


L1: Introduction

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Sun Yat-sen University

教育部产学合作协同育人项目-面向数字经济的新商科建设教改课程

2022 Data Mining and Machine Learning LN3125

https://wang-shan.gitee.io/dm-ml/

https://tianchi.aliyun.com/ailab/course/detail/981

Trends

Machine learning trend

Business analytics trend

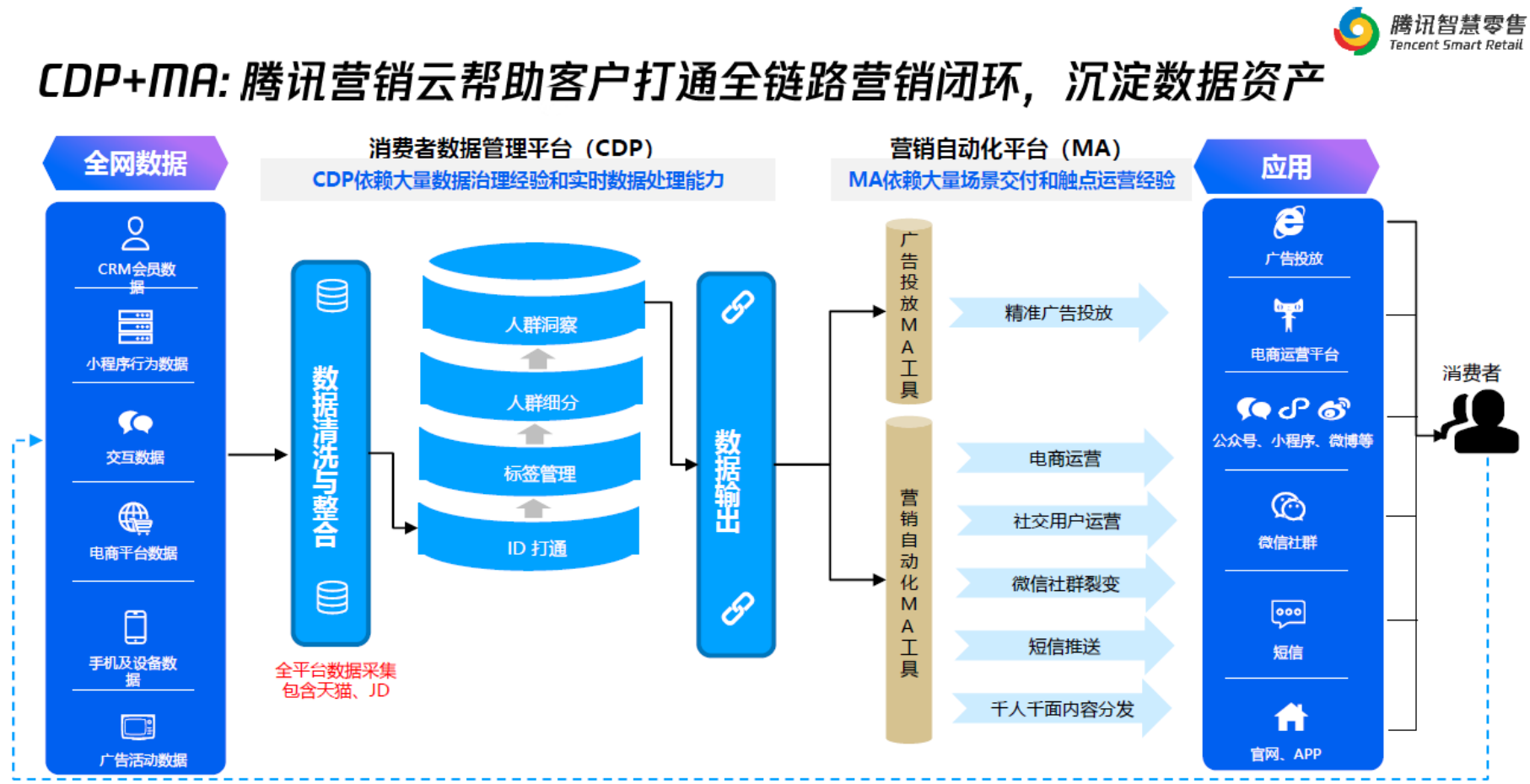
https://trends.google.com

What is Business Analytics

- Turn data into information/value.
  - Business managers need to make decisions.
  - They need to make the most informed decisions that they can and generate value.

- Decision making under uncertainty.
  - Most of the decisions are based on guesses, rather than “facts.”
  - How to make the “best” guess possible as well as how to measure the accuracy of their guesses.

Turn Data to Value

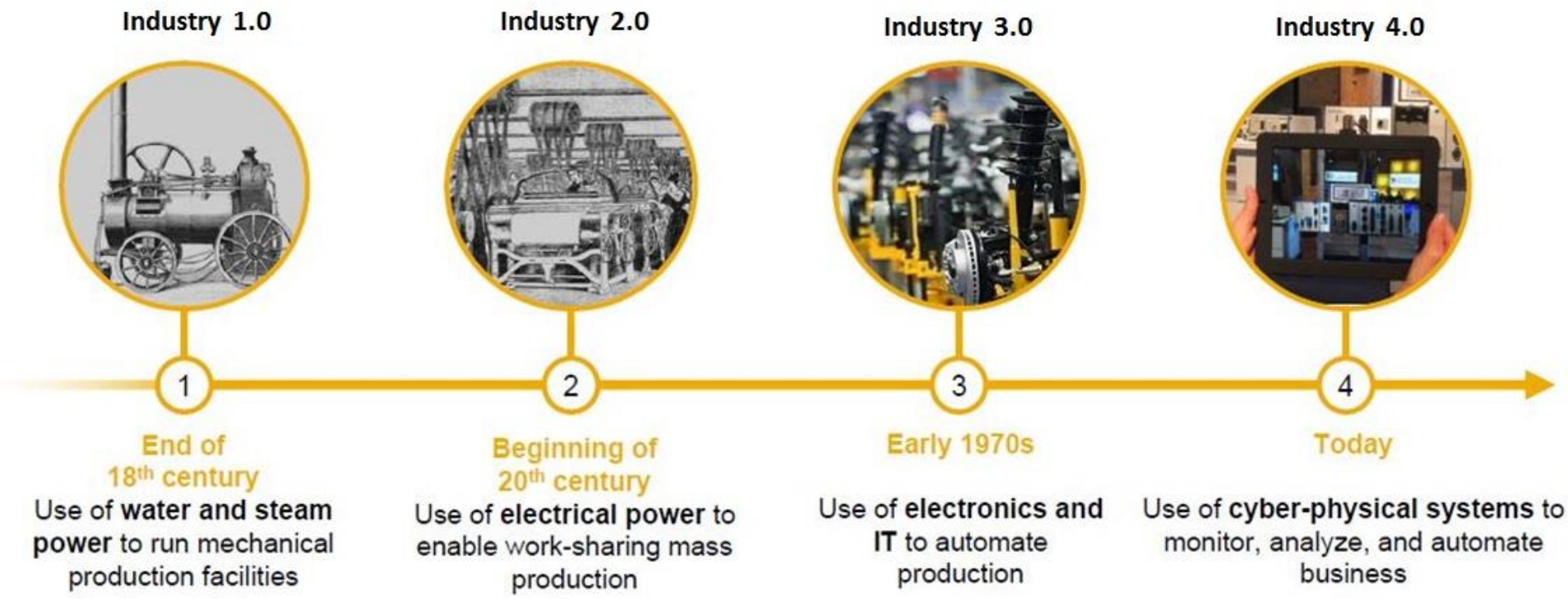


Credit to: Tencent CSIG

Why machine learning?

Industry Revolution 4.0

Four Phases of Industrialization

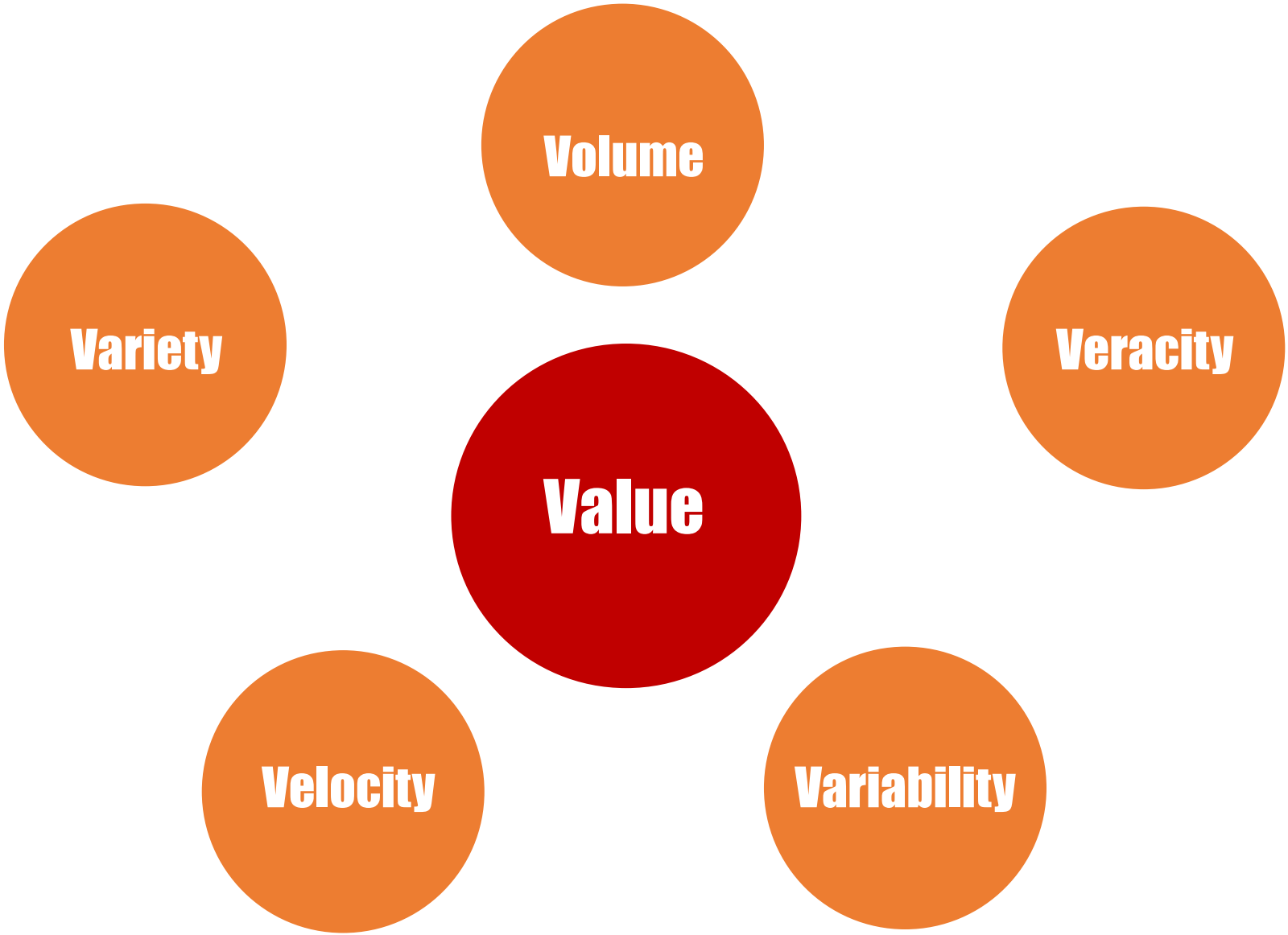


Big Data


10:10 AM
SAMSUNG
10:37 PM
ThinkPad
BlackBerry


淘
阿里巴巴
Alibaba.com
Suning.com
苏宁易购
amazon
JD.COM 京东
GROUPON
去哪儿?
Qunar.Com
Expedia
HSBC
Apps
• Straps
• Shirts
• Wrist-worn
• Clips
• Shoe-worn / Foot pods

6 V's of Big Data

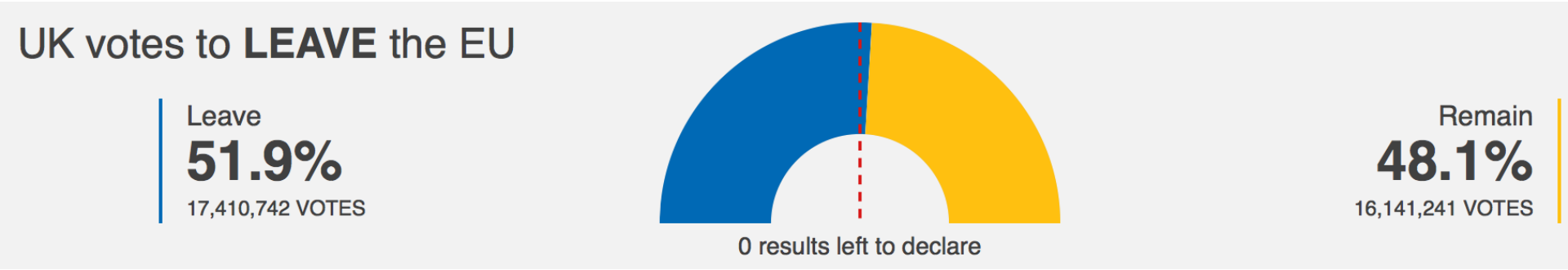


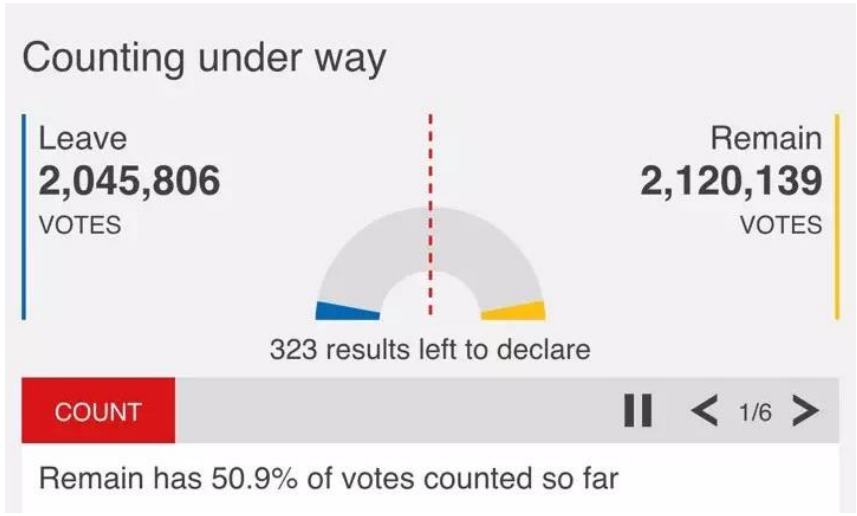
Business value of big data

- Estimates suggest that by better integrating big data, **healthcare** could save as much as **$300 billion a year** — that's equal to reducing costs by $1000 a year for every man, woman, and child.
- For a typical Fortune 1000 company, just a 10% increase in data accessibility will result in more than **$65 million** additional net income.
- Retailers who leverage the full power of big data could increase their operating margins by as much as **60%**.
- **73%** of organizations have already invested or plan to invest in big data by 2016.
- **Less than 0.5% of all data is ever analysed and used!**

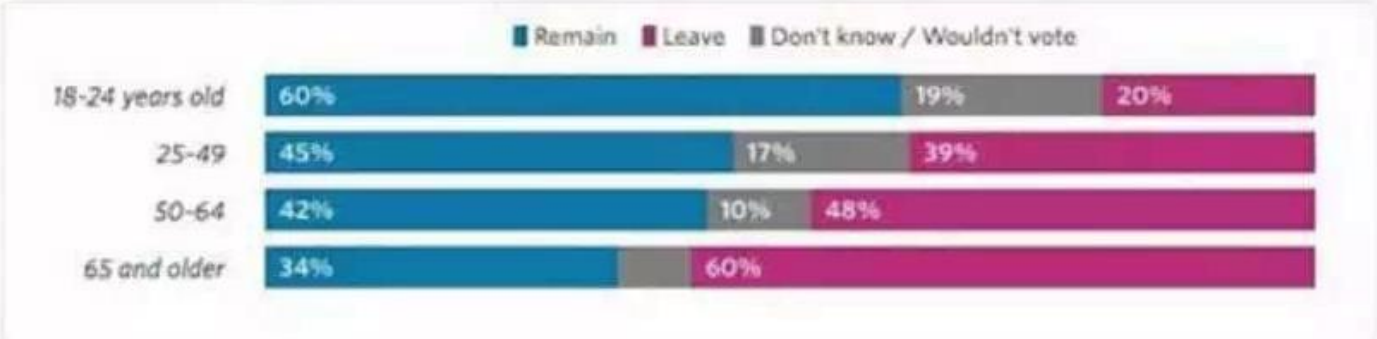
[Forbes on Sep 30, 2015]

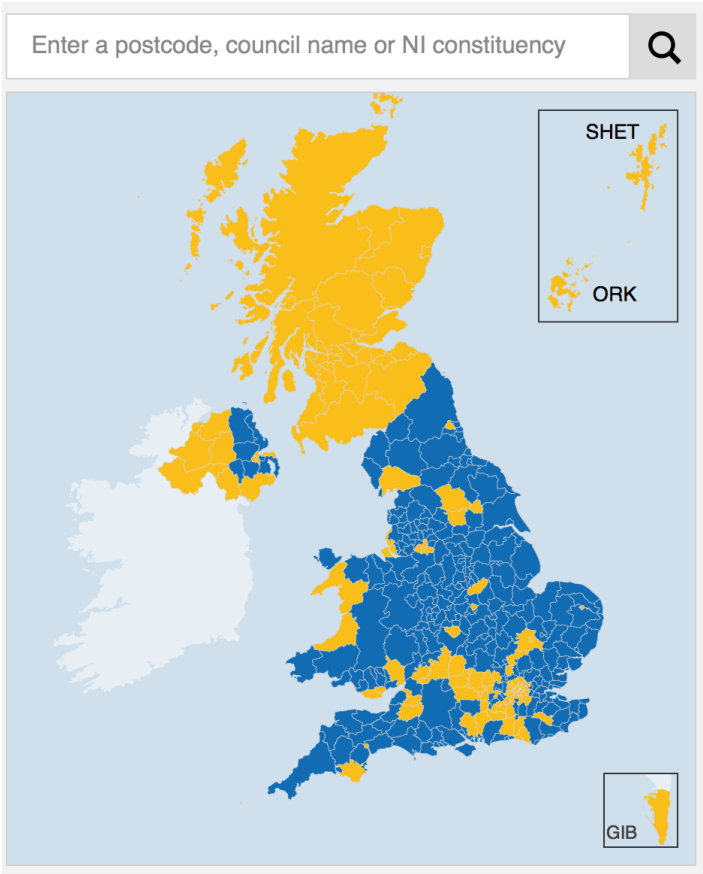
Just Being Big May Not Get You There …





Why machine learning?





England

Leave **53.4%**
15,188,406 VOTES

Remain **46.6%**
13,266,996 VOTES

Counting complete

Turnout: 73.0%

Northern Ireland

Leave **44.2%**
349,442 VOTES

Remain **55.8%**
440,437 VOTES

Counting complete

Turnout: 62.9%

Scotland

Leave **38.0%**
1,018,322 VOTES

Remain **62.0%**
1,661,191 VOTES

Counting complete

Turnout: 67.2%

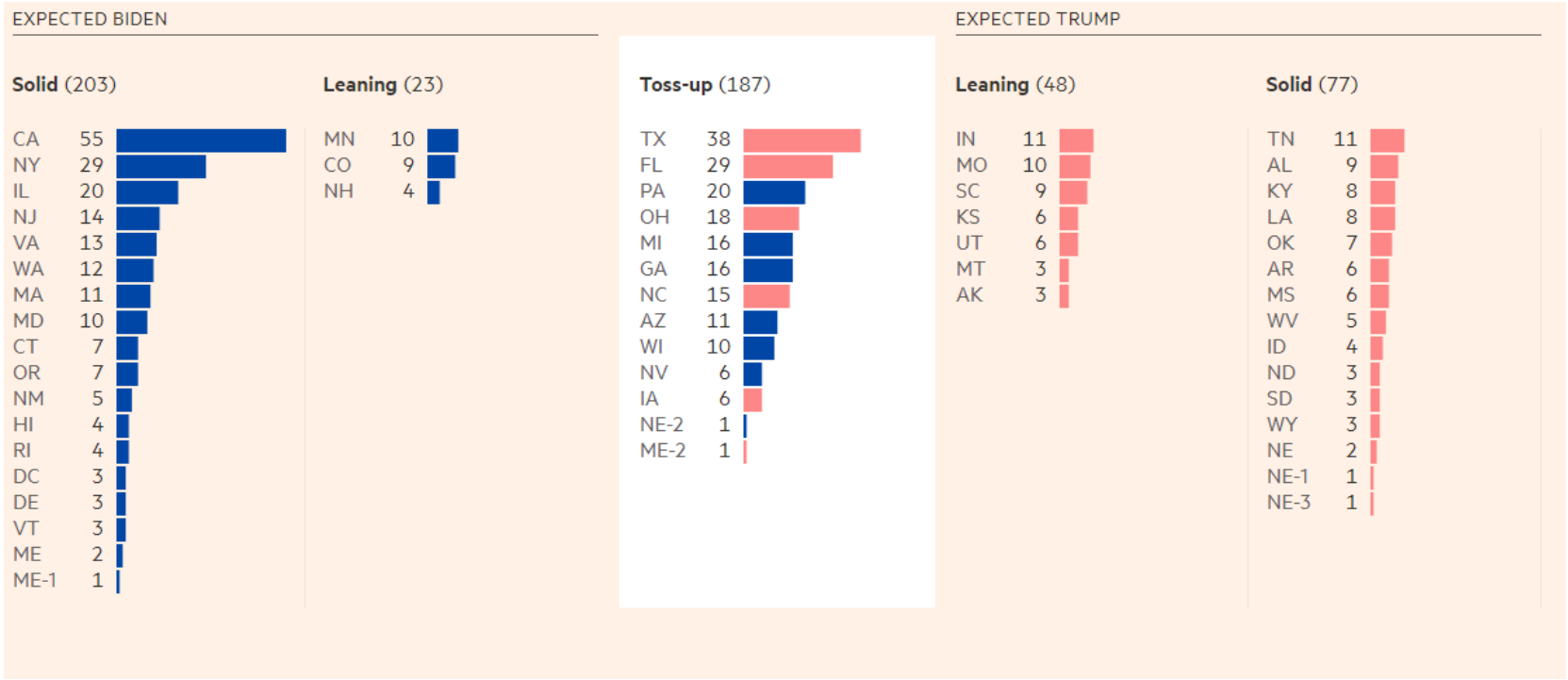
Wales

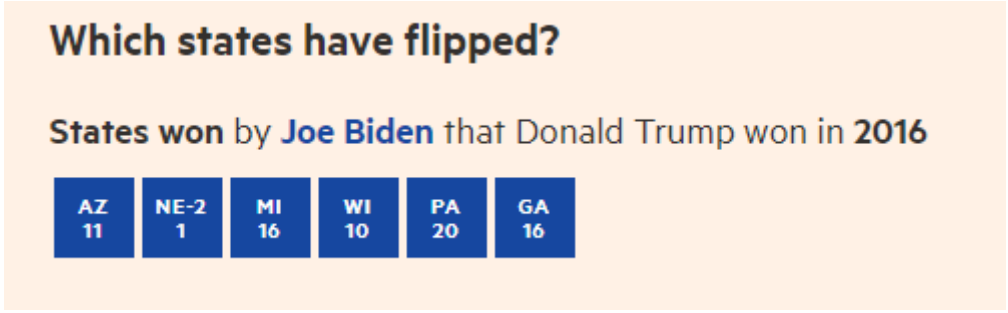
Leave **52.5%**
854,572 VOTES

Remain **47.5%**
772,347 VOTES

Another Example…

Another Example…





- Big Data by itself, regardless of the size, type, or speed, is worthless.
- Big Data + “big” analytics = value
- Big Data brought big challenges
  - Effectively and efficiently capturing, storing, and analyzing Big Data
  - New breed of technologies needed
  - Hadoop, MapReduce, Spark
  - Unstructured data: text mining, social media analysis
- We need machine learning!

What is machine learning?

A subset of artificial intelligence involved with the creation of algorithms which can modify itself without human intervention to produce desired output - by feeding itself through structured data

Applications of ML

Pioneer: Walmart

- Beer and Diaper

Walmart
Save money. Live better.

Transaction No.	Item 1	Item 2	Item 3	…Item N
100	Beer	Diaper	Chocolate	
101	Milk	Chocolate	Shampoo	
102	Beer	Wine	Vodka	
103	Beer	Cheese	Diaper	
104	Ice Cream	Diaper	Beer	
…				

Pioneer: Walmart (cont.)

Trans No.	Item 1	Item 2	Item 3	…	Day	Time	Customer Info.
100	Beer	Diaper	Chocolate		Fri	6:15pm	Male, 30, …
101	Milk	Chocolate	Shampoo		Sun	10:10am	Female, 25,…
102	Beer	Wine	Vodka		Sat	5:30pm	Male, 24,…
103	Beer	Cheese	Diaper		Fri	6:30pm	Male, 32,…
104	Ice Cream	Diaper	Beer		Fri	7:00pm	Male, 28,…
…							

Target Customer Predictive Analytics

http://www.youtube.com/watch?v=RC5HNTj3Dag&feature=related

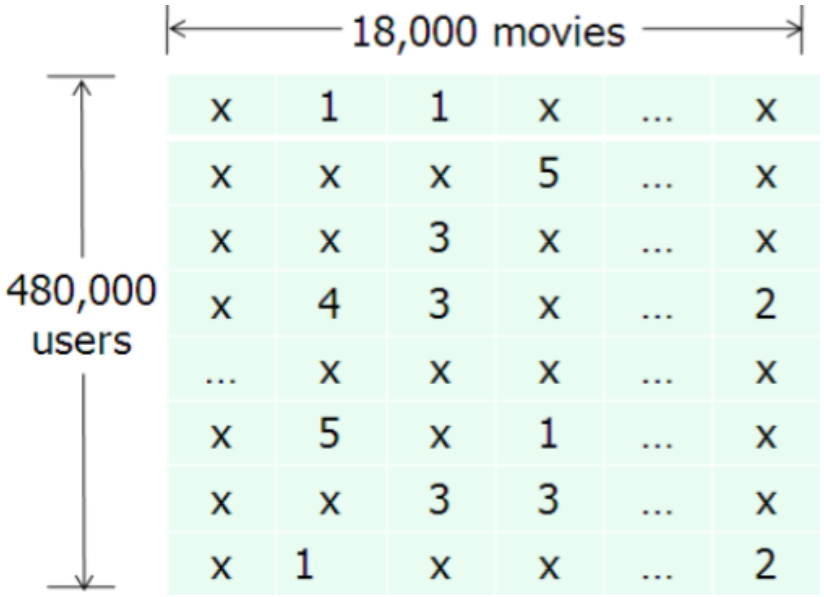
Netflix Movie Recommendation

- A US-based DVD retail company (1997 -)
- As of April 2019, ~ 100 million subscribers

- Good recommendation = happy customer = business value (outstanding product: House of Cards)

The Netflix Competition (2006-2009)

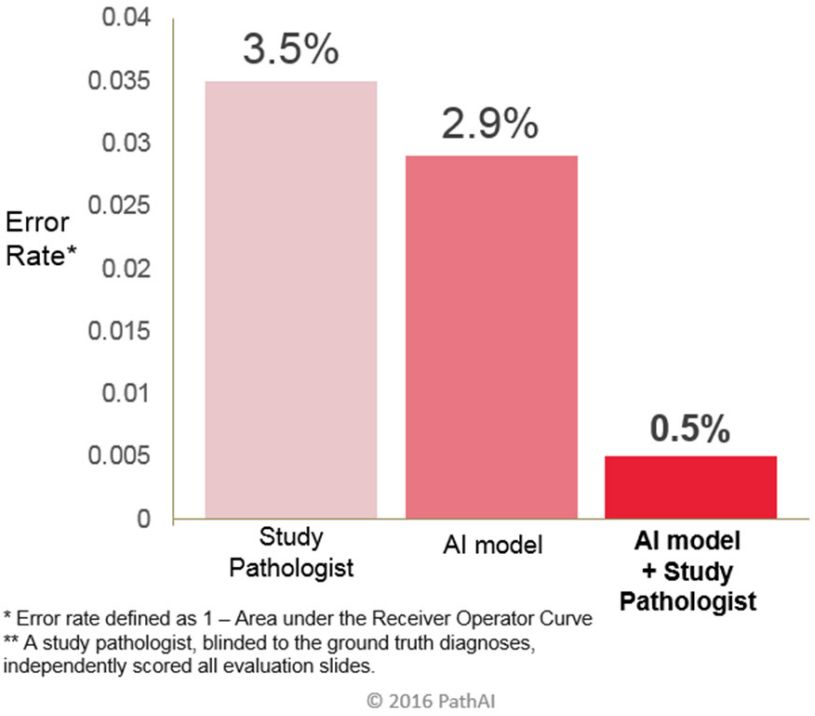
- Netflix offers $1M for an improved recommender algorithm
- Training data: 100 million ratings



- Test data
  - Last few ratings of each user (2.8 million)
- Winner BellKor's Pragmatic Theory, using a combination of > 800 models
  https://www.youtube.com/watch?v=ImpV70uLxyw
  - Two main classes: nearest neighbors and principal component analysis

Breast Cancer Diagnoses

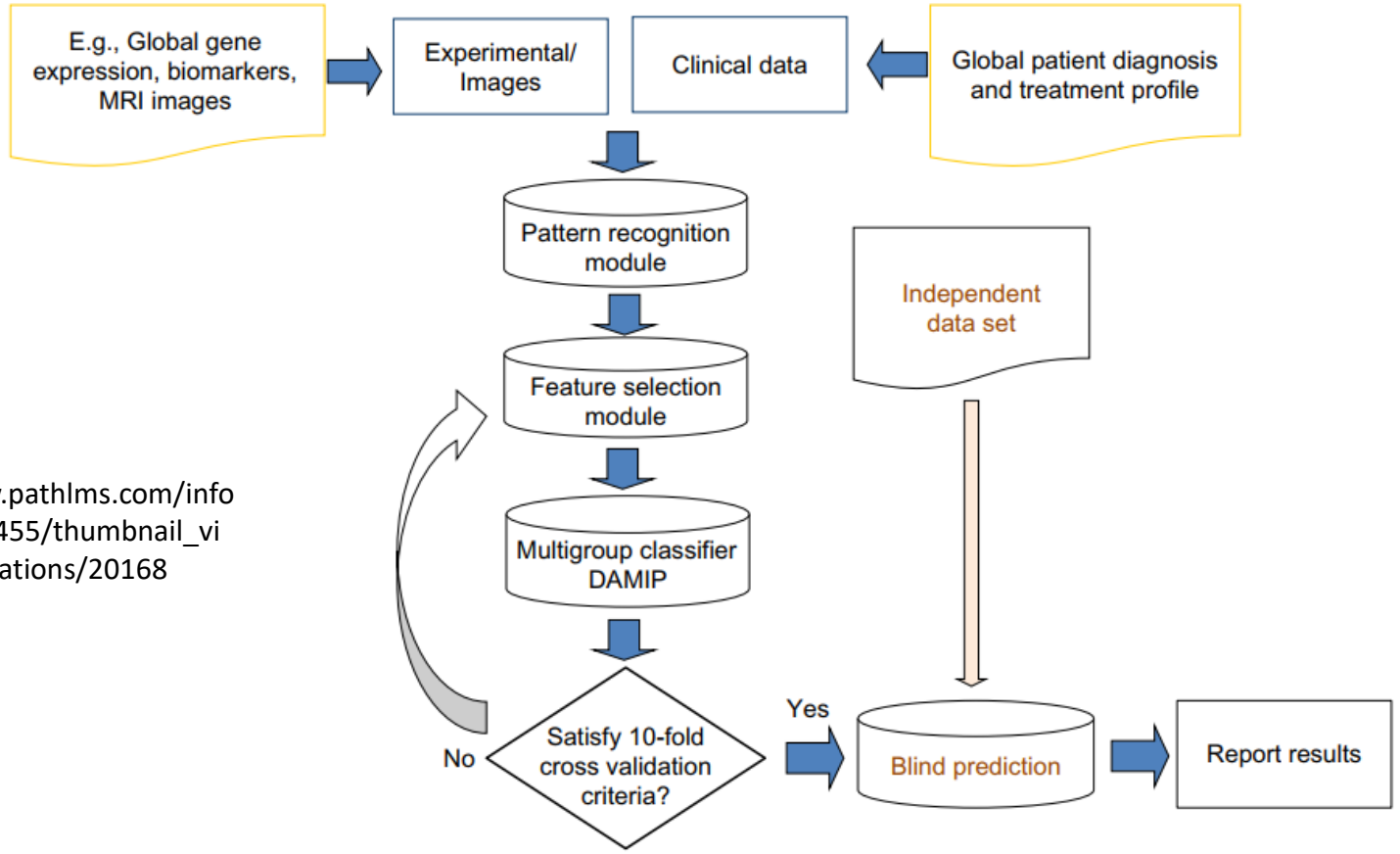
(AI + Pathologist) > Pathologist



D. Wang, A. Khosla, R. Gargeya, H. Irshad, and A. H. Beck, "Deep Learning for Identifying Metastatic Breast Cancer," arXiv preprint arXiv:1606.05718, 2016.

Predicting Vaccine Immunogenicity

- How different individuals respond to vaccination?

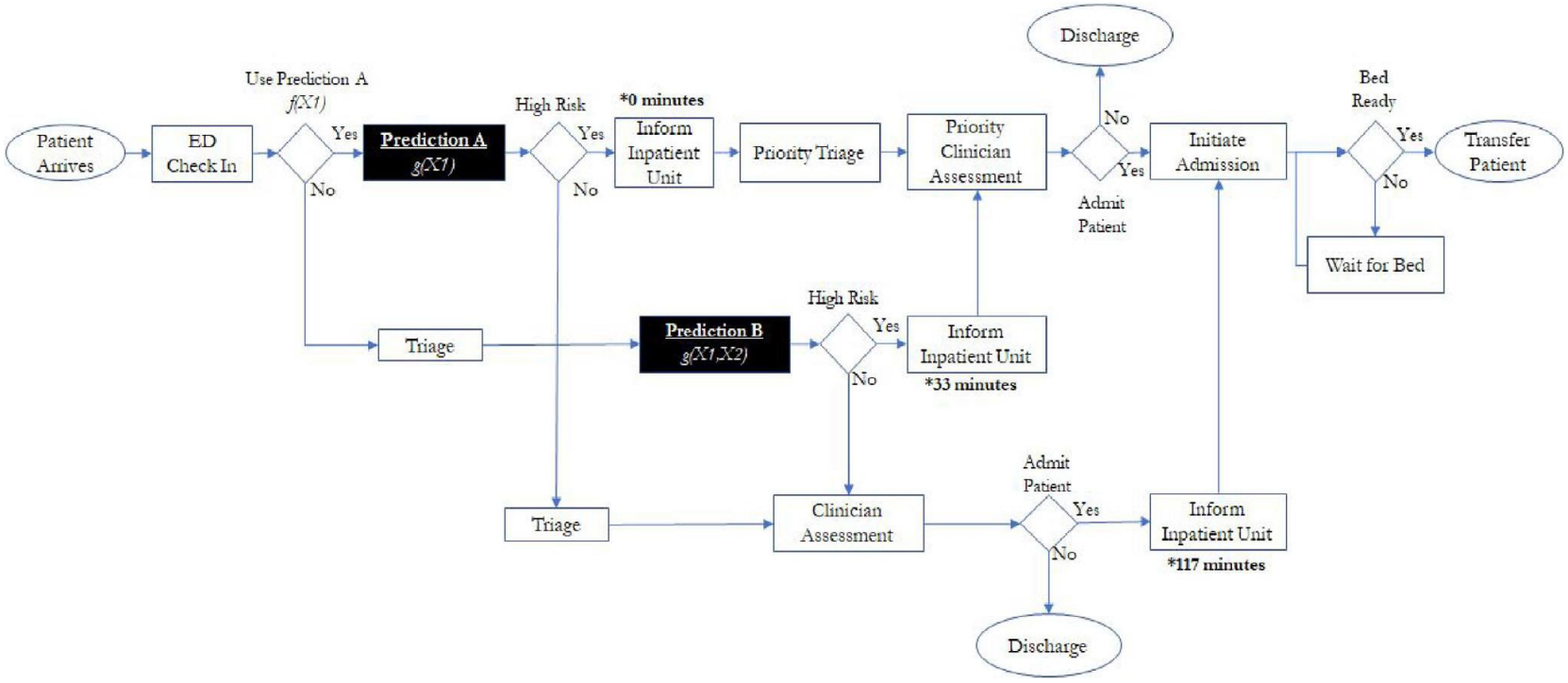


https://www.pathlms.com/informs/events/455/thumbnail_video_presentations/20168

Lee, Eva K., et al. "Machine learning for predicting vaccine immunogenicity." *Interfaces* 46.5 (2016): 368-390.

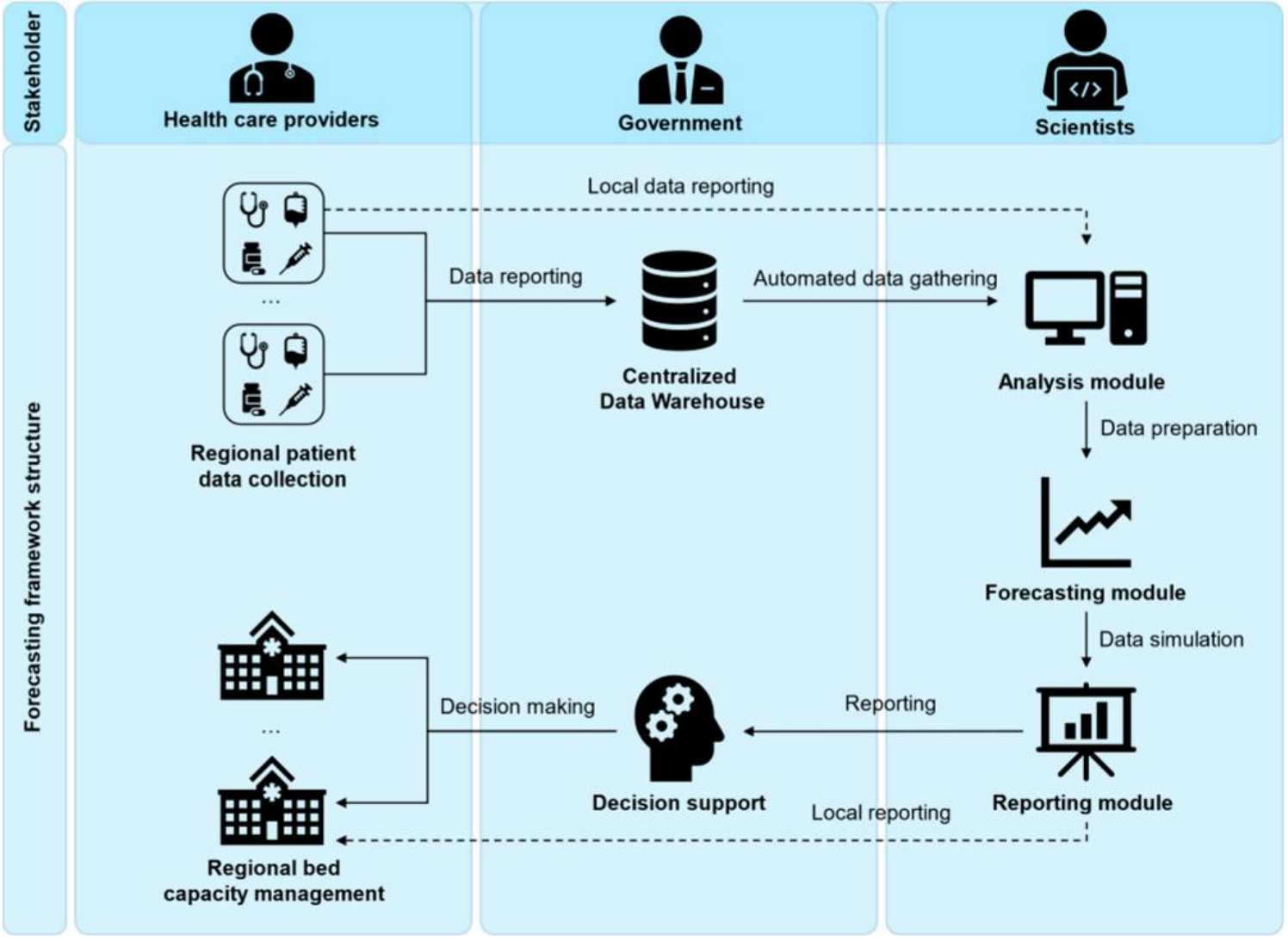
Predicting ED Triage

- Whether a patient will be admitted to an interior hospital unit or discharged from the ED



Somanchi, Sriram, Idris Adjerid, and Ralph Gross. "To Predict or Not to Predict: The Case of the Emergency Department." *Production and Operations Management* 31.2 (2022): 799-818.

Predicting COVID-19 Hospital Bed Occupancy

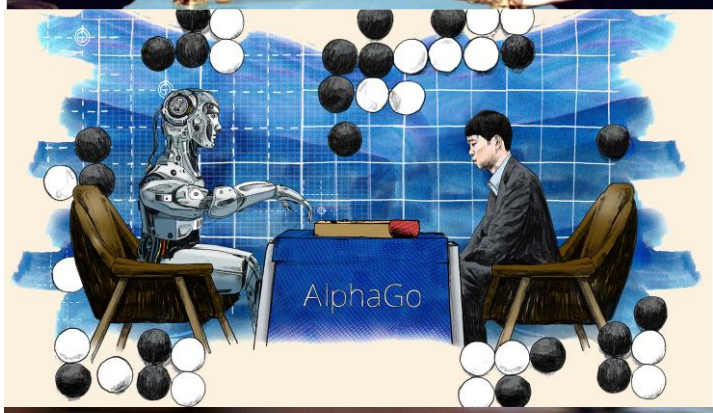


Heins, Jakob, et al. "A scalable forecasting framework to predict COVID-19 hospital bed occupancy." *INFORMS Journal on Applied Analytics* (2022).

Game playing

- IBM Deep Blue (1996)
  - 4-2 Garry Kasparov on Chess
  - A large number of crafted rules
  - Huge space search

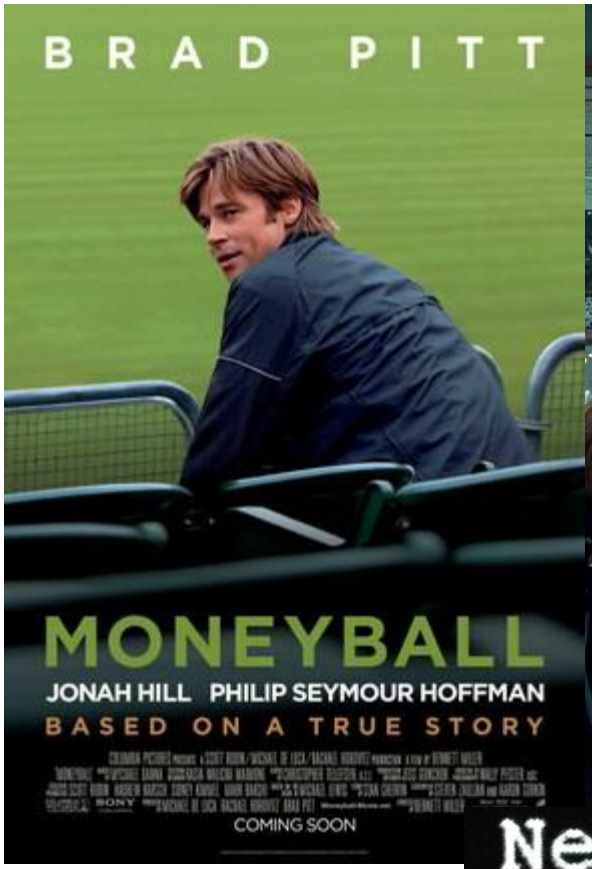
- Google AlphaGo (2016)
  - 4-1 Lee Sedol on Go
  - Deep reinforcement learning on big data



- AlphaGo Zero (2017)
  - Deep reinforcement learning with self generated data

Silver, D., et al. Mastering the game of Go with deep neural networks and tree search. Nature 529.7587, 484-489 (2016)
Silver, D., et al. Mastering the game of Go without human knowledge. Nature 550, 354–359 (2017)

Baseball: Moneyball



New York Yankees
$114,457,768
vs
$39,722,689
Oakland Athletics

https://youtu.be/-4QPVo0UIzc

https://www.bilibili.com/video/av58360594

Text Generation

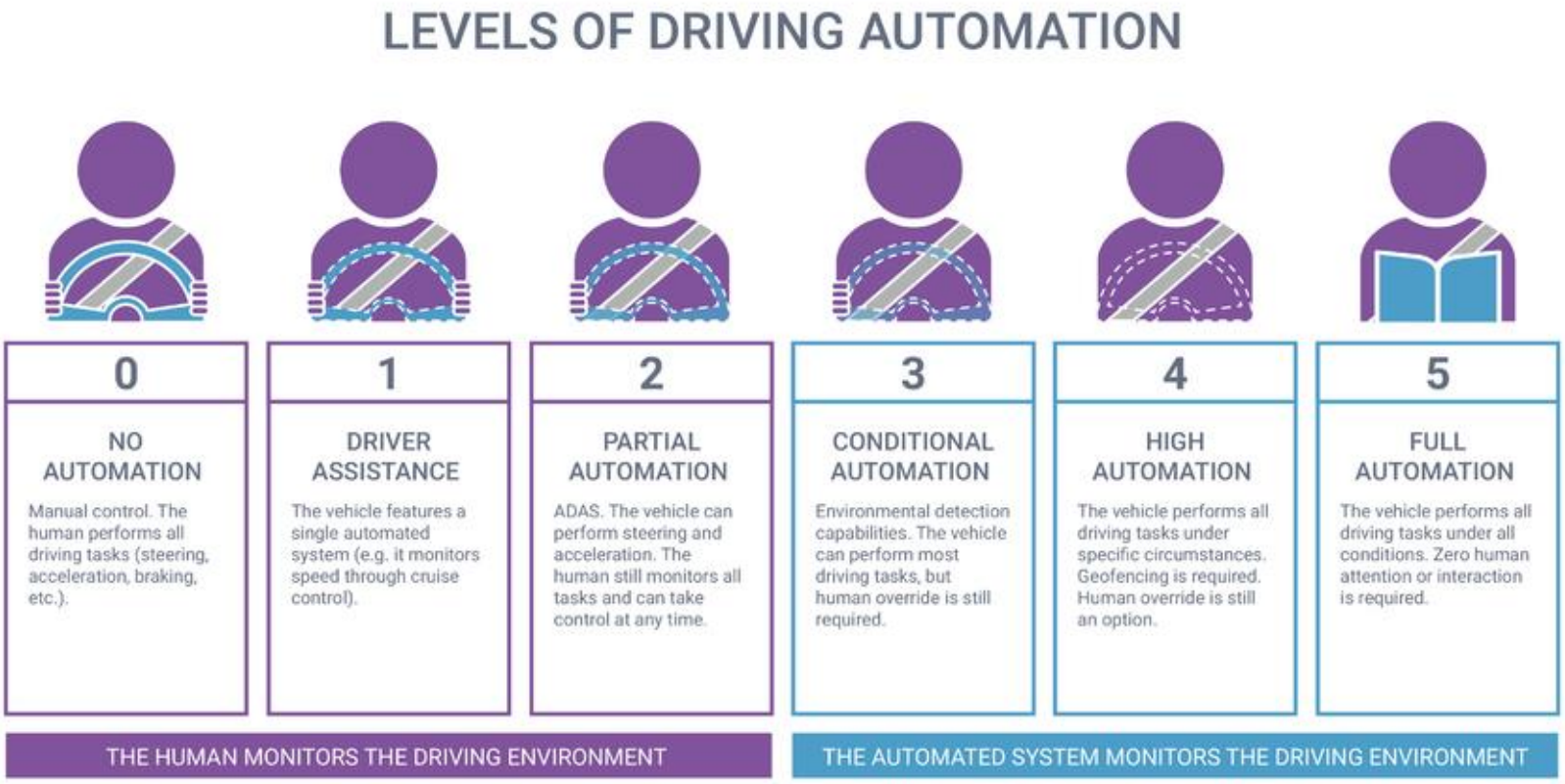
- Making decision of selecting the next word
- Chinese poem example. Can you distinguish?

Human	Machine
南陌春风早，东邻去日斜。	山夜有雪寒，桂里逢客时。
紫陌追随日，青门相见时。	此时人且饮，酒愁一节梦。
胡风不开花，四气多作雪。	四面客归路，桂花开青竹。

Lantao Yu, Weinan Zhang, et al. Seqgan: sequence generative adversarial nets with policy gradient. AAAI 2017.

Jiaxian Guo, Sidi Lu, Weinan Zhang et al. Long Text Generation via Adversarial Training with Leaked Information. AAAI 2018.

Driving Automation



Driving Automation (cont.)

Researchers predict that by 2025, we will see about 8 million unmanned or semi-unmanned cars driving on the road.

Rue La La Flash Sales

Event

Style

- Revenue: increase 9.7%

Ferreira, Kris Johnson, Bin Hong Alex Lee, and David Simchi-Levi. "Analytics for an online retailer: Demand forecasting and price optimization." Manufacturing & service operations management 18.1 (2016): 69-88.

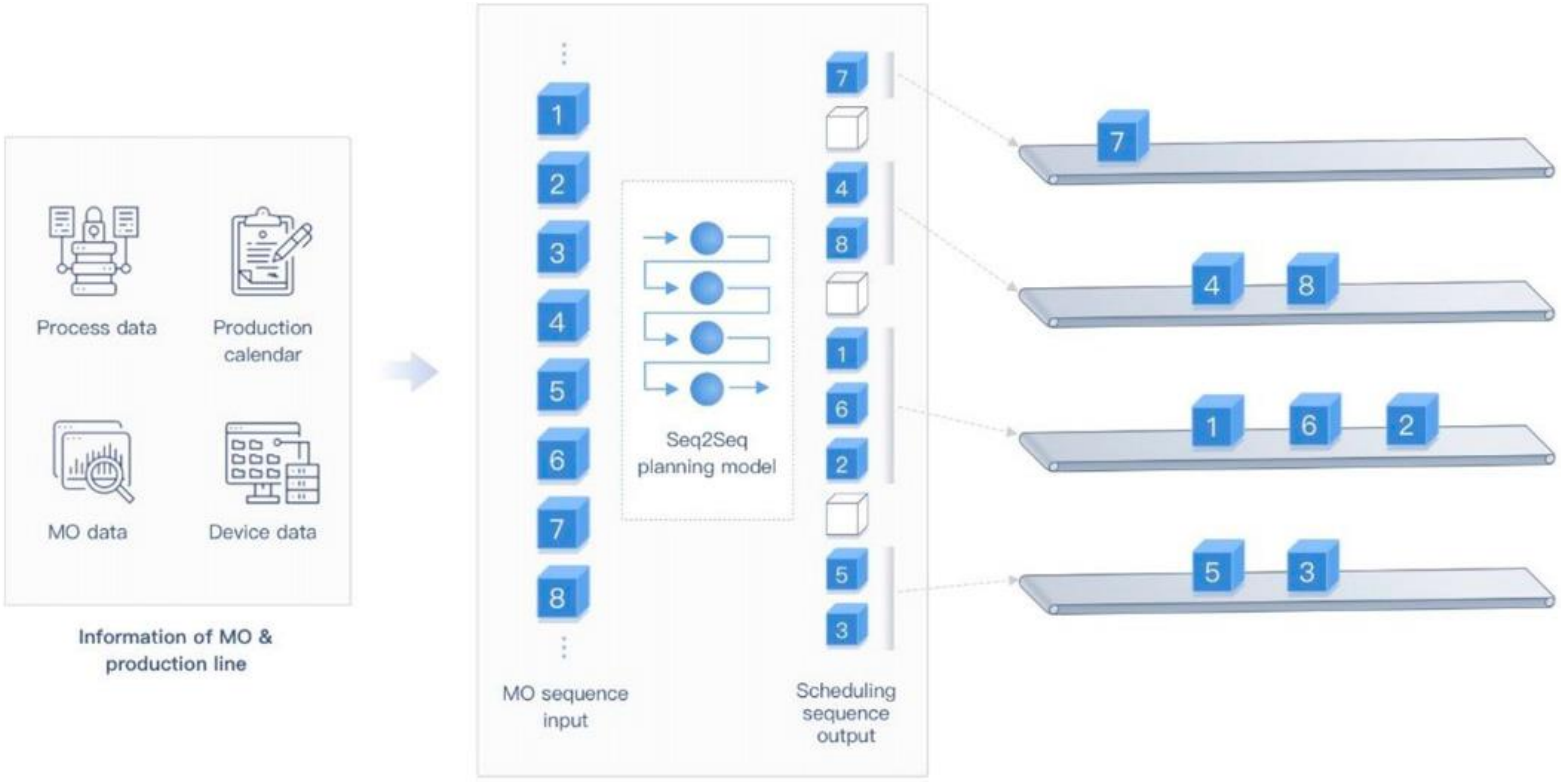
JD's Intelligent Warehouse Robots

- storage rack-moving robots

- Fulfillment expense ratio: to 6.5%
- Same-day/one day order: 90%

Qin, Hengle, et al. "JD. com: Operations Research Algorithms Drive Intelligent Warehouse Robots to Work." INFORMS Journal on Applied Analytics 52.1 (2022): 42-55.

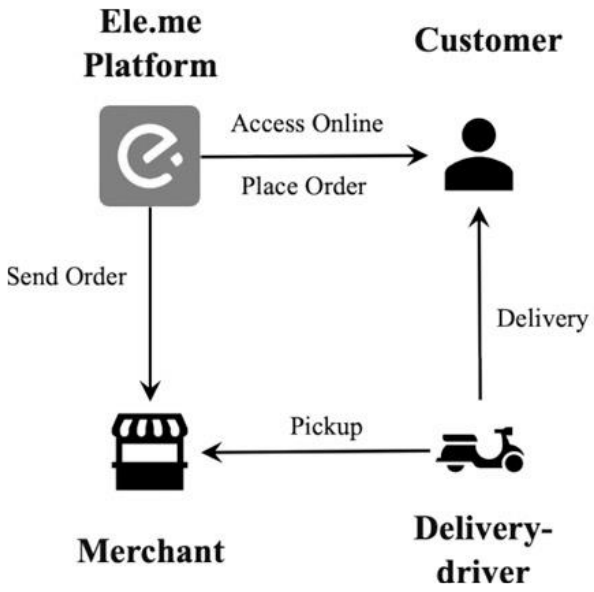
Lenovo Manufacturing Scheduling with RL

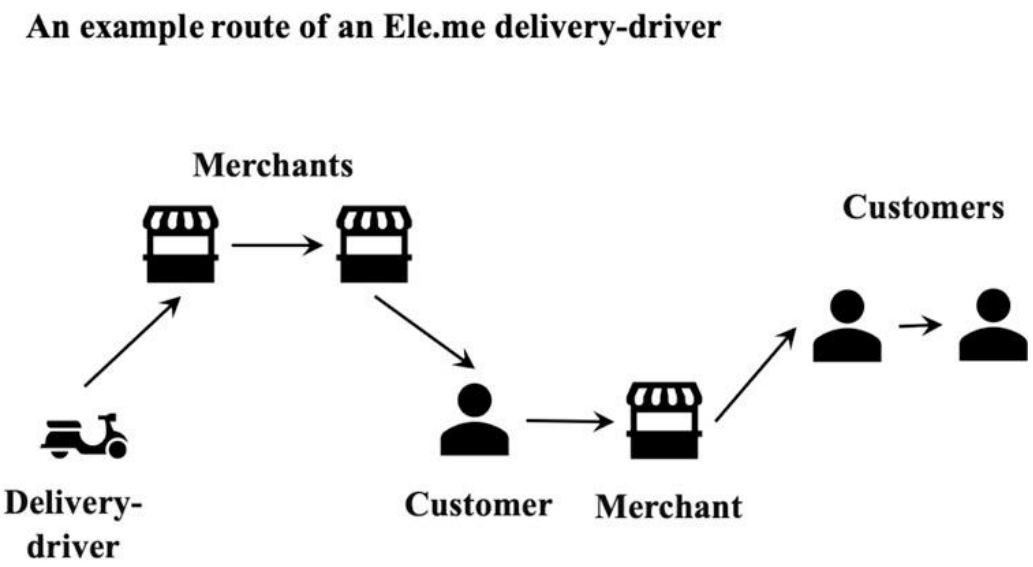


- Backlog: reduce 20%
- Fulfillment rate: improve 23%
- Revenue: increase $1.91 billion in 2019, $2.69 billion 2020

Liang, Yi, et al. "Lenovo Schedules Laptop Manufacturing Using Deep Reinforcement Learning." *INFORMS Journal on Applied Analytics* 52.1 (2022): 56-68.

Alibaba Solves Routing Problems with ML





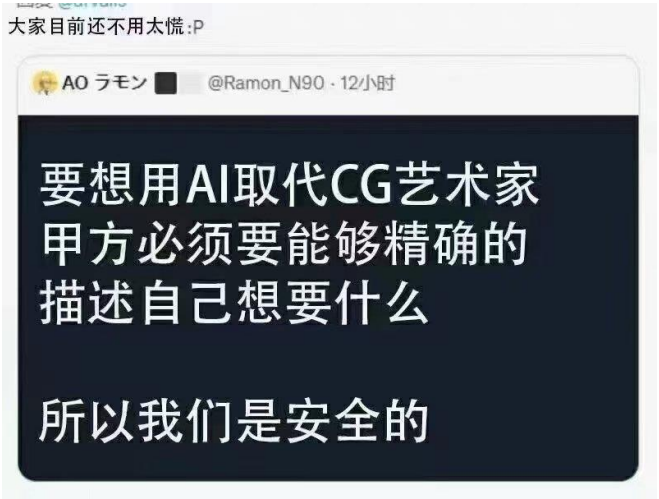
- Solve VRPs in several Alibaba subsidiaries
- Cost: save $50 million

Hu, Haoyuan, et al. "Alibaba Vehicle Routing Algorithms Enable Rapid Pick and Delivery." *INFORMS Journal on Applied Analytics* 52.1 (2022): 27-41.

Critical Thinking

- “reproducibility crisis”(复现性危机)
  - https://www.wired.com/story/machine-learning-reproducibility-crisis/

- The role of human with machine learning



Quick wrap-up

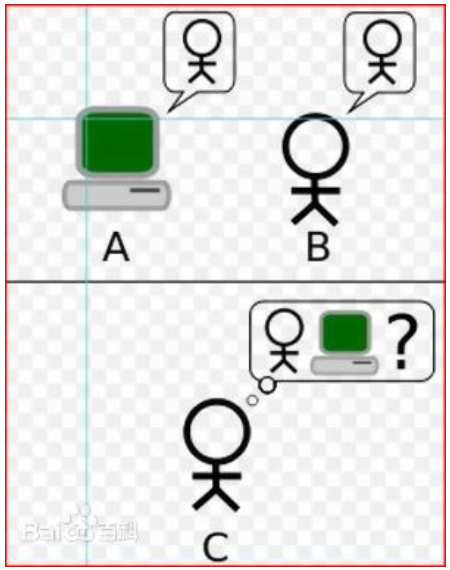
- Business analytics = data → value + decision
- How to turn (big) data into information/value?
- How to make right decisions?
- Machine learning can help us!

History of ML

The Turing Test

- Alan Mathison Turing
  - 1912-1954
  - the father of theoretical computer science and artificial intelligence

- The Turing Test
  - originally called the imitation game
  - a test of a machine's ability to exhibit intelligent behavior indistinguishable from that of a human

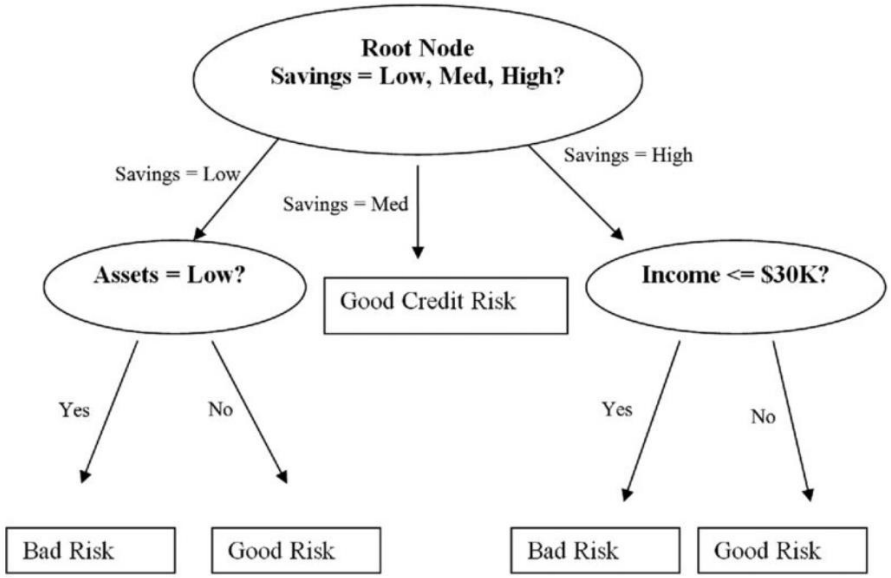


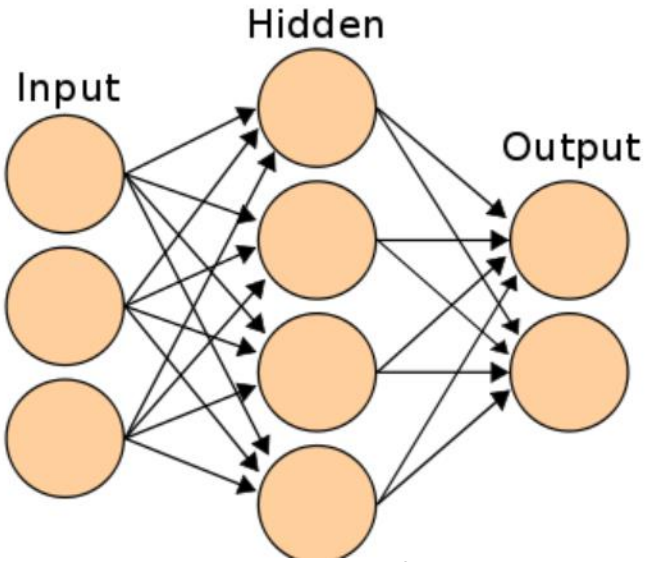
https://www.bilibili.com/video/BV1xs411S77R

History of machine learning

- 1950s
  - Samuel's checker player
  - Machine learning term created
- 1960s
  - Neural networks: Perceptron
  - Pattern recognition
- 1970s
  - Symbolic concept induction
    - "Logic theorist": We can give machine intelligence if we give them logic
  - Expert systems and the knowledge acquisition bottleneck
    - Only with logic is far from intelligence
    - Machines need knowledge
    - Then find it is hard to teach knowledge summarized by humans to machines
    - It would be better if machines can learn knowledge by themselves!
  - Quinlan's ID3

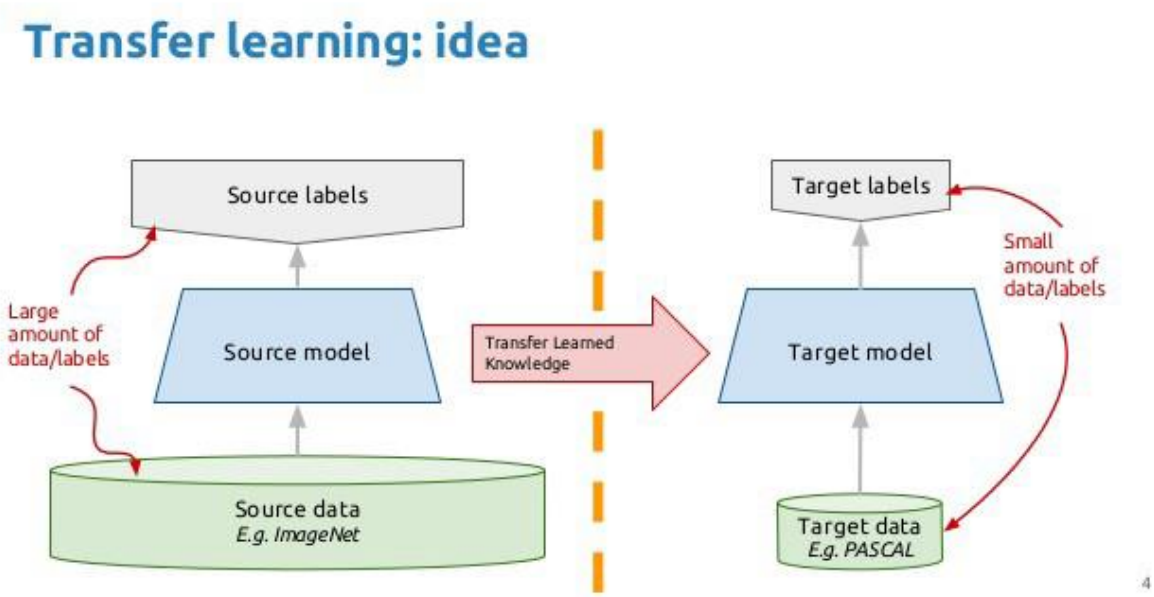
- 1980s
  - Advanced decision tree
    - Learning from samples
    - Simple and efficient
    - Ability to represent knowledge
    - Easy to demonstrate
    - But is hard to learn for large dataset
  - Explanation-based Learning
  - Learning and planning
  - Analogy (类比)
  - Cognitive architectures
  - Resurgence of neural networks
    - Learning from samples
    - Limits: rely heavily on parameters
  - Valiant's PAC Learning Theory (probably approximately correct)





- 1990s
  - Data mining
  - Adaptive software agents and web applications
  - Text learning
  - Reinforcement learning (RL)
  - Ensembles: Bagging, Boosting, and Stacking
  - Bayes Net learning
  - Support vector machines
  - Kernel methods

- 2000s
  - Transfer Learning
  - Sequence labeling
  - Collective classification and structured outputs
  - Computer systems applications
  - Email management
  - Personalized assistants

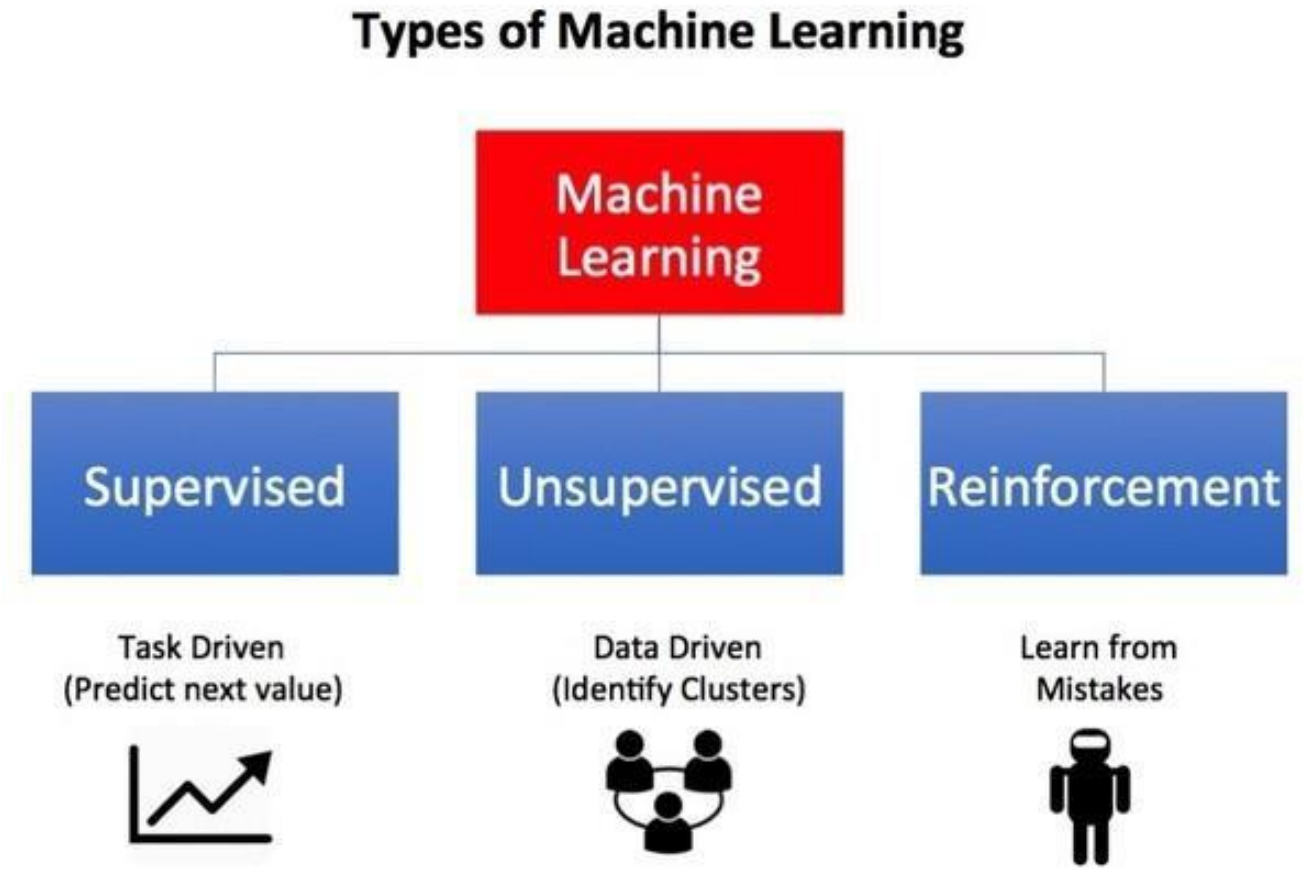


- 2010s
  - Deep learning
    - Good performances in images/speeches
    - Rely on good parameters (compared to good user previously)
    - Lack of theoretical guarantees but lower threshold to users
  - Learning from big data
  - Learning with GPUs or HPC
  - Multi-task & lifelong learning
  - Deep reinforcement learning
  - Massive applications to vision, speech, text, networks, behavior etc.
  - Meta-learning and AutoML
  - …

- https://www.bilibili.com/video/BV1jt411b7di

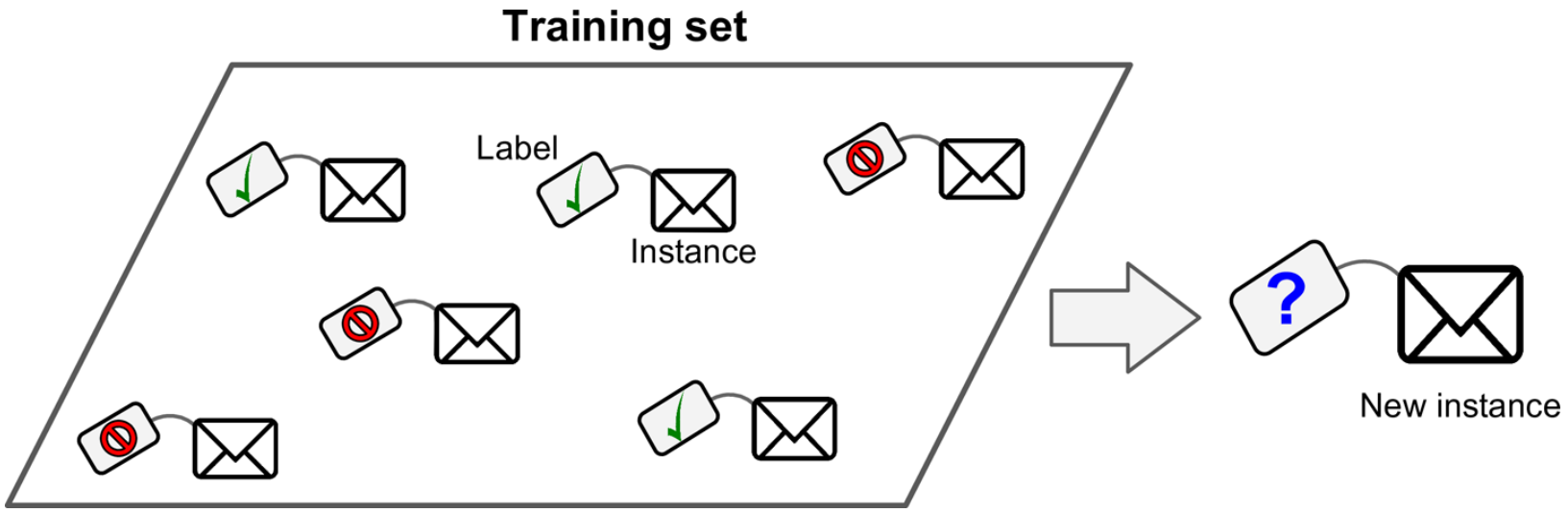
Classifications of ML

Classifications of machine learning



Supervised learning

- Learning a function that maps an input to an output based on example input-output pairs

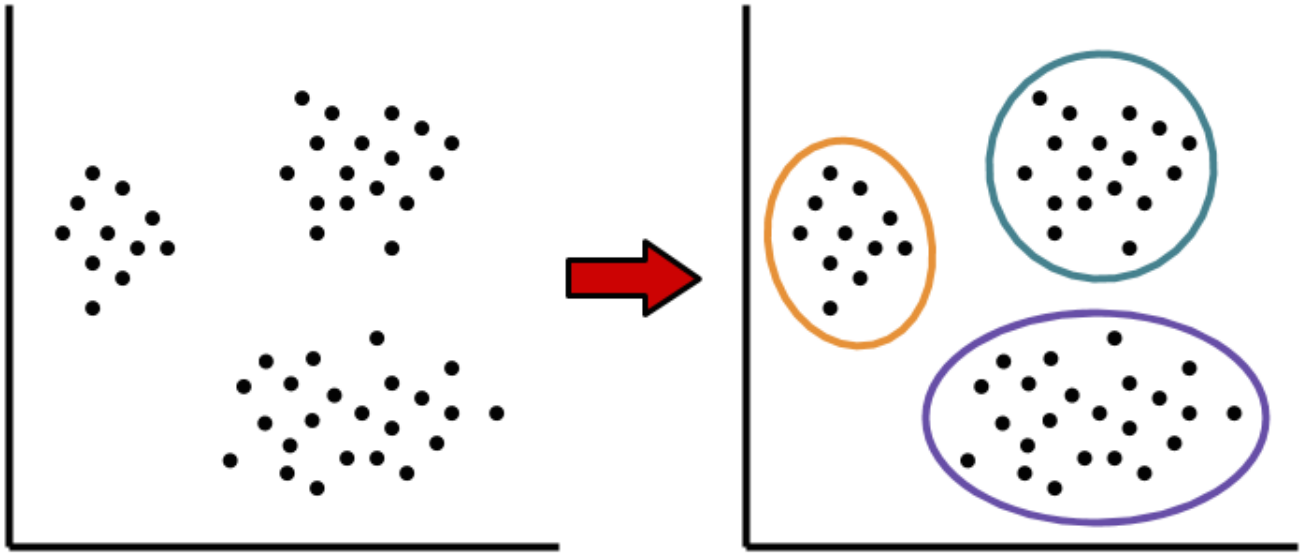


Supervised learning (cont.)

- Linear regression
- Logistic regression
- Decision trees
- Support Vector Machines
- Multi-layer perceptron (one kind of neural networks)
- etc.

Unsupervised learning

- Finding previously unknown patterns in data set without pre-existing labels

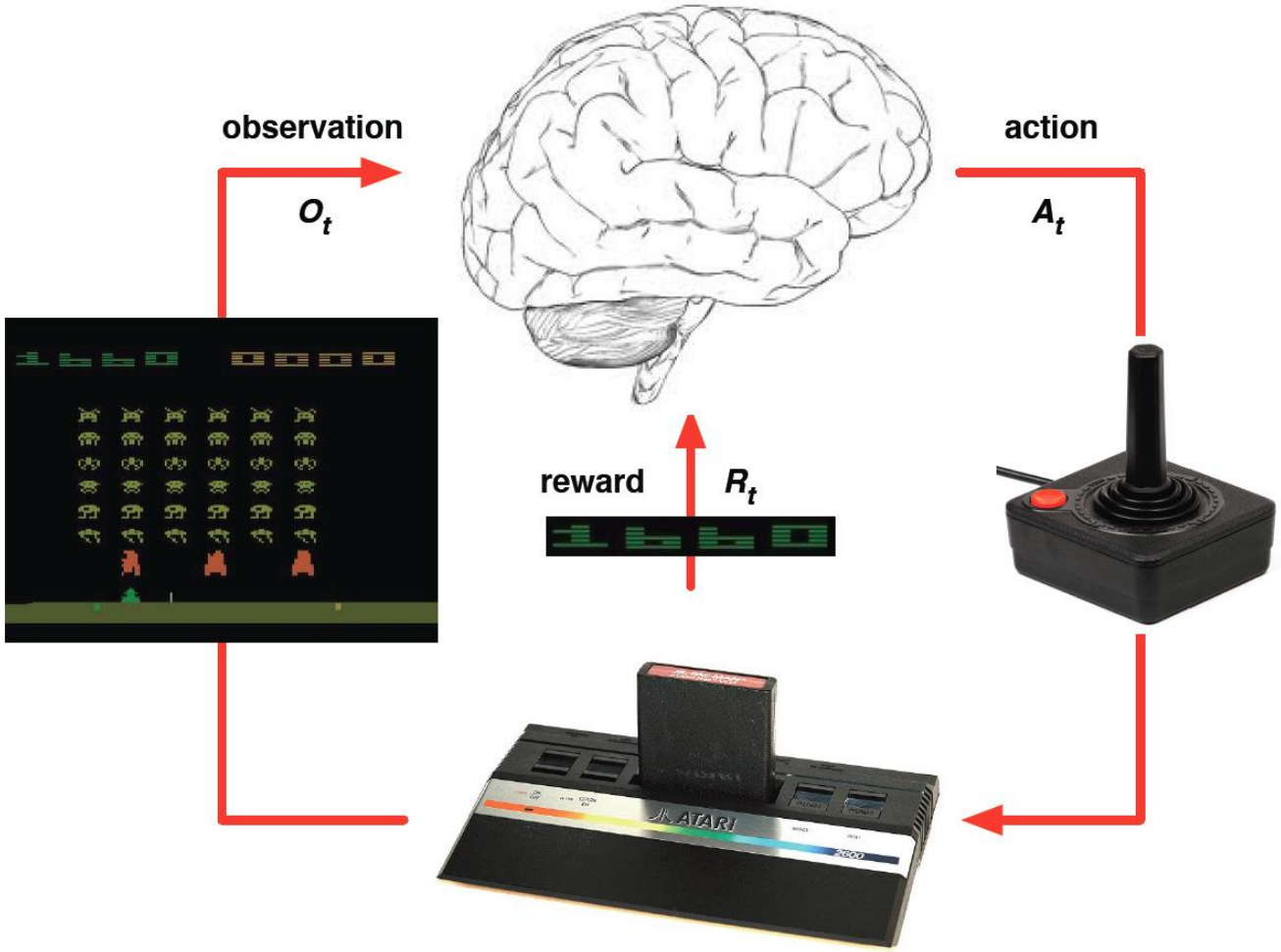


Unsupervised learning (cont.)

- Clustering
- Principal component analysis
- Autoencoders
- Expectation–maximization method (EM)
- etc.

Reinforcement learning

- Taking actions in an environment in order to maximize some notion of cumulative reward



Reinforcement learning (cont.)

- Markov decision process (MDP)
- Approximate dynamic programming (ADP)
- Q-learning
- Deep Q Network (still a kind of neural networks)
- etc.

Deep learning?

- A neural network which is very deep

- When we need?
  - Handle huge amount of data
  - Learn high-level features from data
  - Solve complex problem

- What it needs?
  - High-end machines (GPU etc.)
  - More computational time

Course outline

- Supervised learning
  - Linear regression
  - Logistic regression
  - SVM and kernel
  - Tree models
- Deep learning
  - Neural networks
  - Convolutional NN
  - Recurrent NN
- Unsupervised learning
  - Clustering
  - PCA, SVD
  - EM

Lecture 1 wrap-up

- ✓What is machine learning
- ✓Machine learning applications
- ✓History of machine learning
- ✓Classifications of machine learning

Reference: VE 445, Shuai LI (SJTU); MSBA 7002, Haipeng SHEN (HKU)

Assignment 1

- **Submit a life photo** to http://xzc.cn/BWWbw3Pzz7
  - Due: Aug. 31, 11:59pm

Questions?

Shan Wang (王杉)

https://wang-shan.gitee.io/