Neural Enquirer: Learning to Query Tables in Natural Language

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Model Architecture

- A fully “neuralized”, end-to-end differentiable system that jointly models semantic parsing and query execution
- Derives distributed representations of queries and knowledge-base (KB) tables
- Executes distributed queries against KB tables through a cascaded pipeline of neural network components called Executors
- Query execution logic is learned via end-to-end training using QA pairs

Executor

An executor executes a query against the table and outputs annotations that encode intermediate execution results, which are saved in memory layers. Each executor consists of a Reader and an Annotator.

Reader: fetch data from each row m via attentive reading:

- File name embeddings
- Query embedding
- Table embedding
- Query Encoder
- Reader
- Annotator
- Weighted sum
- Attention weights
- File field embeddings

Annotator: carry out execution and output row/table annotations that encode intermediate execution results.

- Row Annotations: model execution on each row. Handle operations that require only row-wise, local information (e.g. select, where)
- Table Annotations: capture superlative operations (e.g. \( \text{max}, \text{min} \)) by aggregating table-wise, global execution results using max-pooling.

A combination of row and table annotations enables the model to perform a wide variety of real-world query operations.

A Synthetic QA Task

Data

Generate natural language questions and 10 × 10 KB tables from a synthetic schema of Olympic Games:

<table>
<thead>
<tr>
<th>Query Type</th>
<th>Example Questions with Logical Form Templates</th>
</tr>
</thead>
<tbody>
<tr>
<td>SELECT, WHERE</td>
<td>How many people participated in the Games in Beijing?</td>
</tr>
<tr>
<td>SELECT, WHERE</td>
<td>argmax/min(F₁, F₂)</td>
</tr>
<tr>
<td>WHERE, SUPERLATIVE</td>
<td>Where was the latest Games hosted?</td>
</tr>
<tr>
<td>WHERE, SUPERLATIVE</td>
<td>argmax/min(F₁, F₂)</td>
</tr>
<tr>
<td>NEST</td>
<td>Which country hosted the longest Games before the Games in Athens?</td>
</tr>
<tr>
<td>NEST</td>
<td>argmax/min(F₁, F₂)</td>
</tr>
</tbody>
</table>

Results

- SEMPRE: [Pasupat and Liang, 2015]
- N2N: end-to-end training of Neural Enquirer using QA pairs
- SbS: step-by-step training via controlling the attentive reading weights

Attention Weights Visualization

Q₁: Which country hosted the longest Games before the Games in Athens?

| Query | Chair country (unknown by the model)
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SELECT</td>
<td>2018</td>
</tr>
<tr>
<td>WHERE</td>
<td>( \text{host}_\text{city} = \text{Athens} )</td>
</tr>
<tr>
<td>argmax/min(F₁, F₂)</td>
<td>99.5%</td>
</tr>
</tbody>
</table>

end-to-end training

step-by-step training