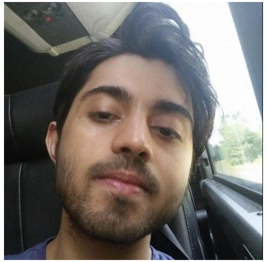
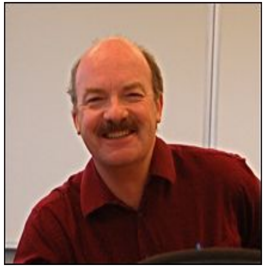
Iterative Search for Weakly Supervised Semantic Parsing







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This talk in one slide

- Training semantic parsing with denotation-only supervision is challenging because of **spuriousness**: incorrect logical forms can yield correct denotations.
- Two solutions:
    - Iterative training: Online search with initialization ⇆ MML over offline search output
    - Coverage during online search
- State-of-the-art single model performances:
    - WikiTableQuestions with comparable supervision
    - NLVR semantic parsing with significantly less supervision

Semantic Parsing for Question Answering

Athlete	Nation	Olympics	Medals
Gillis Grafström	Sweden (SWE)	1920–1932	4
Kim Soo-Nyung	South Korea (KOR)	1988-2000	6
Evgeni Plushenko	Russia (RUS)	2002–2014	4
Kim Yu-na	South Korea (KOR)	2010–2014	2
Patrick Chan	Canada (CAN)	2014	2

WikiTableQuestions, Pasupat and Liang (2015)

Question: Which athlete was from South Korea after the year 2010?

Answer: Kim Yu-Na

Reasoning:

1) Get rows where *Nation* is *South Korea*
2) Filter rows where value in *Olympics* > *2010*.
3) Get value from *Athlete* column

Program:

```
(select_string
   (filter_in
     (filter_> all_rows olympics 2010)
    south_korea)
 athlete)
```

Weakly Supervised Semantic Parsing

$\mathbf{x_i}$: Which athlete was from South Korea after 2010?

~~$\mathbf{y_i}$: `(select_string (filter_in (filter_> all_rows olympics 2010) south_korea) athlete)`~~

$\mathbf{z_i}$: Kim Yu-Na

$\mathbf{w_i}$:

Athlete	Nation	Olympics	Medals
Kim Yu-na	South Korea	2010–2014	2
Tenley Albright	United States	1952-1956	2

Train on $D = \{x_i, w_i, z_i\}_{i=1}^{N}$

Test: Given x_{N+k}, w_{N+k} find y_{N+k} such that $[\![y_{N+k}]\!]^{w_{N+k}} = z_{N+k}$

Challenge: Spurious logical forms

Athlete	Nation	Olympics	Medals
Gillis Grafström	Sweden (SWE)	1920–1932	4
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Which athletes are from South Korea after 2010? Kim Yu-Na

Logical forms that lead to answer:

Athlete from South Korea after 2010

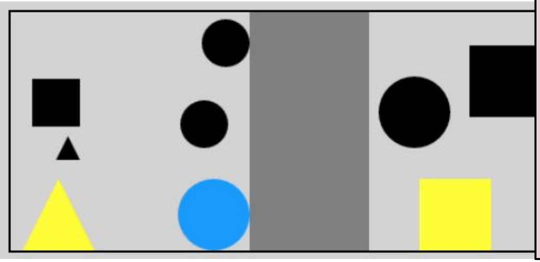
Athlete from South Korea with 2 medals

First athlete in the table with 2 medals

Athlete in row 4

Challenge: Spurious logical forms

There is exactly one square touching the bottom of a box True



Due to binary denotations, 50% of logical forms give correct answer!

lead to answer:

touching bottom of boxes

Count of yellow squares is 1

There exists a yellow triangle

There exists an object

Cornell Natural Language Visual Reasoning, Suhr et al., 2017

Training Objectives

Proposal: Alternate between the two objectives while gradually increasing the search space!

Maximum Marginal Likelihood

Eg.: Li

Krishn

Maxin

set of

$$\max_{\theta} \prod_{x_i, w_i, z_i \in D} \sum_{y_i \in Y \,|\, [\![y_i]\!]^{w_i} = z_i} p(y_i | x_i; \theta)$$

... but we need a good set of approximate logical forms

Reward/Cost -based approaches

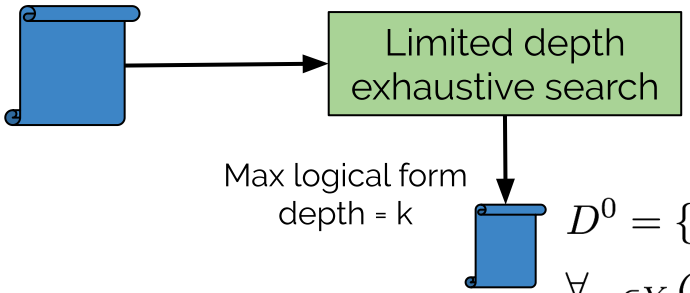
7, 2018),

$$\min_{\theta} \sum_{I=1}^{N} \mathbb{E}_{p(y_i|x_i;\theta)} \mathcal{C}(x_i, y_i, w_i, d_i)$$

... but random initialization can cause the search to get stuck in the exponential search space

Spuriousness solution 1: Iterative search

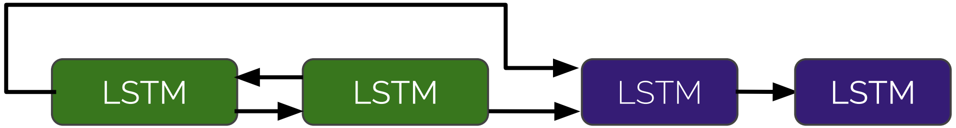
$$D = \{x_i, w_i, z_i\}_{i=1}^{N}$$



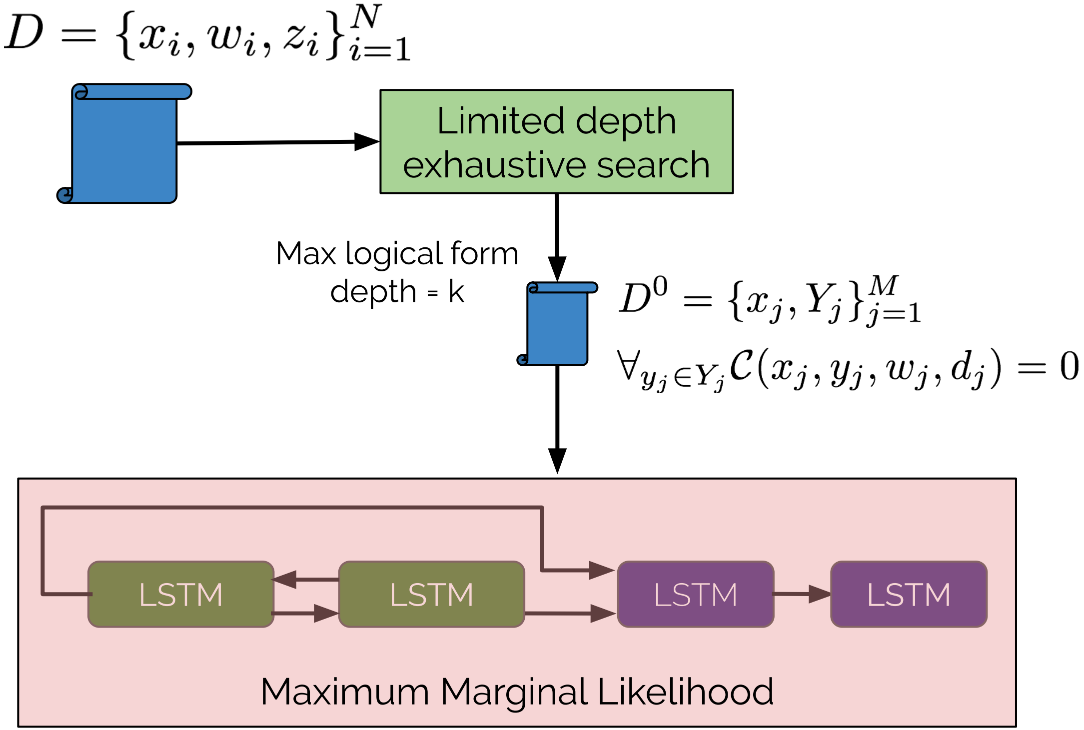
$$D^0 = \{x_j, Y_j\}_{j=1}^{M}$$

$$\forall_{y_j \in Y_j} \mathcal{C}(x_j, y_j, w_j, d_j) = 0$$

Step 0: Get seed set of logical forms till depth **k**



Spuriousness solution 1: Iterative search

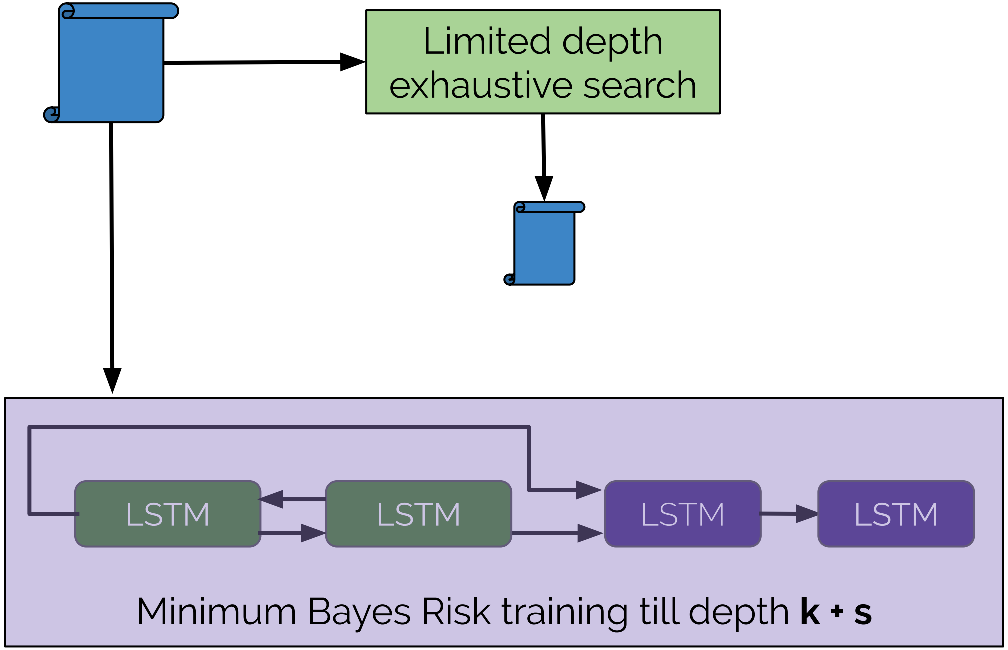


Step 0: Get seed set of logical forms till depth **k**

Step 1: Train model using MML on seed set

Spuriousness solution 1: Iterative search

$$D = \{x_i, w_i, z_i\}_{i=1}^{N}$$



Step 0: Get seed set of logical forms till depth **k**

Step 1: Train model using MML on seed set

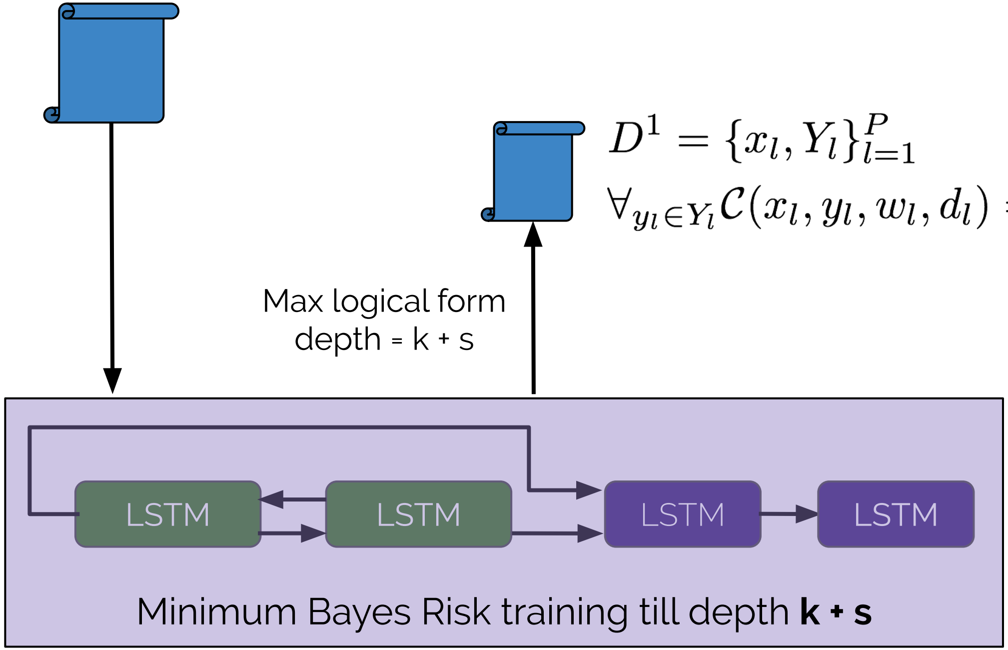
Step 2: Train using MBR **on all data** till a greater depth **k + s**

Spuriousness solution 1: Iterative search

$$D = \{x_i, w_i, z_i\}_{i=1}^{N}$$

$$D^1 = \{x_l, Y_l\}_{l=1}^{P}$$

$$\forall_{y_l \in Y_l} \mathcal{C}(x_l, y_l, w_l, d_l) = 0$$



Step 0: Get seed set of logical forms till depth **k**

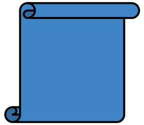
Step 1: Train model using MML on seed set

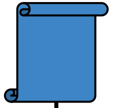
Step 2: Train using MBR **on all data** till a greater depth **k + s**

Step 3: Replace offline search with trained MBR and update seed set

Spuriousness solution 1: Iterative search

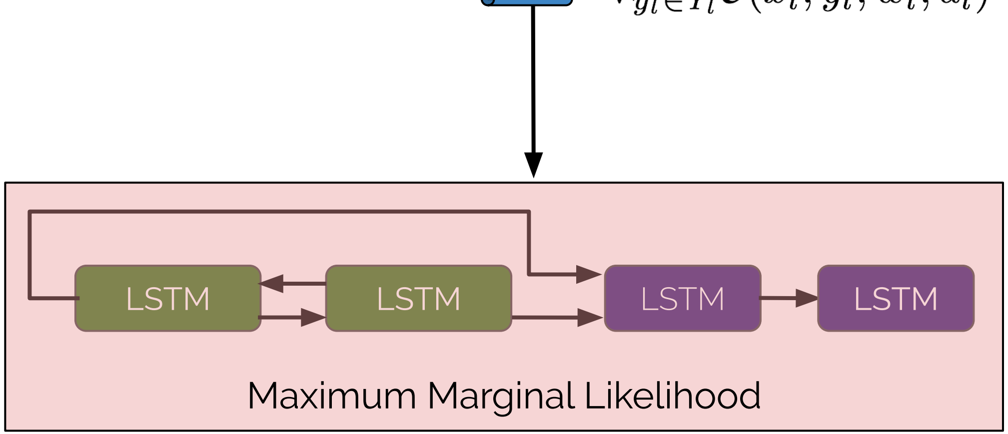
$D = \{x_i, w_i, z_i\}_{i=1}^{N}$





$D^1 = \{x_l, Y_l\}_{l=1}^{P}$

$\forall_{y_l \in Y_l} \mathcal{C}(x_l, y_l, w_l, d_l) = 0$



Step 0: Get seed set of logical forms till depth **k**

Step 1: Train model using MML on seed set

Step 2: Train using MBR **on all data** till a greater depth **k + s**

Step 3: Replace offline search with trained MBR and update seed set

k : k + s; Go to Step 1

Iterate till dev. accuracy stops increasing

Spuriousness Solution 2: Coverage guidance

There is exactly one square touching the bottom of a box.

(count_equals (square (touch_bottom all_objects)) 1)

- **Insight:** There is a significant amount of trivial overlap
- **Solution**: Use overlap as a measure guide search

Spuri ce

There is exac
bottom.

Target symbo
count_e
1
square
touch_b

Coverage cos
symbols that
form

top
→ bottom
→ above
→ below
→ square
→ circle
le → triangle
→ yellow
→ black
blue
big
→ small
→ medium

Example:

Sentence: **There is exactly one square touching the bottom of a box.**

Triggered target symbols: `{count_equals, square, 1, touch_bottom}`

Coverage costs of candidate logical forms:

Logical form	Coverage
`(count_equals (square (touch_bottom all_objects)) 1)`	0
`(count_equals (square all_objects) 1)`	1
`(object_exists all_objects)`	4

Training with Coverage Guidance

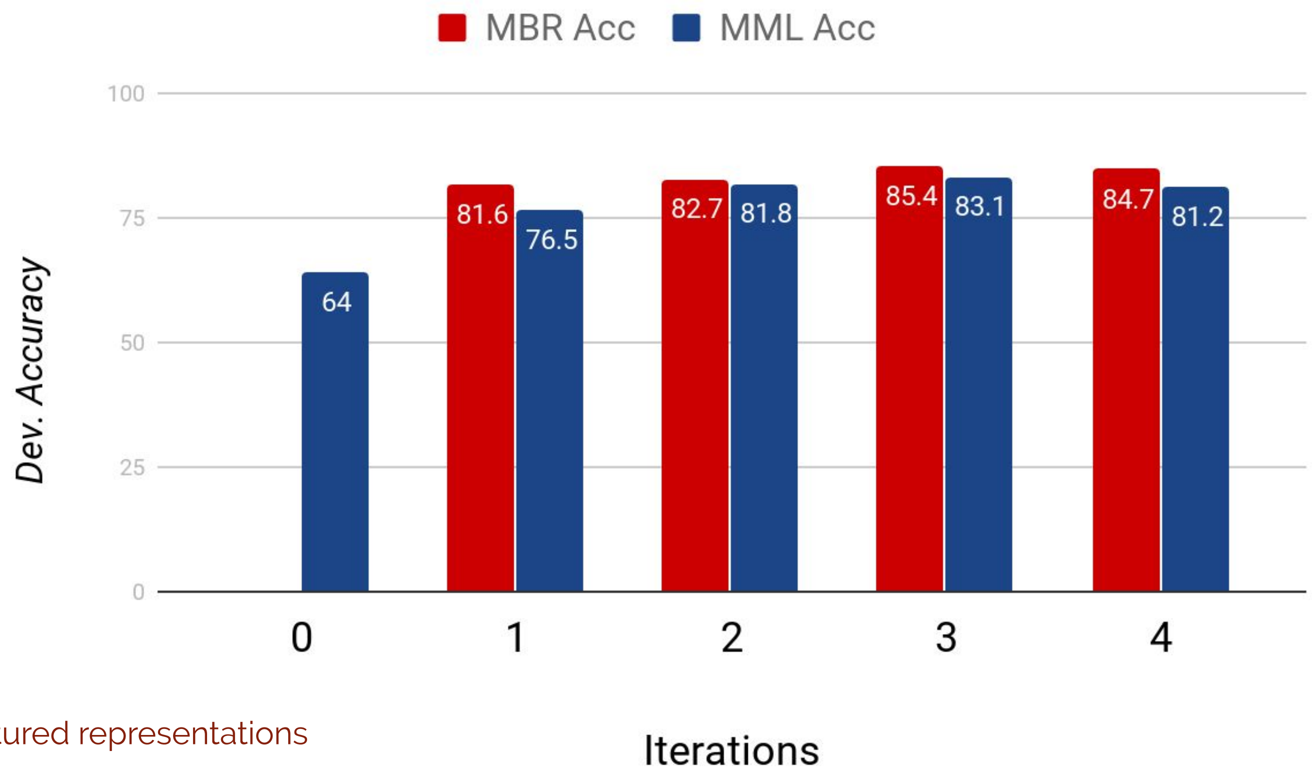
- Augment the reward-based objective:

$$\min_{\theta} \sum_{I=1}^{N} \mathbb{E}_{p(y_i|x_i;\theta)} \mathcal{C}(x_i, y_i, w_i, d_i)$$

now $\mathcal{C}$ is defined a linear combination of **coverage** and **denotation** costs

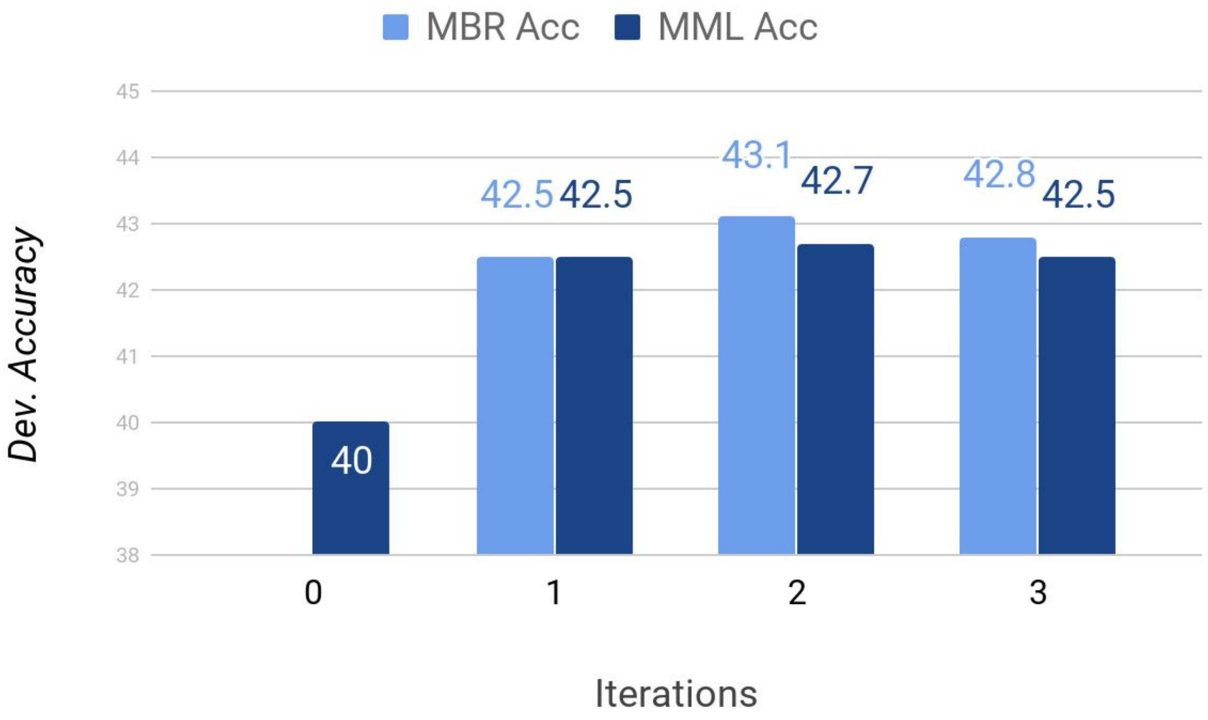
$$\mathcal{C}(x_i, y_i, w_i, d_i) = \lambda \mathcal{S}(y_i, x_i) + (1 - \lambda) \mathcal{T}(y_i, w_i, d_i)$$

Results of training with iterative search on NLVR*



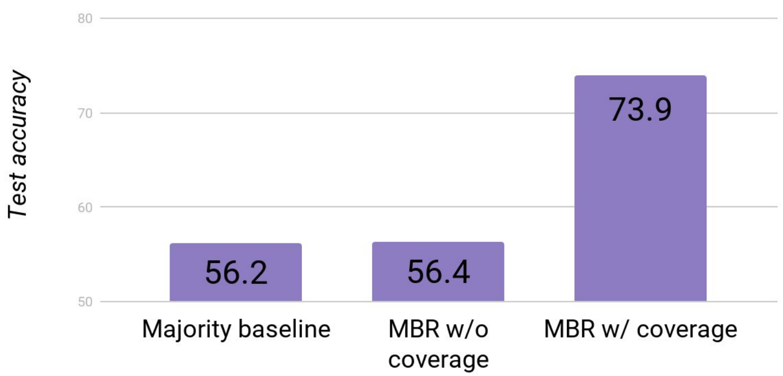
* using structured representations

Results of training with iterative search on WikiTableQuestions



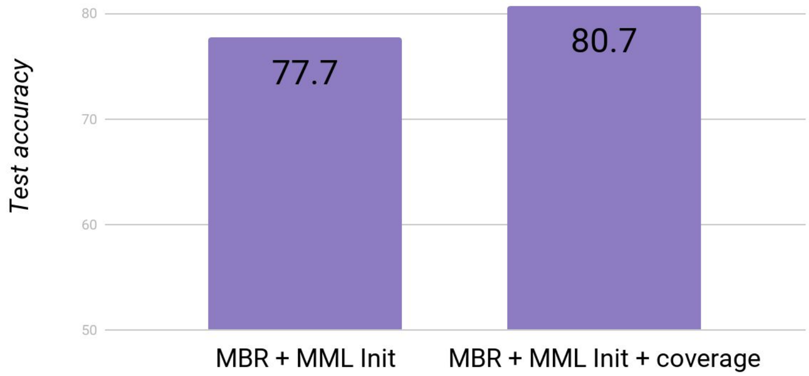
Results of using coverage guided training on NLVR*

Model does not learn without coverage!



when trained from scratch

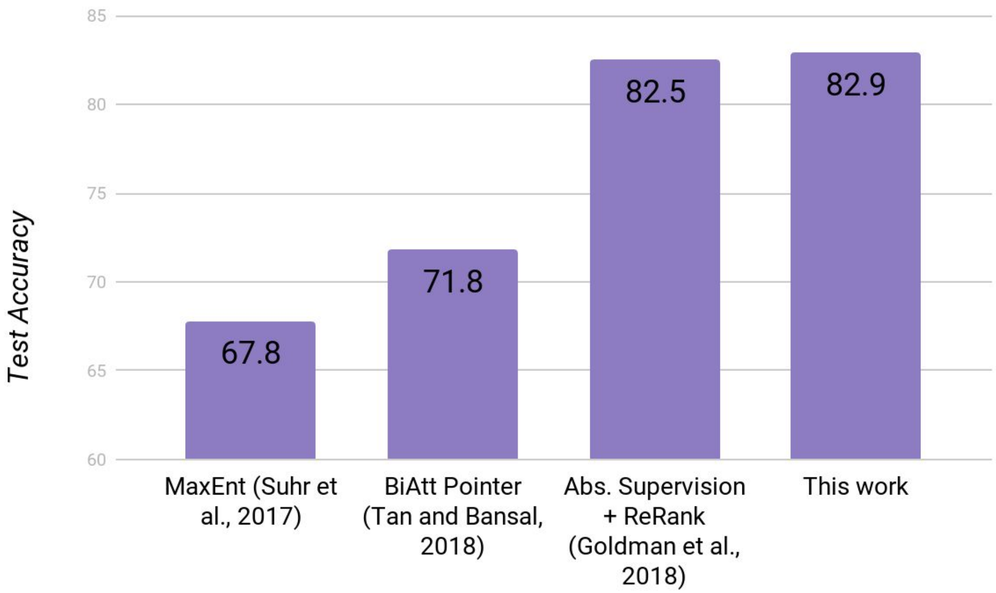
Coverage helps even with strong initialization



when model initialized from an MML model trained on a seed set of offline searched paths

* using structured representations

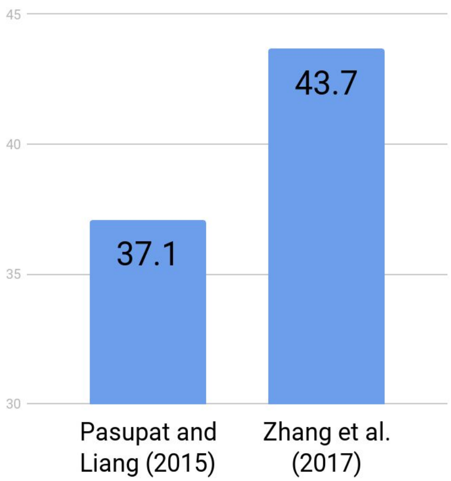
Comparison with previous approaches on NLVR*



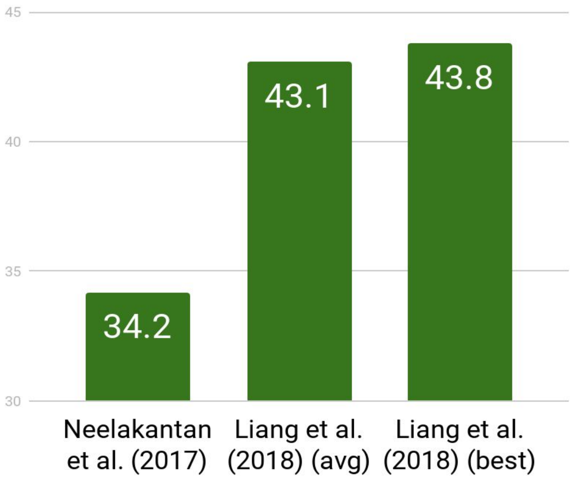
- MaxEnt, BiAttPonter are not semantic parsers
- Abs. supervision + Rerank uses manually labeled abstractions of utterance - logical form pairs to get training data for a supervised system, and reranking
- Our work outperforms Goldman et al., 2018 with fewer resources

* using structured representations

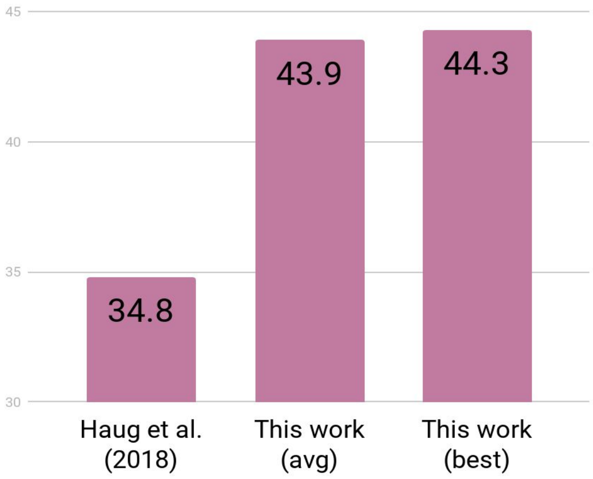
Comparison with previous approaches on WikiTableQuestions



Non-neural models



Reinforcement Learning models



Non-RL Neural Models

Summary

- Spuriousness is a challenge in training semantic parsers with weak supervision
- Two solutions:
  - Iterative training: Online search with initialization ⇆ MML over offline search output
  - Coverage during online search
- SOTA single model performances:
  - WikiTableQuestions: **44.3%**
  - NLVR semantic parsing: **82.9%**

Thank you!
Questions?