Relation Extraction with Relation Topics
- Information Fusion in Natural Language Processing

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Information Fusion in Natural Language Processing

- DeepQA (Watson) has >100 components.

**TWREX**: Topicalized Wide Relation and Entity eXtraction

Statistical Relation Extraction Module
Outline

- **Background:**
  - Relation Detection
  - Watson Pipeline
  - Relation Detection in Watson

- **TWREX Architecture**
  - Challenges
  - Construction of Relation Repository
  - Relation Topics
  - Integration (Information Fusion)

- Experiments & Conclusions
Relation Extraction

- Relation extraction: to classify the relation between two entity mentions into one of predefined relation classes: `locatedAt?` `customerOf?` `employedBy?`

- Example:
  - “The New Jersey Devils have signed Adam Larsson to a three-year, entry-level contract”

- Applications:
  - Information extraction
  - Machine reading
  - Question answering
  - Etc … …

- Challenges
  - Expressiveness of language:
    - IBM hired James, James started at IBM, James worked for IBM, …
How Relation Extraction module is used in the DeepQA pipeline?

- On primary search results, before candidate answer generation
- On supporting evidence, before deep evidence scoring
How Relation Extraction is Used to Create Candidate Answers/ Score Passages

- **Candidate Answer Generation**
  
  The question
  
  "The Screwtape Letters" from a senior devil to an under devil are by this man better known for children's books.

  contains an instance of the "**authorof**" relation, whose arguments are identified as this man and "**the Screwtape Letters**".

  We can look up potential answers in our structured database based on the relations detected.

- **Evidence Scoring**

  The question:

  *This hockey defenseman ended his career on June 5, 2008.*

  and a supporting passage share "**activeyearsenddate**" relation:

  *On June 5, 2008, Wesley announced his retirement after his 20th NHL season.*

  Assign a high similarity score if the question and the passage share some semantic relations.
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TWREX: Goal and Challenges

- **Goal:** reuse the knowledge from the existing domains for the new domains

- **Challenges:**
  - Need to construct a relation repository that has sufficient coverage.
  - Need to redundancy, noisy information in the repository.
    For example, DBpedia has relations like “birthplace”, “placeofbirth”, “hometown”, etc
  - Need an efficient way to make use of the knowledge brought in by the other relations.
The Overall Architecture

- **Challenge 1**: Automatic Extraction with Machine Learning (no extra human labelling)
  - Relation Repository (>7,000 Relations)
    - Recall: 80.24%, Precision: 84.6%

- **Challenge 2**: Diffusion Wavelets (no extra human labelling, parameter free)
  - Integrate relation topics for new domain
  - Relation Topics

- **Challenge 3**: Integrate relation topics for new domain
  - ACE Data
Step 1: Building Relation Repository

Relation Repository
(>7,000 Relations,
>600,000 Examples)
Recall: 80.24%, Precision: 84.6%

For example, the Wikipedia page for “Albert Einstein” contains an infobox property “alma mater” with value “University of Zurich”, and the first sentence mentioning the arguments is the following: “Einstein was awarded a PhD by the University of Zurich”, which expresses the relation.
Step 2: Extract Relation Topics

Relation Repository
(>7,000 Relations)
Recall: 80.24%,
Precision: 84.6%

Diffusion Wavelets
(no extra human labelling,
parameter free)

Relation Topic Example

Existing Topic Models (LDA, LSI):
*a multinomial distribution over words.*

Relation Topic:
*We define a relation topic as a multinomial distribution over relations.*

A Relation Topic Example

\[
\text{doctoralstudents (0.113201), candidate (0.014662), academicadvisors (0.008623), notablesstudents (0.003829),}...
\]

\# = 7600

where doctoraladvisor is a DBpedia relation and 0.683366 is its contribution to the topic.
Representation of Relation (dependency path)

- An Example of *ActiveYearEndDate* relation: “He retired in 1991.”
  
  - person100007846 | year115203791 | - | in | retire

  - person100007846 | year115203791 | retirement | - | announce

  \[\text{Yago Type of Argument 1} \quad \text{Prep} \quad \text{Verb}\]

\[\text{Yago Type of Argument 2} \quad \text{Noun}\]

\[
\begin{align*}
\text{retire} & \quad \text{(subj)} & \quad \text{He retired in 1991} & \quad \text{mod_v_prep} \\
\text{he} & \quad \text{(objprep)} & \quad \text{in} & \quad \text{(objpref)} \\
\text{year} & \quad (\text{obj}) & \quad \text{1991} & \quad (\text{obj})
\end{align*}
\]

\[\text{A relation is represented by a set of <rule, count> pairs.}\]

\[
\begin{align*}
\text{person100007846} & \quad \text{year115203791} & \quad - & \quad \text{in} & \quad \text{retire} & \quad (5) \\
\text{person100007846} & \quad \text{year115203791} & \quad \text{retirement} & \quad - & \quad \text{announce} & \quad (2)
\end{align*}
\]
Create Relation-Relation Correlation Matrix

- Some relations share some rules.
- Create the relation-relation correlation matrix.

\[
\text{Rule} \quad \begin{array}{c}
\text{Relation} \\
A \\
\text{Count}
\end{array}
\]

\[AA^T \text{ is relation correlation matrix}\]

- Apply Diffusion Wavelets [Coifman, Maggioni, 2006] to extract relation topics from the correlation matrix.
Diffusion Wavelets

- Input:
  - the correlation matrix.

- Output:
  - the number of levels of the topical hierarchy, as well as the topics at each level.

- Comparison with other topic modeling techniques (e.g. LDA, LSI)
  - No need to specify the number of topics
  - Multilevel
  - Fast

More Relation Topic Examples (Level 2)

<table>
<thead>
<tr>
<th>Topic</th>
<th>founded</th>
<th>built</th>
<th>establisheddate</th>
<th>…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topic 1</td>
<td>0.219976</td>
<td>0.036247</td>
<td>0.027167</td>
<td>…</td>
</tr>
<tr>
<td>Topic 2</td>
<td>0.332123</td>
<td>0.198355</td>
<td>0.065609</td>
<td>…</td>
</tr>
<tr>
<td>Topic 3</td>
<td>architecture 0.895874</td>
<td>style 0.029560</td>
<td>architecturestyle 0.013483</td>
<td>…</td>
</tr>
<tr>
<td>Topic 4</td>
<td>subfamilia 0.783230</td>
<td>family 0.017283</td>
<td>genus 0.006933</td>
<td>…</td>
</tr>
</tbody>
</table>
Step 3: Integration

Input: “Sauve announced his retirement from the NHL in 1989.”

Sauve announced his retirement from the NHL in 1989.

Compute the similarity of the given sentence and each of the existing relations.

7600 similarity scores

a kernel that matches the corresponding arguments, dependency paths, and bag-of-words in the sentence.

Project the results onto the relation topic space, resulting in a set of new topic features.

Topic features $c = \#$ relation topics

Other features, like syntactic features
The Overall TWREX Architecture

Relation Examples:
- AircraftBomber, Birthdate,
- Battles, Budget, Education,
- Parent, Starring, etc

Relation Repository
- (>7,000 Relations)
- Recall: 80.24%
- Precision: 84.6%

Integrate relation topics
for new domain

Integrate relation topics
for new domain

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Experimental Results: Relation Topics

Table 1: Number of topics at different levels (DBpedia Relations) under 5 different settings: use args, noun, preposition and verb; arg₁ only; arg₂ only; noun only and verb only.

<table>
<thead>
<tr>
<th>Level</th>
<th>args &amp; words</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7628</td>
</tr>
<tr>
<td>2</td>
<td>269</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2: 3 topics at level 5 (all word types and args).

<table>
<thead>
<tr>
<th>Top 4 Relations and Their Contributions</th>
</tr>
</thead>
<tbody>
<tr>
<td>starring 86.6%, writer 3.8%, producer 3.2%, director 1.6%</td>
</tr>
<tr>
<td>birthplace 75.3%, clubs 6.1%, deathplace 5.1%, location 4.1%</td>
</tr>
<tr>
<td>clubs 55.3%, teams 9.3%, nationalteam 6.3% college 6.0%</td>
</tr>
</tbody>
</table>

Table 3: Some topics at level 2 (all word types and args).

<table>
<thead>
<tr>
<th>Top Relations</th>
</tr>
</thead>
<tbody>
<tr>
<td>activeyearsenddate, careerend, finalyear, retired</td>
</tr>
<tr>
<td>commands, partof, battles, notablecommanders</td>
</tr>
<tr>
<td>occupation, shortdescription, profession, dates</td>
</tr>
<tr>
<td>influenced, schooltradition, notableideas, maininterests</td>
</tr>
<tr>
<td>destinations, end, through, posttown</td>
</tr>
<tr>
<td>prizes, award, academyawards, highlights</td>
</tr>
<tr>
<td>inflow, outflow, length, maxdepth</td>
</tr>
<tr>
<td>after, successor, endingterminus</td>
</tr>
<tr>
<td>college, almamater, education</td>
</tr>
</tbody>
</table>
Evaluation: 2004 ACE Data

12% performance improvement without using any domain specific setting

Recall: 78%, Precision: 69%

Reason for the improvement over the State of the Art Methods:

Bring in the knowledge from the existing relations.

<table>
<thead>
<tr>
<th>Approaches</th>
<th>P(%)</th>
<th>R(%)</th>
<th>F(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convolution Tree Kernel</td>
<td>72.5</td>
<td>56.7</td>
<td>63.6</td>
</tr>
<tr>
<td>Composite Kernel (linear)</td>
<td>73.50</td>
<td>67.00</td>
<td>70.10</td>
</tr>
<tr>
<td>Syntactic Kernel</td>
<td>69.23</td>
<td>70.50</td>
<td>70.35</td>
</tr>
<tr>
<td>Nguyen, etc (2009)</td>
<td>76.60</td>
<td>67.00</td>
<td>71.50</td>
</tr>
<tr>
<td>Baseline</td>
<td>62.00</td>
<td>61.19</td>
<td>61.15</td>
</tr>
<tr>
<td>Baseline + Topics</td>
<td>69.15</td>
<td>77.88</td>
<td>73.24</td>
</tr>
</tbody>
</table>

Table: Performance comparison of different approaches with SVM over the ACE 2004 data. P: Precision, R: Recall, F: F-measure.
Conclusion

- TWREX is a Watson component. It makes use of the information fusion concept.

- A novel approach to relation extraction by reusing the knowledge gained from the other domains
  - Use dbpedia and wikipedia to automatically gather instances for a large repository of relations.
  - Use diffusion wavelets to extract topics space
  - Use topics space features in addition to traditional features in relation extraction

- Results: topics provide +12% improvement on ACE 2004 relation extraction task

- Future Work