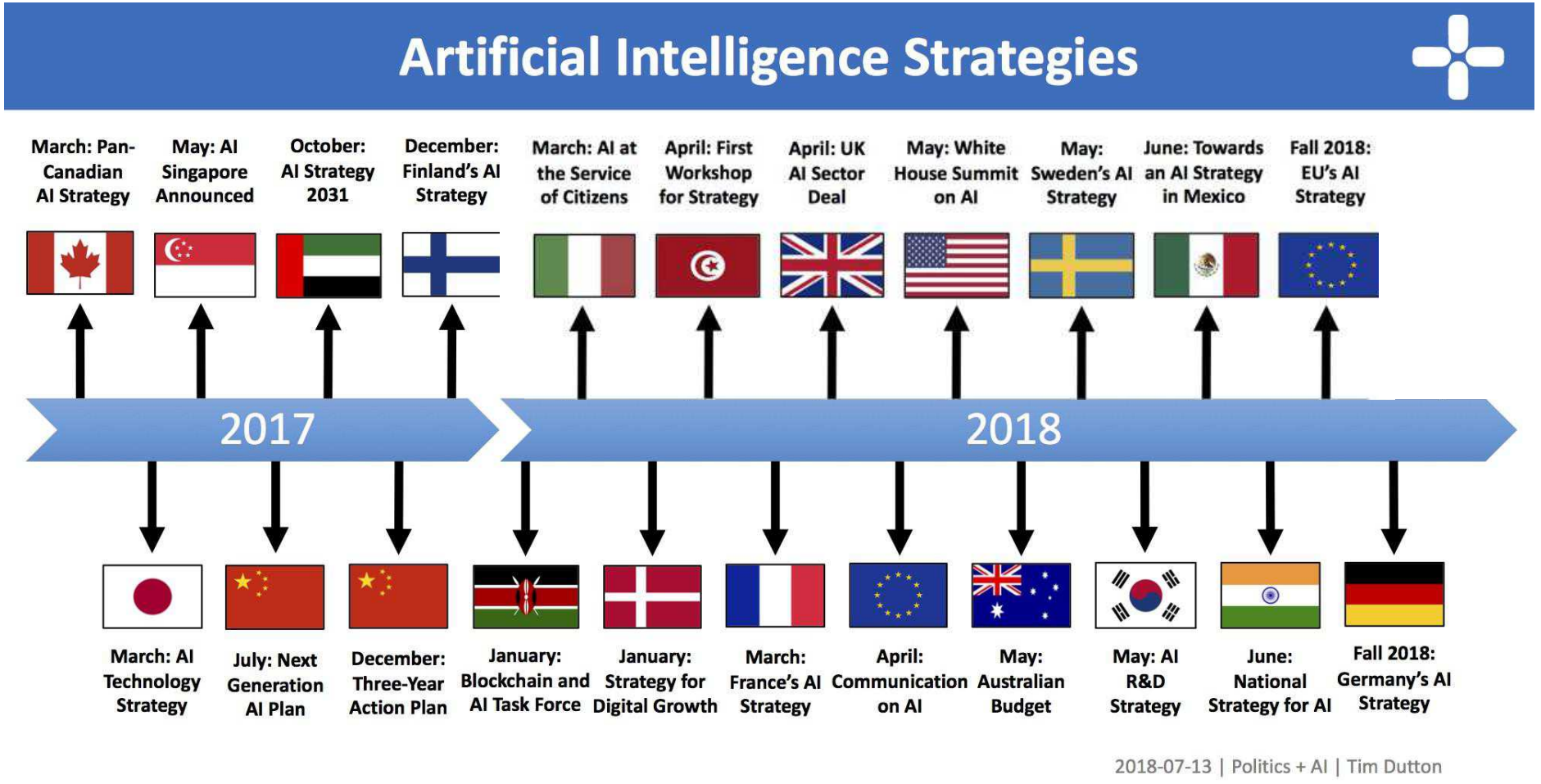
浅谈人工智能的下个十年

Jie Tang

Computer Science

Tsinghua University

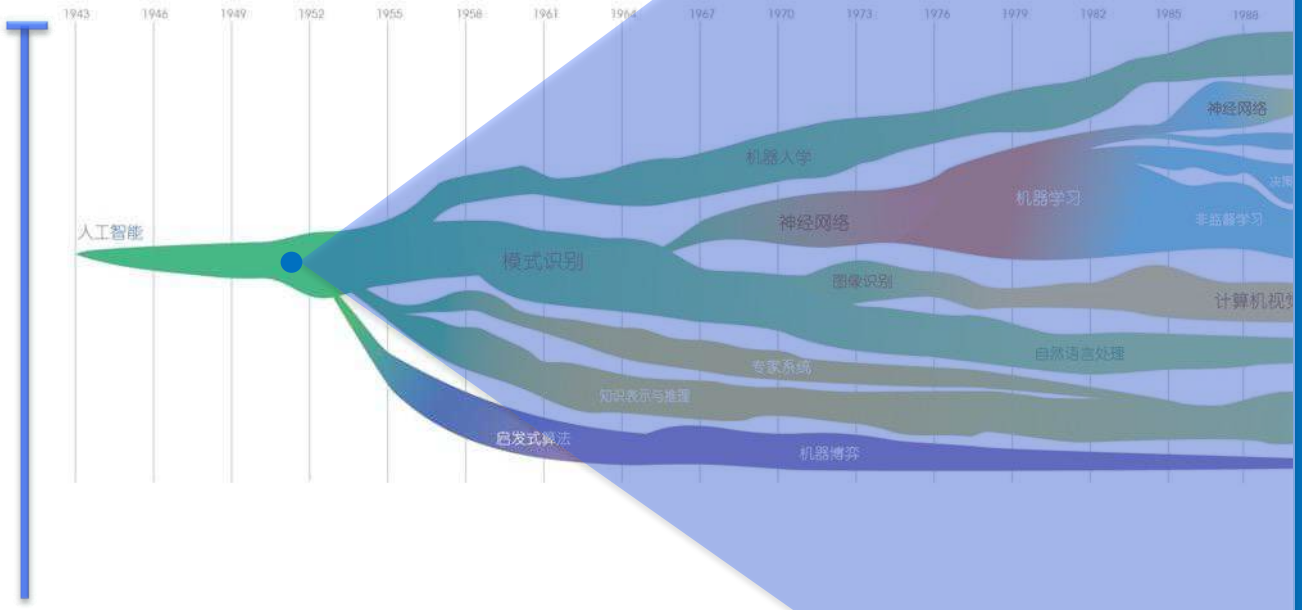
人工智能的第三次浪潮


Artificial Intelligence Strategies
March: Pan-Canadian AI Strategy
May: AI Singapore Announced
October: AI Strategy 2031
December: Finland's AI Strategy
March: AI at the Service of Citizens
April: First Workshop for Strategy
April: UK AI Sector Deal
May: White House Summit on AI
May: Sweden's AI Strategy
June: Towards an AI Strategy in Mexico
Fall 2018: EU's AI Strategy
2017
2018
March: AI Technology Strategy
July: Next Generation AI Plan
December: Three-Year Action Plan
January: Blockchain and AI Task Force
January: Strategy for Digital Growth
March: France's AI Strategy
April: Communication on AI
May: Australian Budget
May: AI R&D Strategy
June: National Strategy for AI
Fall 2018: Germany's AI Strategy
2018-07-13 | Politics + AI | Tim Dutton

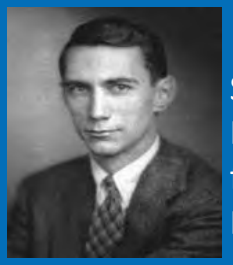
人工智能历史

SEARCH

人工智能领域发展趋势



1950计算机象棋博弈



Claude Shannon

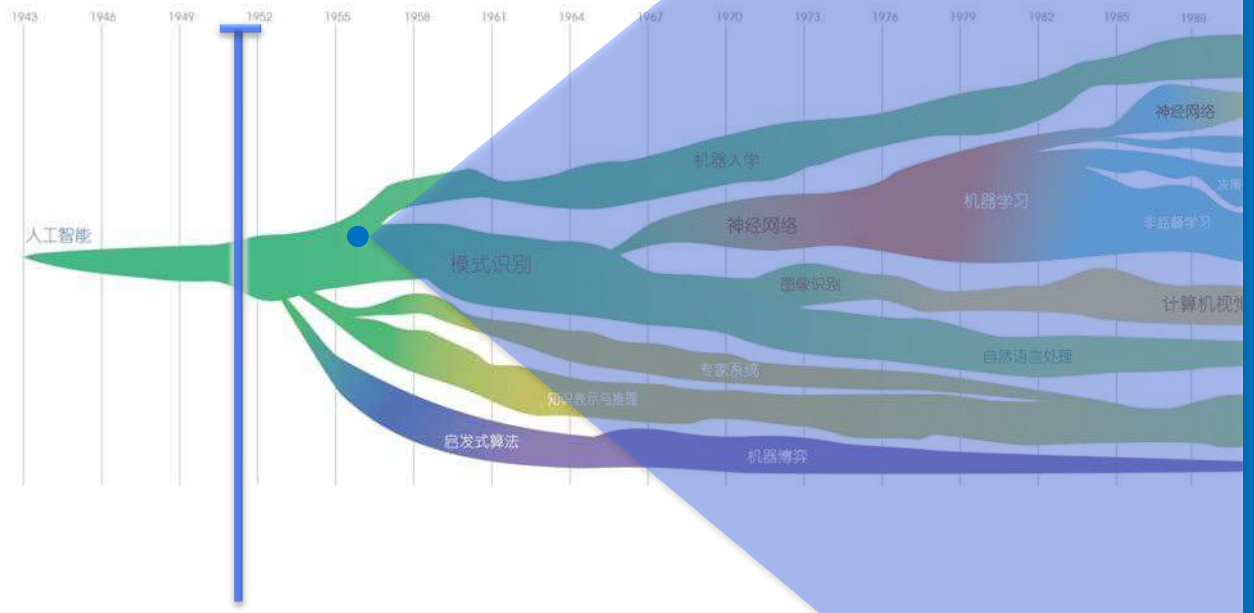
Shannon, Claude E. "XXII. Programming a computer for playing chess." Philosophical magazine 41.314 (1950): 256-275.

1954图灵测试

Alan Turing

Turing, Alan M. "Solvable and unsolvable problems." Science News-ens. fr 39 (1954).

人工智能领域发展趋势 P



1956达特茅斯会议


John McCarthy


Marvin Minsky


Nathan Rochester


Claude Shannon

McCarthy, J., et al. "Dartmouth Conference." Dartmouth Summer Research Conference on Artificial Intelligence. 1956

1959一般问题解决器

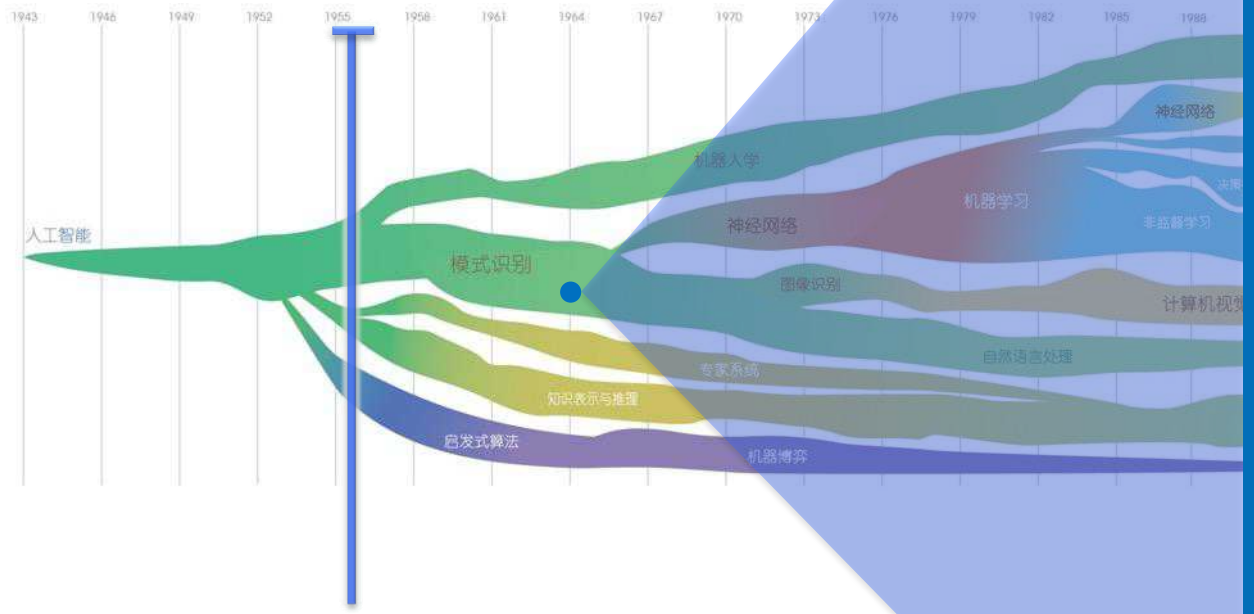

Herbert Simon


J.C. Shaw


Allen Newell

Newell, A.; Shaw, J.C.; Simon, H.A. (1959). Report on a general problem-solving program. Proceedings of the International Conference on Information Processing. pp. 256–264.

人工智能领域发展趋势 P



1964 理解自然语言输入

Daniel Bobrow

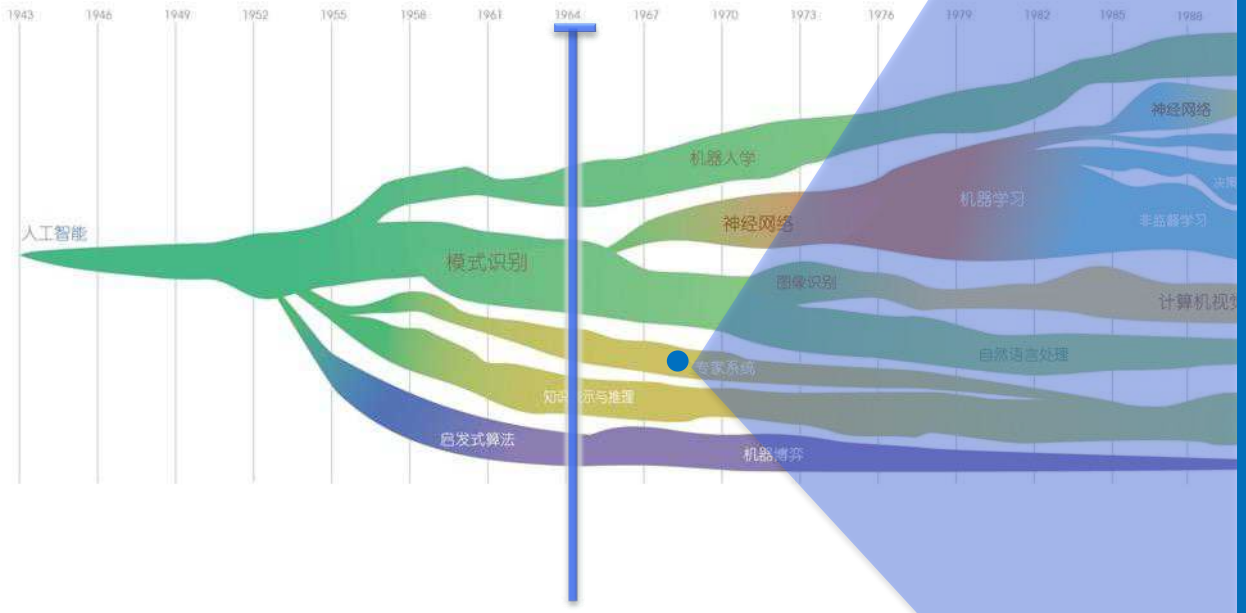
Bobrow, Daniel G. "Natural language input for a computer problem solving system." (1964)

1966 ELIZA人机对话

Joseph Weizenbaum

Weizenbaum, Joseph. "ELIZA—a computer program for the study of natural language communication between man and machine." Communications of the ACM 9.1 (1966): 36-45.

人工智能领域发展趋势

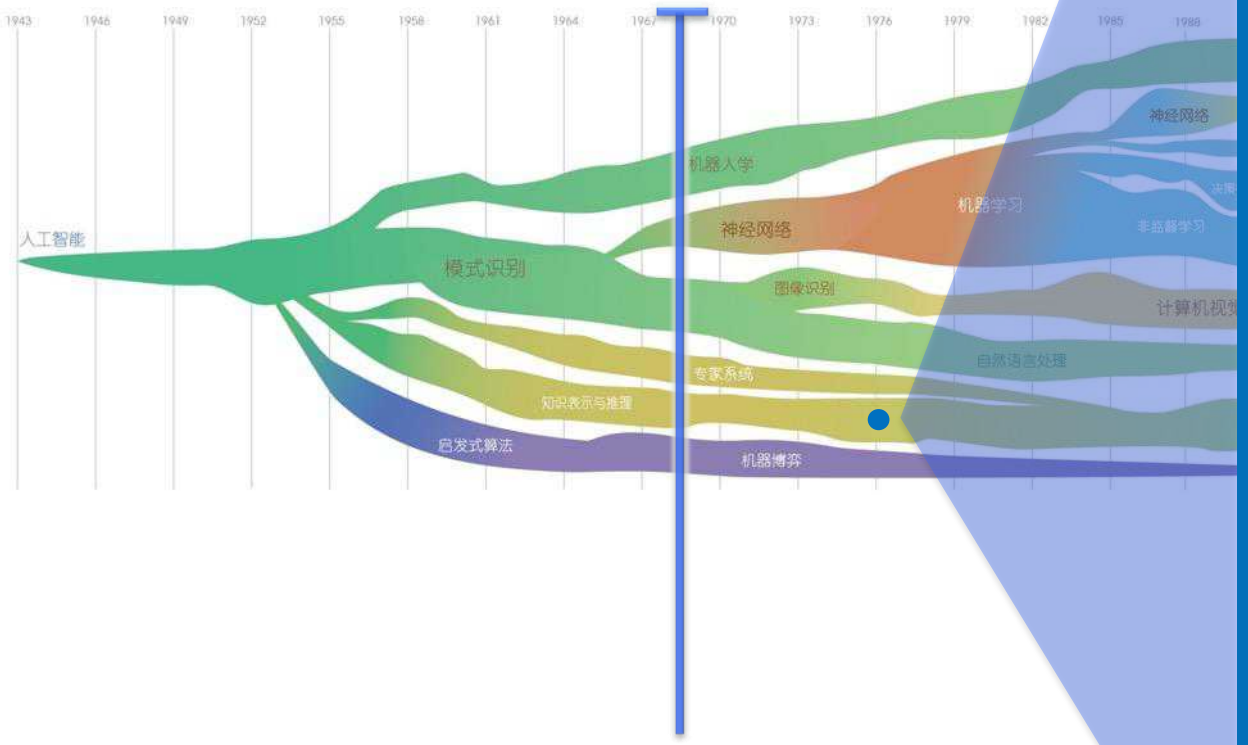


1968 世界首个专家系统DENDRAL

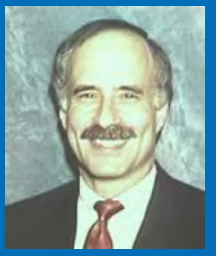
Edward Feigenbaum

Buchanan, Bruce, Georgia Sutherland, and Edward A. Feigenbaum. Heuristic DENDRAL: a program for generating explanatory hypotheses in organic chemistry. Defense Technical Information Center, 1968.

人工智能领域发展趋势



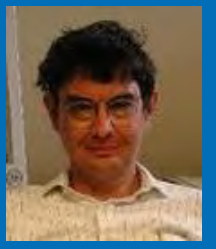
1976 大规模知识库构建与维护



Randall Davis

Applications of meta level knowledge to the construction, maintenance and use of large knowledge bases[M]. Stanford University, Computer Science Department, AI Laboratory, 1976.

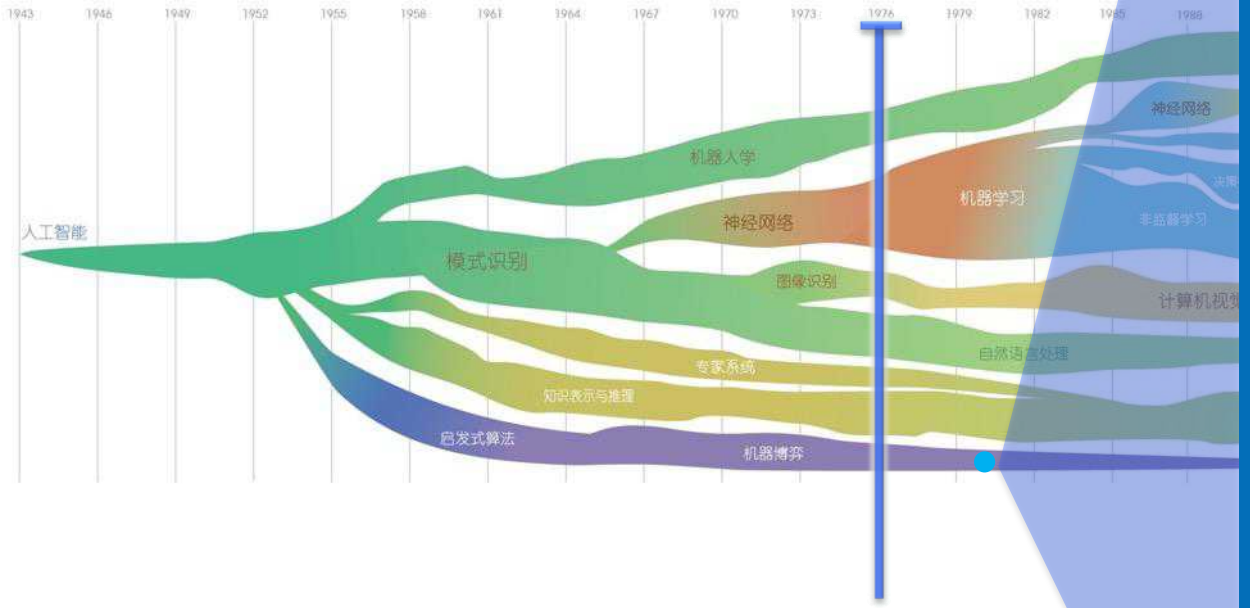
1980 非单调逻辑



Drew McDermott, Jon Doyle

McDermott D, Doyle J. Non-monotonic logic I[J]. Artificial intelligence, 1980, 13(1): 41-72.

人工智能领域发展趋势

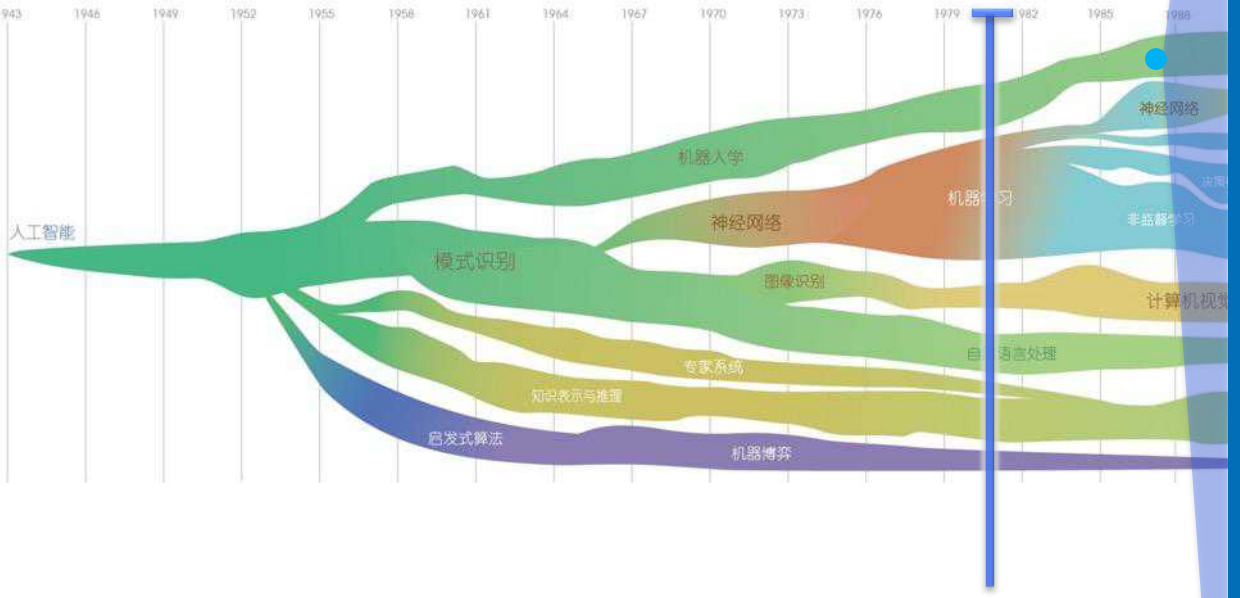


1980 计算机战胜双陆棋世界冠军

Hans Berliner

Berliner H J. Backgammon computer program beats world champion[J]. Artificial Intelligence, 1980, 14(2): 205-220.

人工智能领域发展趋势

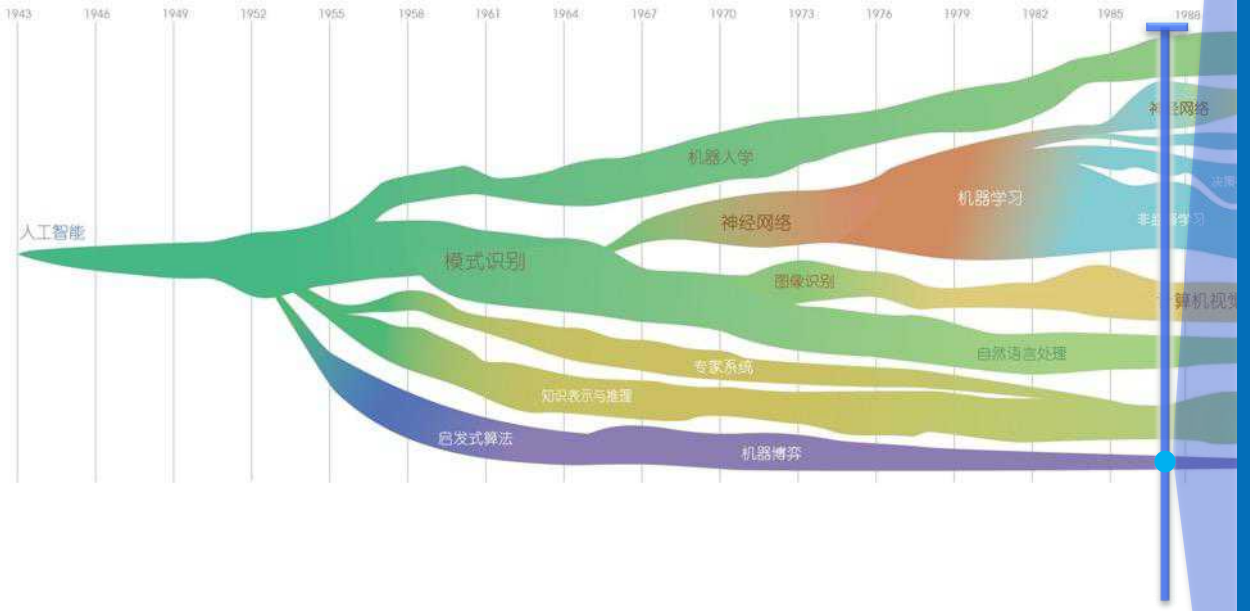


1987 基于行为的机器人学

Rodney Brooks

Brooks R. A robust layered control system for a mobile robot[J]. Robotics and Automation, IEEE Journal of, 1986, 2(1): 14-23

人工智能领域发展趋势



1987 自我学习双陆棋程序

Gerry Tesauro

Tesauro G. TD-Gammon, a self-teaching backgammon program, achieves master-level play[J]. Neural computation, 1994, 6(2): 215-219.

1998 语义互联网路线图

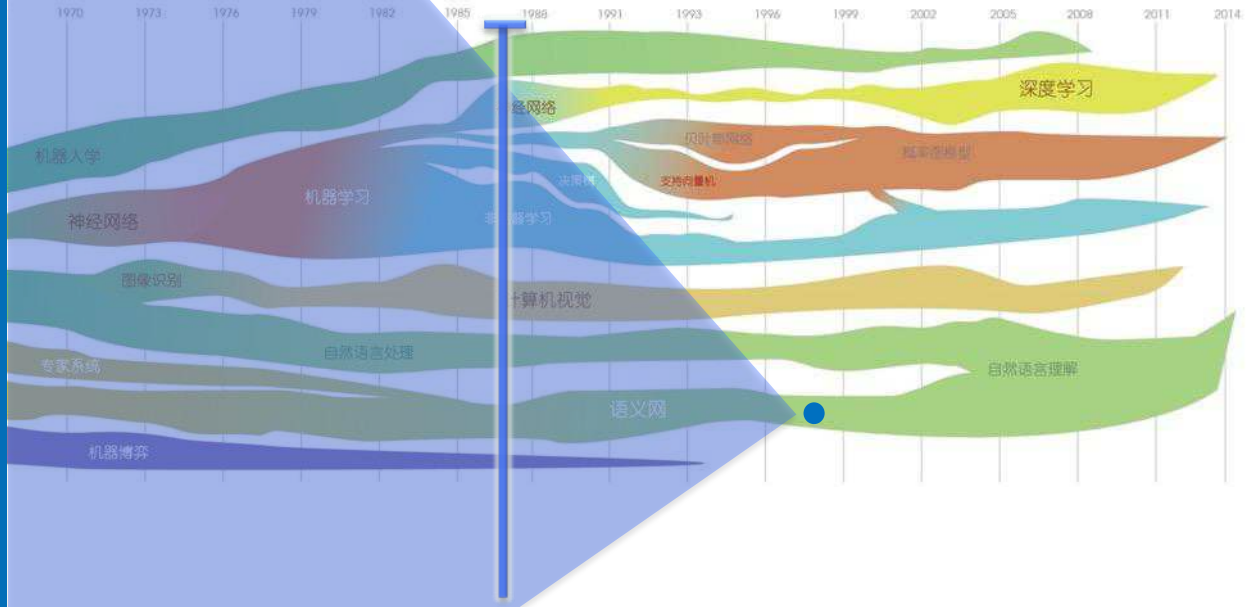
Tim Berners-Lee

Berners-Lee, Tim. "Semantic web road map." (1998).

2004 OWL语言

McGuinness, Deborah L., and Frank Van Harmelen. "OWL web ontology language overview." W3C recommendation 10.2004-03 (2004): 10.

域发展趋势 Powered by AMiner



2006 深度学习

Geoffrey Hinton

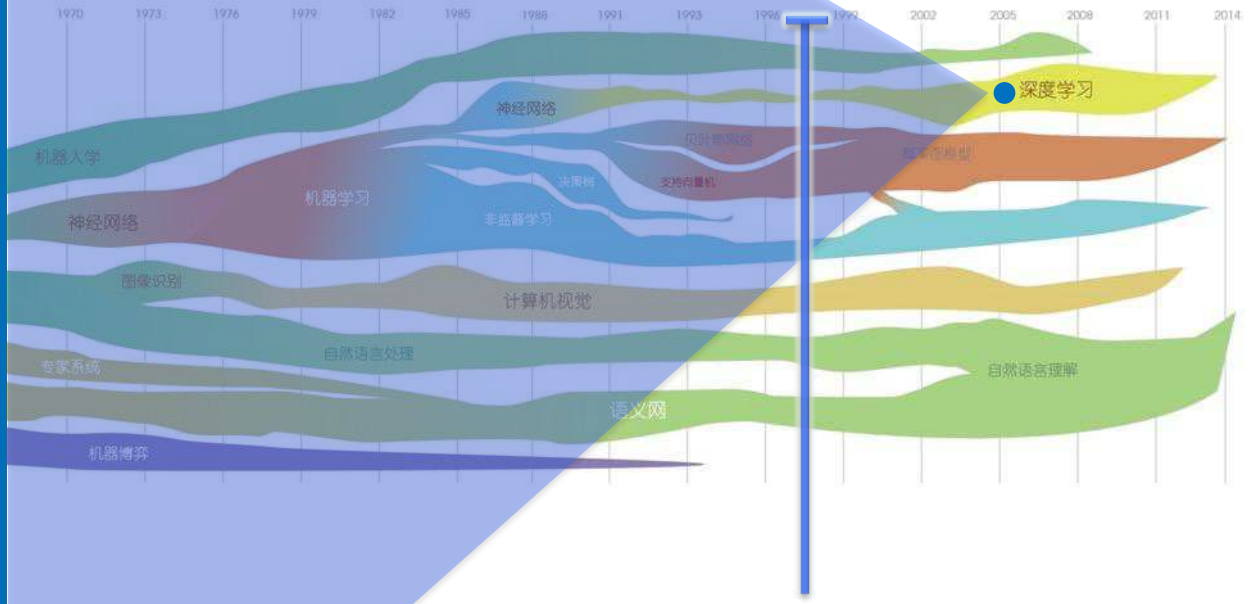
Hinton, Geoffrey E., Simon Osindero, and Yee-Whye Teh. "A fast learning algorithm for deep belief nets." Neural computation 18.7 (2006): 1527-1554.

2011 高层抽象特征构建



Le, Quoc V., et al. "Building high-level features using large scale unsupervised learning." arXiv preprint arXiv:1112.6209 (2011).

域发展趋势 Powered by AMiner

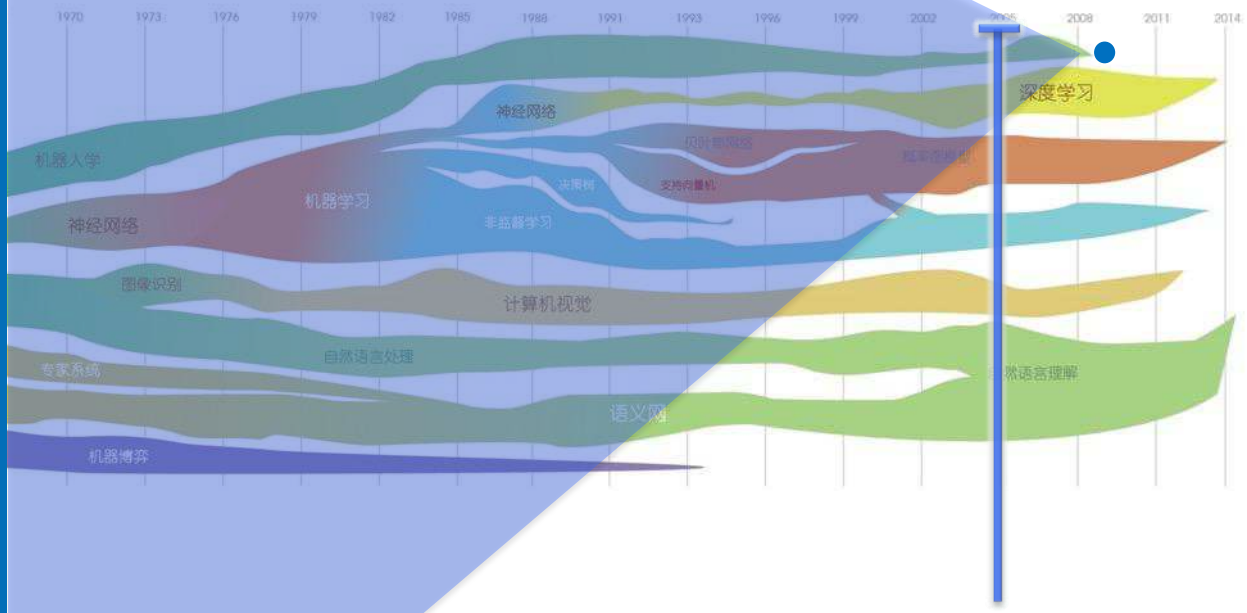


2009 谷歌自动驾驶汽车

Sebastian Thrun

Markoff, John. "Google cars drive themselves, in traffic." The New York Times 10 (2010): A1.

域发展趋势 Powered by AMiner



2011 沃森获得Jeopardy冠军

IBM’ s Watson

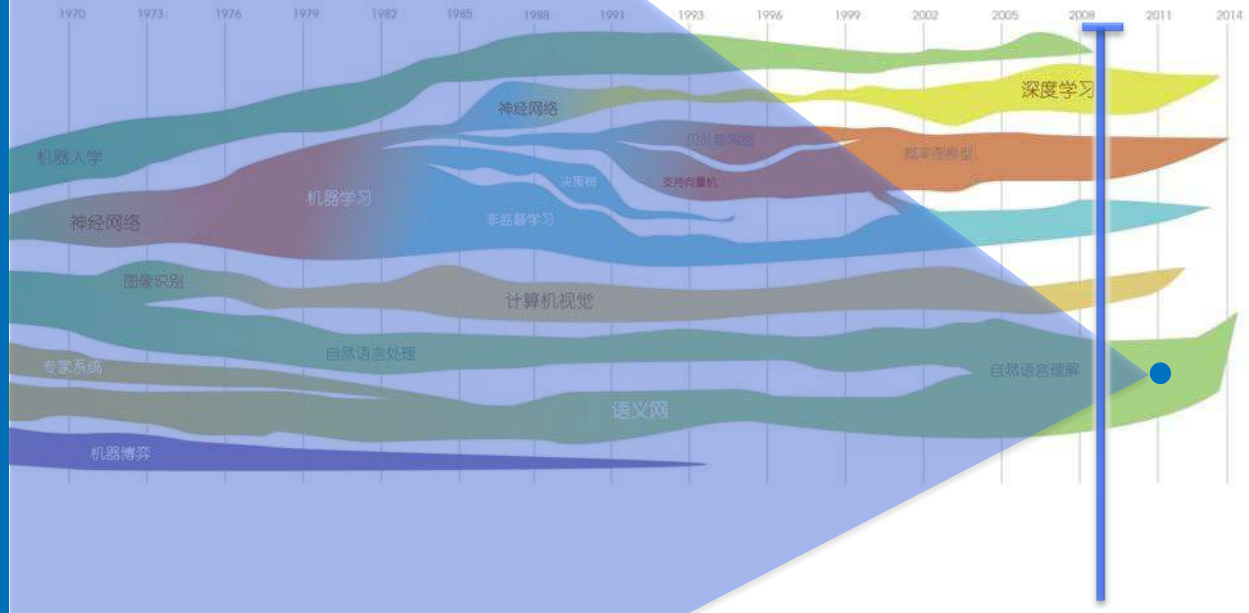
Markoff, John. "Computer program to take on ‘Jeopardy!’." The New York Times (2009).

2011 自然语言问答

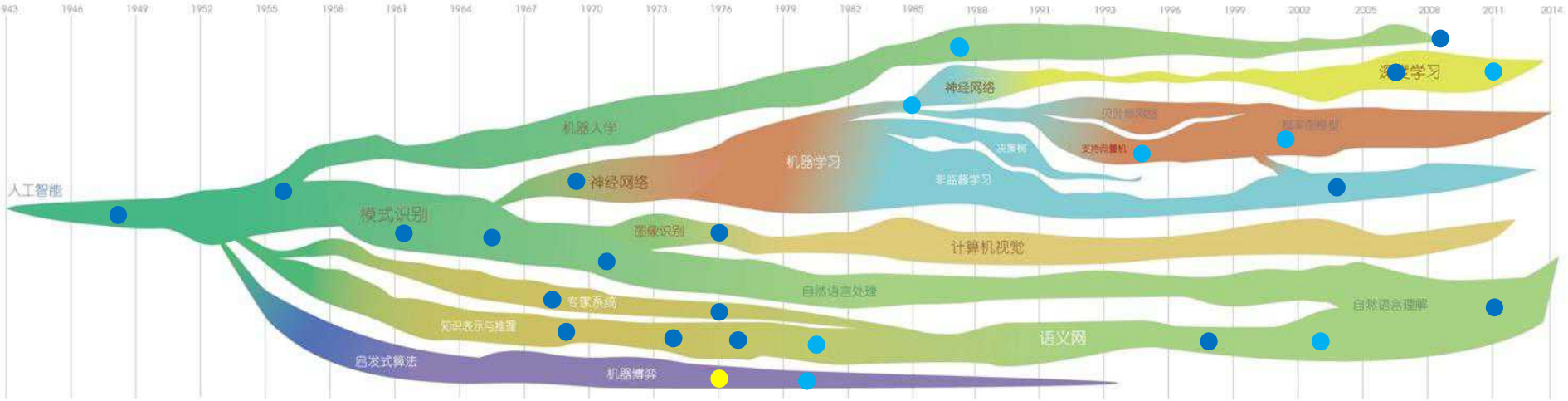
Apple’ s Siri

Sadun, Erica, and Steve Sande. Talking to Siri: Learning the Language of Apple's Intelligent Assistant. Que Publishing, 2013.

域发展趋势 Powered by AMiner



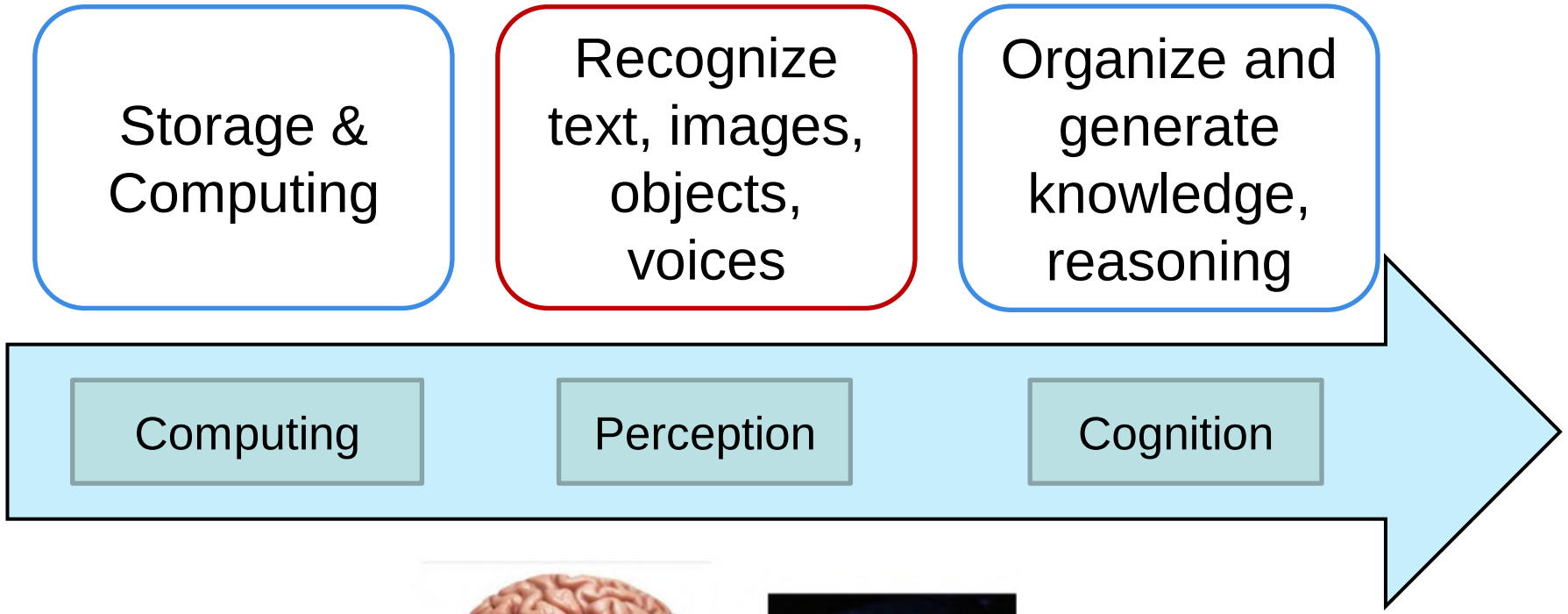
人工智能领域发展趋势 Powered by AMiner




AMiner
人工智能近10年
SEARCH

AI趋势：从感知到认知

- From perceptron to cognition



Stochastic vs Deterministic

Uncertainty!

Artificial Intelligence

AlphaGo

Self-driving

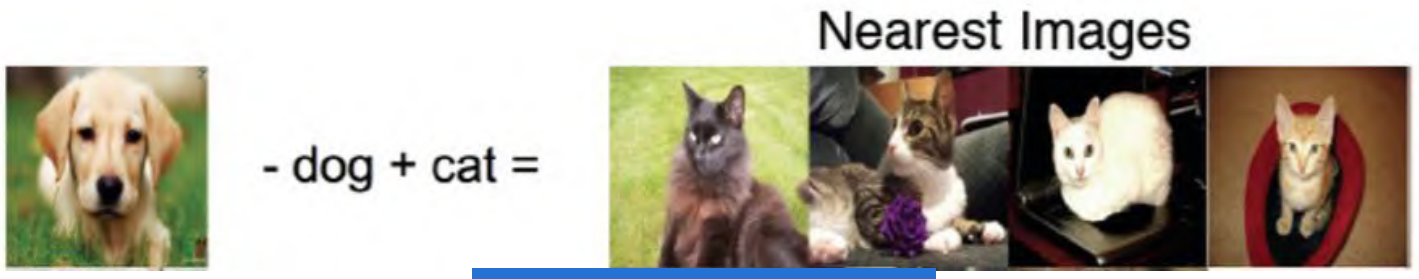


Image recognition

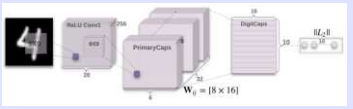
算法

Frank Rosenblatt
Cornell University
psychologist

Geoffery Hinton
University of Toronto
deep learning

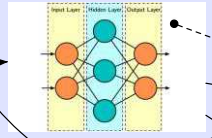
Yann Lecun
New York University
deep learning

Capsule Nets(2017)

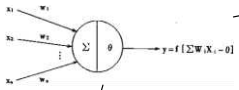


Kaiming He（何恺明）
MSRA => FAIR
computer vision

BPNN/MLP(1986)

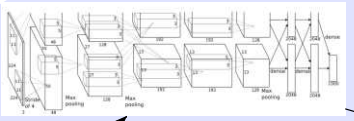


Perceptron(1958)

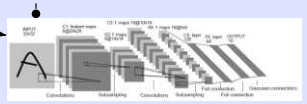


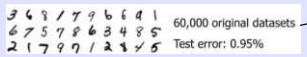
Neocognitron(1980)
[convolution & pooling]

AlexNet(2012)



LeNet/CNN(1998)





Relu, dropout & bigger

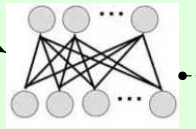
ResNet(2016)

VGG(2014)
GoogLeNet(2015)

DenseNet(2017)

Hopfield Network(1982)
[recurrent & feedback]

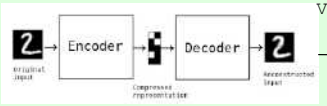
RBM(1986/2006)



stack

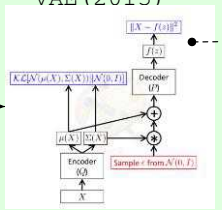
Deep Belief
Nets(2006)

AutoEncoder(1989/2006)
Denosing Autoencoder(2008)



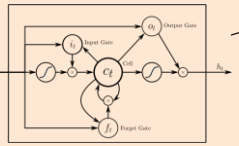
Variational
Inference

VAE(2013)



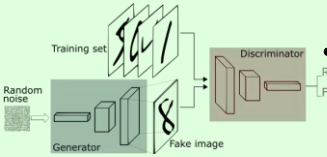
Max Welling
University of Amsterdam
statistical learning

RNN/LSTM(1997)



RNN in Speech
Recognition(2013)

GAN(2014)

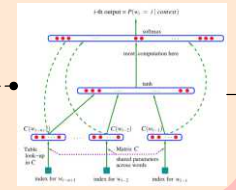


Ian Goodfellow
Google Brain
deep adversarial learning

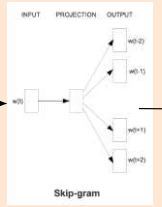
DCGAN(2014)
WGAN(2017)
PGGAN(2017)

SeqGAN(2017)
LeakGAN(2018)

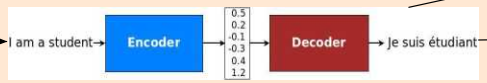
Neural Probabilistic
Language Model(2003)



word2Vec(2013)



Seq2Seq(2014)

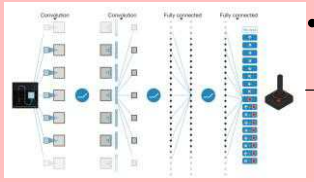


Character CNN(2015)
self-attention(2017)

Jürgen Schmidhuber
IDSIA
Universal AI

Yoshua Bengio
University of Montreal
Deep learning

Deep Q-
learning(2013)

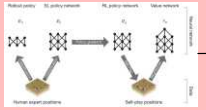


Double DQN(2015)
Dueling Net(2016)

David Silver
DeepMind
Reinforcement learning

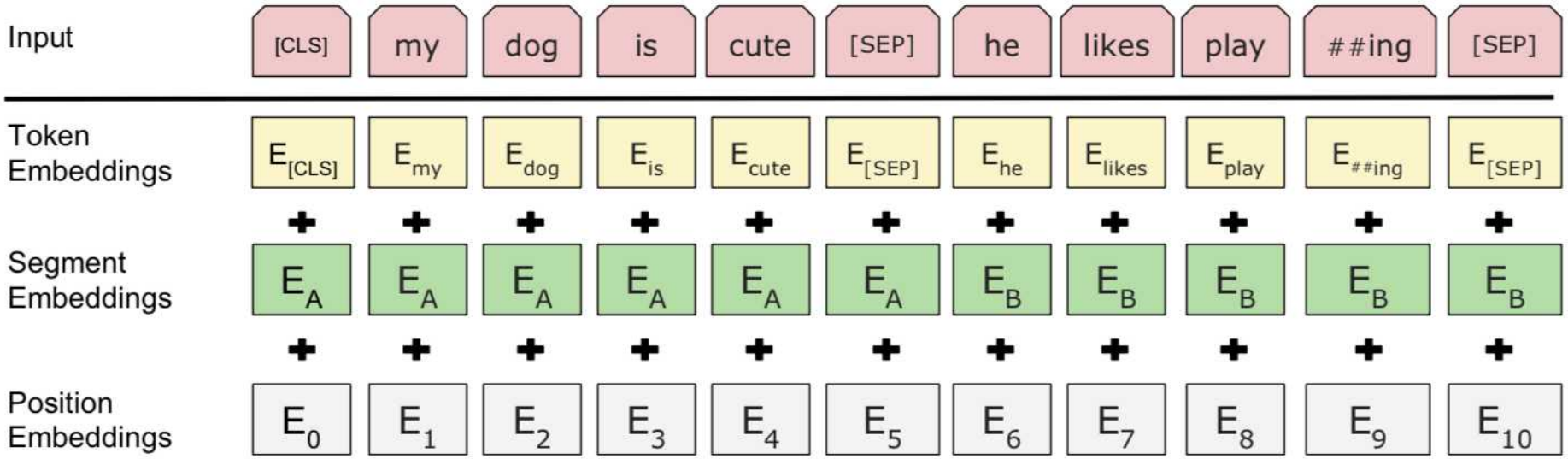
DDPG(2015) → A3C(2016)

AlphaGo(2016)



Alpha Zero(2017)

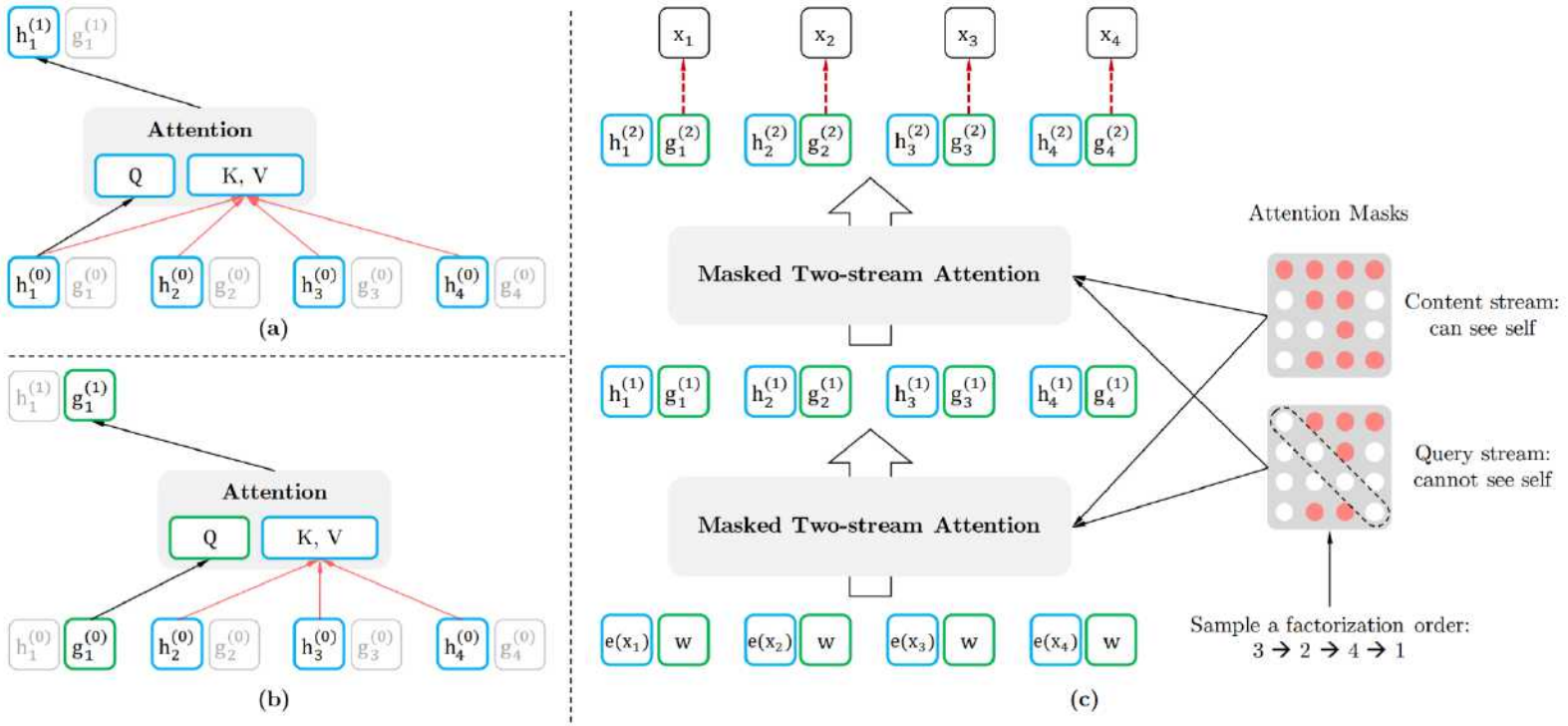
BERT



- Pre-train
- Fine tune
- Beat all state-of-the-arts on 11 NLP tasks in 2018

https://arxiv.org/pdf/1810.04805.pdf

XLNet



- Autoregressive Model
- Beat BERT in 2019

https://arxiv.org/pdf/1906.08237.pdf

ALBERT

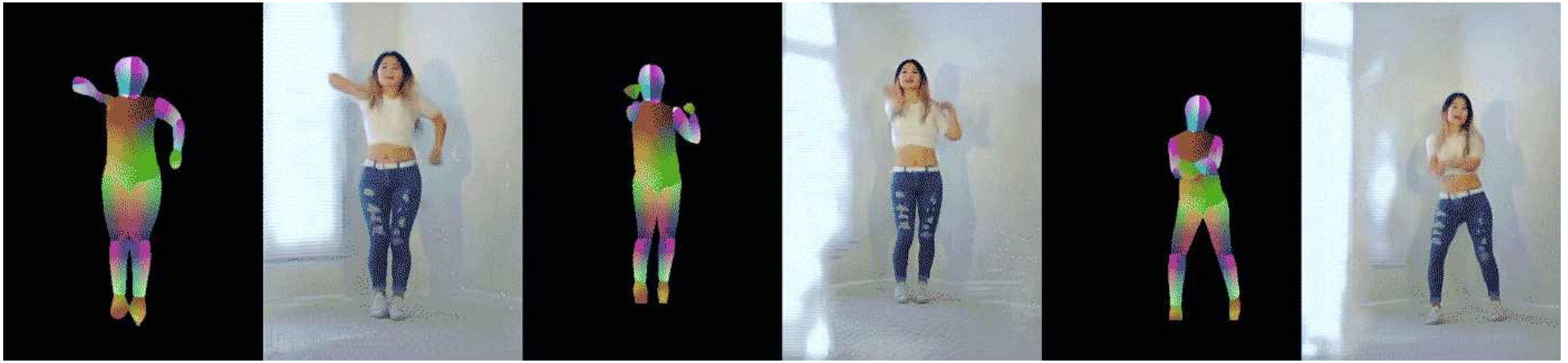
Model		Parameters	SQuAD1.1	SQuAD2.0	MNLI	SST-2	RACE	Avg	Speedup
BERT	base	108M	90.5/83.3	80.3/77.3	84.1	91.7	68.3	82.1	17.7x
	large	334M	92.4/85.8	83.9/80.8	85.8	92.2	73.8	85.1	3.8x
	xlarge	1270M	86.3/77.9	73.8/70.5	80.5	87.8	39.7	76.7	1.0
ALBERT	base	12M	89.3/82.1	79.1/76.1	81.9	89.4	63.5	80.1	21.1x
	large	18M	90.9/84.1	82.1/79.0	83.8	90.6	68.4	82.4	6.5x
	xlarge	59M	93.0/86.5	85.9/83.1	85.4	91.9	73.9	85.5	2.4x
	xxlarge	233M	**94.1/88.3**	**88.1/85.1**	**88.0**	**95.2**	**82.3**	**88.7**	1.2x

- A Lite BERT
- Parameter-reduction techniques
- Beat XLNet and all the others

https://arxiv.org/pdf/1909.11942.pdf

Video-to-Video Synthesis

- The best video synthesis performance

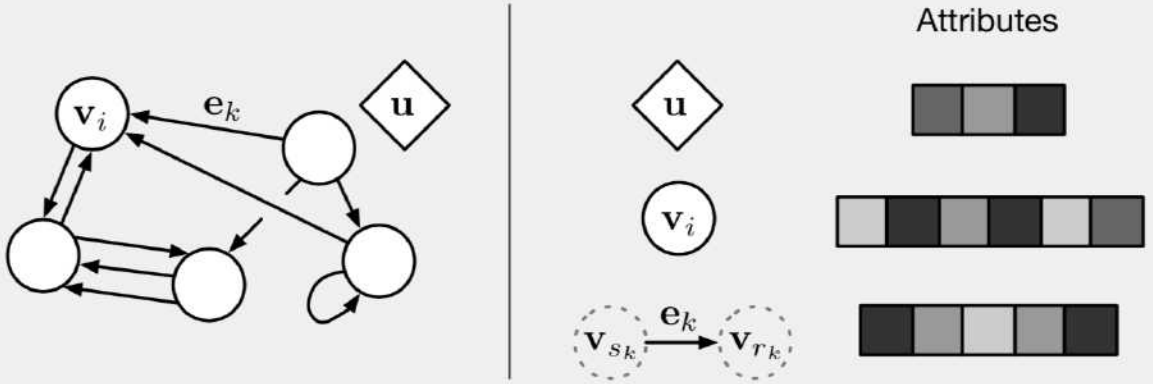


https://arxiv.org/abs/1808.06601

graph_net

- By DeepMind

Box 3: Our definition of "graph"



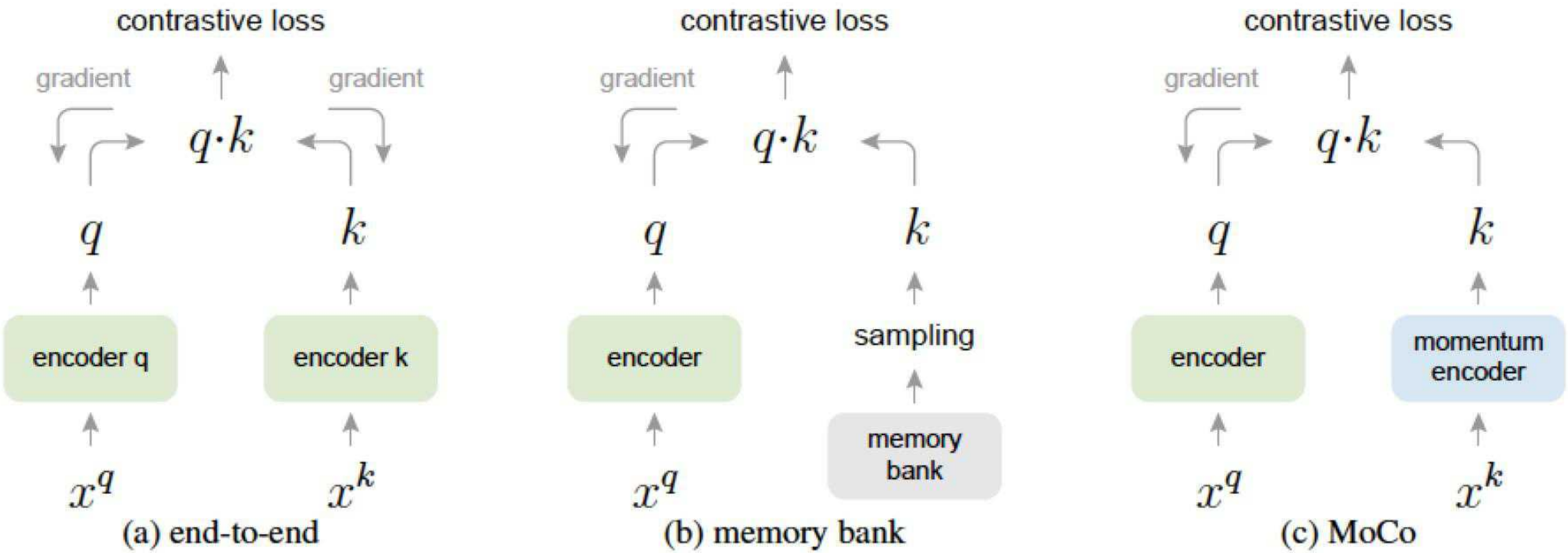
Here we use "graph" to mean a directed, attributed multi-graph with a global attribute. In our terminology, a node is denoted as $\mathbf{v}_i$, an edge as $\mathbf{e}_k$, and the global attributes as $\mathbf{u}$. We also use s_k and r_k to indicate the indices of the sender and receiver nodes (see below), respectively, for edge k. To be more precise, we define these terms as:

Directed : one-way edges, from a "sender" node to a "receiver" node.
Attribute : properties that can be encoded as a vector, set, or even another graph.
Attributed : edges and vertices have attributes associated with them.
Global attribute : a graph-level attribute.
Multi-graph : there can be more than one edge between vertices, including self-edges.

Figure 2 shows a variety of different types of graphs corresponding to real data that we may be interested in modeling, including physical systems, molecules, images, and text.

https://arxiv.org/abs/1806.01261

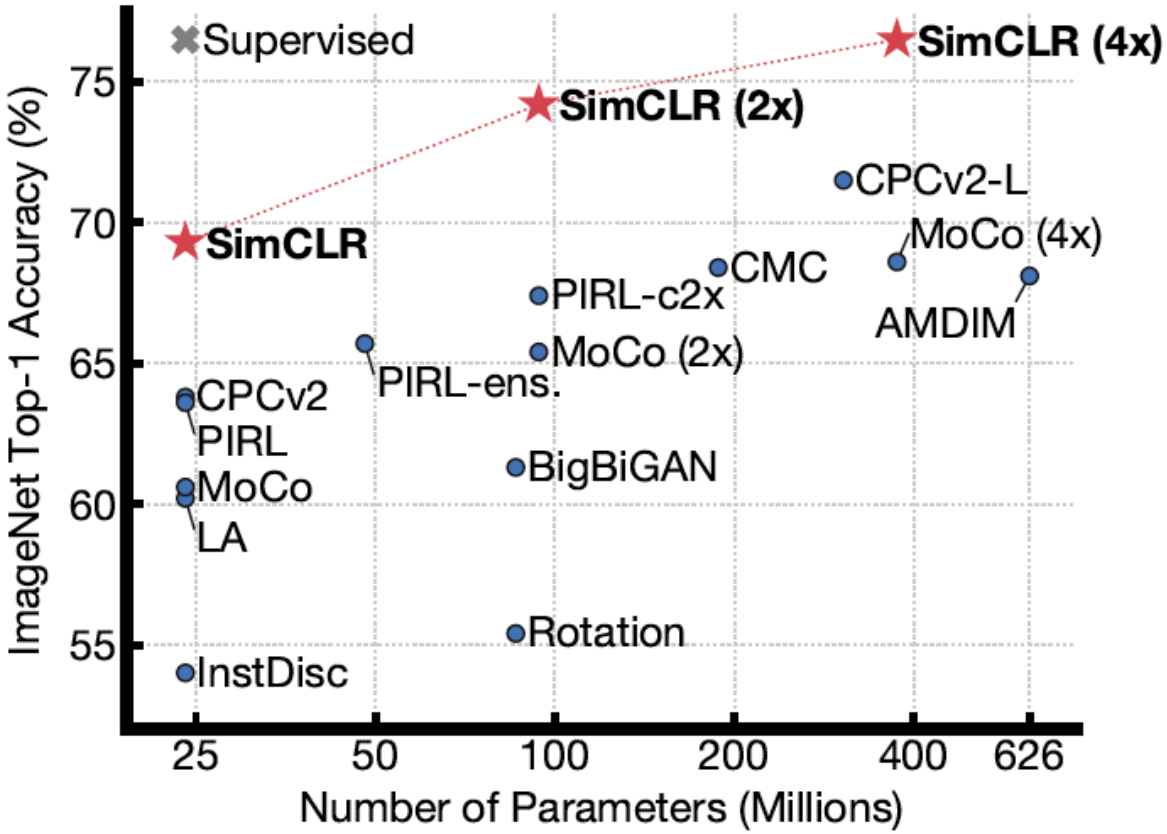
MoCo



- Unsupervised visual representation learning
- Momentum contrastive learning
- Outperform its supervised pre-training counterparts

https://arxiv.org/abs/1911.05722

SimCLR



- Simplified contrastive learning framework
- Outperform previous self-supervised and semi-supervised methods on ImageNet

https://arxiv.org/abs/2002.05709


AMiner
人工智能未来…
SEARCH

第三代人工智能的理论体系

- 早在2015年，张钹老师就提出第三代人工智能体系的雏形；2017年DARPA发起XAI项目，从可解释的机器学习系统、人机交互技术以及可解释的心理学理论三个方面，全面开展可解释性AI系统的研究
- 2018年底，正式公开提出**第三代人工智能的理论框架体系**
  - 建立**可解释、鲁棒性**的人工智能理论和方法
  - 发展**安全、可靠、可信及可扩展**的人工智能技术
  - 推动人工智能**创新**应用
- 具体实施路线图
  - 与**脑科学**融合，发展脑启发的人工智能理论
  - **数据与知识融合**的人工智能理论与方法
- 第三代人工智能的理念在国内外获得广泛影响力

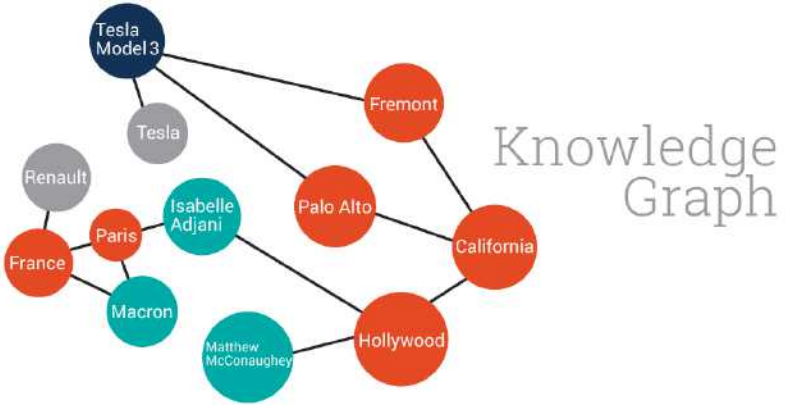
认知图谱 (Cognitive Graph)

—知识图谱, 认知推理, 逻辑表达

知识图谱

- “Knowledge graph”由Google于2012年提出
- 知识工程，专家系统
- CYC: 世界上历史最长的AI项目 (1985)

Edward Feigenbaum
Father of KB
Turing Award



Tim Berners Lee
Father of WWW
Turing Award

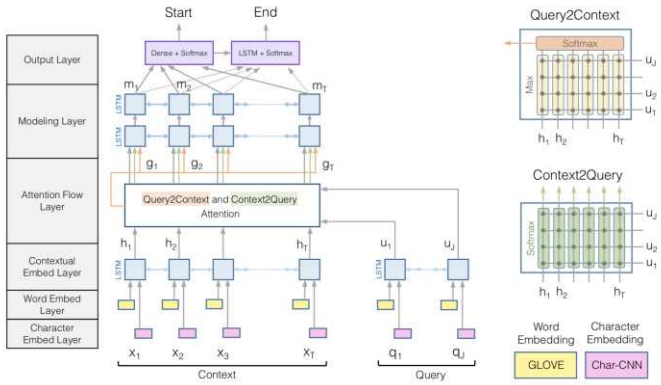
认知图谱：算法与认知的结合

Question: Who is the director of the 2003 film which has scenes in it filmed at the Quality Cafe in Los Angeles?

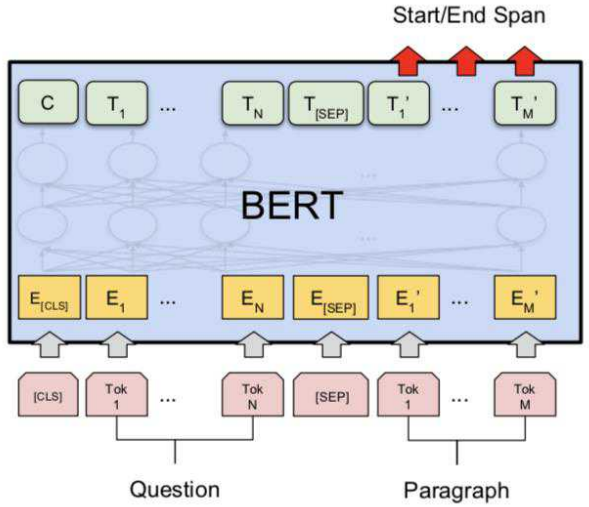
算法：BIDAF, BERT, XLNet

- 目标：理解整个文档，而不仅仅是局部片段
- 但仍然缺乏在知识层面上的推理能力

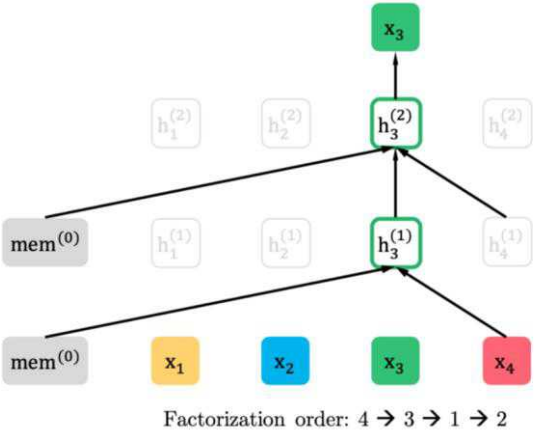
BiDAF



BERT



XLNet

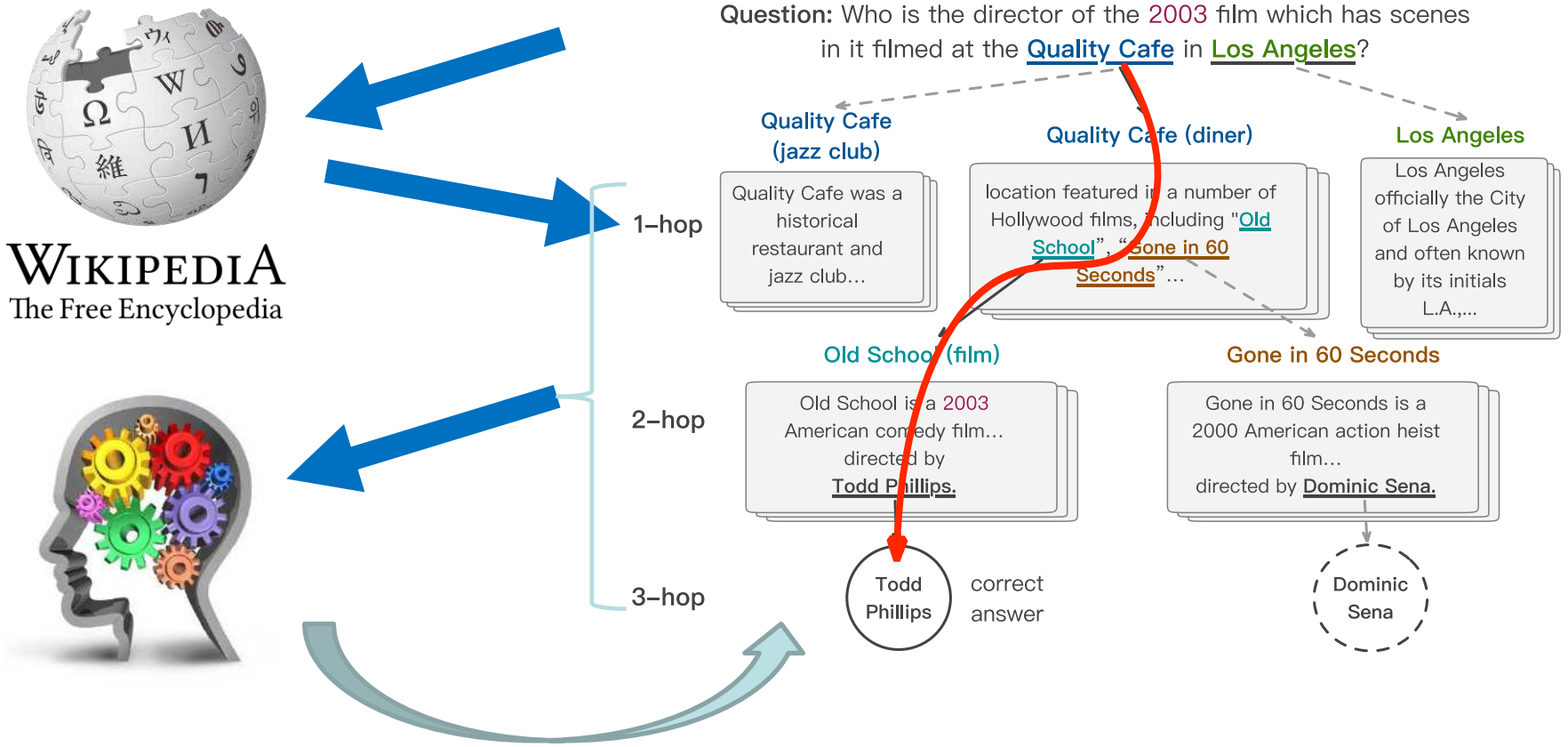


挑战：可解释性

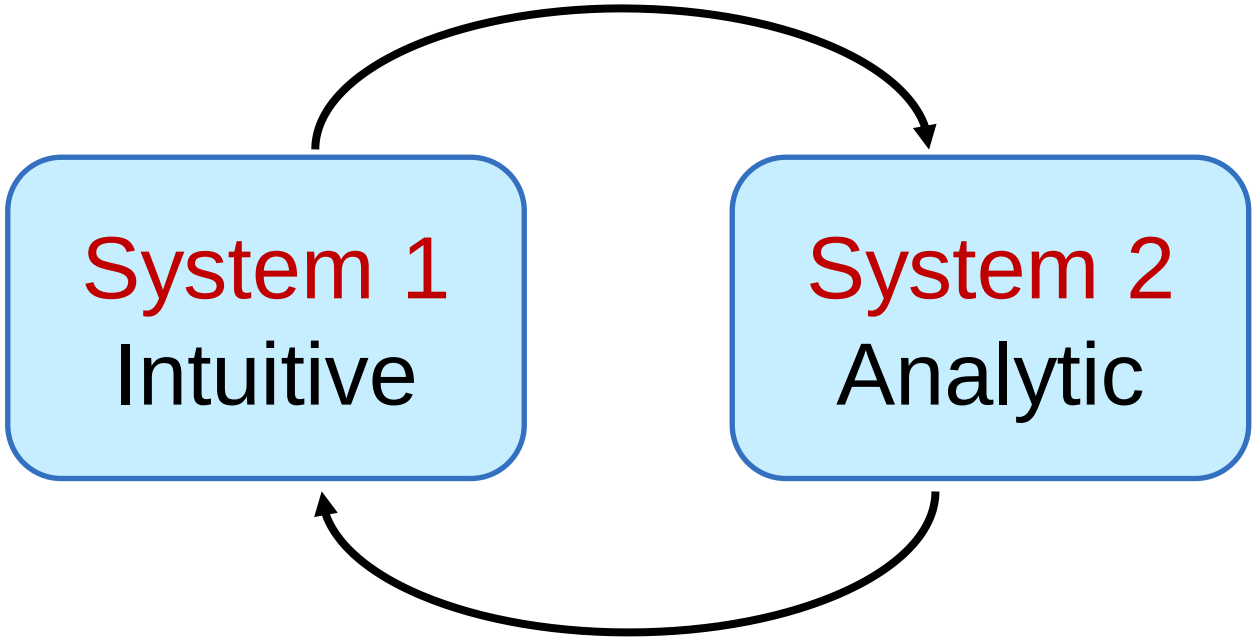
- 大部分阅读理解方法都只能看做**黑盒**：
  - 输入：问题和文档
  - 输出：答案文本块（在文档中的起止位置）

- 如何让用户可以验证答案的对错：
  - 推理路径或者子图
  - 每个推理节点上的支撑事实
  - 用于对比的其他可能答案和推理路径

认知图谱：知识表示，推理和决策



和认知科学的结合



Dual Process Theory (Cognitive Science)

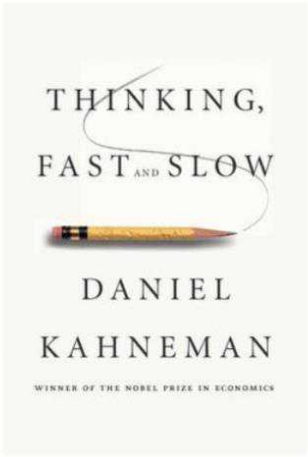
SYSTEM 1 VS. SYSTEM 2 COGNITION

2 systems (and categories of cognitive tasks):

Manipulates high-level / semantic concepts, which can be recombined combinatorially

System 1

- Intuitive, fast, **UNCONSCIOUS**, non-linguistic, habitual
- Current DL



System 2

- Slow, logical, sequential, **CONSCIOUS**, linguistic, algorithmic, planning, reasoning
- Future DL

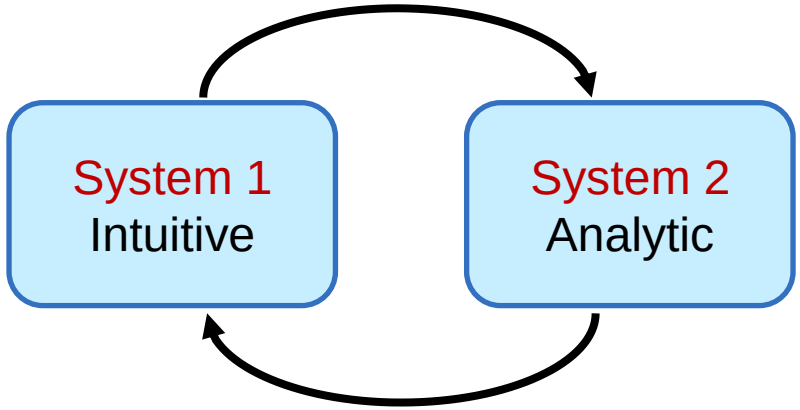
Mila

3

1. From Bengio's NIPS'2019 Keynote

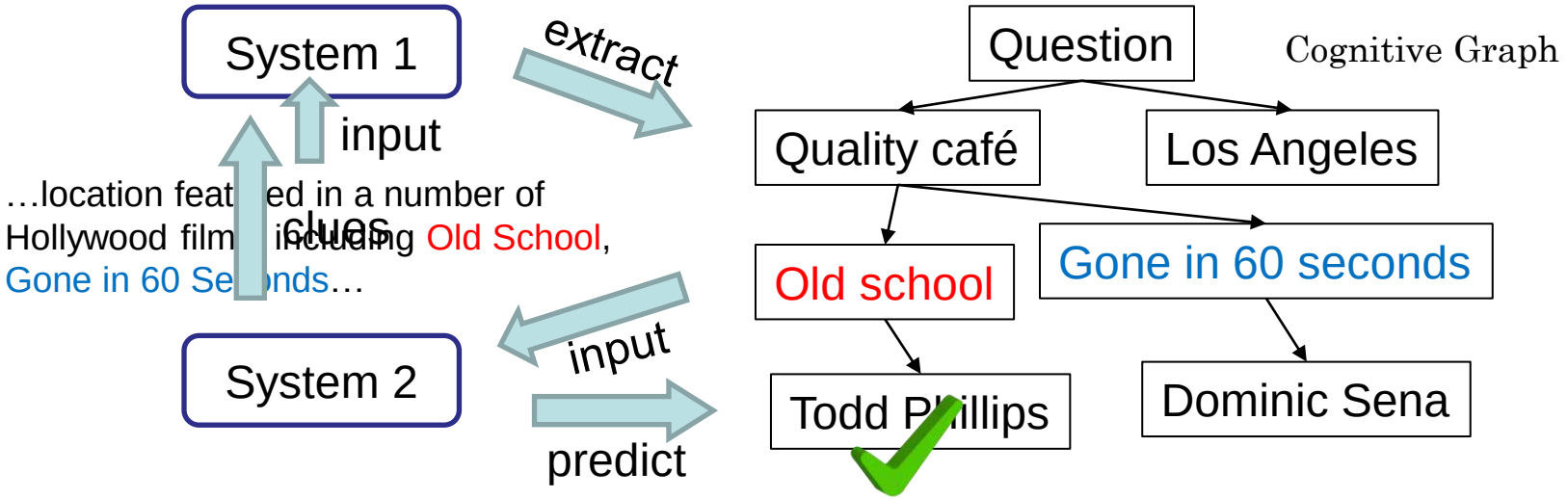
Reasoning w/ Cognitive Graph

- System 1:
  - Knowledge expansion by association in text when reading
- System 2:
  - Decision making w/ all the information

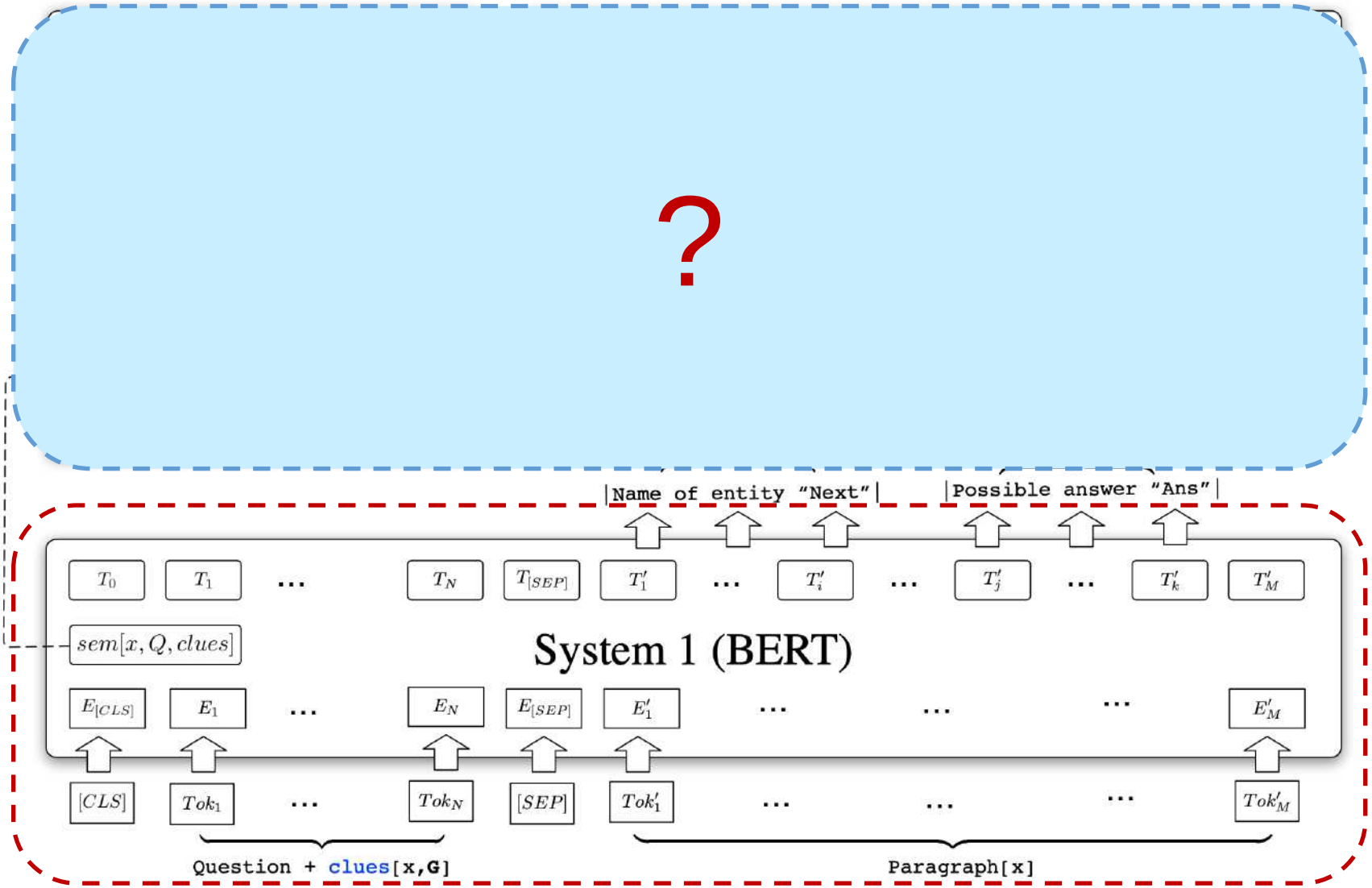


CogQA: Cognitive Graph for QA

- An iterative framework corresponding to dual process theory
- System 1
  - extract entities to build the cognitive graph
  - generate semantic vectors for each node
- System 2
  - Do reasoning based on semantic vectors and graph
  - Feed clues to System 1 to extract next-hop entities

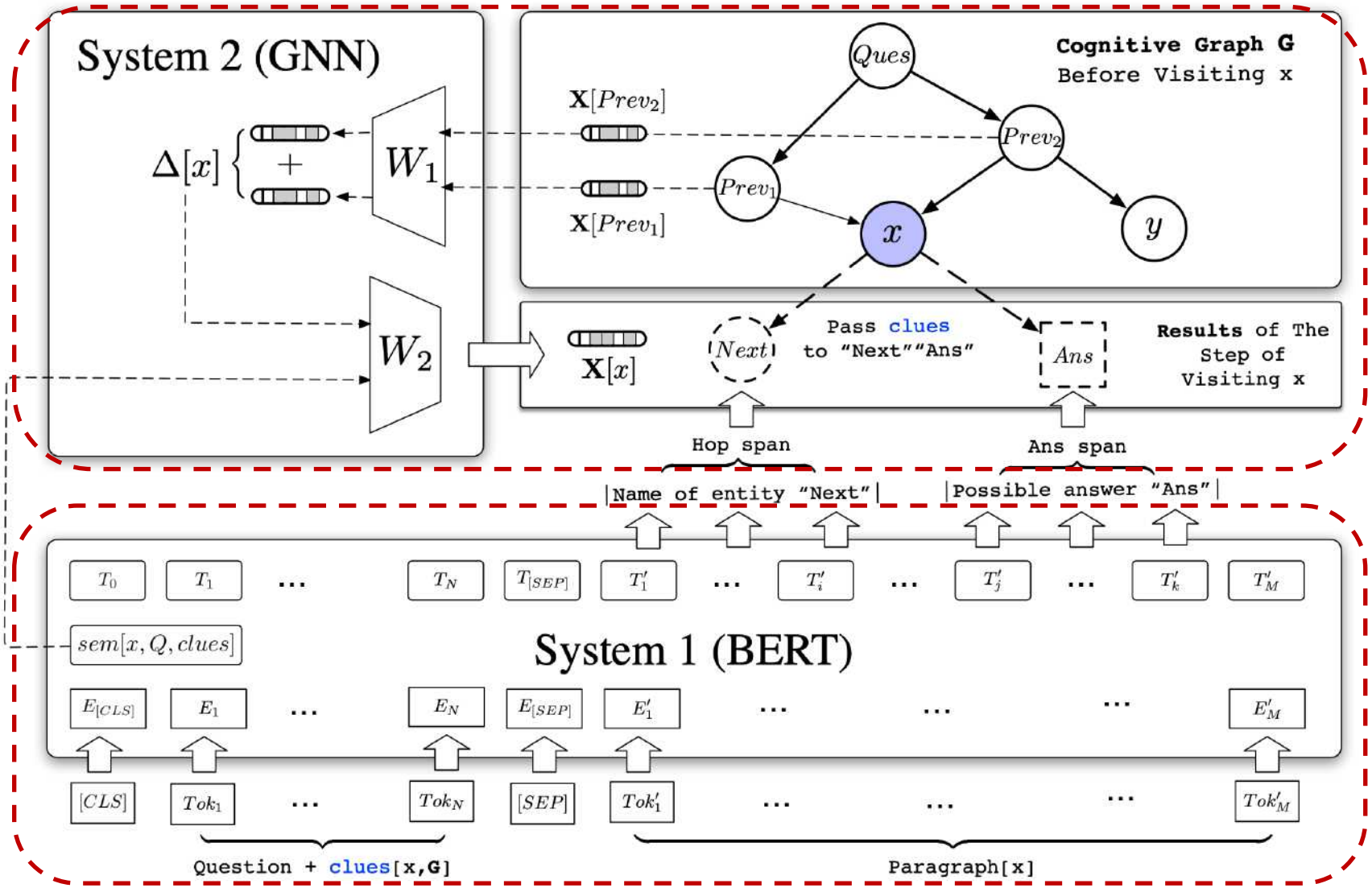


Cognitive Graph: DL + Dual Process Theory



1. M. Ding, C. Zhou, Q. Chen, H. Yang, and J. Tang. Cognitive Graph for Multi-Hop Reading Comprehension at Scale. ACL'19.

Cognitive Graph: DL + Dual Process Theory

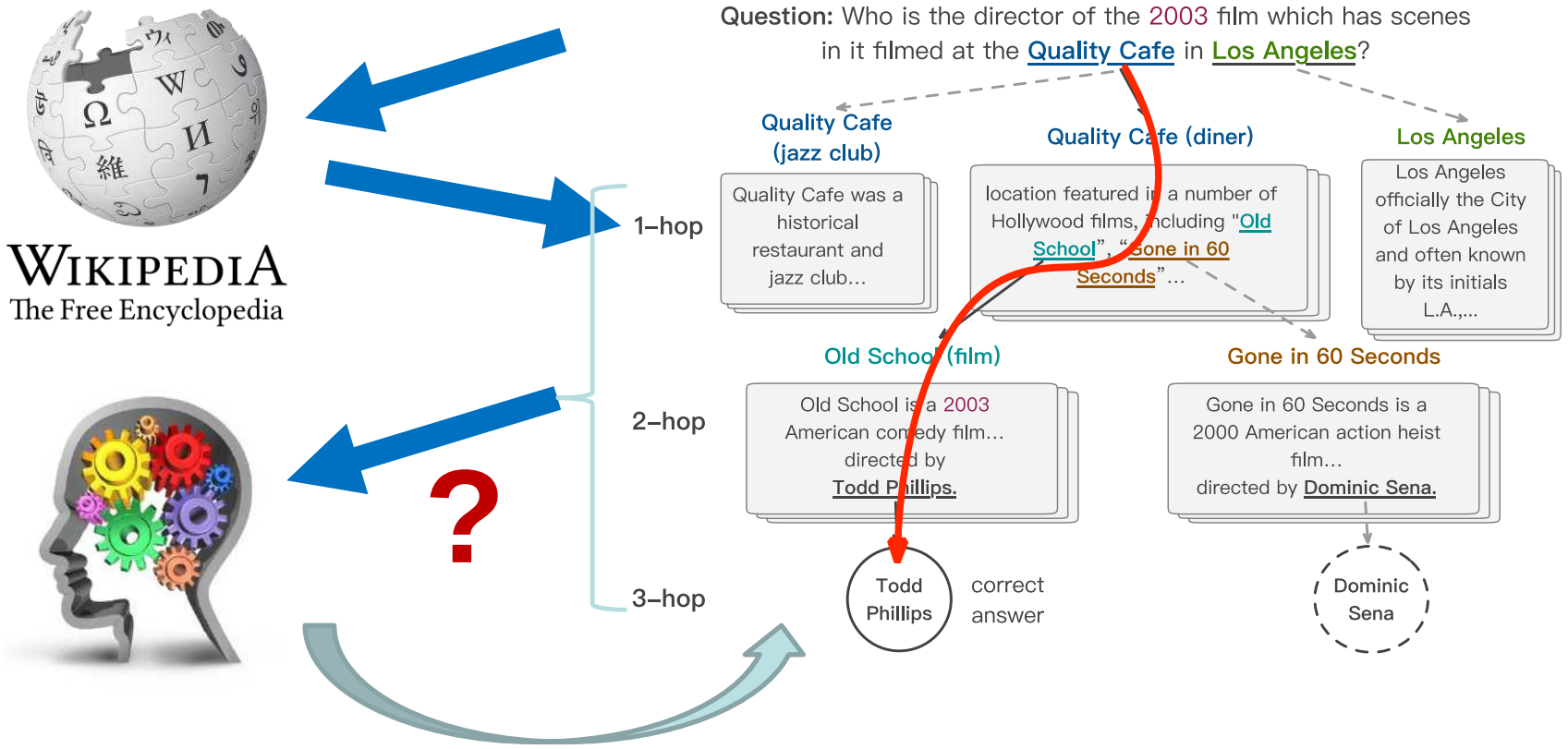


System 2: explicit decision

System 1: implicit knowledge expansion

1. M. Ding, C. Zhou, Q. Chen, H. Yang, and J. Tang. Cognitive Graph for Multi-Hop Reading Comprehension at Scale. ACL'19.

Cognitive Graph: Representation, Reasoning, and Decision



认知与推理

—Trillion-scale common-sense knowledge graph

Edward Feigenbaum
Turing Award Winner

Tim Berners Lee
Turing Award
Winner

Big Data ⇨ Knowledge ⇨ Intelligence

* AI = Knowledge + Intelligence

1. J. Tang, J. Zhang, L. Yao, J. Li, L. Zhang, and Z. Su. ArnetMiner: Extraction and Mining of Academic Social Networks. KDD'08. pp.990-998.

Related Publications

- Ming Ding, Chang Zhou, Qibin Chen, Hongxia Yang, and Jie Tang. Cognitive Graph for Multi-Hop Reading Comprehension at Scale. ACL'19.
- Jie Zhang, Yuxiao Dong, Yan Wang, Jie Tang, and Ming Ding. ProNE: Fast and Scalable Network Representation Learning. IJCAI'19.
- Yukuo Cen, Xu Zou, Jianwei Zhang, Hongxia Yang, Jingren Zhou and Jie Tang. Representation Learning for Attributed Multiplex Heterogeneous Network. KDD'19.
- Fanjin Zhang, Xiao Liu, Jie Tang, Yuxiao Dong, Peiran Yao, Jie Zhang, Xiaotao Gu, Yan Wang, Bin Shao, Rui Li, and Kuansan Wang. OAG: Toward Linking Large-scale Heterogeneous Entity Graphs. KDD'19.
- Qibin Chen, Junyang Lin, Yichang Zhang, Hongxia Yang, Jingren Zhou and Jie Tang. Towards Knowledge-Based Personalized Product Description Generation in E-commerce. KDD'19.
- Yifeng Zhao, Xiangwei Wang, Hongxia Yang, Le Song, and Jie Tang. Large Scale Evolving Graphs with Burst Detection. IJCAI'19.
- Yu Han, Jie Tang, and Qian Chen. Network Embedding under Partial Monitoring for Evolving Networks. IJCAI'19.
- Yifeng Zhao, Xiangwei Wang, Hongxia Yang, Le Song, and Jie Tang. Large Scale Evolving Graphs with Burst Detection. IJCAI'19.
- Jiezhong Qiu, Yuxiao Dong, Hao Ma, Jian Li, Chi Wang, Kuansan Wang, and Jie Tang. NetSMF: Large-Scale Network Embedding as Sparse Matrix Factorization. WWW'19.
- Jiezhong Qiu, Jian Tang, Hao Ma, Yuxiao Dong, Kuansan Wang, and Jie Tang. DeepInf: Modeling Influence Locality in Large Social Networks. KDD'18.
- Jiezhong Qiu, Yuxiao Dong, Hao Ma, Jian Li, Kuansan Wang, and Jie Tang. Network Embedding as Matrix Factorization: Unifying DeepWalk, LINE, PTE, and node2vec. WSDM'18.
- Jie Tang, Jing Zhang, Limin Yao, Juanzi Li, Li Zhang, and Zhong Su. ArnetMiner: Extraction and Mining of Academic Social Networks. KDD'08.

For more, please check here http://keg.cs.tsinghua.edu.cn/jietang

Thank you !

Jie Tang, KEG, Tsinghua U

Download all data & Codes

http://keg.cs.tsinghua.edu.cn/jietang
https://keg.cs.tsinghua.edu.cn/cogdl/
https://github.com/THUDM