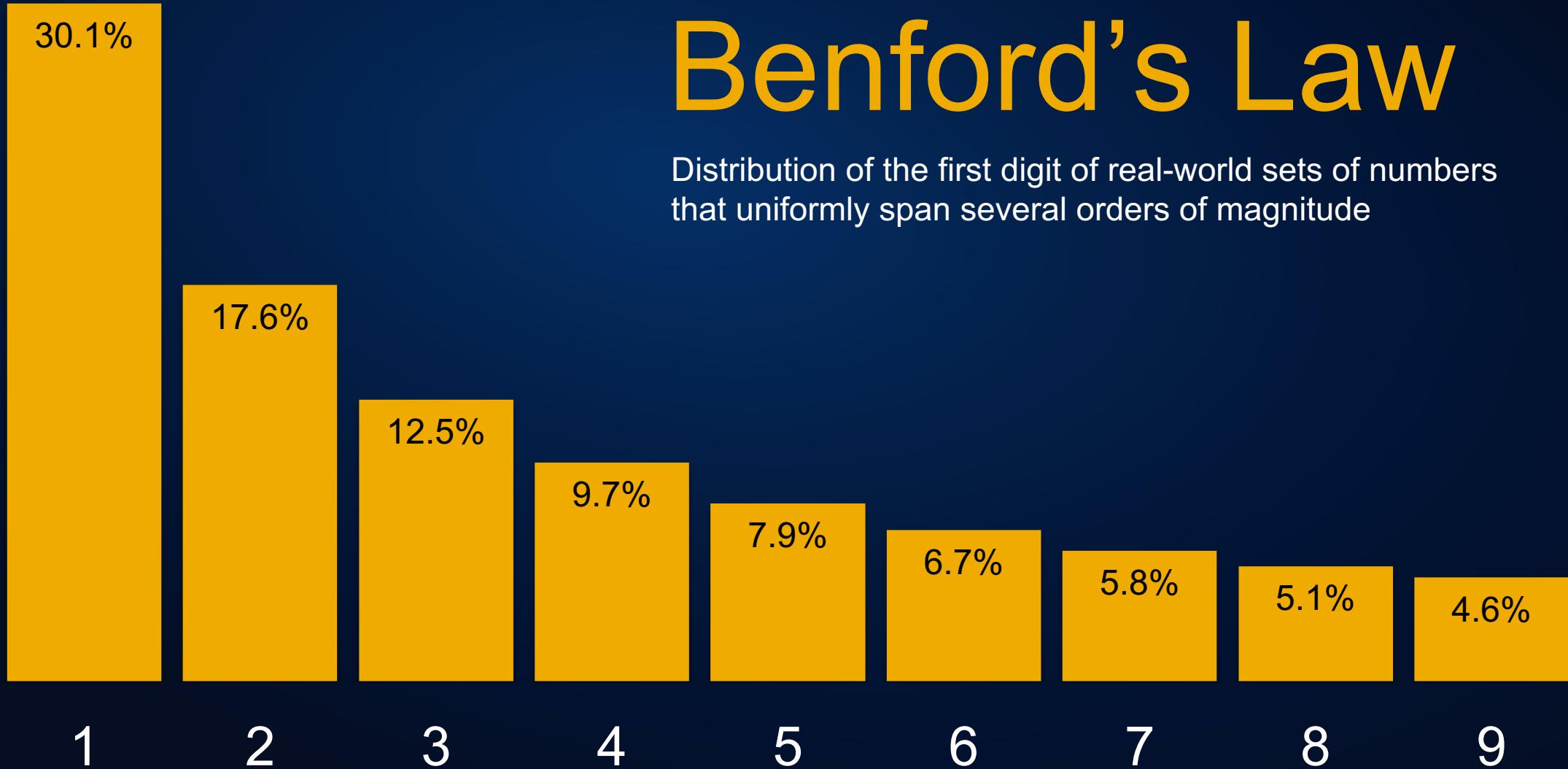
8.327,-

482,-

2.945,-

Benford's Law

Distribution of the first digit of real-world sets of numbers
that uniformly span several orders of magnitude



数据科学

小测验.

These numbers were found in two tax declarations. One is entirely made up. Which one?

Benford's Law, also called the First-Digit Law

EUR	EUR
127,-	937,-
2.863,-	82.654,-
10.983,-	18.465,-
694,-	725,-
29.309,-	98.832,-
32,-	7.363,-
843,-	4.538,-
119.846,-	38,-
18.744,-	8.327,-
1.946,-	482,-
275,-	2.945,-

“ Exercises Preparation

1. Python 3.6 / Anaconda
2. Numpy, pandas, Matplotlib, Scikit-learn, Tensor flow, Jupyter
3. <http://pandas.pydata.org/pandas-docs/stable/10min.html#min>
4. <http://scikit-learn.org/stable/tutorial/basic/tutorial.html>
5. http://matplotlib.org/users/pyplot_tutorial.html

“ Exercises Preparation: conda command

1. conda create -n <env_name> python = <ver> <list of packages>
2. source activate <env_name>
3. conda install <package_name>
4. conda list
5. Jupyter notebook





Thank you!

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Email: x.wu@sap.com