Kristy Lee
CS288 Project 4 Report

I ran the supervised model and the latent model on the development set multiple times, and observed the general trend that the supervised model on average returned dev denotation accuracies that were higher than the dev denotation accuracies returned by the latent model. Dev denotation accuracies returned by the supervised model include [0.8536585365853658, 0.8780487804878049, 0.8292682926829268], and dev denotation accuracies returned by the latent model include [0.8292682926829268, 0.7804878048780488, 0.8048780487804879, 0.6829268292682927] upon training multiple times. I propose that this noticeable trend is due to the fact that the latent model is trained using question-answer pairs, the databases, and the execution function for retrieving the denotation from the world and logical form of the parser state, rather than having a logical form accompany a question to affect the model output as is the case for the supervised model. The latent model is only trained on questions and answers/denotations alone which provides a less detailed linkage between questions and the correct denotations than when supervised with a logical form.

Some of the common mistakes observed across the models are the following:
For **dev example 41**, both models consistently return an incorrect denotation for the question "is virginia east of west virginia?". From the logical form `(lambda $w (exists $x (and (kb-virginia $w) (east-rel $w $x) (kb-west_virginia $x))))`, both models only return two out of the three literals in the and conjunction, which implies that the models don't capture the location idea well, especially with "virginia east" and "west virginia" placed close together in the question providing a source of confusion for virginia.
For **dev example 39**, both models frequently return an incorrect denotation for the question "is there a national park in west virginia?". One of the predicted logical forms returned by the supervised model was `(lambda $w (exists $x (and (kb-monongahela_national_forest $w) (park $w) (in-rel $w $x) (park $x) (kb-west_virginia $x))))` and the denotation as an empty set, while one of the predicted logical forms the latent model is `(lambda $w (exists $x (and (in-rel $w $x) (kb-west_virginia $x))))` and the corresponding denotation `{'charleston', 'monongahela_national_forest', 'tygart_lake'};` the target logical form is `(lambda $w (exists $x (and (park $w) (in-rel $w $x) (kb-west_virginia $x))))` and target denotation is `{'monongahela_national_forest'}`. While both models made a mistake, the differences in the predicted logical forms imply that the supervised model tries to construct too specific a logical form in response to the question: kb-monongahela_national_forest was not mentioned in the question but was returned in the logical form; this might be due to the effect of supervision. The latent model, with lack of supervision, returned a not-detailed logical form that lacked the park literal, which implies that it has risk of not being focused on the entire question due to its limited training.
Dev examples 2, 6, 23, 35 all asked "what's the capital of virginia?" and the supervised model and latent models both frequently returned incorrect predicted logical forms and denotations for this question, which implies that there is no difference between using supervision versus not in producing a correct denotation "richmond" for the question.

These are common mistakes observed across the models, but generally the supervised model tends to make less mistakes than the latent model in producing the correct denotation. The latent model makes similar mistakes as the supervised model, and also makes additional mistakes in some questions that involve specificity of location of state/city. Some examples:
Dev example 11 asks the question "what cities in west virginia?" and `(lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-west_virginia $x))))` is the true logical form, but the predicted logical form is `(lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-virginia $x))))`. The true denotation is an empty set; the predicted denotation is `{'richmond', 'virginia_beach'}` which is wrong. The model fails to catch "west virginia" in the question and only catches virginia, meaning it is less keen to a sense of location in entities to distinguish west virginia from virginia.
Dev example 16 asks the question "what state is south of west virginia?" and `(lambda $w (exists $x (and (state $w) (south-rel $w $x) (kb-west_virginia $x))))`, but the predicted logical form is `(lambda $w (exists $x (and (state $w) (south-rel $w $x) (kb-virginia $x))))`. The true denotation is `{'virginia'}` and the predicted denotation is `{'north_carolina'}`. The latent model once again fails to distinguish between west virginia and virginia, and because of that fails to produce the correct denotation "virginia" but instead produces the denotation "north carolina," the state south of virginia.

This implies that the latent model, upon not being trained with logical forms supervising the questions, is less able to detect details/ideas of location inside questions. This is a problem the supervised model is better at avoiding than the latent model.

```
dev example 11
dev question: what cities in west virginia ?
dev true LF: (lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-west_virginia
$x))))
dev pred LF: (lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-virginia $x))))
dev true denotation: set()
dev pred denotation: {'richmond', 'virginia_beach'}
dev denotation match: False
dev example 16
dev question: what state is south of west virginia ?
dev true LF: (lambda $w (exists $x (and (state $w) (south-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $w (exists $x (and (state $w) (south-rel $w $x) (kb-virginia
$x))))
dev true denotation: {'virginia'}
dev pred denotation: {'north_carolina'}
dev denotation match: False
```

The supervised model tends to make less mistakes than the latent model in providing the correct denotation. The latent model makes similar mistakes as the supervised model.

Here are some interesting differences between the models in terms of returning the correct denotation for the question.

The supervised model produces a dev denotation accuracies of `0.8780487804878049` upon running the "evaluate_predictions" function using the supervised model. The supervised model tends to return the correct denotations in the development set frequently, and this is because in the supervised model training, logical forms accompany each question and influence the denotation outputted by the model. The predicted logical forms tend to match the true logical form; however, sometimes they don't match the true logical form exactly and yet yield the expected denotation. For example, for dev example 4, the true logical form for the question "what city is on the ocean ?" is "(lambda $w (exists $x (and (city $w) (on-rel $w $x) (ocean $x))))". The model predicts the logical form "(lambda $w (exists $x (and (city $w) (on-rel $w $x) (kb-atlantic_ocean $x))))", which differs in returning the entity predicate (kb-atlantic_ocean $x) instead of the category predicate (ocean $x). Nevertheless, the returned denotation {'virginia_beach'} matches the true denotation, because (ocean $x) would return true for $x as $x specifically is atlantic_ocean. This makes sense because Virginia Beach is on the Atlantic Ocean. About 7 of the dev set examples have a similar issue.

The latent model produces a dev denotation accuracy of `0.7804878048780488`.

```
dev example 1
dev question: what states are there ?
dev true LF: (lambda $w (and (state $w)))
dev pred LF: (lambda $w (and (state $w)))
dev true denotation: {'north_carolina', 'virginia', 'west_virginia'}
dev pred denotation: {'north_carolina', 'virginia', 'west_virginia'}
dev denotation match: True

dev example 2
dev question: what 's the capital of virginia ?
```

```
dev true LF: (lambda $w (exists $x (and (capital-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $w (exists $x (and (capital-rel $w $x) (kb-virginia $x))))
dev true denotation: {'richmond'}
dev pred denotation: {'richmond'}
dev denotation match: True

dev example 3
dev question: what cities are in virginia ?
dev true LF: (lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-virginia $x))))
dev true denotation: {'richmond', 'virginia_beach'}
dev pred denotation: {'richmond', 'virginia_beach'}
dev denotation match: True

dev example 4
dev question: what city is on the ocean ?
dev true LF: (lambda $w (exists $x (and (city $w) (on-rel $w $x) (ocean $x))))
dev pred LF: (lambda $w (exists $x (and (city $w) (on-rel $w $x) (kb-atlantic_ocean
$x))))
dev true denotation: {'virginia_beach'}
dev pred denotation: {'virginia_beach'}
dev denotation match: True

dev example 5
dev question: what oceans are there ?
dev true LF: (lambda $w (and (ocean $w)))
dev pred LF: (lambda $w (and (ocean $w)))
dev true denotation: {'atlantic_ocean'}
dev pred denotation: {'atlantic_ocean'}
dev denotation match: True

dev example 6
dev question: what is the capital of virginia ?
dev true LF: (lambda $w (exists $x (and (capital-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $w (exists $x (and (capital-rel $w $x) (kb-virginia $x))))
dev true denotation: {'richmond'}
dev pred denotation: {'richmond'}
dev denotation match: True

dev example 7
dev question: does west virginia abut the atlantic ocean ?
dev true LF: (lambda $w (exists $x (and (kb-west_virginia $w) (abut-rel $w $x)
(kb-atlantic_ocean $x))))
dev pred LF: (lambda $w (exists $x (and (west-rel $w $x) (kb-atlantic_ocean $x))))
dev true denotation: set()
dev pred denotation: {'richmond', 'north_carolina', 'virginia_beach', 'virginia'}
dev denotation match: False

dev example 8
dev question: what state is south of virginia ?
dev true LF: (lambda $w (exists $x (and (state $w) (south-rel $w $x) (kb-virginia
$x))))
```

```
dev pred LF: (lambda $w (exists $x (and (state $w) (south-rel $w $x) (kb-virginia
$x))))
dev true denotation: {'north_carolina'}
dev pred denotation: {'north_carolina'}
dev denotation match: True

dev example 9
dev question: what state is east of west virginia ?
dev true LF: (lambda $w (exists $x (and (state $w) (east-rel $w $x) (kb-west_virginia
$x))))
dev pred LF: (lambda $w (exists $x (and (state $w) (east-rel $w $x) (kb-west_virginia
$x))))
dev true denotation: {'virginia'}
dev pred denotation: {'virginia'}
dev denotation match: True

dev example 10
dev question: what cities are in virginia ?
dev true LF: (lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-virginia $x))))
dev true denotation: {'richmond', 'virginia_beach'}
dev pred denotation: {'richmond', 'virginia_beach'}
dev denotation match: True

dev example 11
dev question: what cities in west virginia ?
dev true LF: (lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-west_virginia
$x))))
dev pred LF: (lambda $w (exists $x (and (city $w) (west-rel $w $x) (kb-virginia
$x))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True

dev example 12
dev question: what states have borders on the atlantic ocean ?
dev true LF: (lambda $w (exists $x (and (state $w) (border-rel $w $x)
(kb-atlantic_ocean $x))))
dev pred LF: (lambda $w (exists $x (and (state $w) (border-rel $w $x)
(kb-atlantic_ocean $x))))
dev true denotation: {'north_carolina', 'virginia', 'west_virginia'}
dev pred denotation: {'north_carolina', 'virginia', 'west_virginia'}
dev denotation match: True

dev example 13
dev question: what cities are along the atlantic ocean ?
dev true LF: (lambda $w (exists $x (and (city $w) (along-rel $w $x)
(kb-atlantic_ocean $x))))
dev pred LF: (lambda $w (exists $x (and (city $w) (along-rel $w $x)
(kb-atlantic_ocean $x))))
dev true denotation: {'virginia_beach'}
dev pred denotation: {'virginia_beach'}
```

```
dev denotation match: True

dev example 14
dev question: what cities are near richmond ?
dev true LF: (lambda $w (exists $x (and (city $w) (near-rel $w $x) (kb-richmond
$x))))
dev pred LF: (lambda $w (exists $x (and (city $w) (near-rel $w $x) (kb-richmond
$x))))
dev true denotation: {'virginia_beach'}
dev pred denotation: {'virginia_beach'}
dev denotation match: True

dev example 15
dev question: what state is west of virginia ?
dev true LF: (lambda $w (exists $x (and (state $w) (west-rel $w $x) (kb-virginia
$x))))
dev pred LF: (lambda $w (exists $x (and (state $w) (west-rel $w $x) (kb-virginia
$x))))
dev true denotation: {'west_virginia'}
dev pred denotation: {'west_virginia'}
dev denotation match: True

dev example 16
dev question: what state is south of west virginia ?
dev true LF: (lambda $w (exists $x (and (state $w) (south-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $w (exists $x (and (state $w) (south-rel $w $x)
(kb-west_virginia $x))))
dev true denotation: {'virginia'}
dev pred denotation: {'virginia'}
dev denotation match: True

dev example 17
dev question: what cities are near richmond ?
dev true LF: (lambda $w (exists $x (and (city $w) (near-rel $w $x) (kb-richmond
$x))))
dev pred LF: (lambda $w (exists $x (and (city $w) (near-rel $w $x) (kb-richmond
$x))))
dev true denotation: {'virginia_beach'}
dev pred denotation: {'virginia_beach'}
dev denotation match: True

dev example 18
dev question: what city is southeast of richmond ?
dev true LF: (lambda $w (exists $x (and (city $w) (southeast-rel $w $x) (kb-richmond
$x))))
dev pred LF: (lambda $w (exists $x (and (city $w) (southeast-rel $w $x) (kb-richmond
$x))))
dev true denotation: {'virginia_beach'}
dev pred denotation: {'virginia_beach'}
dev denotation match: True
```

```
dev example 19
dev question: what states have a coast on the atlantic ocean ?
dev true LF: (lambda $w (exists $x (and (state $w) (on-rel $w $x) (kb-atlantic_ocean
$x))))
dev pred LF: (lambda $w (exists $x (and (state $w) (on-rel $w $x) (kb-atlantic_ocean
$x))))
dev true denotation: {'north_carolina', 'virginia', 'west_virginia'}
dev pred denotation: {'north_carolina', 'virginia', 'west_virginia'}
dev denotation match: True

dev example 20
dev question: what state contains virginia beach ?
dev true LF: (lambda $w (exists $x (and (state $w) (contain-rel $w $x)
(kb-virginia_beach $x))))
dev pred LF: (lambda $w (exists $x (and (state $w) (contain-rel $w $x))))
dev true denotation: {'virginia'}
dev pred denotation: {'virginia'}
dev denotation match: True

dev example 21
dev question: what ocean borders virginia ?
dev true LF: (lambda $w (exists $x (and (ocean $w) (border-rel $w $x) (kb-virginia
$x))))
dev pred LF: (lambda $w (and (ocean $w)))
dev true denotation: {'atlantic_ocean'}
dev pred denotation: {'atlantic_ocean'}
dev denotation match: True

dev example 22
dev question: what ocean borders west virginia ?
dev true LF: (lambda $w (exists $x (and (ocean $w) (border-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $w (exists $x (and (ocean $w) (border-rel $w $x) (kb-virginia
$x))))
dev true denotation: {'atlantic_ocean'}
dev pred denotation: {'atlantic_ocean'}
dev denotation match: True

dev example 23
dev question: what is the capital of virginia ?
dev true LF: (lambda $w (exists $x (and (capital-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $w (exists $x (and (capital-rel $w $x) (kb-virginia $x))))
dev true denotation: {'richmond'}
dev pred denotation: {'richmond'}
dev denotation match: True

dev example 24
dev question: is richmond the capital of west virginia ?
dev true LF: (lambda $w (exists $x (and (kb-richmond $w) (capital-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $w (exists $x (and (capital-rel $w $x) (kb-west_virginia $x))))
dev true denotation: set()
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dev pred denotation: set()
dev denotation match: True

dev example 25
dev question: is virginia inside of west virginia ?
dev true LF: (lambda $w (exists $x (and (kb-virginia $w) (inside-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $w (exists $x (and (inside-rel $w $x) (kb-west_virginia $x))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True

dev example 26
dev question: is virginia beach inside of west virginia ?
dev true LF: (lambda $w (exists $x (and (kb-virginia_beach $w) (inside-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $w (exists $x (and (inside-rel $w $x) (kb-west_virginia $x))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True

dev example 27
dev question: is richmond the capital of virginia ?
dev true LF: (lambda $w (exists $x (and (kb-richmond $w) (capital-rel $w $x)
(kb-virginia $x))))
dev pred LF: (lambda $w (exists $x (and (kb-richmond $w) (capital-rel $w $x)
(kb-virginia $x))))
dev true denotation: {'richmond'}
dev pred denotation: {'richmond'}
dev denotation match: True

dev example 28
dev question: is virginia beach in the atlantic ocean ?
dev true LF: (lambda $w (exists $x (and (kb-virginia_beach $w) (in-rel $w $x)
(kb-atlantic_ocean $x))))
dev pred LF: (lambda $w (exists $x (and (in-rel $w $x) (kb-atlantic_ocean $x))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True

dev example 29
dev question: is the atlantic ocean in virginia ?
dev true LF: (lambda $w (exists $x (and (kb-atlantic_ocean $w) (in-rel $w $x)
(kb-virginia $x))))
dev pred LF: (lambda $w (exists $x (and (kb-atlantic_ocean $w) (in-rel $w $x)
(kb-virginia $x))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True

dev example 30
dev question: is richmond in the atlantic ocean ?
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dev true LF: (lambda $w (exists $x (and (kb-richmond $w) (in-rel $w $x)
(kb-atlantic_ocean $x))))
dev pred LF: (lambda $w (exists $x (and (kb-richmond $w) (in-rel $w $x)
(kb-atlantic_ocean $x))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True

dev example 31
dev question: is the atlantic ocean in west virginia ?
dev true LF: (lambda $w (exists $x (and (kb-atlantic_ocean $w) (in-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $w (exists $x (and (kb-atlantic_ocean $w) (in-rel $w $x)
(kb-west_virginia $x))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True

dev example 32
dev question: what states are there ?
dev true LF: (lambda $w (and (state $w)))
dev pred LF: (lambda $w (and (state $w)))
dev true denotation: {'virginia', 'west_virginia'}
dev pred denotation: {'virginia', 'west_virginia'}
dev denotation match: True

dev example 33
dev question: what national parks are there ?
dev true LF: (lambda $w (and (park $w)))
dev pred LF: (lambda $w (and (park $w)))
dev true denotation: {'monongahela_national_forest'}
dev pred denotation: {'monongahela_national_forest'}
dev denotation match: True

dev example 34
dev question: what lakes are there ?
dev true LF: (lambda $w (and (lake $w)))
dev pred LF: (lambda $w (and (lake $w)))
dev true denotation: {'tygart_lake'}
dev pred denotation: {'tygart_lake'}
dev denotation match: True

dev example 35
dev question: what 's the capital of virginia ?
dev true LF: (lambda $w (exists $x (and (capital-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $w (exists $x (and (capital-rel $w $x) (kb-virginia $x))))
dev true denotation: {'richmond'}
dev pred denotation: {'richmond'}
dev denotation match: True

dev example 36
dev question: what cities are in virginia ?
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dev true LF: (lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-virginia $x))))
dev true denotation: {'richmond'}
dev pred denotation: {'richmond'}
dev denotation match: True

dev example 37
dev question: what state is west of virginia ?
dev true LF: (lambda $w (exists $x (and (state $w) (west-rel $w $x) (kb-virginia
$x))))
dev pred LF: (lambda $w (exists $x (and (state $w) (west-rel $w $x) (kb-virginia
$x))))
dev true denotation: {'west_virginia'}
dev pred denotation: {'west_virginia'}
dev denotation match: True

dev example 38
dev question: what state is the monongahela national forest in ?
dev true LF: (lambda $w (exists $x (and (state $w) (in-rel $x $w)
(kb-monongahela_national_forest $x))))
dev pred LF: (lambda $w (exists $x (and (state $w) (in-rel $w $x)
(kb-monongahela_national_forest $x))))
dev true denotation: {'west_virginia'}
dev pred denotation: set()
dev denotation match: False

dev example 39
dev question: is there a national park in west virginia ?
dev true LF: (lambda $w (exists $x (and (park $w) (in-rel $w $x) (kb-west_virginia
$x))))
dev pred LF: (lambda $w (exists $x (and (park $w) (in-rel $w $x) (park $x)
(kb-west_virginia $x))))
dev true denotation: {'monongahela_national_forest'}
dev pred denotation: set()
dev denotation match: False

dev example 40
dev question: is richmond east of west virginia ?
dev true LF: (lambda $w (exists $x (and (kb-richmond $w) (east-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $w (exists $x (and (kb-richmond $w) (west-rel $w $x)
(kb-west_virginia $x))))
dev true denotation: {'richmond'}
dev pred denotation: set()
dev denotation match: False

dev example 41
dev question: is virginia east of west virginia ?
dev true LF: (lambda $w (exists $x (and (kb-virginia $w) (east-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $w (exists $x (and (kb-west_virginia $w) (west-rel $w $x)
(kb-west_virginia $x))))
```

```
dev true denotation: {'virginia'}
dev pred denotation: set()
dev denotation match: False

{'dev_denotation_acc': 0.8780487804878049}



dev example 1
dev question: what states are there ?
dev true LF: (lambda $w (and (state $w)))
dev pred LF: (lambda $x (exists $w (and (state $w) (state $x))))
dev true denotation: {'north_carolina', 'virginia', 'west_virginia'}
dev pred denotation: {'north_carolina', 'virginia', 'west_virginia'}
dev denotation match: True

dev example 2
dev question: what 's the capital of virginia ?
dev true LF: (lambda $w (exists $x (and (capital-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (capital $x) (capital-rel $x
$w))))
dev true denotation: {'richmond'}
dev pred denotation: set()
dev denotation match: False

dev example 3
dev question: what cities are in virginia ?
dev true LF: (lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (city $x) (in-rel $x $w))))
dev true denotation: {'richmond', 'virginia_beach'}
dev pred denotation: {'richmond', 'virginia_beach'}
dev denotation match: True

dev example 4
dev question: what city is on the ocean ?
dev true LF: (lambda $w (exists $x (and (city $w) (on-rel $w $x) (ocean $x))))
dev pred LF: (lambda $x (exists $w (and (kb-atlantic_ocean $w) (city $x) (on-rel $x
$w))))
dev true denotation: {'virginia_beach'}
dev pred denotation: {'virginia_beach'}
dev denotation match: True

dev example 5
dev question: what oceans are there ?
dev true LF: (lambda $w (and (ocean $w)))
dev pred LF: (lambda $x (exists $w (and (ocean $w) (ocean $x))))
dev true denotation: {'atlantic_ocean'}
dev pred denotation: {'atlantic_ocean'}
dev denotation match: True

dev example 6
dev question: what is the capital of virginia ?
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dev true LF: (lambda $w (exists $x (and (capital-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (capital-rel $x $w))))
dev true denotation: {'richmond'}
dev pred denotation: {'richmond'}
dev denotation match: True

dev example 7
dev question: does west virginia abut the atlantic ocean ?
dev true LF: (lambda $w (exists $x (and (kb-west_virginia $w) (abut-rel $w $x)
(kb-atlantic_ocean $x))))
dev pred LF: (lambda $x (exists $w (and (kb-atlantic_ocean $w) (west-rel $x $w))))
dev true denotation: set()
dev pred denotation: {'richmond', 'north_carolina', 'virginia_beach', 'virginia'}
dev denotation match: False

dev example 8
dev question: what state is south of virginia ?
dev true LF: (lambda $w (exists $x (and (state $w) (south-rel $w $x) (kb-virginia
$x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (state $x) (south-rel $x
$w))))
dev true denotation: {'north_carolina'}
dev pred denotation: {'north_carolina'}
dev denotation match: True

dev example 9
dev question: what state is east of west virginia ?
dev true LF: (lambda $w (exists $x (and (state $w) (east-rel $w $x) (kb-west_virginia
$x))))
dev pred LF: (lambda $x (exists $w (and (kb-west_virginia $w) (state $x) (east-rel $x
$w))))
dev true denotation: {'virginia'}
dev pred denotation: {'virginia'}
dev denotation match: True

dev example 10
dev question: what cities are in virginia ?
dev true LF: (lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (city $x) (in-rel $x $w))))
dev true denotation: {'richmond', 'virginia_beach'}
dev pred denotation: {'richmond', 'virginia_beach'}
dev denotation match: True

dev example 11
dev question: what cities in west virginia ?
dev true LF: (lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-west_virginia
$x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (city $x) (west-rel $x
$w))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True
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dev example 12
dev question: what states have borders on the atlantic ocean ?
dev true LF: (lambda $w (exists $x (and (state $w) (border-rel $w $x)
(kb-atlantic_ocean $x))))
dev pred LF: (lambda $x (exists $w (and (kb-atlantic_ocean $w) (state $x) (border-rel
$x $w))))
dev true denotation: {'north_carolina', 'virginia', 'west_virginia'}
dev pred denotation: {'north_carolina', 'virginia', 'west_virginia'}
dev denotation match: True

dev example 13
dev question: what cities are along the atlantic ocean ?
dev true LF: (lambda $w (exists $x (and (city $w) (along-rel $w $x)
(kb-atlantic_ocean $x))))
dev pred LF: (lambda $x (exists $w (and (kb-atlantic_ocean $w) (city $x) (along-rel
$x $w))))
dev true denotation: {'virginia_beach'}
dev pred denotation: {'virginia_beach'}
dev denotation match: True

dev example 14
dev question: what cities are near richmond ?
dev true LF: (lambda $w (exists $x (and (city $w) (near-rel $w $x) (kb-richmond
$x))))
dev pred LF: (lambda $x (exists $w (and (kb-richmond $w) (city $x) (near-rel $x
$w))))
dev true denotation: {'virginia_beach'}
dev pred denotation: {'virginia_beach'}
dev denotation match: True

dev example 15
dev question: what state is west of virginia ?
dev true LF: (lambda $w (exists $x (and (state $w) (west-rel $w $x) (kb-virginia
$x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (state $x) (west-rel $x
$w))))
dev true denotation: {'west_virginia'}
dev pred denotation: {'west_virginia'}
dev denotation match: True

dev example 16
dev question: what state is south of west virginia ?
dev true LF: (lambda $w (exists $x (and (state $w) (south-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-west_virginia $w) (state $x) (west-rel $x
$w))))
dev true denotation: {'virginia'}
dev pred denotation: set()
dev denotation match: False

dev example 17
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dev question: what cities are near richmond ?
dev true LF: (lambda $w (exists $x (and (city $w) (near-rel $w $x) (kb-richmond
$x))))
dev pred LF: (lambda $x (exists $w (and (kb-richmond $w) (city $x) (near-rel $x
$w))))
dev true denotation: {'virginia_beach'}
dev pred denotation: {'virginia_beach'}
dev denotation match: True

dev example 18
dev question: what city is southeast of richmond ?
dev true LF: (lambda $w (exists $x (and (city $w) (southeast-rel $w $x) (kb-richmond
$x))))
dev pred LF: (lambda $x (exists $w (and (kb-richmond $w) (city $x) (southeast-rel $x
$w))))
dev true denotation: {'virginia_beach'}
dev pred denotation: {'virginia_beach'}
dev denotation match: True

dev example 19
dev question: what states have a coast on the atlantic ocean ?
dev true LF: (lambda $w (exists $x (and (state $w) (on-rel $w $x) (kb-atlantic_ocean
$x))))
dev pred LF: (lambda $x (exists $w (and (kb-atlantic_ocean $w) (state $x) (on-rel $x
$w))))
dev true denotation: {'north_carolina', 'virginia', 'west_virginia'}
dev pred denotation: {'north_carolina', 'virginia', 'west_virginia'}
dev denotation match: True

dev example 20
dev question: what state contains virginia beach ?
dev true LF: (lambda $w (exists $x (and (state $w) (contain-rel $w $x)
(kb-virginia_beach $x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia_beach $w) (state $x)
(contain-rel $x $w))))
dev true denotation: {'virginia'}
dev pred denotation: {'virginia'}
dev denotation match: True

dev example 21
dev question: what ocean borders virginia ?
dev true LF: (lambda $w (exists $x (and (ocean $w) (border-rel $w $x) (kb-virginia
$x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (ocean $x)
(kb-atlantic_ocean $x))))
dev true denotation: {'atlantic_ocean'}
dev pred denotation: {'atlantic_ocean'}
dev denotation match: True

dev example 22
dev question: what ocean borders west virginia ?
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dev true LF: (lambda $w (exists $x (and (ocean $w) (border-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (ocean $x)
(kb-atlantic_ocean $x))))
dev true denotation: {'atlantic_ocean'}
dev pred denotation: {'atlantic_ocean'}
dev denotation match: True

dev example 23
dev question: what is the capital of virginia ?
dev true LF: (lambda $w (exists $x (and (capital-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $x (exists $w (and (capital $w) (kb-west_virginia $x))))
dev true denotation: {'richmond'}
dev pred denotation: set()
dev denotation match: False

dev example 24
dev question: is richmond the capital of west virginia ?
dev true LF: (lambda $w (exists $x (and (kb-richmond $w) (capital-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-west_virginia $w) (kb-richmond $x)
(west-rel $x $w))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True

dev example 25
dev question: is virginia inside of west virginia ?
dev true LF: (lambda $w (exists $x (and (kb-virginia $w) (inside-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-west_virginia $w) (kb-west_virginia
$x))))
dev true denotation: set()
dev pred denotation: {'west_virginia'}
dev denotation match: False

dev example 26
dev question: is virginia beach inside of west virginia ?
dev true LF: (lambda $w (exists $x (and (kb-virginia_beach $w) (inside-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-west_virginia $w) (kb-west_virginia $x)
(west-rel $x $w))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True

dev example 27
dev question: is richmond the capital of virginia ?
dev true LF: (lambda $w (exists $x (and (kb-richmond $w) (capital-rel $w $x)
(kb-virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (kb-richmond $x)
(capital-rel $x $w))))
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dev true denotation: {'richmond'}
dev pred denotation: {'richmond'}
dev denotation match: True

dev example 28
dev question: is virginia beach in the atlantic ocean ?
dev true LF: (lambda $w (exists $x (and (kb-virginia_beach $w) (in-rel $w $x)
(kb-atlantic_ocean $x))))
dev pred LF: (lambda $x (exists $w (and (kb-atlantic_ocean $w) (kb-west_virginia $x)
(in-rel $x $w))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True

dev example 29
dev question: is the atlantic ocean in virginia ?
dev true LF: (lambda $w (exists $x (and (kb-atlantic_ocean $w) (in-rel $w $x)
(kb-virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (kb-atlantic_ocean $x)
(in-rel $x $w))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True

dev example 30
dev question: is richmond in the atlantic ocean ?
dev true LF: (lambda $w (exists $x (and (kb-richmond $w) (in-rel $w $x)
(kb-atlantic_ocean $x))))
dev pred LF: (lambda $x (exists $w (and (kb-atlantic_ocean $w) (kb-richmond $x)
(in-rel $x $w))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True

dev example 31
dev question: is the atlantic ocean in west virginia ?
dev true LF: (lambda $w (exists $x (and (kb-atlantic_ocean $w) (in-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-west_virginia $w) (kb-atlantic_ocean $x)
(west-rel $x $w))))
dev true denotation: set()
dev pred denotation: set()
dev denotation match: True

dev example 32
dev question: what states are there ?
dev true LF: (lambda $w (and (state $w)))
dev pred LF: (lambda $x (exists $w (and (state $w) (state $x))))
dev true denotation: {'virginia', 'west_virginia'}
dev pred denotation: {'virginia', 'west_virginia'}
dev denotation match: True
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dev example 33
dev question: what national parks are there ?
dev true LF: (lambda $w (and (park $w)))
dev pred LF: (lambda $x (exists $w (and (park $w) (kb-monongahela_national_forest
$x))))
dev true denotation: {'monongahela_national_forest'}
dev pred denotation: {'monongahela_national_forest'}
dev denotation match: True

dev example 34
dev question: what lakes are there ?
dev true LF: (lambda $w (and (lake $w)))
dev pred LF: (lambda $x (exists $w (and (lake $w) (lake $x))))
dev true denotation: {'tygart_lake'}
dev pred denotation: {'tygart_lake'}
dev denotation match: True

dev example 35
dev question: what 's the capital of virginia ?
dev true LF: (lambda $w (exists $x (and (capital-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (kb-west_virginia $x)
(kb-virginia $x))))
dev true denotation: {'richmond'}
dev pred denotation: set()
dev denotation match: False

dev example 36
dev question: what cities are in virginia ?
dev true LF: (lambda $w (exists $x (and (city $w) (in-rel $w $x) (kb-virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (city $x) (in-rel $x $w))))
dev true denotation: {'richmond'}
dev pred denotation: {'richmond'}
dev denotation match: True

dev example 37
dev question: what state is west of virginia ?
dev true LF: (lambda $w (exists $x (and (state $w) (west-rel $w $x) (kb-virginia
$x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (state $x) (west-rel $x
$w))))
dev true denotation: {'west_virginia'}
dev pred denotation: {'west_virginia'}
dev denotation match: True

dev example 38
dev question: what state is the monongahela national forest in ?
dev true LF: (lambda $w (exists $x (and (state $w) (in-rel $x $w)
(kb-monongahela_national_forest $x))))
dev pred LF: (lambda $x (exists $w (and (kb-monongahela_national_forest $w) (state
$x) (in-rel $x $w))))
dev true denotation: {'west_virginia'}
dev pred denotation: set()
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dev denotation match: False

dev example 39
dev question: is there a national park in west virginia ?
dev true LF: (lambda $w (exists $x (and (park $w) (in-rel $w $x) (kb-west_virginia
$x))))
dev pred LF: (lambda $x (exists $w (and (kb-west_virginia $w)
(kb-monongahela_national_forest $x) (west-rel $x $w))))
dev true denotation: {'monongahela_national_forest'}
dev pred denotation: set()
dev denotation match: False

dev example 40
dev question: is richmond east of west virginia ?
dev true LF: (lambda $w (exists $x (and (kb-richmond $w) (east-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-west_virginia $w) (kb-richmond $x)
(east-rel $x $w))))
dev true denotation: {'richmond'}
dev pred denotation: {'richmond'}
dev denotation match: True

dev example 41
dev question: is virginia east of west virginia ?
dev true LF: (lambda $w (exists $x (and (kb-virginia $w) (east-rel $w $x)
(kb-west_virginia $x))))
dev pred LF: (lambda $x (exists $w (and (kb-virginia $w) (kb-west_virginia $x)
(kb-virginia $x))))
dev true denotation: {'virginia'}
dev pred denotation: set()
dev denotation match: False

{'dev_denotation_acc': 0.7804878048780488}
```