# On Building an Effective and Trustworthy Natural Language Interface:

## *An intelligent agent that can communicate, collaborate, and learn*

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## Research Vision

**Goal:** Building **practically effective** and **trustworthy** Natural Language Interfaces (**NLIs**, e.g., question answering systems, semantic parsers, etc.)
*i.e., performing well in practical applications & knowing when it would fail*

### My research: NLI as **an intelligent agent** that is introspective of its uncertainties (i.e., sources of failure) and can interact with humans to resolve them

**NLIs to computer programs (RQ1)**

**Interactive & collaborative NLIs (RQ2)**

**Learning NLIs from users (RQ3)**

- Humans **talk with** machines
- Applications: Software Engineering, Internet of Things

- Agent **uncertainty** detection
- Human-agent **communication** to resolve uncertainties
- **Collaborative** task completion

- Continual learning **after deployment**
- Learning from **weak but abundant user supervision**

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## RQ1: NLIs to Computer Programs

**Motivation:** humans speak natural language (NL), but machines only interpret programming language (PL).

### 1. Mining <NL, code solution> from Stack Overflow [1]

- StaQC dataset: 148K on Python & 120K on SQL
- One of the largest datasets to date to facilitate downstream tasks

**Check out on GitHub!**

⭐ Star  100      ⑂ Fork  16

### 2. Improving code search with automatic code annotation [2]

Code Search:

NL question    *"How to clone or copy a Python list?"*

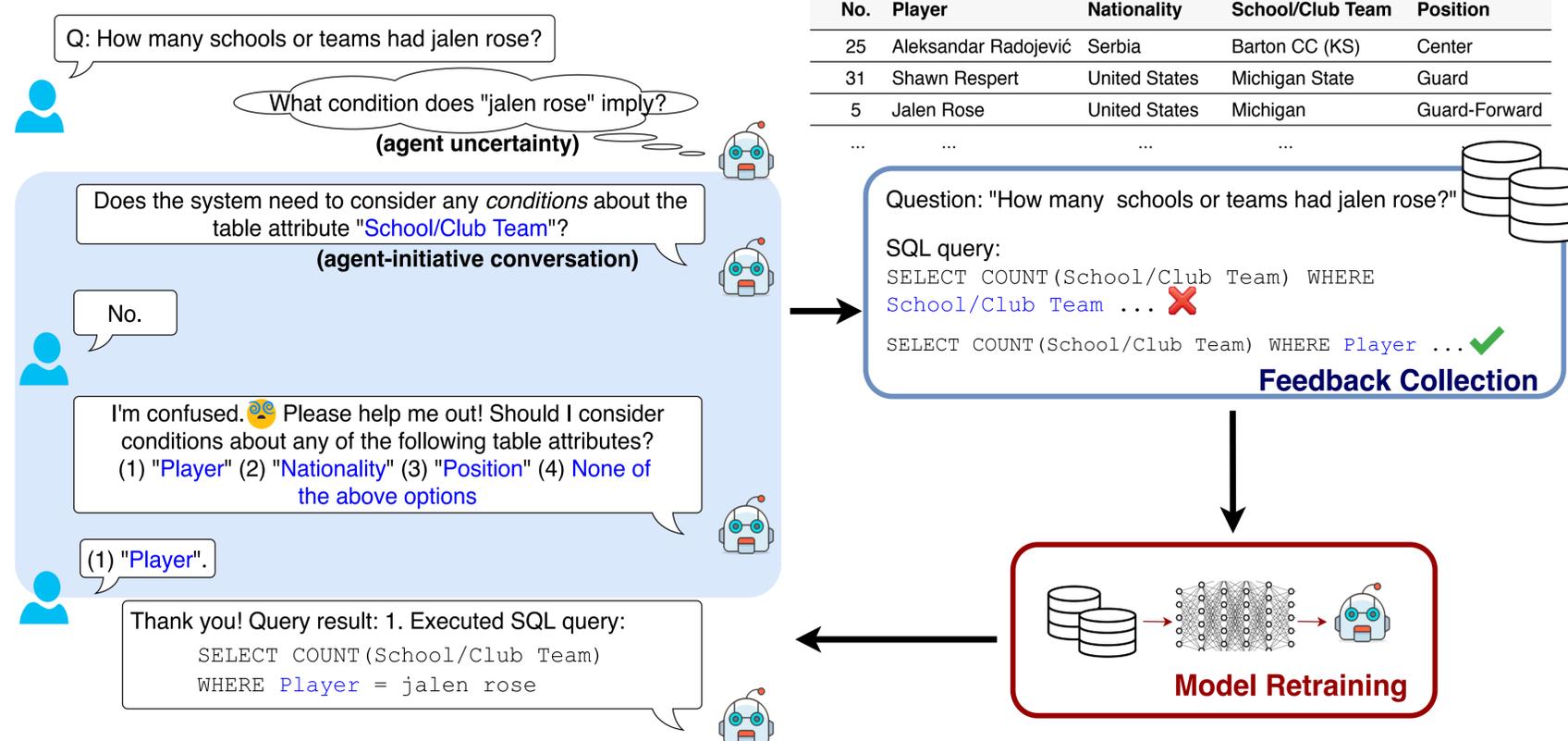| code snippet in storage | solution? |
|---|---|
| `new_list = copy.copy(old_list)` | ✓ |
| `listB = listA[2:]` | ✗ |
| `list1.clear()` | ✗ |

Code Annotation:

code snippet    `SELECT Format(Avg(col2-col1),"hh:mm:ss") AS TimeDiff FROM table1`

NL description    *"Return the average time difference in the format of hour-minute-second"*

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## RQ2&3: Interactive Semantic Parser & Learning from User Interaction
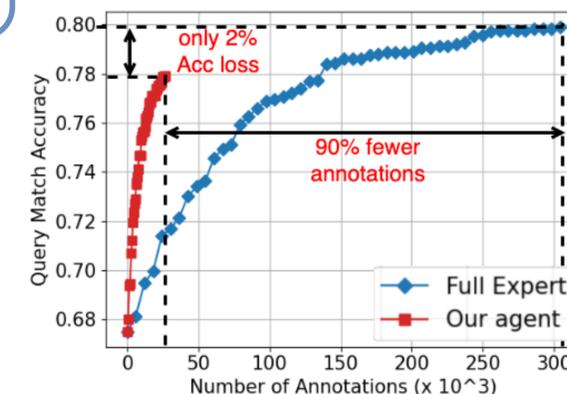
### Interactive Semantic Parsing [3, 4]

- **Agent uncertainties** due to *language ambiguity* and *task complexity*
- Semantic parsing agent **communicates with users** and **asks for clarifications**
- Test time: improve text-to-SQL parsing accuracy for 10% with only 1 user interaction
- **Open-sourced** framework

Q: How many schools or teams had jalen rose?

What condition does "jalen rose" imply? **(agent uncertainty)**

Does the system need to consider any *conditions* about the table attribute "School/Club Team"? **(agent-initiative conversation)**

No.

I'm confused. 🤯 Please help me out! Should I consider conditions about any of the following table attributes? (1) "Player" (2) "Nationality" (3) "Position" (4) None of the above options

(1) "Player".

Thank you! Query result: 1. Executed SQL query:
`SELECT COUNT(School/Club Team) WHERE Player = jalen rose`

| No. | Player | Nationality | School/Club Team | Position |
|---|---|---|---|---|
| 25 | Aleksandar Radojević | Serbia | Barton CC (KS) | Center |
| 31 | Shawn Respert | United States | Michigan State | Guard |
| 5 | Jalen Rose | United States | Michigan | Guard-Forward |
| ... | ... | ... | ... | ... |

Question: "How many schools or teams had jalen rose?"

SQL query:
`SELECT COUNT(School/Club Team) WHERE School/Club Team ...` ❌
`SELECT COUNT(School/Club Team) WHERE Player ...` ✓

**Feedback Collection**

**Model Retraining**

### Learning Semantic Parsers from User Interaction [5]

- Agent **autonomously improves itself** without involving extra developers
- User-annotation-efficient **Imitation Learning** algorithm with theoretical analysis

only 2% Acc loss

90% fewer annotations

Query Match Accuracy vs. Number of Annotations (x 10^3)

Full Expert
Our agent

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[1] **Yao et al.**, StaQC: A Systematically Mined Question-Code Dataset from Stack Overflow, WWW'18.

[2] **Yao et al.**, CoaCor: Code Annotation for Code Retrieval with Reinforcement Learning, WWW'19.

[3] **Yao et al.**, Interactive Semantic Parsing for If-Then Recipes via Hierarchical Reinforcement Learning, AAAI'19.

[4] **Yao et al.**, Model-based Interactive Semantic Parsing: A Unified Formulation and A Text-to-SQL Case Study, EMNLP'19.

[5] **Yao et al.**, An Imitation Game for Learning Semantic Parsers from User Interaction, EMNLP'20.

**Don't hesitate to reach out!**

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Thank you! 😊

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