

# **Semantic Parsing via Paraphrasing**

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Based on: J. Berant and P. Liang "Semantic Parsing via Paraphrasing" ACL 2014



Grounding and question-answering based on real-world images



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### Natural Language Understanding

- Transform the textual input into a logical representation
- The logical representation can be executed to return the answer from the database
- Three major components of the semantic parser
  - Over-approximate the meaning (set of logical forms)
  - Learning-based approach to strive away from bad derivations
  - Compositionality principle to learn 'more from less'

What are the objects that surround the sofa?

## answer(X, ( object(X), close(X,Y), sofa(Y) )).



Sempre



J. Berant et. al. "Semantic Parsing on Freebase from Question Answer pairs" EMNLP 2013



### One derivation







### Main components



### From grammar to program induction







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### Challenges

- "Myriads ways in which knowledge base predicates can be expressed" [1]
  - "What does X do for a living?"
  - What is X's profession"?
- Ontological mismatch problem
  - "The choice of ontology significantly impacts learning" [2]
  - Example: Q1: What is the population of Seattle?
    - Q2: How many people live in Seattle?
    - MR1:  $\lambda x. population(Seattle, x)$
    - MR2:  $count(\lambda x.person(x) \land live(x, Seattle))$
- Missing coverage
  - "out of 500,000 relations extracted by the ReVerb Open IE system
     ... only about 10,000 can be aligned to Freebase" [1]



### Overview of the model





### Canonical utterance construction



[1]	#	Template	Example	Question	Already shown in
	1	p.e	Directed.TopGun	Who directed Top Gun?	nade 4
	2	$p_1.p_2.e$	Employment.EmployerOf.SteveBalmer	Where does Steve Balmer work?	page -
	3	$p.(p_1.e_1 \sqcap p_2.e_2)$	Character.(Actor.BradPitt □ Film.Troy)	Who did Brad Pitt play in Troy?	Assumption about
	4	Type. $t \sqcap z$	Type.Composer $\Pi$ SpeakerOf.French	What composers spoke French?	line it and a survey a sitilary a liter
	5	count(z)	count (BoatDesigner.NatHerreshoff)	How many ships were designed by	limited compositionality
		× /		Nat Herreshoff?	seems to be crucial

### [2] Mapping utterances to logical forms is hard, but generating natural language canonical utterances is not

	d(p) Categ.	Rule	Example			
p.e $\mathbf{R}(p).e$	NP VP PP	$\begin{array}{l} \texttt{WH} \ d(t) \ \texttt{has} \ d(e) \ \texttt{as} \ \texttt{NP} \ ? \\ \texttt{WH} \ d(t) \ (\texttt{AUX}) \ \texttt{VP} \ d(e) \ ? \\ \texttt{WH} \ d(t) \ \texttt{PP} \ d(e) \ ? \end{array}$	What election contest has George Bush as winner? What radio station serves area New-York? What beer from region Argentina?	d(t), d(e) and d(p) are Freebase descriptions		
	NP VP NP VP PP	$\begin{array}{c} \texttt{WH}\ d(t)\ \texttt{VP}\ \texttt{the}\ \texttt{NP}\ d(e)\ ?\\ \\ \texttt{WH}\ d(t)\ \texttt{is}\ \texttt{the}\ \texttt{NP}\ \texttt{of}\ d(e)\ ?\\ \\ \texttt{WH}\ d(t)\ \texttt{AUX}\ d(e)\ \texttt{VP}\ ?\\ \\ \texttt{WH}\ d(t)\ d(e)\ \texttt{PP}\ ?\\ \end{array}$	What mass transportation system served the area Berlin?What location is the place of birth of Elvis Presley?What film is Brazil featured in?What destination Spanish steps near travel destination?	tor 'type', 'entity' and 'property'. The rules for the remaining templates are omitted.		
	NP VP	WH NP is VP by $d(e)$ ?	What <b>structure</b> is <b>designed</b> by Herod?			

#### [3] The problem of mapping to the ontology is reduced to scoring pairs (c,z) based on the paraphrase model



### Overview of the model





### Paraphrase model

$$p_{\theta}(c, z \mid x) = \frac{\exp\{\phi(x, c, z)^{\top}\theta\}}{\sum_{z' \in \mathcal{Z}_x, c' \in \mathcal{C}_z} \exp\{\phi(x, c', z')^{\top}\theta\}}$$



- Association model
  - Determine if x and c contain phrases that are likely to be paraphrases
  - Consider all spans of x and c and identify associations
  - Using PARALEX corpus [1] to look up phrase pairs in a phrase table
  - Using WordNet for the derivation links



	-		
Assoc.	$\operatorname{lemma}(x_{i:j}) \wedge \operatorname{lemma}(c_{i':j'})$		
	$pos(x_{i:j}) \wedge pos(c_{i':j'})$		
	$\operatorname{lemma}(x_{i:j}) = \operatorname{lemma}(c_{i':j'})?$		
	$pos(x_{i:j}) = pos(c_{i':j'})?$		
	lemma $(x_{i:j})$ and lemma $(c_{i':j'})$ are synonyms?		
	lemma $(x_{i:j})$ and lemma $(c_{i':j'})$ are derivations?		
Deletions	Deleted lemma and POS tag		

#### Vector space model

- Association model has problems with the coverage
- Example where the association fails but vector space model works
  - "made" and "headquarter" in "Where is made Kia car?" and "What city is Kia motors a headquarter of
- Represent every utterance x with a vector  $v_x$  that is average of word2vec words
- The score is an embedding of both utterances  $v_x^\top W v_c$

[1] A. Fader et. al. "Paraphrase-Driven Learning for Open Question Answering" ACL 2013



### Results

		ree917	WEBQUESTIONS	Full	do	people	czech	republic	spea
CY13		59.0	_	Decotecal	0.7	8.09	15.34	21.62	24.4
BCFL	.13	62.0	35.7	FREE917					
KCAZ	Z13	68.0	_	WebQuesti	3.86	-3.13	7.81	2.58	14.7
This w	ork	68.5	39.9	czech	0.67	16.55			2 76
Results on the test set				CZCCH	0.01	10.00			2.10
				republic	-8.71	12.47			-10.7
$\bigcirc$ ur sy	stem	<b>730</b>			do	people	czech	republic	
–VSM	500111	71.0	40.5	Diagonal					spea
-Asso	OCIATION	52.7	35.3	Conclusion	2.31	-0.72	1.88	0.27	-0.4
-PARA	PHRASE	31.8	21.3		0.07		1.1 21.	10.00	11
SIMPL	eGen	73.4	40.4	• Paraphrase <sup>a</sup> m	OČIČÍ	is impo	ortant	12.33	
Full m	atrix	52.7	35.3	Removince AS	SOAL		resu	ts in	5.21
Diagor	nal	50.4	30.6						
Identit	У	50.7	30.4	larger degrad		compa	irea to	D V SIVI	9.69
JACCA	RD	69.7	31.3	Full matrix for	VSM	works	the h	best	
Edit		40.8	24.8	Identity	do	people	czech	republic	spea
WDD	C06	71.0	29.8	offical	2.26	-1.41	0.89	0.07	-0.5
Ablation studies on the validation set					0.62	4 10	11 01	10 78	19 '
$\frac{language}{language}$					0.02	4.19	11.91	10.78	12.
<ul> <li>WebQuestions - a large-scale dataset with question</li> </ul>						7.31	pair	S	5.42
<ul> <li>Google Suggest API is used to build a set of quest</li> </ul>						4.34			9.44

- Examples:
  - What character did Natalie Portman play in Star Wars?
  - What kind of money to take to Bahamas?
  - What did Edward Jenner do for living?



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### From grounding to question answering



C. Matuszek, et. al. "A Joint Model of Language and Perception Grounded Attribute Learning" ICML 2012





mug in front of the monitor;mug1;2;(lambda \$x (exists \$y (and (mug \$x) (front-rel \$x \$y) (monitor \$y))))

J. Krishnamurthy, et. al. "Jointly Learning to Parse and Perceive: Connecting Natural Language to the Physical World" TACL 2013



curtain behind the armchair?, guitar)



QA: (what is beneath the candle holder, decorative plate)

QA: (what is in front of the curtain?, guitar)

QA: (what is in front of the wall divider?, cabinet)

M. Malinowski and M. Fritz "A Multi-World Approach to Question Answering about Real-World Scenes based on Uncertain Input", NIPS 2014 (to appear)



### Main components

