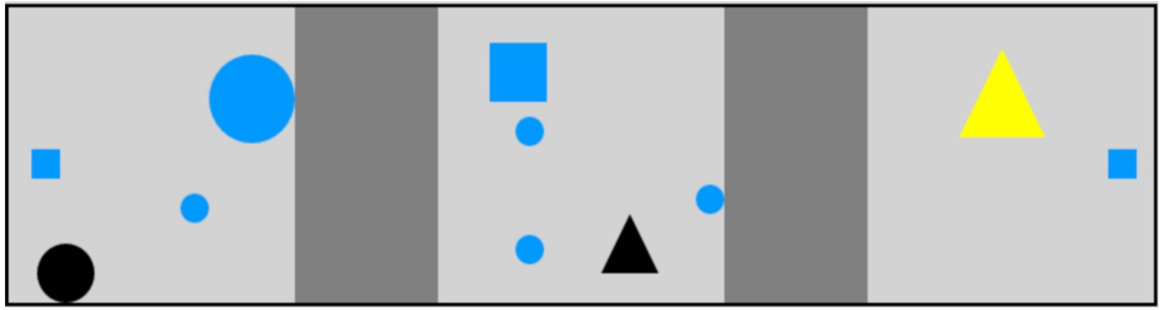
Weakly Supervised Semantic Parsing with Execution-based Spurious Program Filtering

Kang-il Lee, Segwang Kim, Kyomin Jung

Machine Intelligence Lab, Seoul National University

Weakly Supervised Semantic Parsing

Task

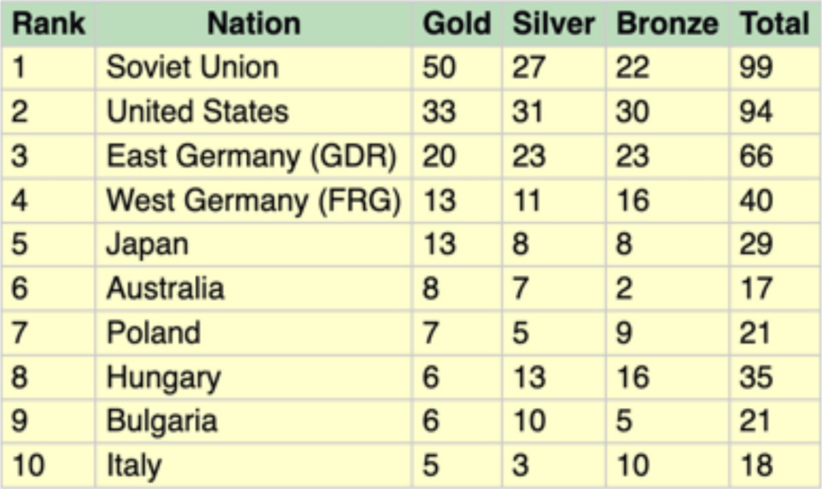


x : There is a blue square

w : [[{color: blue, shape: square}, {color: black, shape: circle}…], …]

z : objExists(square(blue(all_objects)))

y : True



Rank	Nation	Gold	Silver	Bronze	Total
1	Soviet Union	50	27	22	99
2	United States	33	31	30	94
3	East Germany (GDR)	20	23	23	66
4	West Germany (FRG)	13	11	16	40
5	Japan	13	8	8	29
6	Australia	8	7	2	17
7	Poland	7	5	9	21
8	Hungary	6	13	16	35
9	Bulgaria	6	10	5	21
10	Italy	5	3	10	18

x : How many nations won more than ten silver medals?

w : [[{Rank: 1}, {Nation: Soviet Union}, {Gold: 50}…], …]

z : count(filterNumberGreater(allRows, column:Silver, 10))

y : 5

- Goal: **map x into z which produces y when executed on w**

- The dataset includes only utterance x, world w and denotation y

- **Ground truth program z is not given**

Weakly Supervised Semantic Parsing

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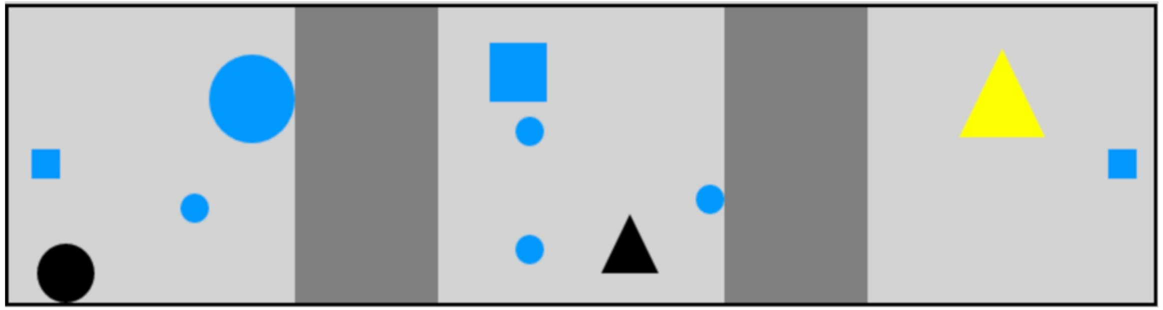


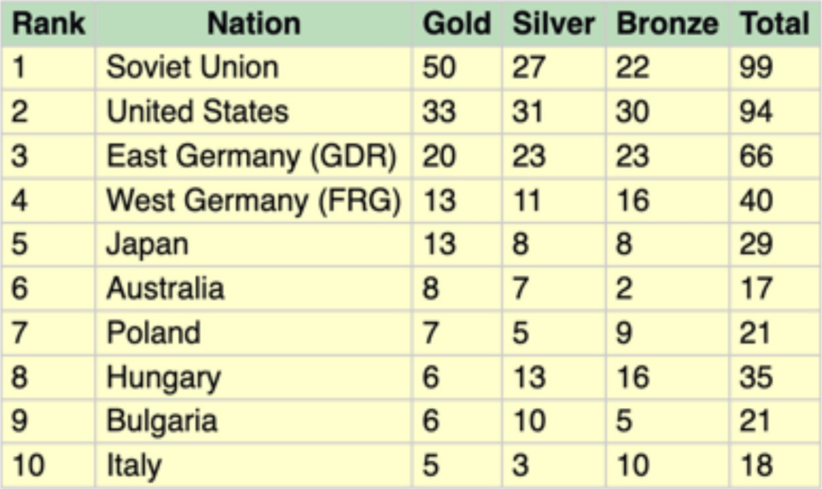
x : There is a blue square

w : [[{color: blue, shape: square}, {color: black, shape: circle}…], …]

z : objExists(square(blue(all_objects)))

z': objExists(black(circle(all_objects)))

y : True



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x : How many nations won more than ten silver medals?

w : [[{Rank: 1}, {Nation: Soviet Union}, {Gold: 50}…], …]

z : count(filterNumberGreater(allRows, column:Silver, 10))

z': select(filterIn(allRows, column:Nation, Japan), column:Rank)

y : 5

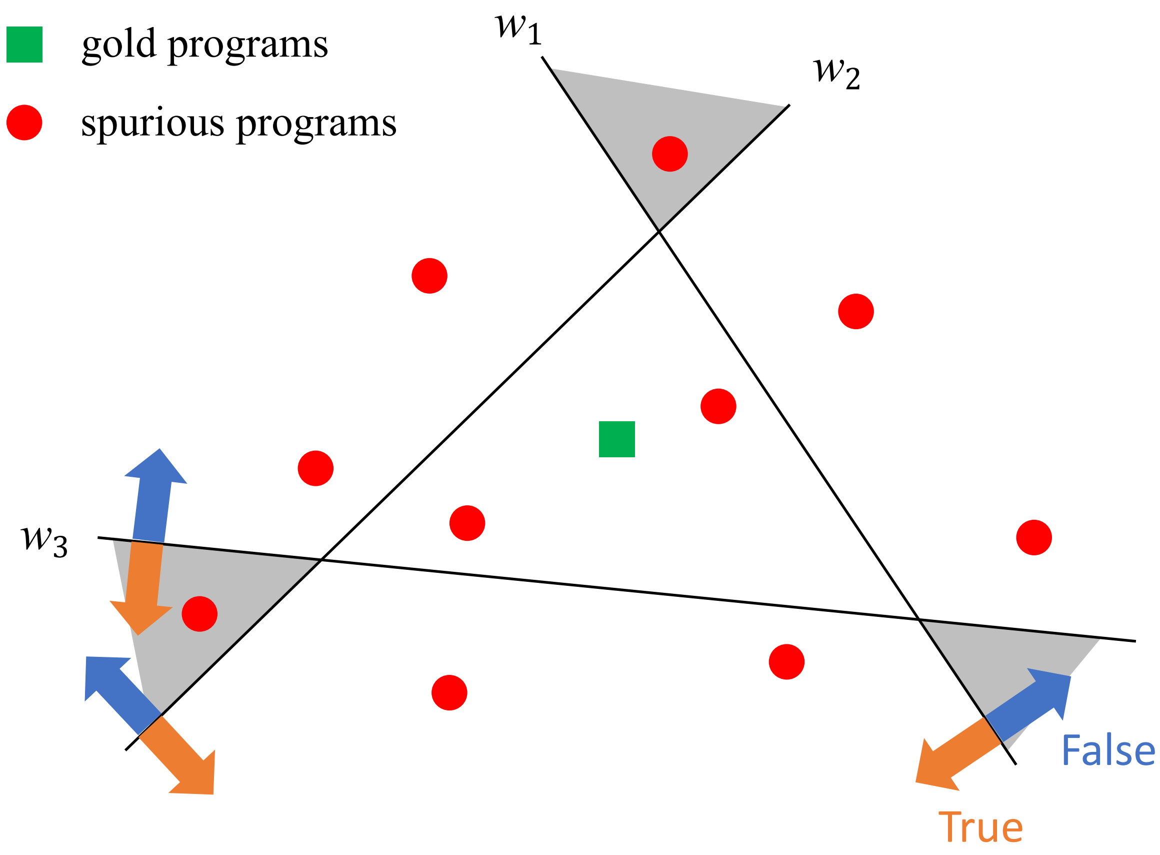
- A search algorithm generates a pool of hypothesis programs to build training examples

- Programs with incorrect execution results are filtered out

- **Spurious programs** like *z′*, whose **meaning is wrong but execution result is coincidentally correct**, are major challenges of the task

Execution-based Program Representation

Motivation



- Retrieved worlds (wj's) divide the programs into several groups by their execution results.

- **Our intuition**: Gold programs lie near the centroid and spurious programs lie far from the centroid.

- By running majority vote based on the execution results, programs in the gray regions may be filtered.

Filtering Programs with Majority Vote

Proposed Method

Hard Vote

- First get the centroid program representation r_*.

- Each program's contribution may be weighted by some metric $W(\cdot)$ (e.g. model likelihood).

$$r_*^j = \underset{e \in E}{\operatorname{argmax}} \sum_{i=1}^{k} W(z_i) \mathbb{1}(r_i^j = e)$$

- Program score is calculated based on the distance from the centroid representation r_* (higher the closer).

$$s_i = \frac{1}{n} \sum_{j=1}^{n} \mathbb{1}(r_i^j = r_*^j)$$

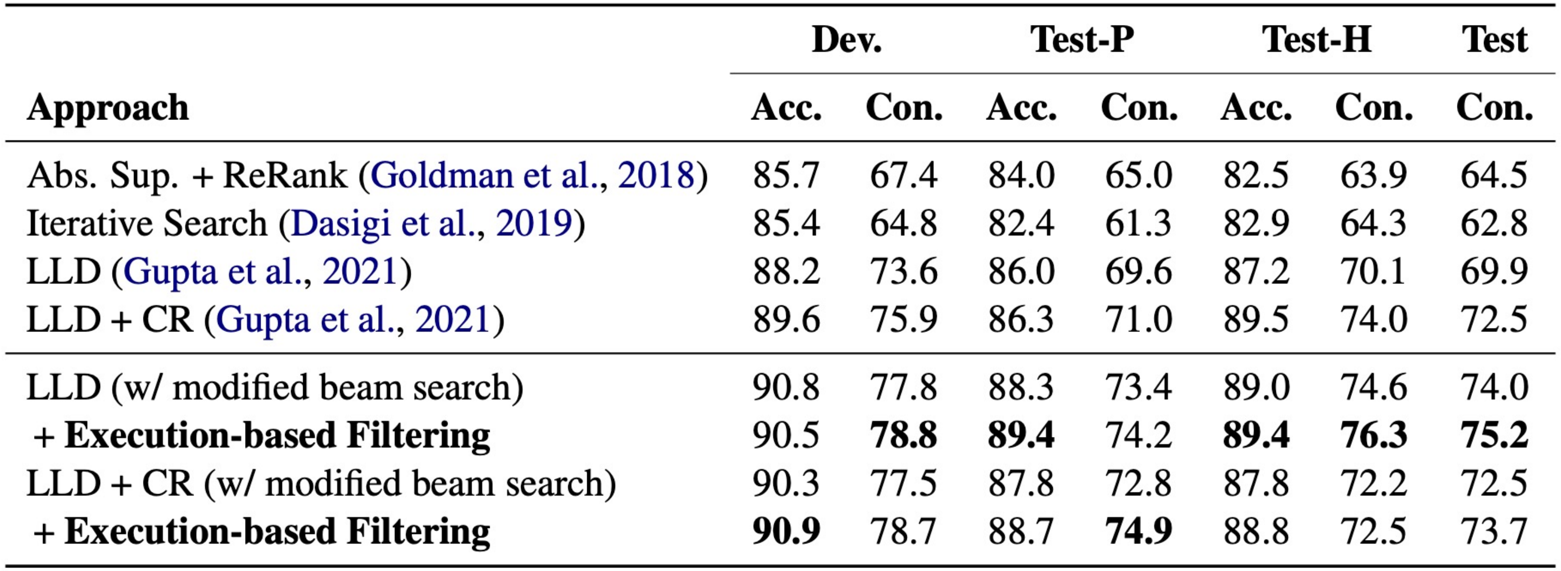
Soft Vote

- Instead of using centroid representation, each program contributes to the result (There is no explicit winner).

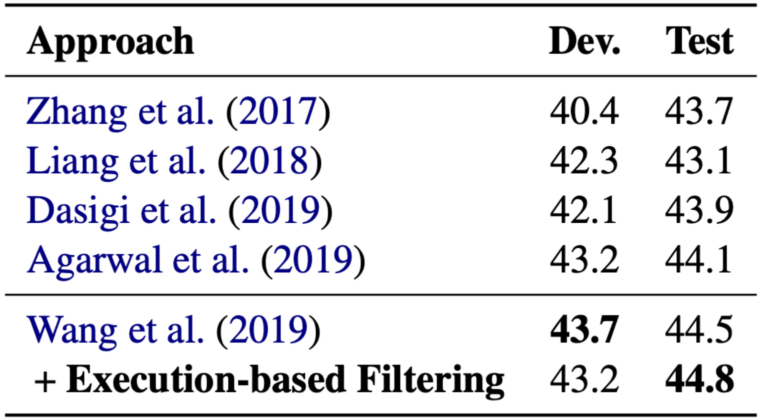
$$s_i = \sum_{j=1}^{n} \sum_{l=1}^{k} W(z_l) \mathbb{1}(r_i^j = r_l^j)$$

Main Results on NLVR and WikiTableQuestions

Experiments & Analysis



	Dev.		Test-P		Test-H		Test
Approach	**Acc.**	**Con.**	**Acc.**	**Con.**	**Acc.**	**Con.**	**Con.**
Abs. Sup. + ReRank (Goldman et al., 2018)	85.7	67.4	84.0	65.0	82.5	63.9	64.5
Iterative Search (Dasigi et al., 2019)	85.4	64.8	82.4	61.3	82.9	64.3	62.8
LLD (Gupta et al., 2021)	88.2	73.6	86.0	69.6	87.2	70.1	69.9
LLD + CR (Gupta et al., 2021)	89.6	75.9	86.3	71.0	89.5	74.0	72.5
LLD (w/ modified beam search)	90.8	77.8	88.3	73.4	89.0	74.6	74.0
+ **Execution-based Filtering**	90.5	**78.8**	**89.4**	74.2	**89.4**	**76.3**	**75.2**
LLD + CR (w/ modified beam search)	90.3	77.5	87.8	72.8	87.8	72.2	72.5
+ **Execution-based Filtering**	**90.9**	78.7	88.7	**74.9**	88.8	72.5	73.7



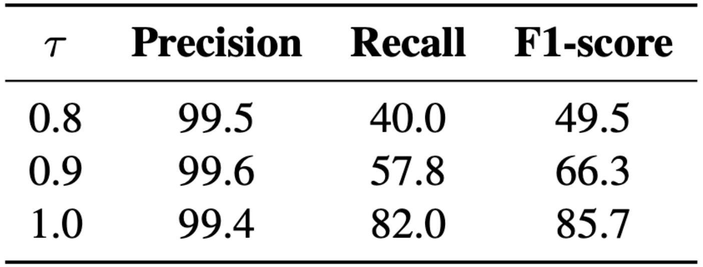
Approach	**Dev.**	**Test**
Zhang et al. (2017)	40.4	43.7
Liang et al. (2018)	42.3	43.1
Dasigi et al. (2019)	42.1	43.9
Agarwal et al. (2019)	43.2	44.1
Wang et al. (2019)	**43.7**	44.5
+ **Execution-based Filtering**	43.2	**44.8**

- Our method improves the performance of base parsers consistently.

- Our method is domain-agnostic and can augment existing weakly supervised semantic parser.

Score-spuriousness correlation

Experiments & Analysis

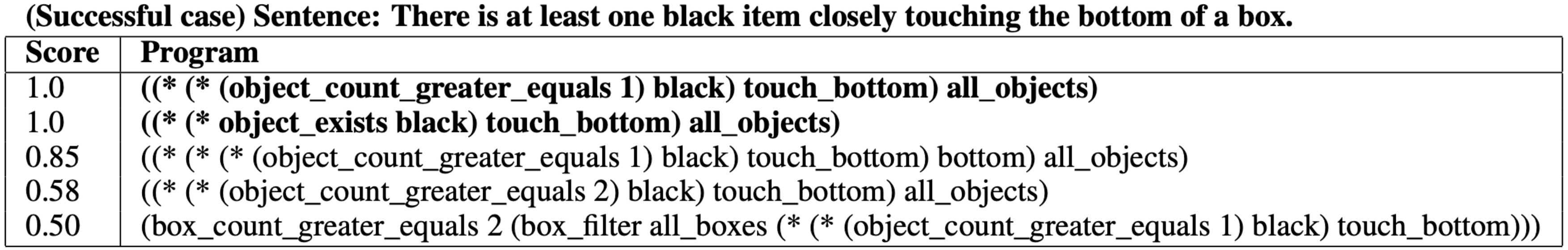


τ	**Precision**	**Recall**	**F1-score**
0.8	99.5	40.0	49.5
0.9	99.6	57.8	66.3
1.0	99.4	82.0	85.7

- Spurious program detection performance on 30 NLVR training examples with various thresholds τ.

Correlation statistics

- Pearson correlation: 0.358
- ROC-AUC: 0.738
- Correct program scores: mean 0.997, std 0.029
- Spurious program scores: mean 0.899, std 0.155



(Successful case) Sentence: There is at least one black item closely touching the bottom of a box.

Score	**Program**
1.0	**((* (* (object_count_greater_equals 1) black) touch_bottom) all_objects)**
1.0	**((* (* object_exists black) touch_bottom) all_objects)**
0.85	((* (* (* (object_count_greater_equals 1) black) touch_bottom) bottom) all_objects)
0.58	((* (* (object_count_greater_equals 2) black) touch_bottom) all_objects)
0.50	(box_count_greater_equals 2 (box_filter all_boxes (* (* (object_count_greater_equals 1) black) touch_bottom)))