浅谈人工智能的下一个十年

Jie Tang
Computer Science
Tsinghua University

PPT可以在主页下载：http://keg.cs.tsinghua.edu.cn/jietang/
或者：Google “Jie Tang”
人工智能的第三次浪潮
人工智能历史
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."

1954图灵测试

Alan Turing

Turing, Alan M. "Solvable and unsolvable problems."
1956达特茅斯会议


1959一般问题解决器

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
1968 世界首个专家系统DENDRAL

Edward Feigenbaum

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

1980 计算机战胜双陆棋世界冠军

Hans Berliner

人工智能领域发展趋势

1987 基于行为的机器人学

Rodney Brooks

1998 语义互联网路线图

Tim Berners-Lee


2004 OWL语言

2006 深度学习

Geoffrey Hinton


2011 高层抽象特征构建

2009 谷歌自动驾驶汽车

Sebastian Thrun

2011 沃森获得 Jeopardy 冠军
IBM’s Watson

2011 自然语言问答
Apple’s Siri
人工智能领域发展趋势

Powered by AMiner
人工智能近10年
人工智能

- 博弈对策
- 无人驾驶

- dog + cat =

图像识别

Nearest Images
Look broader
国务院印发《新一代人工智能发展规划》

“要把人工智能发展放在国家战略层面系统布局、主动谋划，牢牢把握人工智能发展新阶段国际竞争的战略主动，打造竞争新优势、开拓发展空间，有效保障国家安全。” 2017, July
National AI Strategies

• Example Countries
  – In 2017, Canada launched Pan-Canadian Artificial Intelligence Strategy
    • AMII, Vector, Mila
  – This year, UK is putting AI and Data at the heart of its Industrial Strategy
  – In March 2018, France announces his AI strategy with investing €1.5 billion over 5 yrs on AI research and innovation
  – US recently also release a national strategy for artificial intelligence. Moreover,
    • OpenAI
    • TensorFlow
部分国际AI开放平台
– OpenAI (Sutskever)
– Mila (Bengio)
– Vector Institute (Hinton)
OpenAI

- Research Director: Ilya Sutskever
- Sponsored by
  - 马斯克
  - Y Combinator总裁阿尔特曼
  - 天使投资人彼得•泰尔等

目标：制造通用机器人和使用自然语言的聊天机器人

单个机械手还原魔方：Dactyl机器人

击败Dota2游戏国际职业选手：OpenAI Five

强化学习算法游戏模拟平台：Gym

通用强化学习算法测评平台：Universe

<table>
<thead>
<tr>
<th>模型</th>
<th>总参数量</th>
<th>网络层数</th>
<th>训练数据量级</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPT</td>
<td>1.25亿</td>
<td>12</td>
<td>十亿词</td>
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<tr>
<td>GPT-2</td>
<td>15亿</td>
<td>48</td>
<td>百亿词</td>
</tr>
<tr>
<td>GPT-3</td>
<td>1750亿</td>
<td>96</td>
<td>千亿词</td>
</tr>
</tbody>
</table>

全球第一个通用预训练语言模型，启发了BERT，当前参数最大的模型，在多项NLP任务中表现优异
Mila (Bengio)

• Founder: Yoshua Bengio
• 以人为本的AI平台
  - 培养年轻人
  - 专注Deep Learning
• 创新创业
Vector Institute (Hinton)

- Founder: Geoffrey Hinton
- 以研究为主
  - 专注Deep Learning
- 创新创业
AI in Tsinghua

• In September, we established Tsinghua AI Institute
  – By Prof. Bo Zhang

• Focus
  – Fundamental theories and methodologies
  – Interdisciplinarity
Beijing AI Institute

- In November, Beijing launched Beijing AI Institute
  - By Dr. Hongjiang Zhang
- Focus
  - ground-breaking research
学科领域交叉与渗透
AI History

- Logic Theory Machine
- Perceptron
- Expert System
- Decision Tree
- Big Data
- Deep Learning

Hot degree

1956 1980 2000

First Second Third
AI趋势：从感知到认知

- 从感知到认知

Storage & Computing

Recognize text, images, objects, voices

Organize and generate knowledge, reasoning

计算 感知 认知

Stochastic vs Deterministic
Uncertainty!
机器学习快速发展

**Classification Models**
- Decision tree
- Bayesian Classifier
- Perceptron
- Neural Networks

**Sequential Learning**
- HMM, MEMM, CRF, Voted Perceptron

**Graphical Models**
- Factor Graph
- Exponential Model
- Topic Model (PLSI, LDA)

**Maximal Margin**
- SVM (Vapnik)

**Deep Learning**
- DNN, CNN, ResNet

**Recurrent Nets**
- RNN, LSTM, GRU

**Deep Generative Models**
- DBN, AutoEncoder, VAE, GAN, WGAN

**Reinforcement Learning**
- Q-Learning
- Policy Gradient
- Actor-Critic
- TRPO

**Deep RL**
- DQN, VIN, A3C

For more from [http://aminer.cn/](http://aminer.cn/)
预训练模型BERT

<table>
<thead>
<tr>
<th>Input</th>
<th>[CLS]</th>
<th>my</th>
<th>dog</th>
<th>is</th>
<th>cute</th>
<th>[SEP]</th>
<th>he</th>
<th>likes</th>
<th>play</th>
<th>#ing</th>
<th>[SEP]</th>
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<tbody>
<tr>
<td><strong>Token Embeddings</strong></td>
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<tr>
<td>$E_{[CLS]}$</td>
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<td>$E_{dog}$</td>
<td>$E_{is}$</td>
<td>$E_{cute}$</td>
<td>$E_{[SEP]}$</td>
<td>$E_{he}$</td>
<td>$E_{likes}$</td>
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<tr>
<td><strong>Segment Embeddings</strong></td>
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<td>$E_{A}$</td>
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<tr>
<td><strong>Position Embeddings</strong></td>
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<td>$E_{0}$</td>
<td>$E_{1}$</td>
<td>$E_{2}$</td>
<td>$E_{3}$</td>
<td>$E_{4}$</td>
<td>$E_{5}$</td>
<td>$E_{6}$</td>
<td>$E_{7}$</td>
<td>$E_{8}$</td>
<td>$E_{9}$</td>
<td>$E_{10}$</td>
<td></td>
</tr>
</tbody>
</table>

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

Video-to-Video Synthesis

• The best video synthesis performance

自监督学习—MoCo

• 无需标记样本，即可学习图形表示
• Momentum contrastive learning
• 效果甚至超过有监督学习结果

https://arxiv.org/abs/1911.05722
• Simplified contrastive learning framework
• Outperform previous self-supervised and semi-supervised methods on ImageNet

GPT-3

Output: Probabilities over tokens

Softmax

Transposed embedding $W_e^T$

Add & Layer norm

Pointwise feed forward

Add & Layer norm

Masked multi-headed self-attention

Embedding matrix $W_e$

Input: $x$

Transformer Block
Repeat x $L=12$

$h_\ell = \text{transformer\_block}(h_{\ell-1})$

$\ell = 1, \ldots, L$

面向图数据的自监督学习

查询子图
子图 $x^q$

答案子图
子图 $x^{k_0}$
子图 $x^{k_1}$
子图 $x^{k_2}$

图表示 $f_q$
语义匹配
无监督对比学习
图表示 $f_k$

人工智能未来...
第三代人工智能

符号AI
符号模型/规则模型/感知机

第一代

第二代

第三代

认知智能
张钹院士2016年提出第三代人工智能雏形，DARPA 2018年发布AI Next计划。核心思路是推进统计与知识推理融合的计算；与脑认知的融合

大数据驱动的统计学习方法初步实现了针对文本、图像、语音等的感知与识别

感知智能
目前急需的是高质量超大规模知识图谱（AI的基础设施）以及对知识的理解能力（面向认知的深度学习算法）
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
超越深度学习
算法是核心，计算、数据是基础

算法

实现核心：机器通过算法实现人工智能
突破方向：认知智能是下一个突破方向
突破途径：人工智能突破主要通过算法性能的提升，主要有工程学法和模拟法

方法一：工程学方法
采用传统的编程技术，利用大量数据处理经验改进提升算法性能。

方法二：模拟法
模仿人类或其他生物所用的方法或机理，提升算法性能，例如遗传算法和神经网络。

计算能力

现状：使用GPU并行计算神经网络
作用：提升运算速度，降低计算成本
未来：量子计算、速度更快的芯片

知识

现状：互联网发展积累了片段化知识
作用：训练机器，提升算法性能
未来：面向全世界的常识知识图谱

场景驱动、算法为核心、知识为基础
端到端模型的困境：以BERT为例

- 端到端的黑盒模型缺乏解释性和鲁棒性
  - 不知道推理的逻辑链条
  - 易受无关信息的“对抗攻击”

- 无法平衡信息处理精度和规模
  - BERT对于长文本时间空间消耗巨大
  - 直接检索无法考虑多步推理后的相关性

- 为什么人类可以依照逻辑推理，且能利用海量记忆？

例：复杂阅读理解问答

Question: 谁是2003年的电影《Gone in 60 Seconds》在洛杉矶的Quality Cafe的导演？

Quality Cafe (jazz club)
Quality Cafe was a historical restaurant and jazz club...

Quality Cafe (diner)
Located in the city of Los Angeles and often known by its initials L.A.,...

Old School (film)
Old School is a 2003 American comedy film... directed by Todd Phillips.

Gone in 60 Seconds
Gone in 60 Seconds is a 2000 American action heist film... directed by Dominic Sena.

Todd Phillips
correct answer

Los Angeles
Los Angeles officially the City of Los Angeles and often known by its initials L.A.,...

Todd Phillips

脑科学与感知智能

视觉脑区：
- 主要位于枕叶（V1），通过腹（what）背（where）两条通路进行信息加工。

视觉性语言脑区：
- 顶下小叶的角回（书写与口语转换）

听觉性语言脑区：
- 颞叶的Wernicke’s area

语言脑区：
- Broca’s area（协调发音与语法结构）

嗅觉脑区：
- 嗅球、部分杏仁核
- ……
脑科学与认知智能

• 记忆
  – 短期记忆在海马体转化为长期（陈述性）记忆
  – 蛋白质磷酸化修饰（中期）
  – 长时程增强、新蛋白产生（长期记忆）

• 推理
  – 主要在前额叶中进行推理
  – 语言脑区参与
  – 对应工作记忆

（睡眠时前额叶兴奋可以做能推断出自己在做梦的“清醒梦”）
记忆：工作记忆理论

• 尽管对于认知的微观机理尚未研究清楚，我们仍可以探究宏观框架

• 巴德利的工作记忆（Working Memory）机制是里程碑式的工作，探究工作记忆调用多模态信息与长短期记忆转化（科万的分层注意力理论）

• 全局工作空间理论（Global Workspace Theory）是巴斯等人对工作记忆模型的发展，认为“意识”是不同进程争夺全局空间传播信息的结果
基于记忆机制的相关工作

- 神经网络经典工作 LSTM 通过门控机制，模拟长期记忆的遗忘与存储，与经典的 RNN 相比能记住更多步之前的信息。

- Memory Network 的一系列工作，提出使用离散的记忆槽位（Memory slots）记录之前计算的隐向量，再通过向量相似度去索引。

- End-to-End Memory Network 提出如何端到端学习如何使用记忆槽位记录和检索，并以问答作为例子。

- Dynamic Memory Networks 连续通过句子的隐表示来更新目前的“工作记忆向量”。

BERT时代新的挑战

- BERT是预训练的Transformer（多层自注意力模型），目前NLP领域最流行的模型之一。
- 训练时内存消耗巨大，并且关于文本长度呈$O(L^2)$增长。
- 简单的分段计算则难以实现长距离的注意力。
- 而人类的工作记忆内存有限，却可以理解长文本，为什么？
CogLTX: Applying BERT to long texts

- 通过长期记忆到工作记忆的转换，降低BERT处理文本量

MemRecall (initial $z^+ = [Q]$, long text $x = [x_0 \ldots x_{40}]$)

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

1. Concat respectively

$x_0$: Quality Cafe is the name of two different former locations in Downtown Los Angeles, California...

$x_8$: "The Quality Cafe (aka. Quality Diner) is a now-defunct diner...but has appeared as a location featured in a number of Hollywood films, including "Training Day", "Old School"...

$x_{40}$: Old School is a 2003 American comedy film released by DreamWorks Pictures...and directed by Todd Phillips.

2. Get scores by judge

3. Retrieval competition

4. Input

5. Rehearsal

6. Next-step reasoning

new $z^+$

Judge

Decay

Forget other blocks

Select highest scoring blocks

MLP (sigmoid)

BERT
实验效果

Table 1: NewsQA results (%).

<table>
<thead>
<tr>
<th>Model</th>
<th>EM</th>
<th>F₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>Match-LSTM [44]</td>
<td>34.9</td>
<td>50.0</td>
</tr>
<tr>
<td>BiDAF [37]</td>
<td>37.1</td>
<td>52.3</td>
</tr>
<tr>
<td>FastQAExt [47]</td>
<td>42.8</td>
<td>56.1</td>
</tr>
<tr>
<td>AMANDA [20]</td>
<td>48.4</td>
<td>63.7</td>
</tr>
<tr>
<td>MINIMAL [24]</td>
<td>50.1</td>
<td>63.2</td>
</tr>
<tr>
<td>DECAPROP [39]</td>
<td>53.1</td>
<td>66.3</td>
</tr>
<tr>
<td>RoBERTa-large [22] (sliding window)</td>
<td>49.6</td>
<td>66.3</td>
</tr>
<tr>
<td>CogLTX</td>
<td>55.2</td>
<td>70.1</td>
</tr>
</tbody>
</table>

Table 2: Results on HotpotQA distractor (dev). (+hyperlink) means usage of extra hyperlink data in Wikipedia. Models beginning with "~" are ablation studies without the corresponding design.

<table>
<thead>
<tr>
<th>Model</th>
<th>Ans EM</th>
<th>Ans F₁</th>
<th>Sup EM</th>
<th>Sup F₁</th>
<th>Joint EM</th>
<th>Joint F₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline [49]</td>
<td>45.60</td>
<td>59.02</td>
<td>20.32</td>
<td>64.49</td>
<td>10.83</td>
<td>40.16</td>
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<tr>
<td>DecomRC [25]</td>
<td>55.20</td>
<td>69.63</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>QPE [26]</td>
<td>53.86</td>
<td>68.06</td>
<td>57.75</td>
<td>84.49</td>
<td>34.63</td>
<td>59.61</td>
</tr>
<tr>
<td>DFGN [32]</td>
<td>56.31</td>
<td>69.69</td>
<td>51.50</td>
<td>81.62</td>
<td>33.62</td>
<td>59.82</td>
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<td>SAIE [41]</td>
<td>60.36</td>
<td>73.58</td>
<td>56.93</td>
<td>84.63</td>
<td>38.81</td>
<td>64.96</td>
</tr>
<tr>
<td>SAIE-large</td>
<td>66.92</td>
<td>79.62</td>
<td>61.53</td>
<td>86.86</td>
<td>45.36</td>
<td>71.45</td>
</tr>
<tr>
<td>HGN [13] (+hyperlink)</td>
<td>66.07</td>
<td>79.36</td>
<td>60.33</td>
<td>87.33</td>
<td>43.57</td>
<td>71.03</td>
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<tr>
<td>HGN-large (+hyperlink)</td>
<td>69.22</td>
<td>82.19</td>
<td>62.76</td>
<td>88.47</td>
<td>47.11</td>
<td>74.21</td>
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</table>

Table 3: 20NewsGroups results (%).

<table>
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<tr>
<th>Model</th>
<th>Accuracy</th>
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</thead>
<tbody>
<tr>
<td>BoW + SVM</td>
<td>63.0</td>
</tr>
<tr>
<td>Bi-LSTM</td>
<td>73.2</td>
</tr>
<tr>
<td>fastText [15]</td>
<td>79.4</td>
</tr>
<tr>
<td>MS-CNN [28]</td>
<td>86.1</td>
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<tr>
<td>Text GCN [50]</td>
<td>86.3</td>
</tr>
<tr>
<td>MLP over BERT [29]</td>
<td>85.5</td>
</tr>
<tr>
<td>LSTM over BERT [29]</td>
<td>84.7</td>
</tr>
<tr>
<td>CogLTX (Glove init)</td>
<td>87.0</td>
</tr>
<tr>
<td>only long texts</td>
<td>87.4</td>
</tr>
<tr>
<td>– intervention (Glove init)</td>
<td>84.8</td>
</tr>
<tr>
<td>Bm25 init</td>
<td>86.1</td>
</tr>
</tbody>
</table>

Table 4: A+ result (%).

<table>
<thead>
<tr>
<th>Model</th>
<th>Accuracy</th>
<th>Micro-F₁</th>
<th>Macro-F₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>BoW+ SVM</td>
<td>89.9</td>
<td>85.8</td>
<td>55.3</td>
</tr>
<tr>
<td>Bi-LSTM</td>
<td>70.7</td>
<td>62.1</td>
<td>48.2</td>
</tr>
<tr>
<td>TextCNN</td>
<td>95.3</td>
<td>94.1</td>
<td>91.3</td>
</tr>
<tr>
<td>sliding window</td>
<td>94.5</td>
<td>92.7</td>
<td>89.9</td>
</tr>
<tr>
<td>CogLTX(tiny)</td>
<td>95.5</td>
<td>94.4</td>
<td>92.4</td>
</tr>
<tr>
<td>CogLTX(large)</td>
<td>98.2</td>
<td>97.8</td>
<td>97.2</td>
</tr>
</tbody>
</table>

和认知科学的结合

System 1 直觉系统
System 2 逻辑系统

Dual Process Theory (Cognitive Science)
脑认知的双系统

SYSTEM 1 VS. SYSTEM 2 COGNITION

2 systems (and categories of cognitive tasks):

**System 1**
- Intuitive, fast, UNCONSCIOUS, non-linguistic, habitual
- Current DL

**System 2**
- Slow, logical, sequential, CONSCIOUS, linguistic, algorithmic, planning, reasoning
- Future DL

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

1. From Bengio’s NIPS’2019 Keynote
认知图谱：知识表示，推理和决策

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

Quality Cafe (jazz club)
Quality Cafe was a historical restaurant and jazz club...

Quality Cafe (diner)
location featured in a number of Hollywood films, including "Old School", "Gone in 60 Seconds"...

Old School (film)
Old School is a 2003 American comedy film... directed by Todd Phillips.

Gone in 60 Seconds
Gone in 60 Seconds is a 2000 American action heist film... directed by Dominic Sena.

Todd Phillips
correct answer

Los Angeles
Los Angeles officially the City of Los Angeles and often known by its initials L.A.,...
认知图谱的推理模型

• System 1:
  – Knowledge expansion by association in text when reading

• System 2:
  – Decision making w/ all the information
认知图谱的推理模型

• 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

...location featured in a number of Hollywood films, including Old School, Gone in 60 Seconds...
认知图谱的推理模型

认知图谱的推理模型

认知图谱的推理效果

- HotpotQA is a dataset with leaderboard similar to SQuAD
- CogQA ranked 1\textsuperscript{st} from 21, Feb to 15, May (nearly 3 month)

<table>
<thead>
<tr>
<th>Model</th>
<th>Ans</th>
<th>Sup</th>
<th>Joint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EM</td>
<td>$F_1$</td>
<td>Prec</td>
</tr>
<tr>
<td>Dev</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yang et al. (2018)</td>
<td>23.9</td>
<td>32.9</td>
<td>34.9</td>
</tr>
<tr>
<td>Yang et al. (2018)-IR</td>
<td>24.6</td>
<td>34.0</td>
<td>35.7</td>
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<td>BERT</td>
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<td>31.6</td>
<td>33.4</td>
</tr>
<tr>
<td>CogQA-sys1</td>
<td>33.6</td>
<td>45.0</td>
<td>47.6</td>
</tr>
<tr>
<td>CogQA-onlyR</td>
<td>34.6</td>
<td>46.2</td>
<td>48.8</td>
</tr>
<tr>
<td>CogQA-onlyQ</td>
<td>30.7</td>
<td>40.4</td>
<td>42.9</td>
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<tr>
<td>CogQA</td>
<td>37.6</td>
<td>49.4</td>
<td>52.2</td>
</tr>
<tr>
<td>Test</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Yang et al. (2018)</td>
<td>24.0</td>
<td>32.9</td>
<td>-</td>
</tr>
<tr>
<td>QFE</td>
<td>28.7</td>
<td>38.1</td>
<td>-</td>
</tr>
<tr>
<td>DecompRC</td>
<td>30.0</td>
<td>40.7</td>
<td>-</td>
</tr>
<tr>
<td>MultiQA</td>
<td>30.7</td>
<td>40.2</td>
<td>-</td>
</tr>
<tr>
<td>GRN</td>
<td>27.3</td>
<td>36.5</td>
<td>-</td>
</tr>
<tr>
<td>CogQA</td>
<td>37.1</td>
<td>48.9</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 1: Results on HotpotQA (fullwiki setting). The test set is not public. The maintainer of HotpotQA only offers EM and $F_1$ for every submission. N/A means the model cannot find supporting facts.

**Code available at** [https://github.com/THUDM/CogQA](https://github.com/THUDM/CogQA)
认知图谱的推理效果

CogQA Performs much **better** on question with **more hops**!
认知图谱的推理效果

Q: **Ken Pruitt** was a Republican member of an upper house of the legislature with how many members?

Ken Pruitt was a Republican member of the **Florida Senate** …

- **Florida Senate**
  - The Senate has 40 members…

- **Ken Pruitt**
  - … previously a member of the **Florida House of Representatives**.

- **Florida House of Representatives**
  - The House is composed of 120 members…

- 40
- 120

(1) Tree

- **Tree-shape Cognitive Graph**

- Users can verify the answer by comparing it with another possible reasoning chain.

- “**Upper House**” in the question is similar to “**Senate**” not “**House of Representative**”
认知图谱的推理效果

Q: What Cason, CA soccer team features the son of Roy Lassiter?

He is the father of LA Galaxy player Ariel Lassiter.

- **DAG-shape** Cognitive Graph
- Multiple supporting facts provides richer information, increasing the credibility of the answer.

...he had signed with LA Galaxy...
Q: What Lithuanian producer is best known for a song that was one of the most popular songs in Ibiza in 2014?

Walking with Elephants

Marijus Adomaitis ...

Ten Walls.

Marijus Adomaitis ...

his stage name Ten Walls.

(3) Cyclic Graph

• CogQA gives the answer “Marijus Adomaitis” while the ground truth is “Ten Walls”.

• By examining, Ten Walls is just the stage name of Marijus Adomaitis!

• Without cognitive graphs, black-box models cannot achieve it.
Next
认知与推理
—Trillion-scale common-sense knowledge graph

* AI = Knowledge + Intelligence

面向计算的认知框架

背侧通路（非语义信息）
- 视觉性语言模型
- 感知记忆
- Broca模型
- 文本输入
- 长期记忆
- 工作记忆
- MemRecall
- system 1
- system 2
- 自训练/记录
- 语言表达修饰模型
- 回答
挑战与未来(Next 30)

意识
— 让计算机具有自我意识

认知推理 $\iff$ 记忆 $\iff$ 自我意识

• Next AI = Reasoning + Memory + Consciousness

所谓的有意识学习，就是有目标的机器学习，给定数据，训练一个模型，通过模型进行分类（决策），所以有意识学习输出是一个短期记忆模型，但这个短期记忆模型比较简单：数据有限、无背景知识。所以无意意识就对应着长期记忆模型，长期记忆模型有点类似半监督或者无监督学习模型，或者当下比较流行的预训练和自监督学习；无意识处理对应多种长期记忆，所以无意识可以考虑多个不同的处理器，这些处理器之间可以有链接，也可以没有，很多时候是并行处理，但针对特定任务，比如有意识思考某个问题的时候，形成特定连接，包括无意识处理器（无监督模型）和有意识处理器（有监督模型）之间的连接，这里可以考虑成fine-tune。当然连接权重可以通过外界反馈强化学习来实现。无意识处理器之间的连接以及和有意识处理器之间的连接可以类比为注意力机制。最后值得注意的是长期记忆的构造和实现，人脑记忆保存的是模型图，而不是概念图。每个长期记忆都可能是一个模型，可以生成样本，具体学习方法，可以想象一下是一个层次聚类。通过这样就可以用有监督、无监督、强化、注意力、fine-tune来实现GWT模型。
Related Publications

- Wenzheng Feng, Jie Zhang, Yuxiao Dong, Yu Han, Huanbo Luan, Qian Xu, Qiang Yang, Evgeny Kharlamov, and Jie Tang. Graph Random Neural Networks for Semi-Supervised Learning on Graphs. NeurIPS'20.
- Jiezhong Qiu, Qibin Chen, Yuxiao Dong, Jing Zhang, Hongxia Yang, Ming Ding, Kuansan Wang, and Jie Tang. GCC: Graph Contrastive Coding for Structural Graph Representation Pre-Training. KDD'20.
- Zhen Yang, Ming Ding, Chang Zhou, Hongxia Yang, Jingren Zhou, and Jie Tang. Understanding Negative Sampling in Graph Representation Learning. KDD'20.
- Yuxiao Dong, Ziniu Hu, Kuansan Wang, Yizhou Sun and Jie Tang. Heterogeneous Network Representation Learning. IJCAI'20.
- 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.
- 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.
- 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.
- 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, check 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
Question: Who is the director of the 2003 film which has scenes in it filmed at the Quality Café in Los Angeles?

Quality Café
The Quality Café is a now-defunct diner in Los Angeles, California. The restaurant has appeared as a location featured in a number of Hollywood films, including Old School, Gone in 60 Seconds, ...

Los Angeles
Los Angeles is the most populous city in California, the second most populous city in the United States, after New York City, and the third most populous city in North America.

Old School
Old School is a 2003 American comedy film released by DreamWorks Pictures and The Montecito Picture Company and directed by Todd Phillips.

Todd Phillips
Todd Phillips is an American director, producer, screenwriter, and actor. He is best known for writing and directing films, including Road Trip (2000), Old School (2003), Starsky & Hutch (2004), and The Hangover Trilogy.

Alessandro Moschitti
Alessandro Moschitti is a professor of the CS Department of the University of Trento, Italy. He is currently a Principal Research Scientist of the Qatar Computing Research Institute (QCRI).

Tsinghua University
Tsinghua University is a major research university in Beijing and dedicated to academic excellence and global development. Tsinghua is perennially ranked as one of the top academic institutions in China, Asia, and worldwide...
端到端模型的困境：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
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