# Survey on Semantic Parsing
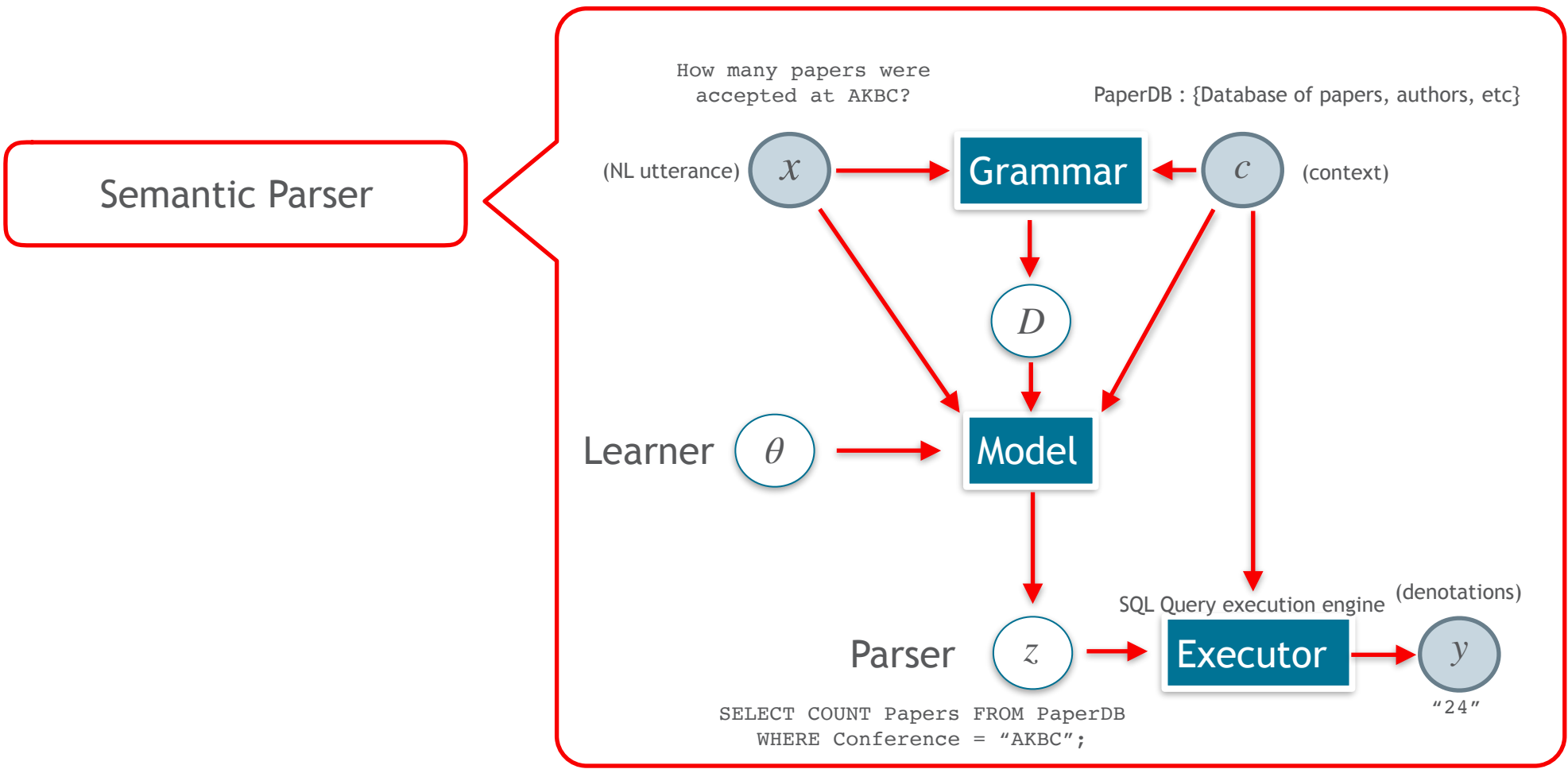
Aishwarya Kamath[1,2], Rajarshi Das[2]
Oracle Labs[1], University of Massachusetts Amherst[2]

Machine Learning Research Group
Oracle Labs

UMassAmherst
College of Information & Computer Sciences
Center for Data Science

## Components



How many papers were accepted at AKBC?

PaperDB: {Database of papers, authors, etc}

Semantic Parser

$x$ (NL utterance) → Grammar ← $c$ (context)

$D$

Learner $\theta$ → Model

Parser $z$ → Executor (SQL Query execution engine) → $y$ (denotations) "24"

SELECT COUNT Papers FROM PaperDB WHERE Conference = "AKBC";

## Datasets

| Dataset | Example | Size |
|---|---|---|
| **GeoQuery** Facts about US geography. Zelle & Mooney 96', | What is the largest city in Massachusetts? | <1k examples Small database |
| **ATIS** Flight booking system. Hemphill et al '90 | "Show me flights from Boston to Miami this Friday" | ~5k examples 27 Tables, ~160k entries |
| **SAIL** Navigation instructions. McMahon et al '06 | Go forward along the pink flowered carpet hall two segments to the intersection with the brick hall | ~3k examples 3 environments |
| **NLVR. & NLVR[2]** NLU for Visual reasoning. Suhr et al '17, '18 | There are two towers with the same height but their base is not the same in color. | ~92k total examples |
| **Scholar** Academic publications. Iyer et al '17 | "Show me papers by Andrew McCallum" | <1k examples |
| **WikiTableQuestions** From semi-structured WikiPedia Tables. Pasupat & Liang '15 | "Greece held its last summer Olympics in which year?" | ~22k examples ~2k tables |
| **WebQuestions** Questions on Freebase. Berant et al '13 Similar: **Free917** | "Which university did Obama go to?" | ~5.8k examples |
| **WikiSQL** HTML WikiPedia Tables. Zhong et al '17 | "How many engine types did Val Musetti use?" | ~80k examples ~24k tables |
| **SPIDER** Complex SQL queries. Yu et al '18 | "What are the name and budget of the departments with average instructor salary greater than the overall average?" | ~10k examples 200 databases 138 domains |
| **CoNaLA** NL to Python Extracted from StackOverflow. Yin et al '18 | `sort list x in reverse order` `x.sort(reverse=True)` | ~2.5k curated examples ~600k noisy examples |

Similar: **Django, HearthStone & MTG, NL2Bash, CONCODE**

## Open Questions

- Multilingual semantic parsing
- Cross domain semantic parsing, building parsers for closed domains with limited data
- Confidence modeling in multi-turn question answering
- Using semantic parsing for RTE
- Using semantic parsing for MT evaluation

## Timeline

**Pattern matching** words from the utterance can get us a long way
— Johnson 84'

⭐ Rule-based Semantic Parsing — 1980s

But wouldn't you need to **write patterns for each type of question and domain**? That doesn't sound very scalable…
— You

That's true! We need models with **learnable parameters** that can generalize to new types of questions

How do we learn these parameters?
— You

Learn a model on **pairs of utterances and logical forms** (think $\lambda$ calculus or database queries)
— Zelle & Mooney '96, Thompson '99

⭐ Statistical Semantic Parsing — 1990s

We can use **lexicalized grammars** that bind together syntax and semantics to make this more efficient. (**CCG based parsing**)
— Zettlemoyer & Collins '05, '07 Kwiatowski et al '10

Hmm, but the same words can be combined with many different categories. You would need a lot of data to learn these!
— You

⭐ Probabilistic CCG parsing — 2000s

So we use **factored lexicons**! Decompose lexicons into lexemes and templates. This reduces the number of parameters that need to be learned
— Kwiatowski et al 2011

Sounds great! But we do still need data annotated with logical forms and I'm not a big fan of writing **complex lambda calculus expressions**…
— You

How about **only using the answers** for training?

Now we can attack general domain question answering on **huge KBs like Freebase** and tables from Wikipedia! But how does the learning work?
— You

⭐ Semantic parsing from denotations — 2010's
— Berant et al '13, Kwiatowski et al '13, Artzi & Zettlemoyer '13, many more…

Consider the **logical form to be latent** and maximize the **marginal likelihood** of data!
— Liang '11, Berant et al '13, Pasupat & Liang '15, Goldman et al '17

How do we ensure that **complex structures** like we see in common language are represented in the dataset?
— You

Data augmentation - Build a **generative model** of (utterances, logical forms) and sample to get more examples where you can **control for complexity**
— Jia & Liang '16

Why don't we just model it as a **sequence to sequence** problem and pretend the MR is just a string?
— Dong & Lapata '16

That's awesome! Now I can use my favorite **Encoder-Decoder** models out of the box for this task!
— You

⭐ Neural Semantic Parsing — 2016

That works pretty well!! But, I seem to have a problem while asking questions about **words that are rare** in text
— You

You can use pointer networks like **attention based copying** for those
— Jia and Liang '16

But using plain Seq2Seq models doesn't guarantee **syntactically valid parses** right?
— You

That's true, so we use parent feeding connections and **recursively generate sub trees** by modeling the presence of parentheses.
— Dong & Lapata '16

Another idea is to **generate valid sketches** first and then condition on them to further refine your parse!
— Dong & Lapata '18

All this still doesn't guarantee **semantically valid parses**!
— You

⭐ Constrained Decoding — 2018

Instead, generate the tree as a sequence of **typed actions**
— Xiao et al '16, Krishnamurthy et al '17, Yin and Neubig '17

Lets use the enormous annotated data from online forums like StackOverflow to train semantic parsers from **NL to code**
— Ling et al '16, Yin & Neubig '17, Rabinovich '17, Iyer et al '19

Another interesting direction is natural language understanding by **visual reasoning**
— Suhr et al '17, '18

This is great, now I'm going to go read the survey paper for more details! Semantic parsing is awesome :D
— You