Automated Template Generation for Question Answering over Knowledge Graphs

Abdalghani Abujabal
Mohamed Yahya
Mirek Riedewald
Gerhard Weikum
Question Answering over KG

“Where did John Steinbeck go to college?”
Question Answering over KG

“Where did John Steinbeck go to college?”
“Where did John Steinbeck go to college?”

Question Answering over KG

studyAt \( ?x \) type college

[Image of John Steinbeck]
Current Approaches

- **Hand-crafted templates** [Unger et al. (WWW’12), Yahya et al. (EMNLP’12), Fader et al. (KDD’14), Yao and Durme, (ACL’14), Bast and Haussmann, (CIKM’15)]

  Templates by Fader et al. (2014)

<table>
<thead>
<tr>
<th>Question Template</th>
<th>Query Template</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who VP \text{PRED} NP \text{ENT}</td>
<td>(?x, PRED, ENT)</td>
<td>“Who founded Google?”</td>
</tr>
</tbody>
</table>
Current Approaches

• Hand-crafted templates [Unger et al. (WWW’12), Yahya et al. (EMNLP’12), Fader et al. (KDD’14), Yao and Durme, (ACL’14), Bast and Haussmann, (CIKM’15)]

Templates by Fader et al. (2014)

<table>
<thead>
<tr>
<th>Question Template</th>
<th>Query Template</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who VP_{PRED} NP_{ENT}</td>
<td>(?x, PRED, ENT)</td>
<td>“Who founded Google?”</td>
</tr>
</tbody>
</table>

1. Human Expertise
Current Approaches

- **Hand-crafted templates** [Unger et al. (WWW’12), Yahya et al. (EMNLP’12), Fader et al. (KDD’14), Yao and Durme, (ACL’14), Bast and Haussmann, (CIKM’15)]

  Templates by Fader et al. (2014)

<table>
<thead>
<tr>
<th>Question Template</th>
<th>Query Template</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who VP_{PRED} NP_{ENT}</td>
<td>(?x, PRED, ENT)</td>
<td>“Who founded Google?”</td>
</tr>
</tbody>
</table>

1. Human Expertise
2. Coverage
Current Approaches

• No/Naive answer typing
  • “Who” —> person
  • “Where” —> location
QUINT

• Generates role-aligned question-query templates automatically
QUINT

• Generates role-aligned question-query templates automatically

• Handles compositional questions

  “Who has played for Manchester United and Real Madrid?”
QUINT

• Generates role-aligned question-query templates automatically

• Handles compositional questions
  “Who has played for Manchester United and Real Madrid?”

• Improved answer typing
Outline

• Template Generation
• Question Answering with Templates
• Experiments
• Conclusion
Outline

• Template Generation
• Question Answering with Templates
• Experiments
• Conclusion
“Where did John Steinbeck go to college?”

Stanford University
"Where did John Steinbeck go to college?"

Stanford University
From Question-Answer to Query
From Question-Answer to Query

\[ \text{JohnSteinbeck}_{\text{ENT}} \xrightarrow{\text{studyAt}_{\text{PRED}}} ?x \quad \text{F1=1.0} \]

\[ \text{JohnSteinbeck}_{\text{ENT}} \xrightarrow{\text{teachAt}_{\text{PRED}}} ?x \quad \text{F1=0} \]
From Question-Answer to Query

JohnSteinbeck_{ENT} \xrightarrow{\text{studyAt}_{PRED}} ?x
From Question-Answer to Query
Question-Query Alignment
Where did John Steinbeck go to college?
Where did John Steinbeck go to college?
John Steinbeck

Where did John Steinbeck go to college?

Integer Linear Programming

studyAt_{PRED}?

JohnSteinbeck_{ENT} -> college_{TYPE}

?x

type

educationalInstitution_{TYPE}
Aligned Question-Query Pair

John Steinbeck ENT

subject

go PRED

to PRED

case

College TYPE

studyAt PRED

?x type

college TYPE
John Steinbeck studyAt college
Outline

• Template Generation
• Question Answering with Templates
• Experiments
• Conclusion
Answering with Templates

“Where did Aaron Rodgers go to high school?”
"Where did Aaron Rodgers go to high school?"
Answering with Templates

“Where did Aaron Rodgers go to high school?”

1. Identify matching question templates
2. Instantiate corresponding query templates

AR studyAt ?x
?x type highSchool

AR playFor ?x

AR bornIn ?x
“Where did Aaron Rodgers go to high school?

Identify matching question templates

Instantiate corresponding query templates

Rank query candidates

AaronRodgers studyAt ?x
?x type highSchool
Answering Compositional Questions

• Coordinating conjunction
  • “Who acted in the Green Mile and Forrest Gump?”

• Relative clauses
  • “actors starring in The Departed who were born in Cambridge”

• A set of rules to decompose a question into sub-questions
  • “Who acted in the Green Mile?” and “Who acted in Forrest Gump?”
Sub-question Answering

“Who acted in the Green Mile?”

?x actedIn TheGreenMile Tom Hanks, David Morse, .. 1

TheGreenMile directedBy ?x Frank Darabont 2
### Sub-question Answering

#### “Who acted in the Green Mile?”

<table>
<thead>
<tr>
<th>?x actedIn TheGreenMile</th>
<th>Tom Hanks, David Morse, ..</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>TheGreenMile directedBy ?x</td>
<td>Frank Darabont</td>
<td>2</td>
</tr>
</tbody>
</table>

#### “Who acted in Forrest Gump?”

<table>
<thead>
<tr>
<th>?x actedIn ForrestGump</th>
<th>Tom Hanks, Sally Field, ..</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>ForrestGump directedBy ?x</td>
<td>Robert Zemeckis</td>
<td>2</td>
</tr>
</tbody>
</table>
Stitching

“Who acted in the Green Mile?”

?x actedIn TheGreenMile Tom Hanks, David Morse, .. 1
TheGreenMile directedBy ?x Frank Darabont 1/2

“Who acted in Forrest Gump?”

?x actedIn ForrestGump Tom Hanks, Sally Field, .. 1
ForrestGump directedBy ?x Robert Zemeckis 1/2
Stitching

“Who acted in the Green Mile?”

?x actedIn TheGreenMile Tom Hanks, David Morse, .. 1

TheGreenMile directedBy ?x Frank Darabont 1/2

“Who acted in Forrest Gump?”

?x actedIn ForrestGump Tom Hanks, Sally Field, .. 1

ForrestGump directedBy ?x Robert Zemeckis 1/2
Outline

• Template Generation
• Question Answering with Templates
• Experiments
• Conclusion
Setup

- WebQuestions
  - 3775 question/answer training pairs
  - 2032 testing questions
Setup

- WebQuestions
  - 3775 question/answer training pairs
  - 2032 testing questions

- ComplexQuestions
  - 150 questions

  “Who has played for Manchester United and Real Madrid?”
## Results on WebQuestions

<table>
<thead>
<tr>
<th>System</th>
<th>WebQuestions Avg. F1</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQQU</td>
<td>49.4</td>
</tr>
<tr>
<td>STAGG</td>
<td>52.5</td>
</tr>
<tr>
<td>Reddy et al.</td>
<td>50.3</td>
</tr>
<tr>
<td>QUINT-untyped</td>
<td>50.8</td>
</tr>
<tr>
<td>QUINT-typed</td>
<td>51</td>
</tr>
</tbody>
</table>
## Results on WebQuestions

<table>
<thead>
<tr>
<th>System</th>
<th>WebQuestions Avg. F1</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQQU (CIKM 2015)</td>
<td>49.4</td>
</tr>
<tr>
<td>STAGG (ACL 2015)</td>
<td>52.5</td>
</tr>
<tr>
<td>Reddy et al. (ACL 2016)</td>
<td>50.3</td>
</tr>
<tr>
<td>QUINT-untyped</td>
<td>50.8</td>
</tr>
<tr>
<td>QUINT-typed</td>
<td>51</td>
</tr>
</tbody>
</table>
Anecdotal Results

Question

“Where did Aaron Rodgers go to high school?

QUINT (typed)

Pleasant Valley High School

QUINT (untyped)

Butte College,
UC Berkeley,
Pleasant Valley High School
## Results on ComplexQuestions

<table>
<thead>
<tr>
<th>System</th>
<th>Avg. F1</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQQU-basic (CIKM 2015)</td>
<td>27.8</td>
</tr>
<tr>
<td>AQQU++ (CIKM 2015)</td>
<td>46.7</td>
</tr>
<tr>
<td>QUINT</td>
<td>49.2</td>
</tr>
</tbody>
</table>
Anecdotal Results

Question

“Who has played for Manchester United and Real Madrid?”

QUINT

Michael Owen, Gabriel Heinze, David Beckham, Cristiano Ronaldo

AQQU-basic

Bob Donaldson, Fred Erentz, Joe Cassidy, James McNaught, Dick Smith, Walter Cartwright, Harry Stafford
Conclusion

• QUINT automatically learns role-aligned question-query templates

• QUINT handles compositional questions

• QUINT supports answer typing
Thanks!