

Question Answering Systems

Reinforcement learning in QA

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10

Question of the day

RL
How can we use reinforcement learning to
improve QA systems?

or
built-from-scratch

You'll find this covered in

- Ask the Right Questions: Active Question Reformulation with Reinforcement Learning
 - Buck et al.
 - ICLR 2018
 - <https://openreview.net/pdf?id=S1CChZ-CZ>
- Go for a Walk and Arrive at the Answer: Reasoning over Paths in Knowledge Bases using Reinforcement Learning → KGR
 - Das et al.
 - ICLR 2018
 - <https://openreview.net/pdf?id=Syg-YfWCW>

Learning in QA

1 ■ Unsupervised/weakly supervised learning

- QUEST, PARALEX, ... *Ravi Chandrasekhar & Hovy 2002*

2 ■ Supervised learning

- AQQU, STAGG, SEMPRE, ...

3 ■ Reinforcement learning: Why?

- AQA, MINERVA, ...

Active QA

more natural: RL framework

Alternative:

- Online learning
- Regression
- Distant supervision

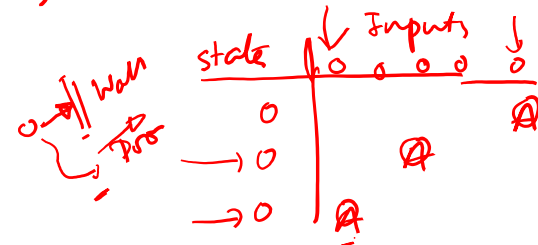
- No training data
- Reward \rightarrow noisy signal towards correctness

$\rightarrow 0.623$
 $\rightarrow -0.121$ *not clear labels*

$\rightarrow +1/-1$ *signal for SL*

model

-
- Take step fwd / stay still R/L/B
- Jungle
- Dirt



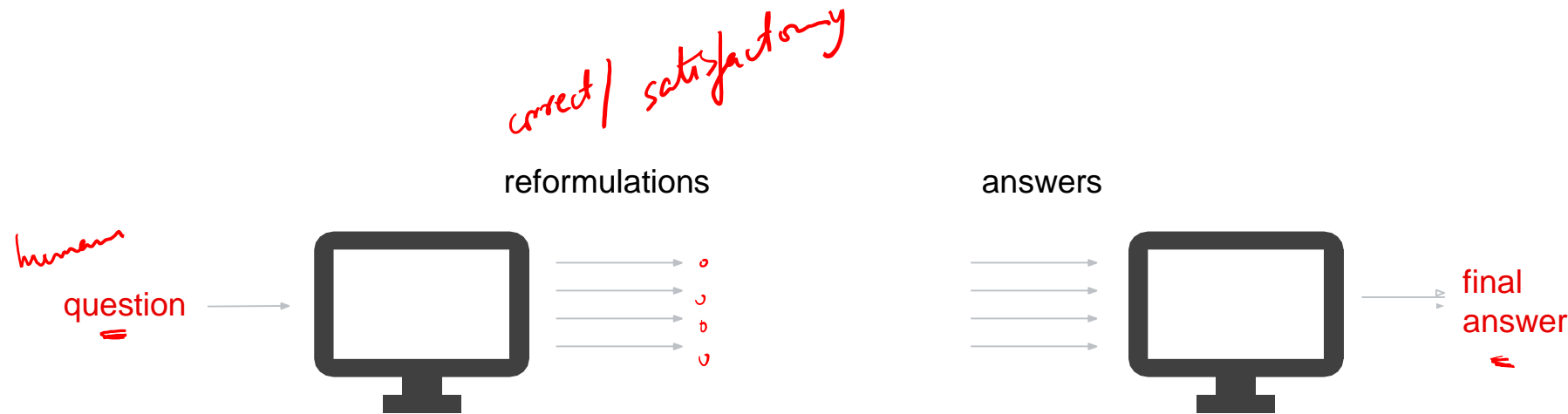
Robot:
go out of a room
why RL?
- lot of training data
trial & error

Games
→ Chess

Research paper 1

Ask the Right Questions: Active Question
Reformulation with Reinforcement Learning

Basic idea

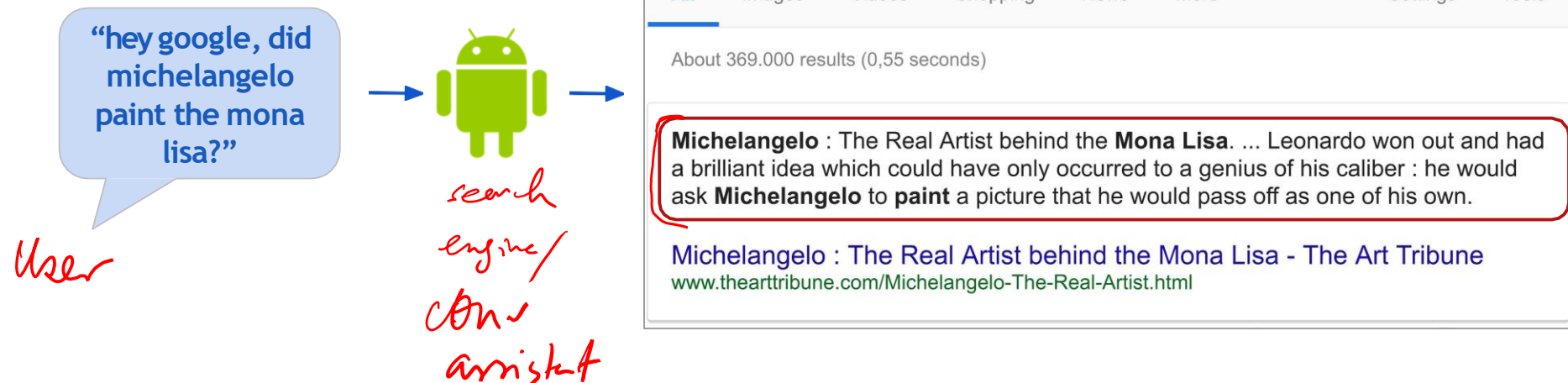


- Train an agent that learns to ask 'optimized' questions
 - Machine learns a non-trivial, non-human, but interesting policy
 - First step towards an interactive language agent
- Handwritten note in red: *to generate new question* (with an arrow pointing to the policy)

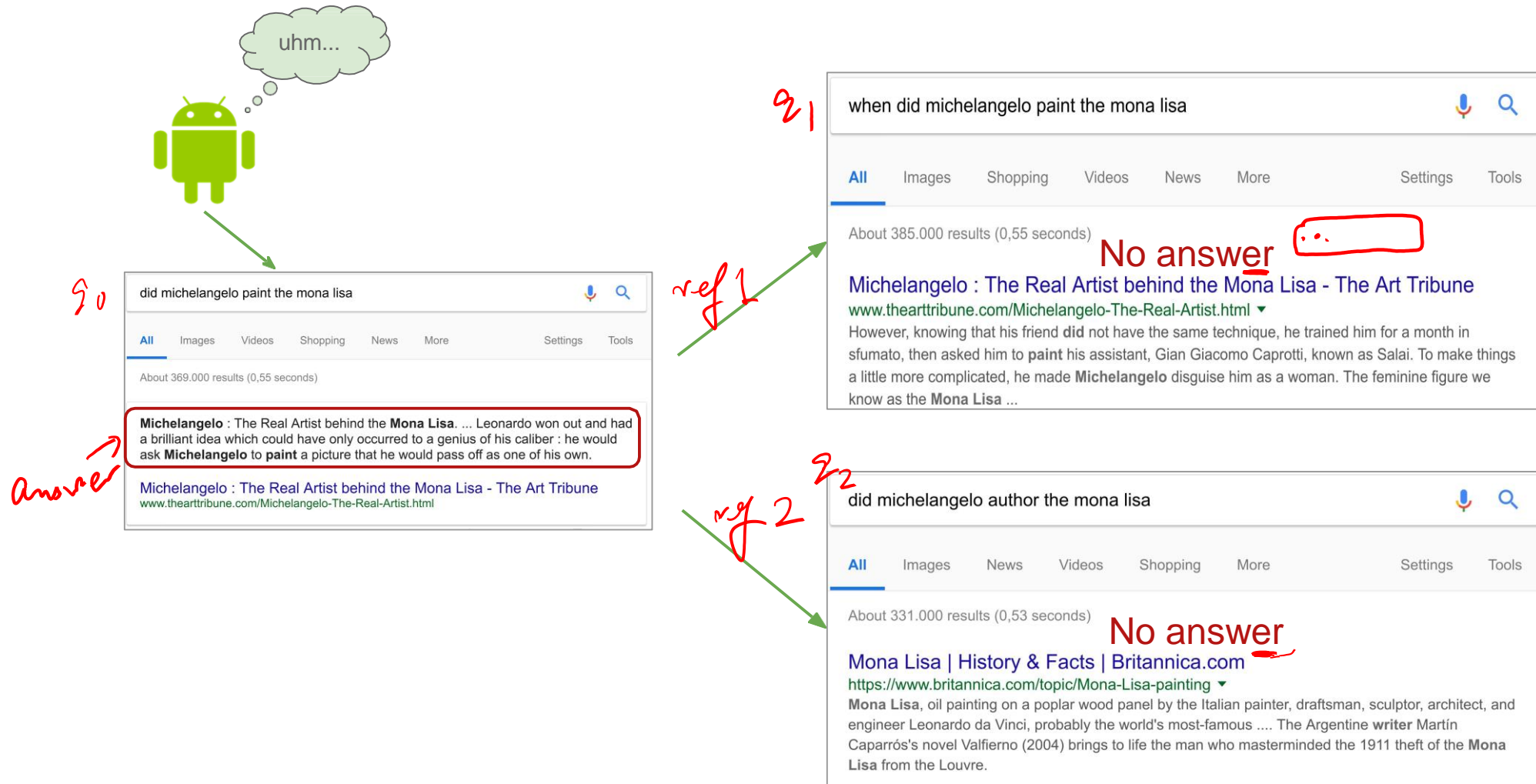
Thanks to Christian Buck for the slides

Intelligent language agent for QA

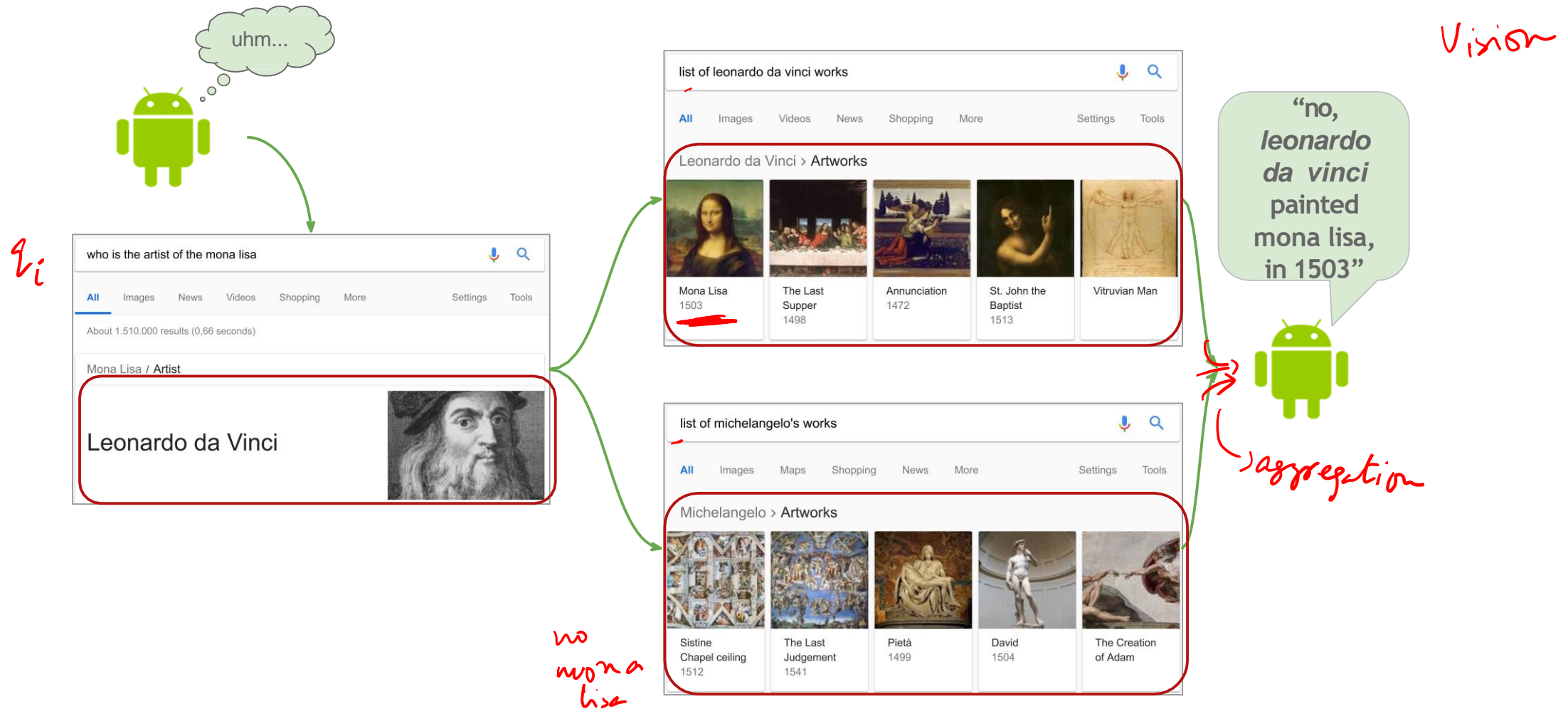
Vision



Intelligent language agent for QA

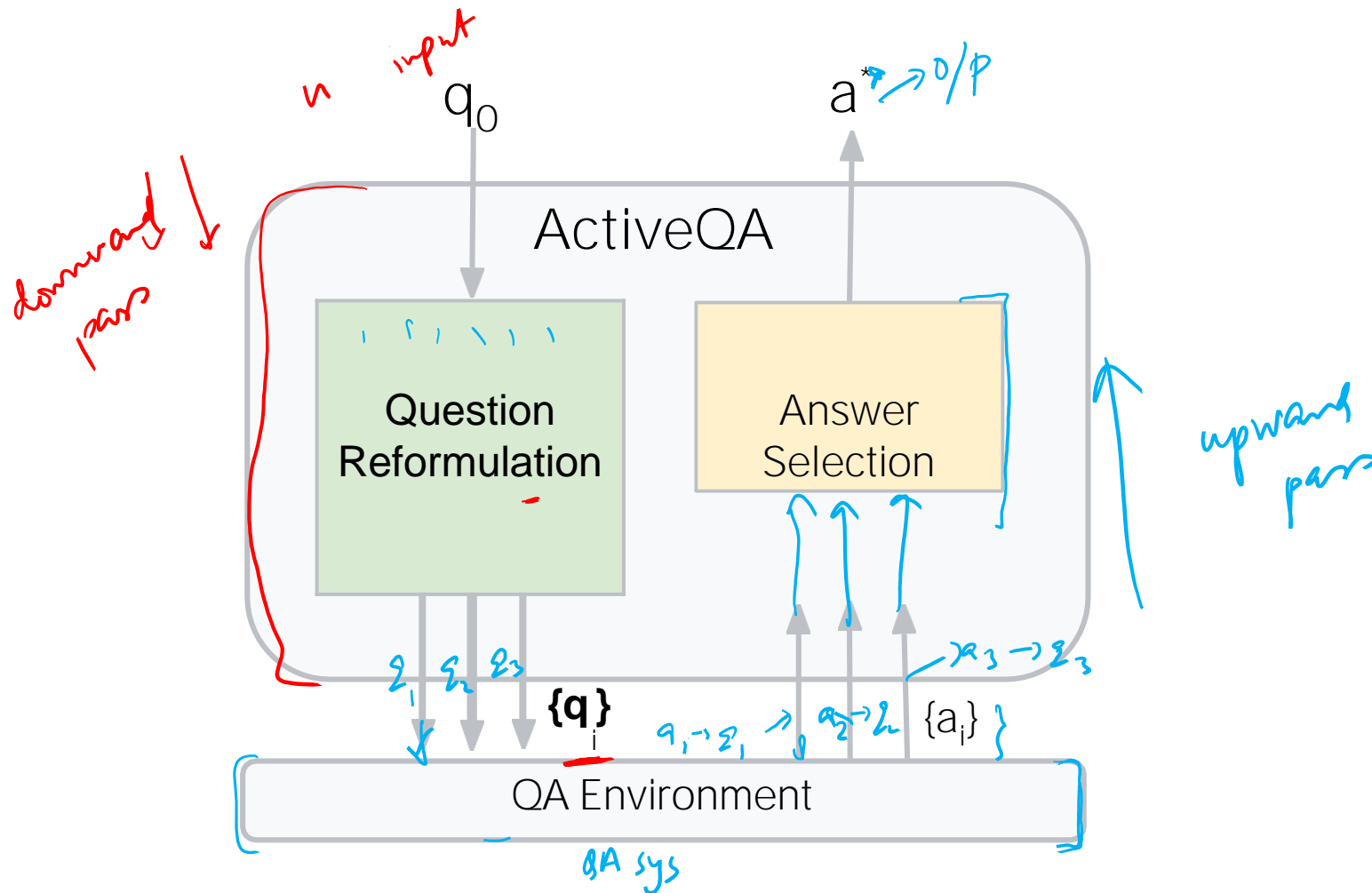


Intelligent language agent for QA



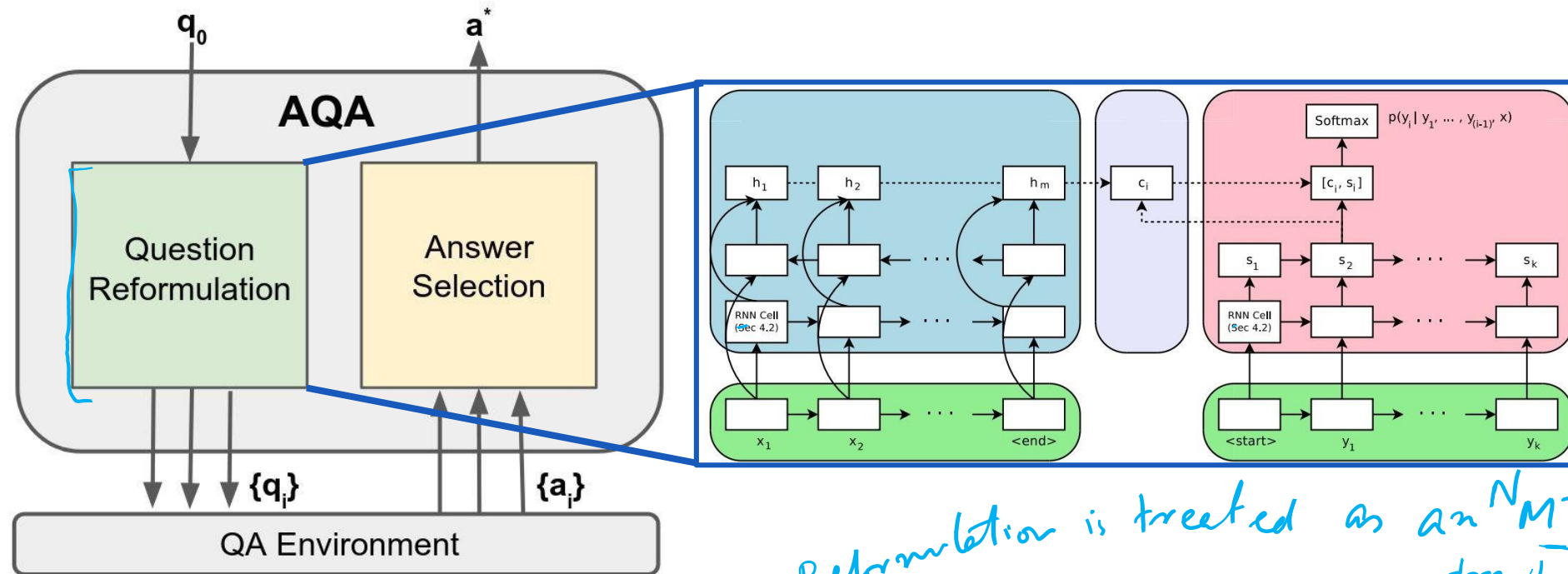
AQA: Active question answering

Active QA



Seq-to-seq

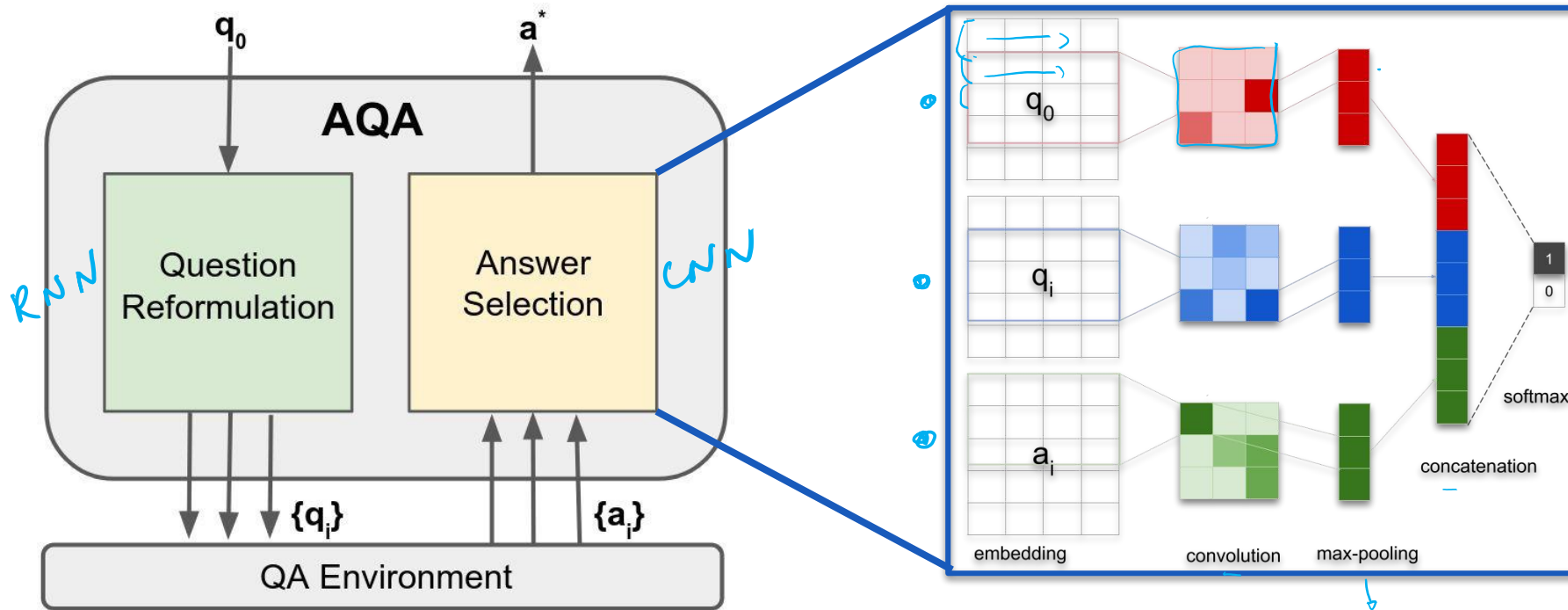
Active QA: Sequence-to-sequence



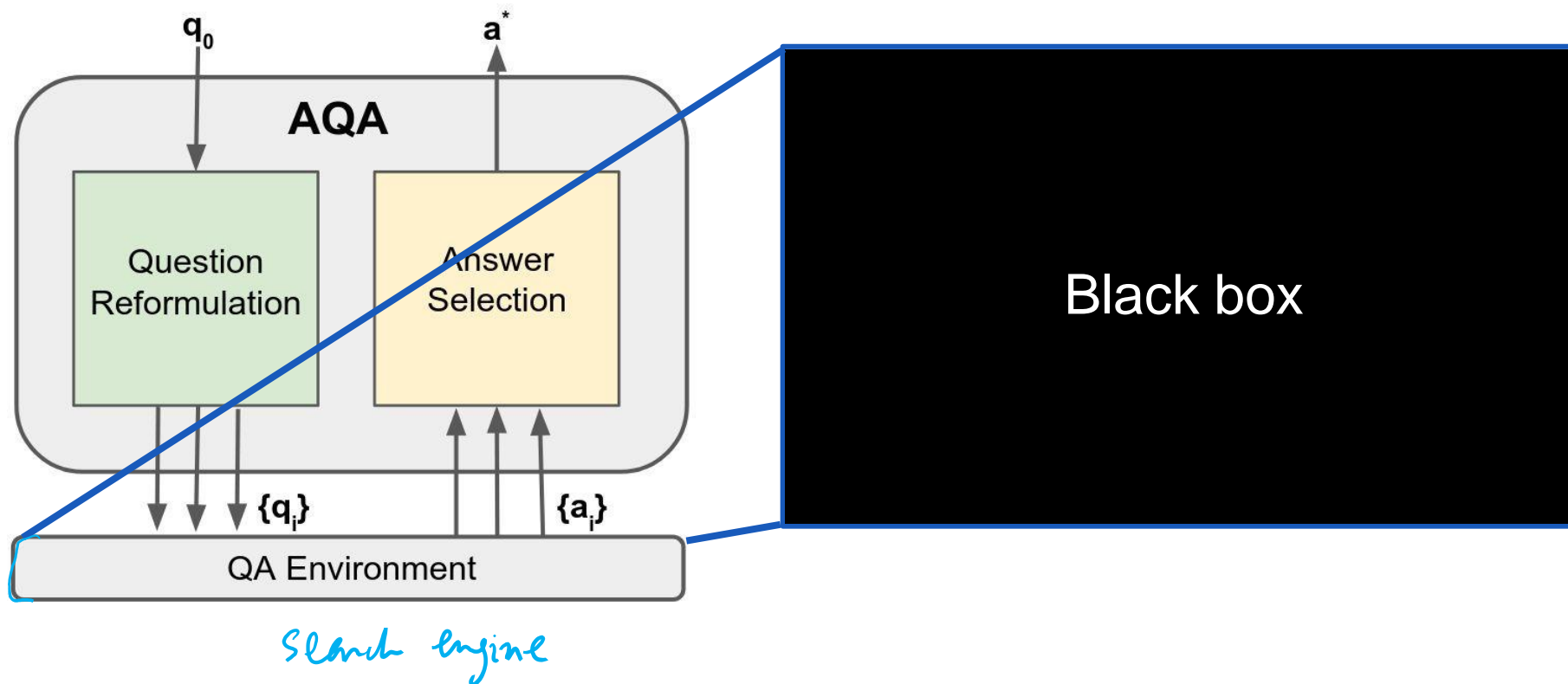
*Image from [Britz et al., 2017]

Reformulation is treated as an NMT task
ENG \rightarrow GER
GER \leftarrow ENG
user's query \leftrightarrow "w/c" lang
- bi-ly base of AE
- where we AE born

Active QA: Answer selection



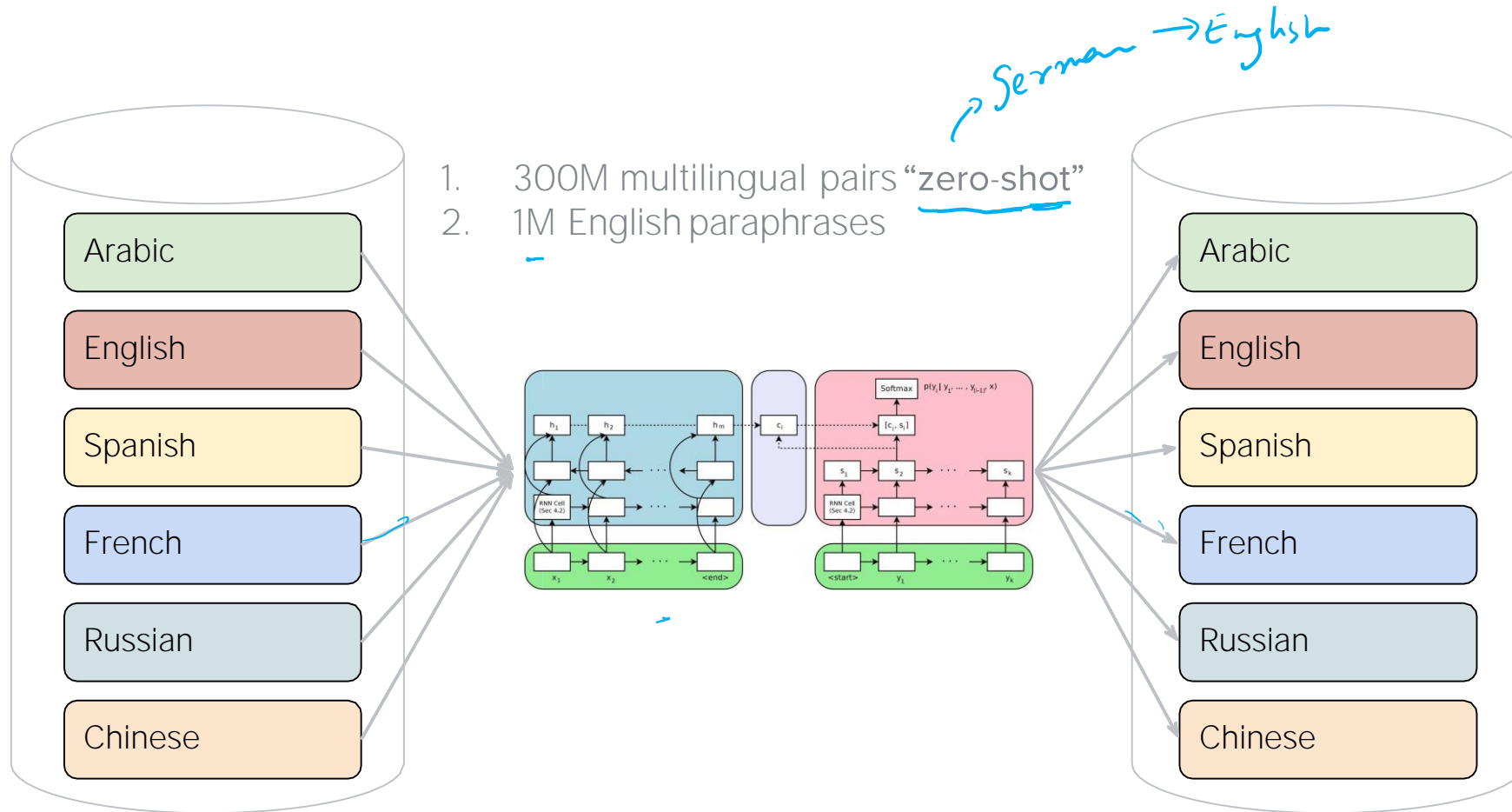
Active QA: Answer selection



Training

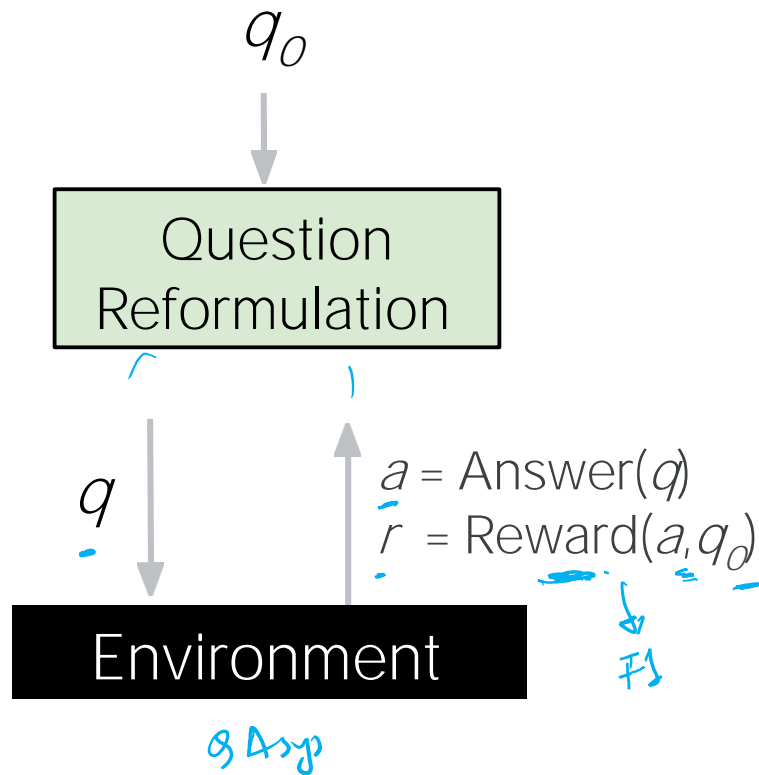
- ■ Supervised paraphrasing
- ■ Question reformulation with reinforcement learning
- ■ Answer selection

Training 1: Initialization with supervised paraphrasing model



Training 2: Reformulation model

RL



Use policy gradient to maximize expected reward:

$$\mathbb{E}_{p(q|q_0)} \text{Reward}(a, q_0)$$

policy network
parameterized policy

REINFORCE
Williams 1992
" & Page 1591

REINFORCE: Monte-Carlo Policy-Gradient Control (episodic) for π_*

Input: a differentiable policy parameterization $\pi(a|s, \theta)$

Algorithm parameter: step size $\alpha > 0$

Initialize policy parameter $\theta \in \mathbb{R}^{d'}$ (e.g., to $\mathbf{0}$)

Loop forever (for each episode):

Generate an episode $S_0, A_0, R_1, \dots, S_{T-1}, A_{T-1}, R_T$, following $\pi(\cdot|\cdot, \theta)$

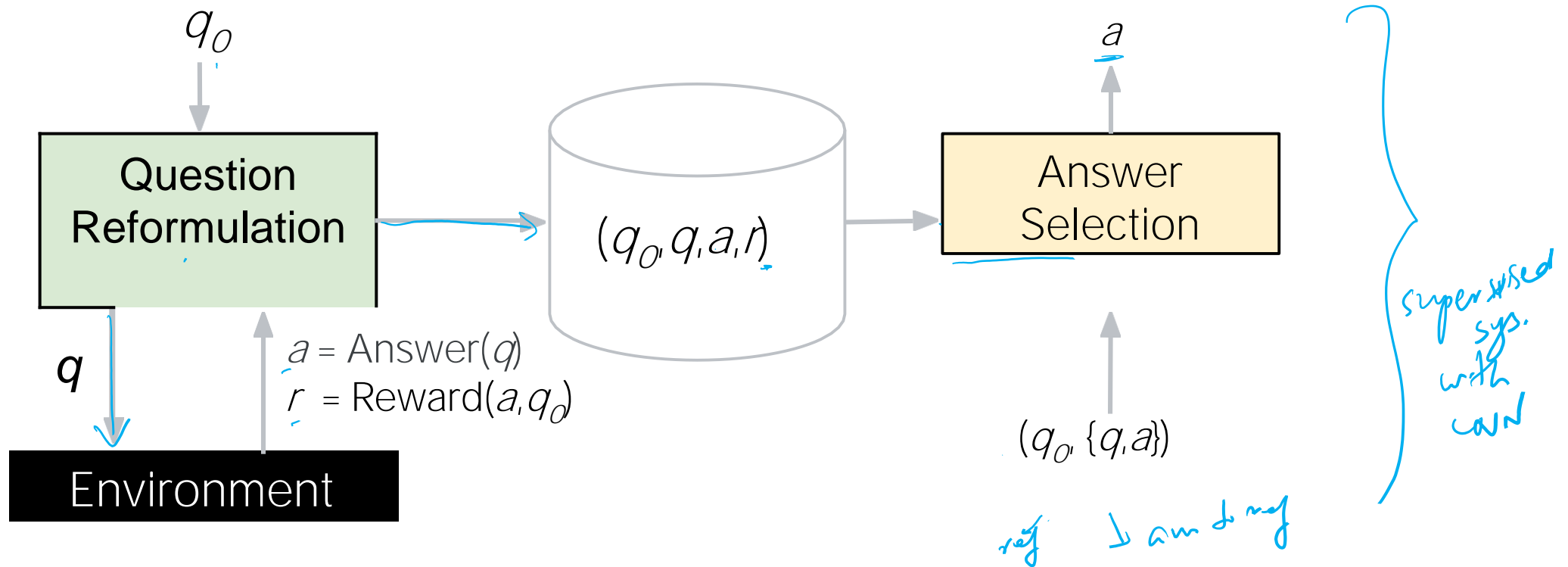
Loop for each step of the episode $t = 0, 1, \dots, T-1$:

$$G \leftarrow \sum_{k=t+1}^T \gamma^{k-t-1} R_k \quad (G_t)$$

$$\theta \leftarrow \theta + \alpha \gamma^t G \nabla \ln \pi(A_t | S_t, \theta)$$

Training 3: Answer selection

Supervised training on tuples scraped during reformulator training



SearchQA: Reading comprehension

MRC
[passage/
context]

Question (J! *clue*): "Highway 71 gets you to America's deepest gorge, Hells Canyon, & this river that flows through it"

Answer: the Snake

Context: Top 50-100 search snippets for the question filtered for giveaways

[Dunn et. al, 2017]

Google Highway 71 gets you to America's deepest gorge, Hells Canyon, & this r

All Maps Videos Images Shopping More Settings Tools

Hells Canyon - Wikipedia
https://en.wikipedia.org/wiki/Hells_Canyon
Hells Canyon is a 10-mile (16 km) wide canyon located along the border of eastern Oregon, eastern Washington and western Idaho in the United States. It is part of the Hells Canyon National Recreation Area and is North America's deepest river gorge at 7,993 feet (2,436 m). The canyon was carved by the waters of the ...
Missing: 24

~~Jeopardy! Archive - Show #7586, aired 2017-09-11
https://www.jeopardy.com/shows/jeopardy!/?game_id=5776
Sep 11, 2017 - Shadi Peleman, a school history teacher from St. Louis, Missouri (whose 2-day cash winnings total \$18,000) ... You didn't know this! Calif. university a 6-mile drive from the Googleplex "anyway" ... Highway 71 gets you to America's deepest gorge, Hells Canyon, & this river that flows through it ...~~

Hells Canyon National Recreation Area: Top Things To Do In Idaho
enjoyyourparks.com/Hells-Canyon-Idaho.html
This location makes Hells Canyon the deepest gorge in North America, even rivaling the Grand Canyon, which is over two thousand feet less deep than Hells ... Bridge near Homestead Idaho on Idaho State Highway 71, the Hells Canyon Scenic Byway is an extremely remote, paved byway that takes visitors through an ...

Familiar with Beamers Copper Creeek Lodge?? - TripAdvisor
[https://www.tripadvisor.co.za/United_States/Idaho_\(ID\)/Idaho_Travel_Forum](https://www.tripadvisor.co.za/United_States/Idaho_(ID)/Idaho_Travel_Forum)
Answer 1 of 9: Looking for a place to stay in Hells Canyon that is not camping. ... Cambridge and Council give you access to the reservoirs about the three dams. ... not a bad deal when you consider that it includes a 200 mile round trip professionally guided jet boat tour of Hells Canyon, the deepest gorge in North America. ...

Hells Canyon: Exploring the Deepest Gorge in North America
<https://rootsrated.com/stories/exploring-the-deepest-gorge-in-north-america>
Feb 16, 2016 - Sliding the earth on the border of Oregon and Idaho, Hells Canyon is the deepest river gorge in North America—deeper than the Grand Canyon, in fact. Alongside ... To get there, head about 150 miles north on Idaho Highway 55 and US 95 to the town of Riggins, where you can pick up last-minute supplies.

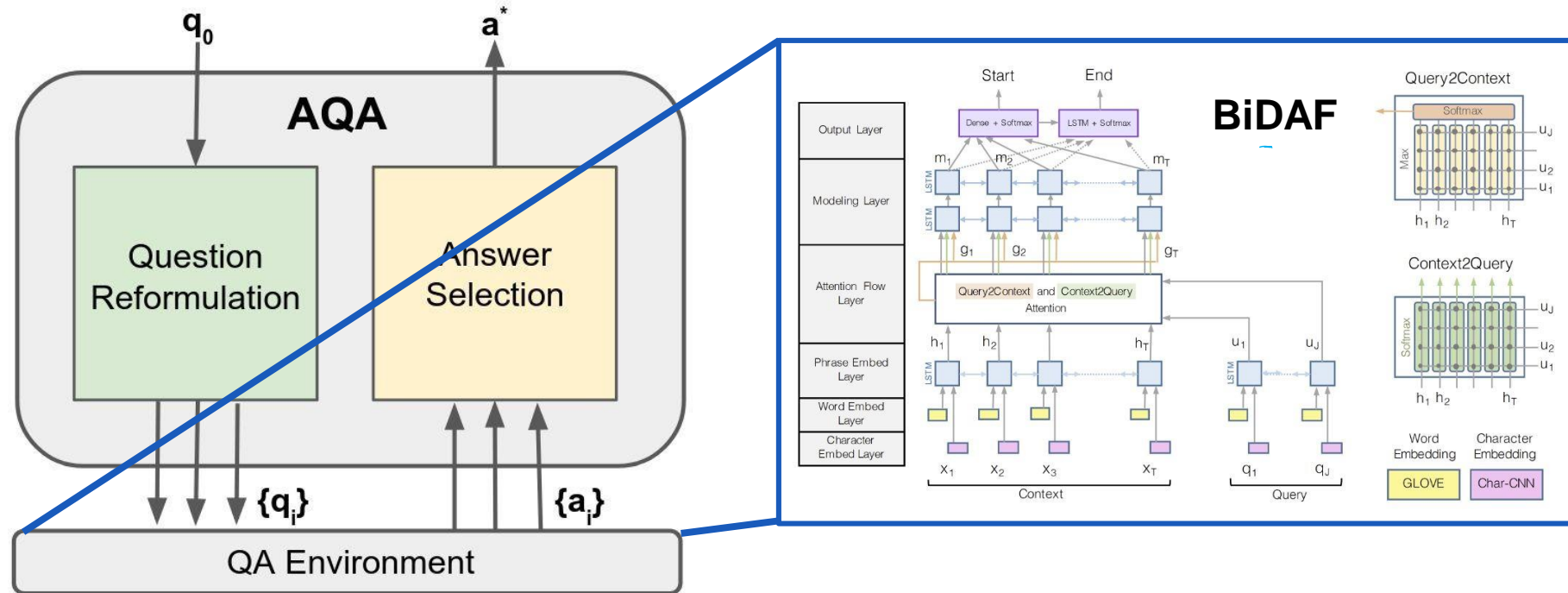
Familiar with Beamers Copper Creeek Lodge ... - TripAdvisor
[https://www.tripadvisor.co.uk/United_States/Idaho_\(ID\)/Idaho_Travel_Forum](https://www.tripadvisor.co.uk/United_States/Idaho_(ID)/Idaho_Travel_Forum)
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The Hells Canyon Scenic Byway | TripCheck - Oregon Traveler ...
<https://www.tripcheck.com/Pages/Scenic-Byways-Hells-Canyon>
About six miles past the junction of Forest Road 39, you'll discover the mighty Snake River as it approaches the southern end of Hells Canyon, the deepest river-carved gorge in North America. According to Nez Perce folklore, Coyote dug Hells Canyon with a big stick to protect ancestors in Oregon's Blue Mountains from the ...

HIGHWAY TO HELL Jeopardy Questions - JeopardyQuestions.com
<https://jeopardyquestions.com/category/highway-to-hell>
View Answer. Category: HIGHWAY TO HELL. Take the 395 in this state to Inyo National Forest and to Devils Postpile along the middle fork of the San Joaquin River. View Answer. Category: HIGHWAY TO HELL. Highway 71 gets you to America's deepest gorge Hells Canyon & this river that flows through it. View Answer ...

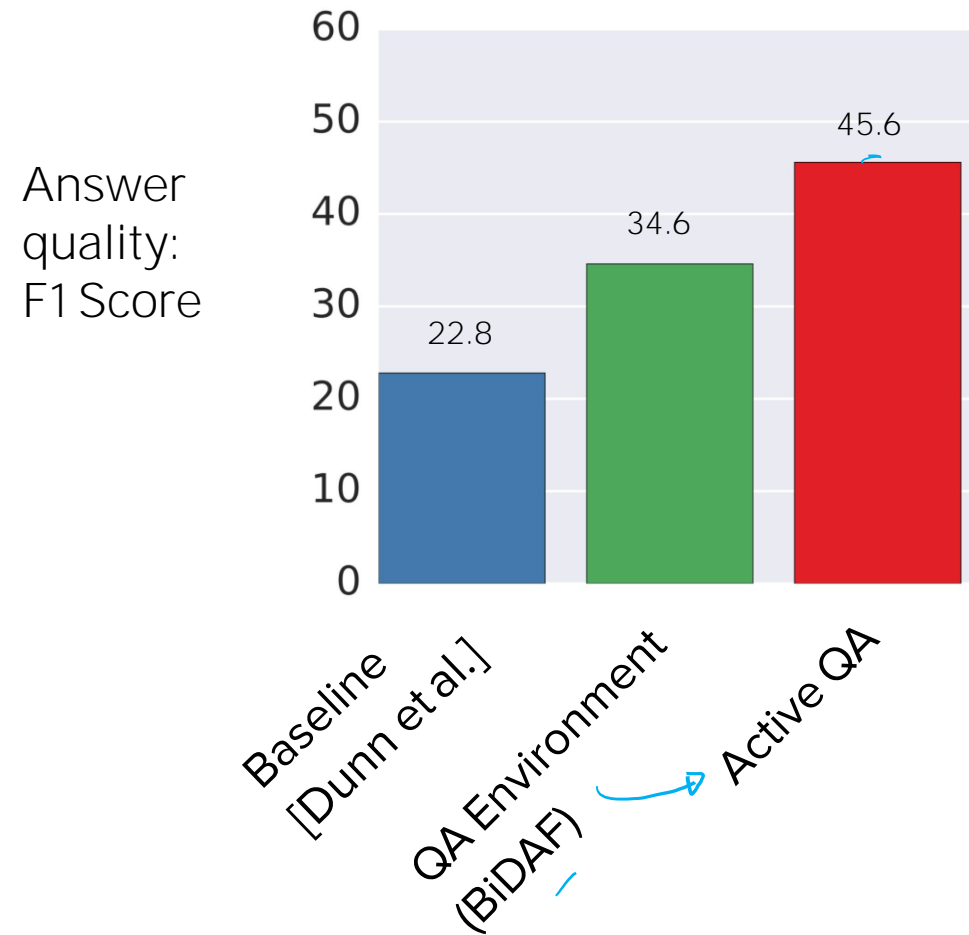
AAA Travel Guides - Hells Canyon National Recreation Area, OR
<https://www.aaa.com/.../hells%20canyon%20national%20recreation%20area-or>
Confined within steep, eroded black basalt walls, the surging Snake River has carved North America's deepest river gorge, measuring 7,913 feet from He Devil Mountain to Copper Creek below. White-water rapids alternating with deep pools characterize this 72-mile free-flowing portion of the Snake River as it races north to ...

ActiveQA: Environment

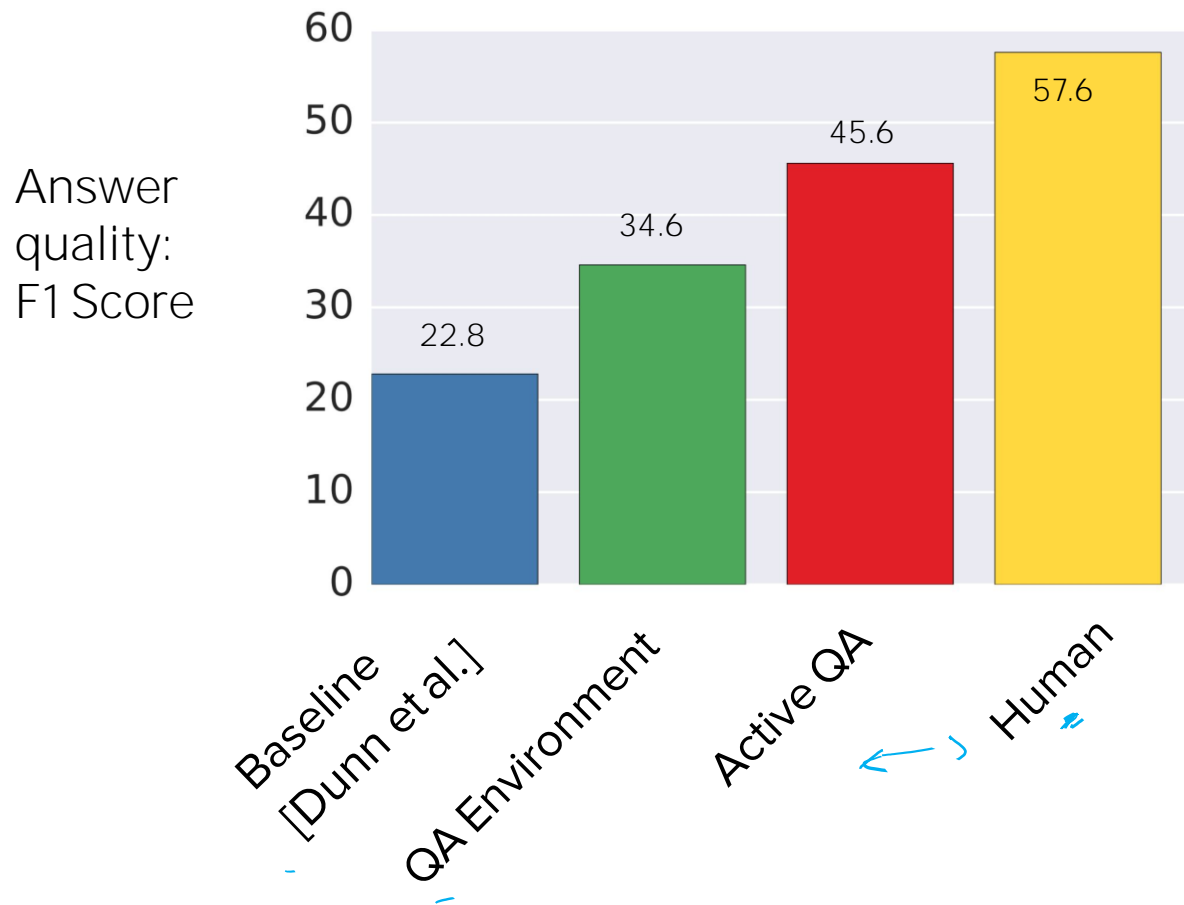


*Image from [Seo et al.2017]

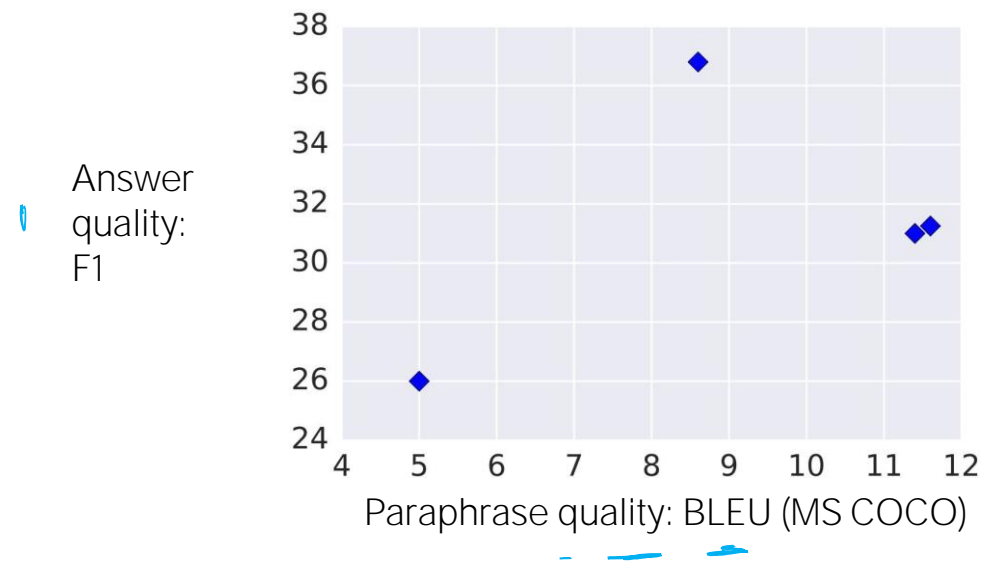
Results



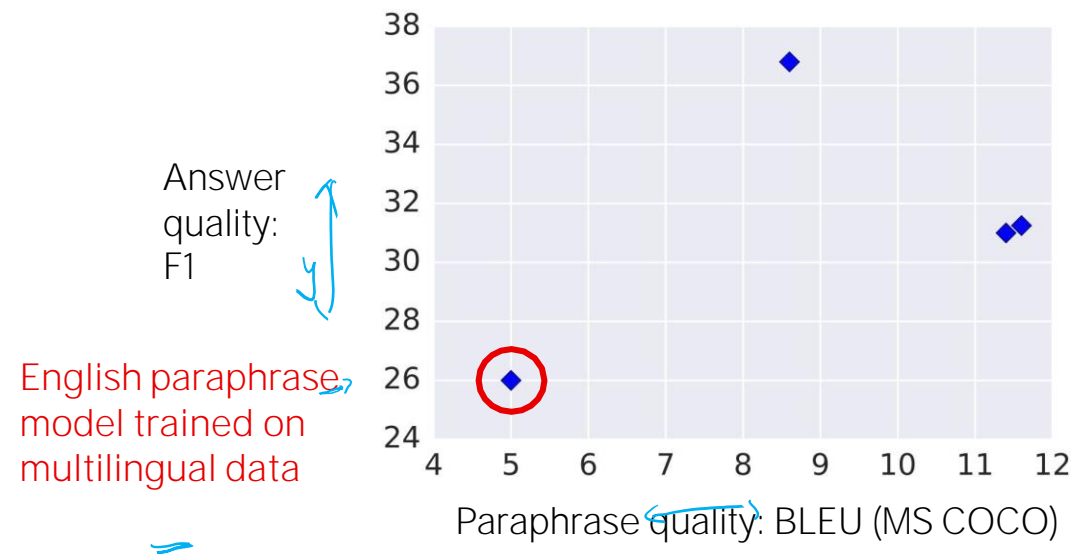
Results



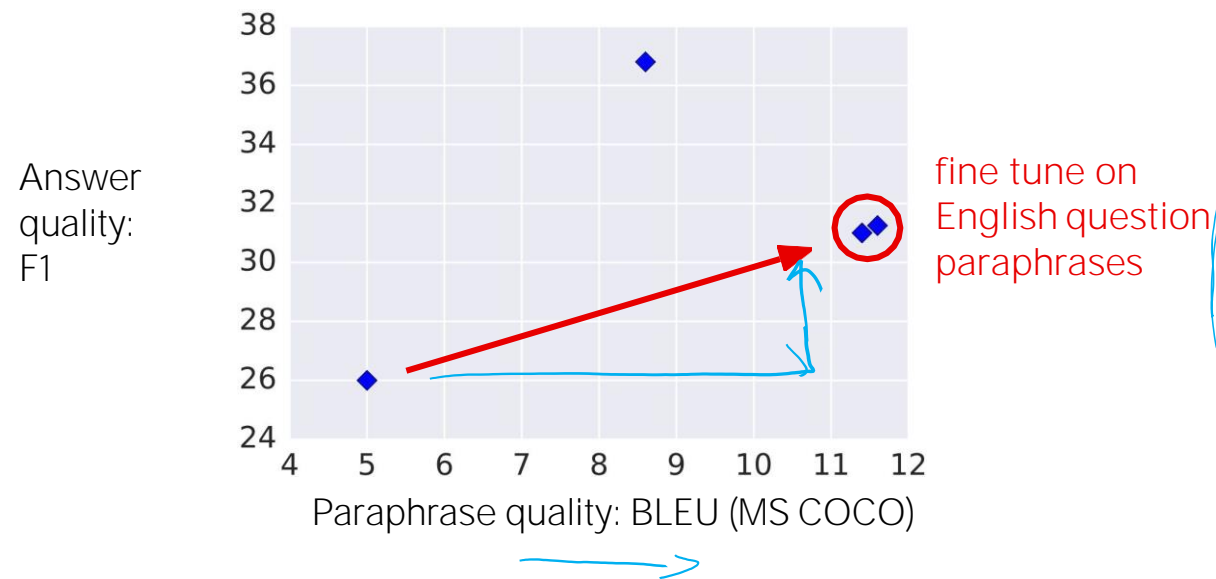
Reformulation quality



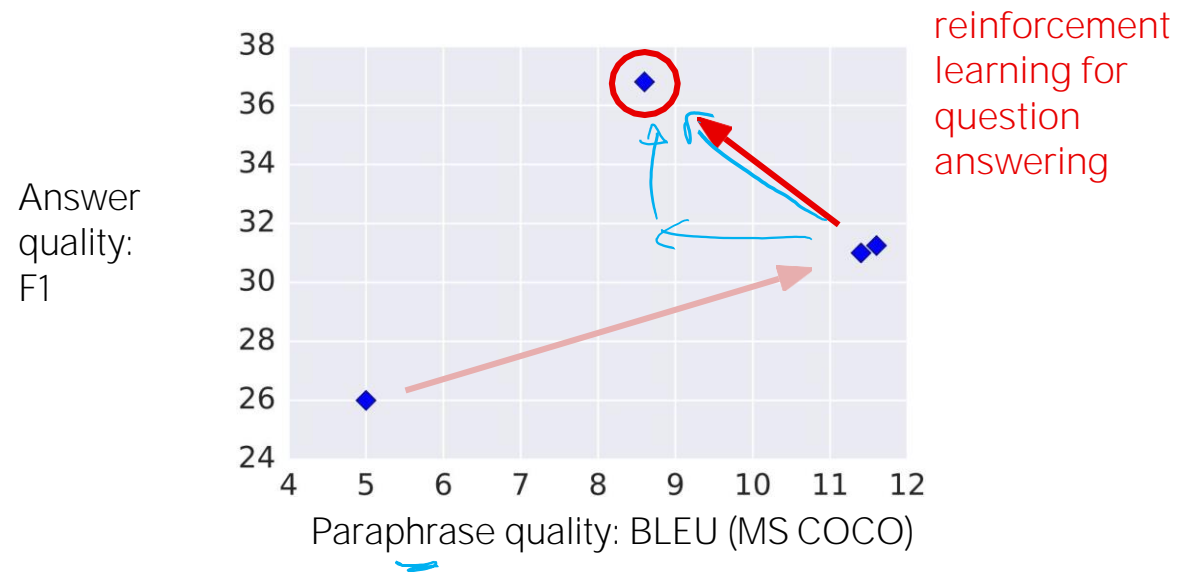
Reformulation quality



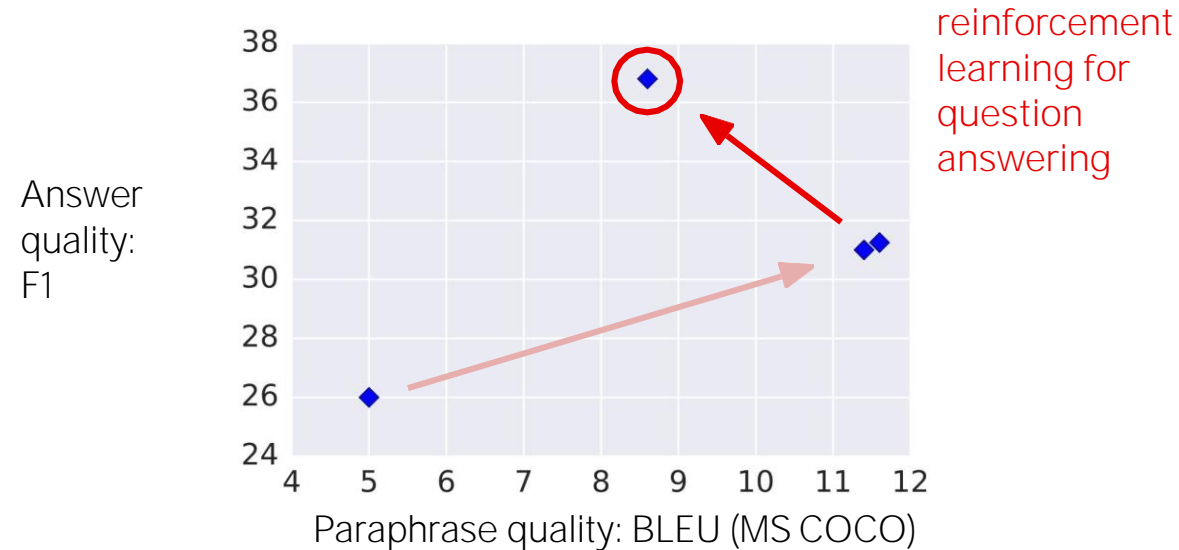
Reformulation quality



Reformulation quality



Reformulation quality



→ Input: type humorous poem bears name irish port city

→ Top reformulation: what is name humorous poem poem bears city city city

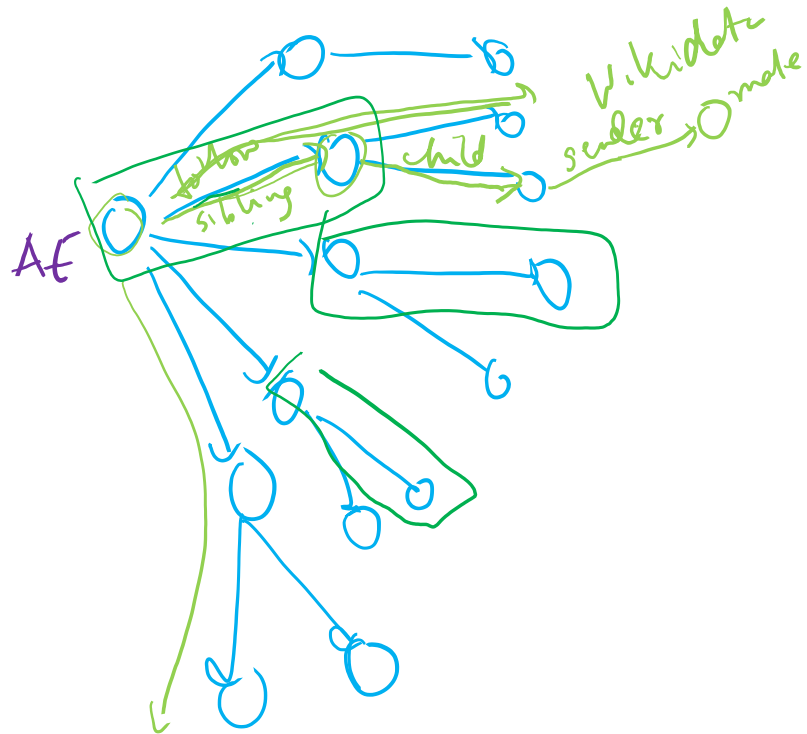
Research paper 2

Go for a Walk and Arrive at the Answer:
Reasoning over Paths in Knowledge Bases
using Reinforcement Learning

MINERVA: Task in KG Reasoning

I/p: relation + start entity
nephew AE

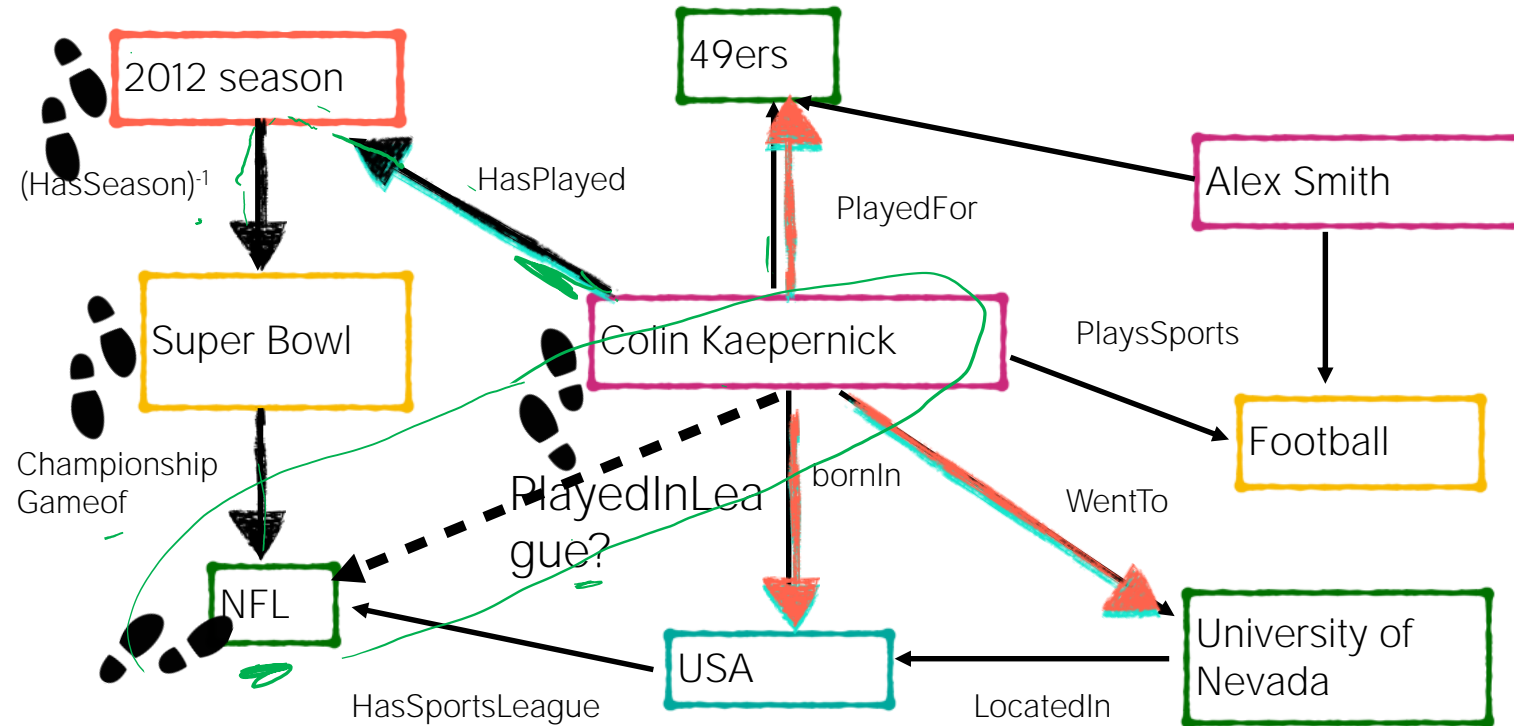
O/p: best path



• KGR ~ QA
↓
SE → NERD
formulation

MINERVA: Task

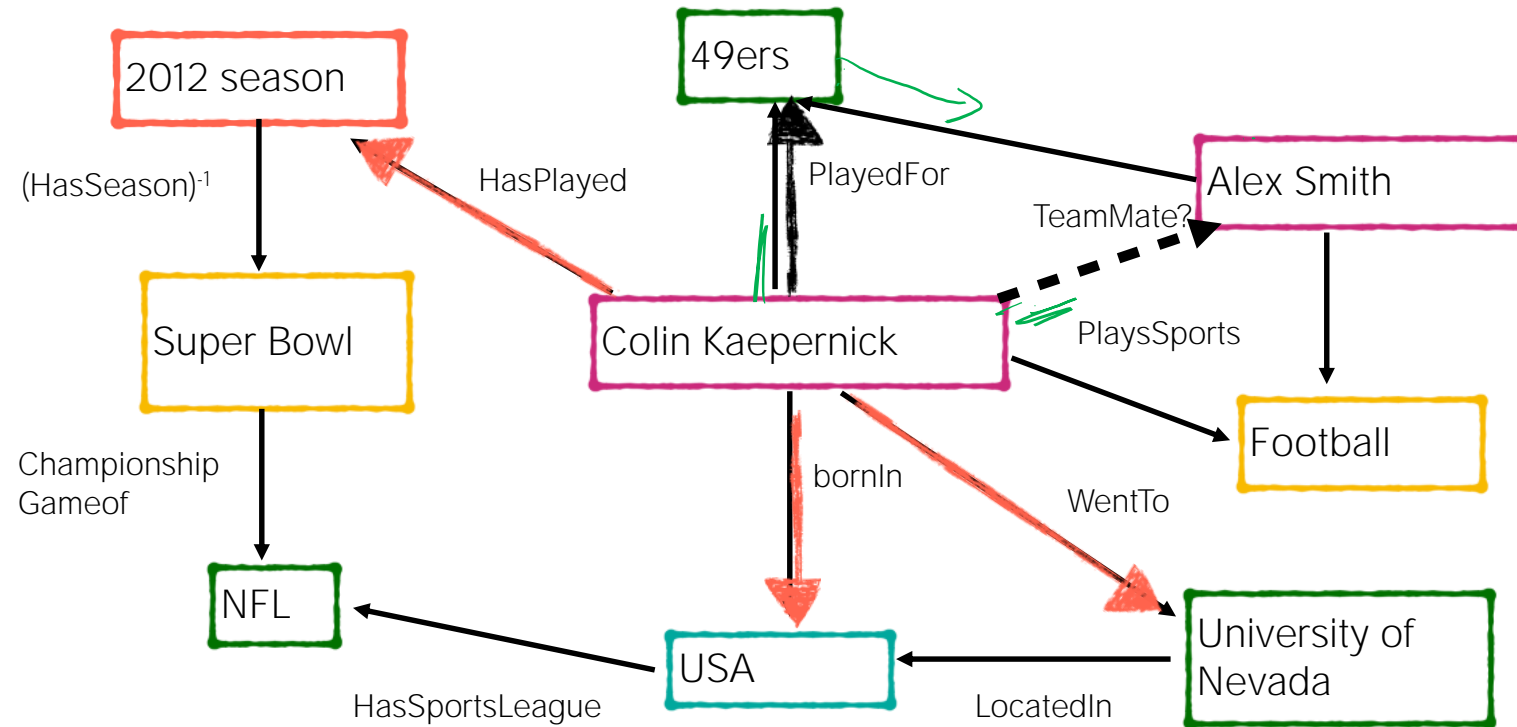
Meandering Trajectories
Networks of Entities
to reach
Verisimilar Answers



question: ?
→ (Colin Kaepernick, PlayedInLeague, ?) rel

Thanks to
Rajarshi Das
for the slides

MINERVA: Task



21P2

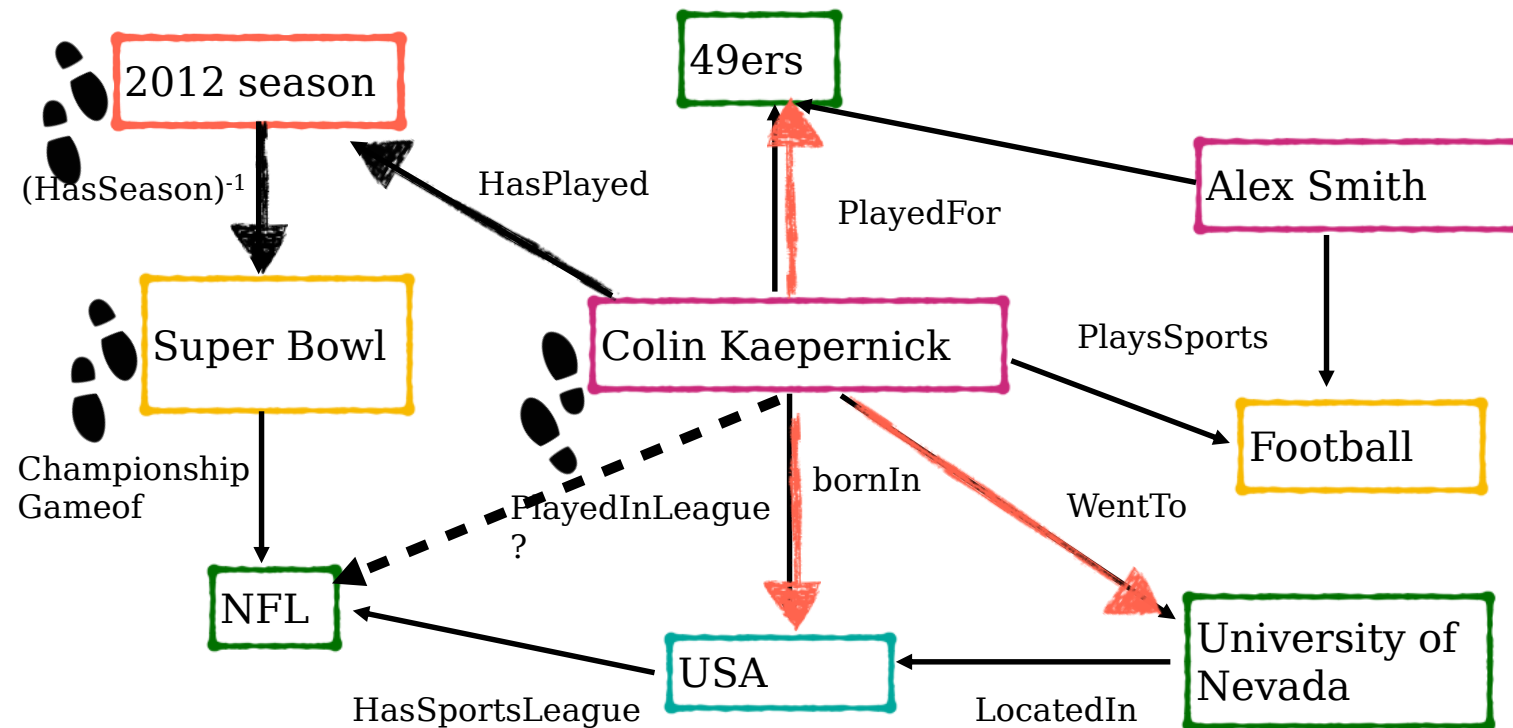
(Colin Kaepernick, PlayedInLeague, ?)

21P2

(Colin Kaepernick, TeamMate/Co-Worker, ?)

Query Dependent
Decision Making!

MINERVA: Model



(Colin Kaepernick, PlayedInLeague, ?)

MINERVA: Model

- Input - (Colin Kaepernick, PlayedInLeague, ?)

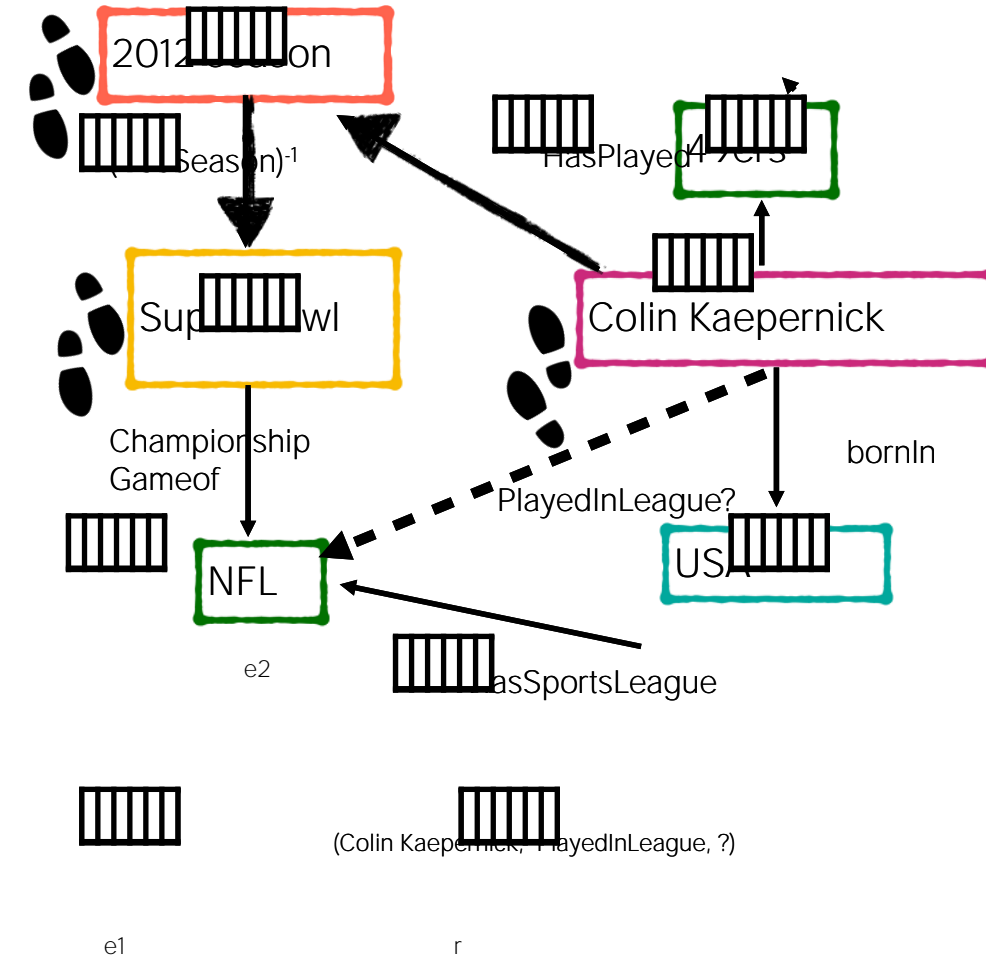
Partially Observed Markov decision process

States - (e_t, e_1, r, e_2)

4-hops

POMDP

Not observed by the agent



MINERVA: Policy

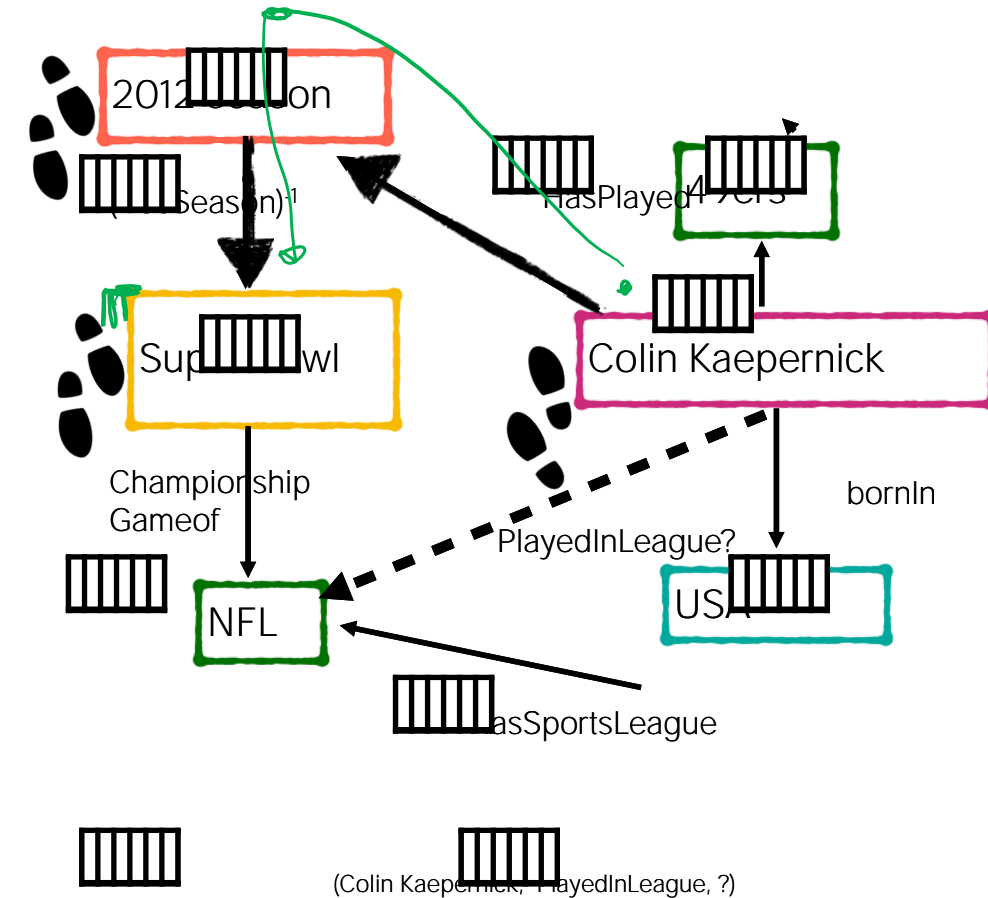
- Input - (Colin Kaepernick, PlayedInLeague, ?)

Partially Observed Markov decision process

States - (e_t, e_1, r, e_2)

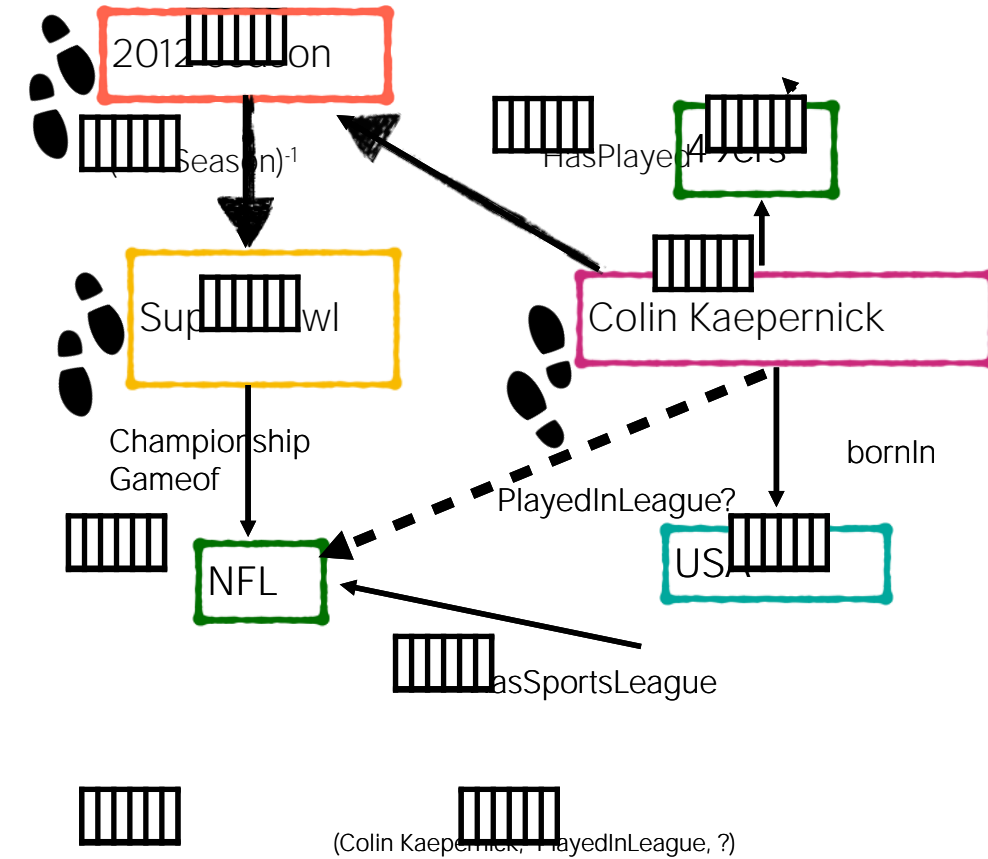
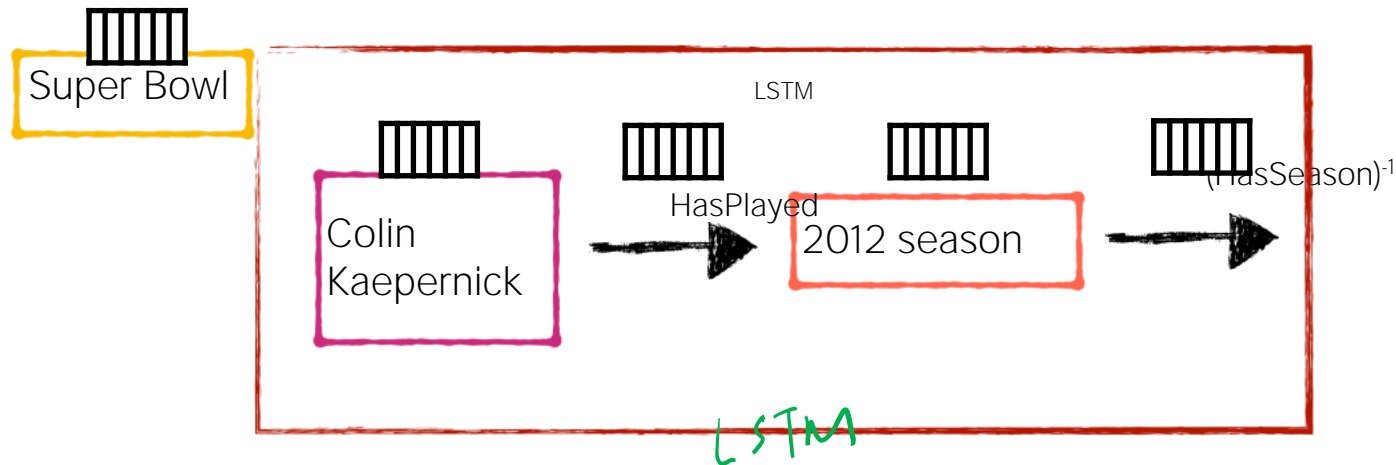
Policy

- Randomized & *history* dependent



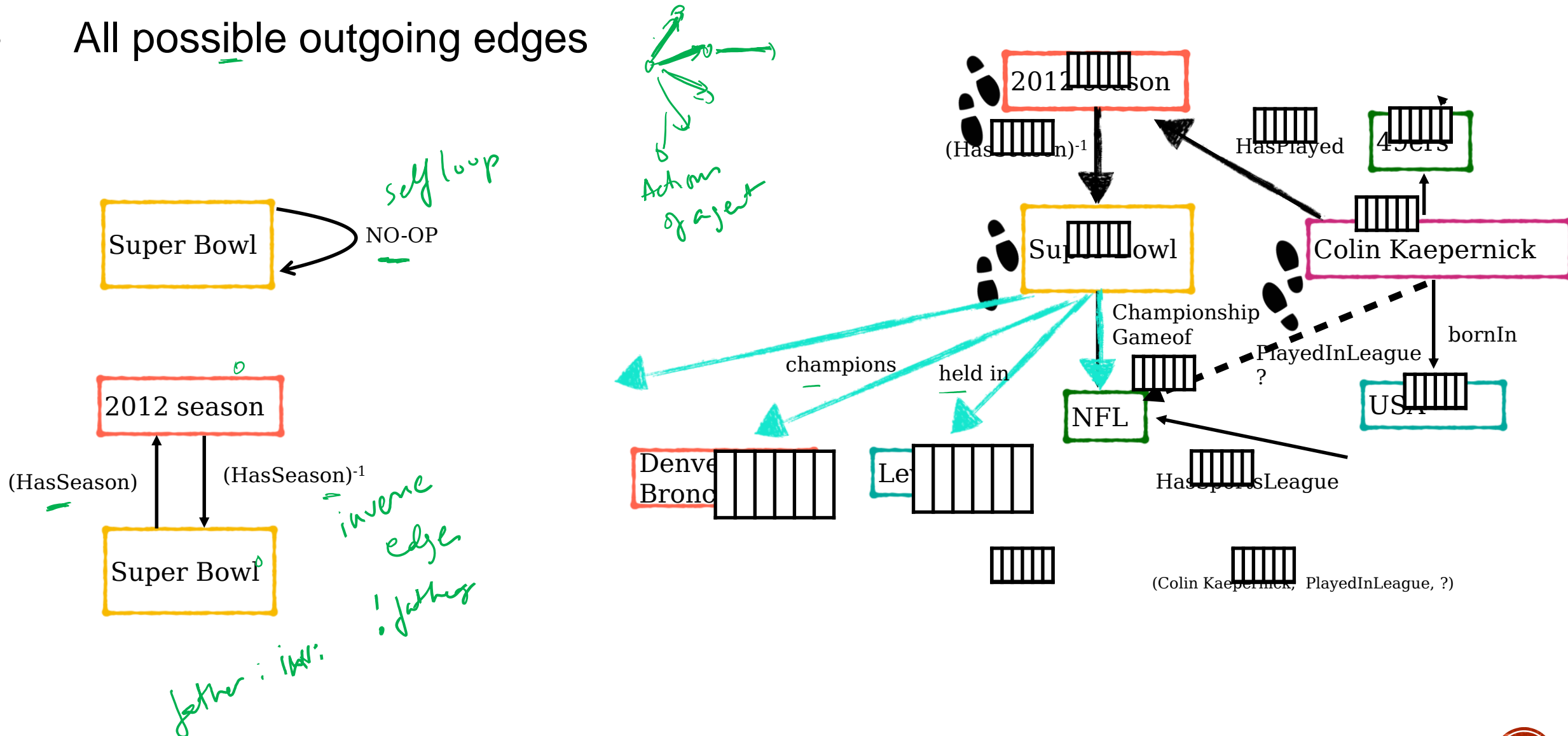
MINERVA: Policy

- History



MINERVA: Actions

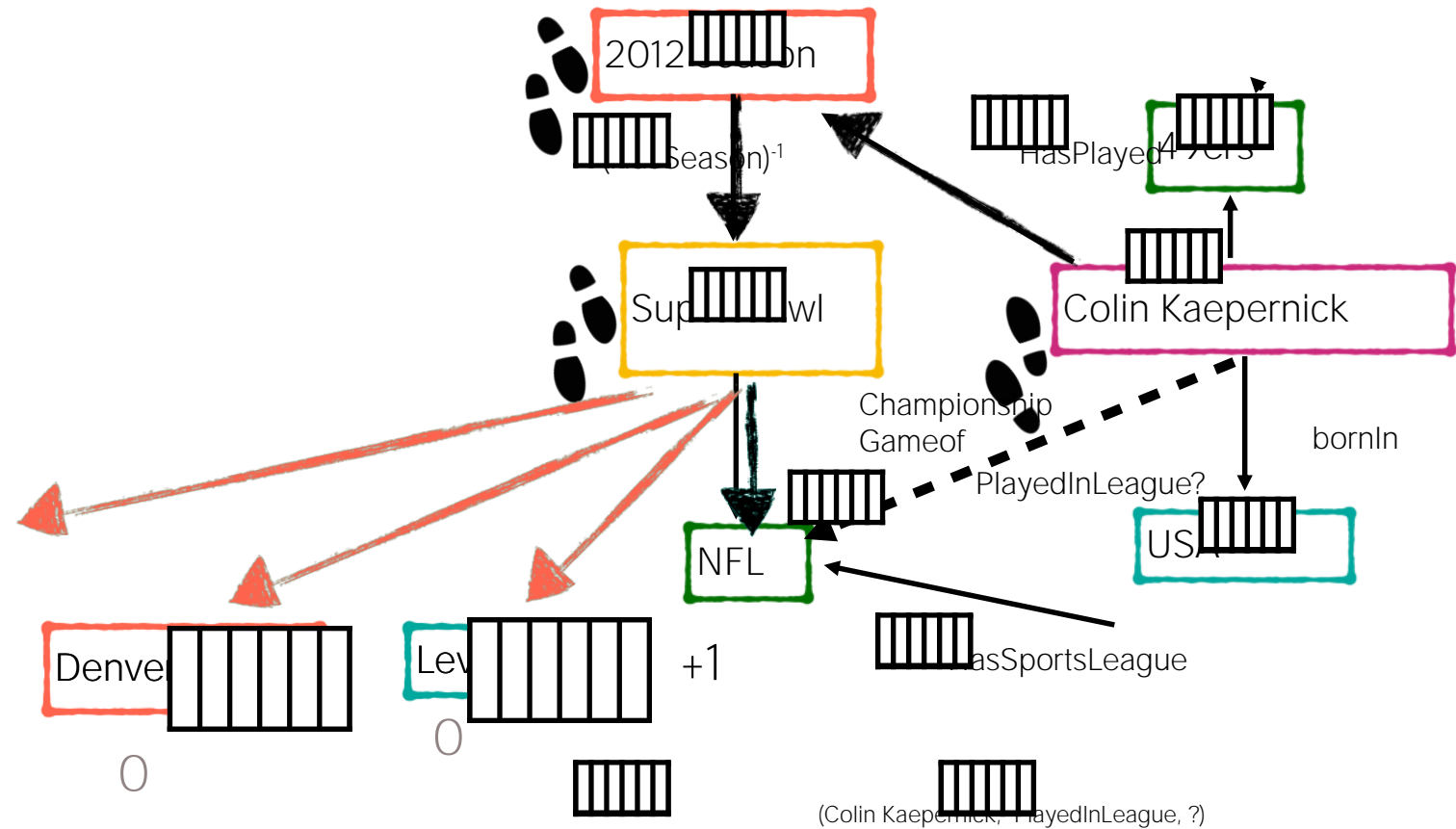
- All possible outgoing edges



MINERVA: Rewards

- $R = \{+1 \text{ if we reach the answer}$
 $0, \text{ otherwise}\}$

noisy
in reality →



MINERVA: Training

cost 1 loss fn. \rightarrow parameter \rightarrow policy

$$J(\theta) = \mathbb{E}_{(e_1, r, e_2) \sim D} \mathbb{E}_{A_1, \dots, A_{T-1} \sim \pi_\theta} [R(S_T) | S_1 = (e_1, e_1, r, e_2)]$$

2 expectation

τ_{e_t}

- Trained using Policy Gradients

$$\nabla_{\theta} J(\theta) \sim \sum_s \mu(s) \sum_a q_{\pi}(s, a) \nabla_{\theta} \pi(a | s, \theta) \quad (\text{Sutton, McAllester, Singh, Mansour, 2000})$$

- Monte Carlo Policy Gradients

$$\theta \leftarrow \theta + \alpha G_t \nabla_{\theta} \log \pi(A_t | S_t, \theta) \quad (\text{Williams, 1992})$$

- Monte Carlo Policy Gradients with Control Variates

$$\theta \leftarrow \theta + \alpha (G_t - b(S_t)) \nabla_{\theta} \log \pi(A_t | S_t, \theta)$$

QA: $\mathbb{E} \dots [R(\overset{\rightarrow a}{f}(g)) - \overset{\text{baseline}}{b}(g_0)] + \lambda H[\pi(g | g_0)]$

- Entropy regularization to sample more diverse paths.

REINFORCE
with baseline

Programming assignment

- Answer ^{simple} questions over toy KG and corpora
- Free to use any tools and resources
- Video to demonstrate method and answering outputs
→ Zoom free
unsupervised, turns *no turns*
- 10 dev and 10 test questions
- Comment on strengths and weaknesses from error analysis on test set
- Deadline: 21 July 2020, 14:00

word2vec,
POS, DP, NERD, ^{pos} language

Hackathon

send me ^{THX}
the Youtube /
Google Drive / OneDrive / Dropbox
link

Conclusions

- Reinforcement learning for QA has a high potential
- Many possibilities, not explored well yet ^{2017 / 2018}
- Needs modeling: Agent, environment, rewards, states, policy, value
- Coercing answers from reformulated questions is a viable strategy for open-domain QA
- RL has showed success in KG reasoning

QAQA

MINERVA

Thank
you