Temporal Role Annotation for Named Entities

Maria Koutraki, Farshad Bakhshandegan-Moghaddam, Harald Sack
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What is a role?

“the position or purpose that someone or something has in a situation, organization, society, or relationship”

- A role is a position
- Anything (in particular named entities) can take over a role

A role is not a named entity, refers to a named entity!

The Pope asked Michelangelo, when the Sistine Chapel ceiling will be ready.

Refers to

Julius II

1 Cambridge dictionary

M. Koutraki et al., FIZ Karlsruhe & AIFB, KIT Karlsruhe
What is a role?

“the position or purpose that someone or something has in a situation, organization, society, or relationship” ¹

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<table>
<thead>
<tr>
<th>ROLE</th>
<th>PERSON</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Pope</td>
<td>asked Michelangelo, when the Sistine Chapel ceiling will be ready.</td>
<td></td>
</tr>
</tbody>
</table>

Categories:

- Permanent roles (e.g. human, mother, ...)
- **Temporal restricted roles** (e.g. CEO of a company, Pope, ...)

¹ Cambridge dictionary

M. Koutraki et al., FIZ Karlsruhe & AIFB, KIT Karlsruhe
Why (Temporal) Roles?
More Motivation…

- Roles for entities in knowledge graphs are present for most entity types.
- Roles represent pivotal information for an entity.
- Roles are in abundance in unstructured textual resources.
- Roles are highly sparse in existing KGs.
- Roles are tied to specific temporal and contextual information.
What are temporal restricted roles and how can we annotate them?
What is a temporal role?

- Roles that specify one or a few particular entities at a specific point in time
- A function which for a given a temporal context returns a named entity (or a few)!

**Head Role:** Identifies the most general variant of a role with potentially high ambiguity

**Role Phrase:** Specifies the role with sufficient details for the successful disambiguation.
Objective - Temporal Role Annotation

Goal: Detect and annotate in an automatic way

- temporal roles and
- role phrases in natural language text
Approach - Head Role Annotator

- Automated approach → sequence classification
  - The roles are influenced by the preceding and succeeding words in a sentence
  - The relation between different segments in a sentence has impact in categorization
- Linear-chain CRF model:

Factor Graphs
1. Local features
2. Contextual features
3. External features

The president of France gave a speech yesterday
Approach - Local Features

Take into account only the information from the individual words

<table>
<thead>
<tr>
<th>id</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>f₁</td>
<td>$w_i$</td>
</tr>
<tr>
<td>f₂</td>
<td>$\text{POS}(w_i)$</td>
</tr>
<tr>
<td>f₃</td>
<td>$\text{NER}(w_i)$</td>
</tr>
<tr>
<td>f₄</td>
<td>$\text{startsWithCapital}(w_i)$</td>
</tr>
<tr>
<td>f₅</td>
<td>$\text{fullyInCapital}(w_i)$</td>
</tr>
<tr>
<td>f₆</td>
<td>$\text{startOfSentence}(w_i)$</td>
</tr>
<tr>
<td>f₇</td>
<td>$\text{Lemma}(w_i)$</td>
</tr>
</tbody>
</table>

Example: *The president of France gave a speech yesterday*

Feature Values for $i=1$:

- $f_1 = \text{"The"}$
- $f_2 = \text{"DT"}$
- $f_3 = \text{"null"}$
- $f_4 = \text{"true"}$
- $f_5 = \text{"false"}$
- $f_6 = \text{"true"}$
- $f_7 = \text{"the"}$

Feature Values for $i=2$:

- $f_1 = \text{"president"}$
- $f_2 = \text{"noun"}$
- $f_3 = \text{"null"}$
- $f_4 = \text{"false"}$
- $f_5 = \text{"false"}$
- $f_6 = \text{"false"}$
- $f_7 = \text{"president"}$
Approach - Contextual Features

Capture the dependencies of a word $w_i$ and its surrounding words $w_{i+2} \ldots w_{i-2}$

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>$f_8$-$f_{11}$</td>
<td>$w_{i-2}, w_{i-1}, w_{i+1}, w_{i+2}$</td>
</tr>
<tr>
<td>$f_{12}$-$f_{15}$</td>
<td>$\text{POS}(w_{i-2}), \text{POS}(w_{i-1}), \text{POS}(w_{i+1}), \text{POS}(w_{i+2})$</td>
</tr>
<tr>
<td>$f_{16}$-$f_{19}$</td>
<td>$\text{NER}(w_{i-2}), \text{NER}(w_{i-1}), \text{NER}(w_{i+1}), \text{NER}(w_{i+2})$</td>
</tr>
</tbody>
</table>

Example: *The king in chess is the most important piece*

Feature Values for $i=2$:

- $f_8$ = "null"
- $f_9$ = "The"
- $f_{10}$ = "in"
- $f_{11}$ = "chess"
Approach - Contextual Features

Capture the dependencies of a word \( w_i \) and its surrounding words \( w_{i-2} \ldots w_{i+2} \)

Exploit the commonalities in the language structure!

Example: *The president of France gave a speech yesterday*

Feature Values for \( i=2 \):

\[
\begin{align*}
\text{f}_{12} &= \text{"null"}, & \text{f}_{13} &= \text{"DT"}, & \text{f}_{14} &= \text{"IN"}, & \text{f}_{15} &= \text{"NNP"}
\end{align*}
\]
Use knowledge from external sources

<table>
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<tr>
<td>$f_{20}$</td>
<td>isInDic($w_i$)</td>
</tr>
<tr>
<td>$f_{21}$</td>
<td>LocalGrammar($w_i$)</td>
</tr>
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</table>

Boolean flag indicating if a token is part of a dictionary
Approach - External Features - Dictionary

- No existing dictionary dedicated to temporal roles
- Automatically construct a dictionary using knowledge graphs (Wikidata)
- Wikidata class role(Q214339) subtree:

- To ensure the temporal aspect of roles consider time-dependent properties (e.g. "replaces", "replaced by")

query:

```sql
SELECT DISTINCT ?role ?roleLabel WHERE {
  ?role instanceOf* subclassOf* wd:Q214339 .
  ?role label ?roleLabel .
  ?person positionHeld ?roleStatement .
  ?roleStatement positionHeld ?role .
  ?roleStatement replaces|replacedBy ?differentRoleHolder .
}
```
Approach - External Features

Use knowledge from external sources

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- Boolean flag indicating if a token matches to a local grammar

<table>
<thead>
<tr>
<th>Local Grammar</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROLE IN (POS) LOCATION (NER)</td>
<td>President of Iran, King of Egypt</td>
</tr>
<tr>
<td>ROLE PERSON (NER)</td>
<td>President Obama, Pope Francis</td>
</tr>
<tr>
<td>DT (POS) ROLE</td>
<td>The King, The Pope</td>
</tr>
<tr>
<td>ROLE IN (POS) ORGANIZATION (NER)</td>
<td>CEO of Apple</td>
</tr>
<tr>
<td>ORGANIZATION (NER) ROLE</td>
<td>Google CEO</td>
</tr>
</tbody>
</table>
Approach - Role Phrase Annotation

- Constituency Parse Tree
- Select nearest to the root Noun-Phrase

The former US President visited Pope Francis
Experimental Setup (1/2)

- **Tested Roles:**
  - President, Pope, Monarch, CEO

- **Baselines:**
  - Temporal Role Dictionary (>200 unique temporal role surfaces)
  - ANNIE job title gazetteer (>1,500 job titles)
Experimental Setup (2/2)

- **Ground Truth:**
  - Manually created dataset
    - New York Times corpus
    - 200 sentences
    - 64% True Positive, 36% False Positive
  - Automatically generated dataset
    - Wikipedia articles

<table>
<thead>
<tr>
<th>Sample</th>
<th>#tokens</th>
</tr>
</thead>
<tbody>
<tr>
<td>True Positive</td>
<td>6M</td>
</tr>
<tr>
<td>False Positive</td>
<td>1.5M</td>
</tr>
<tr>
<td>True Negative</td>
<td>3.3M</td>
</tr>
</tbody>
</table>
Automatically generated GT Creation

Role Dic

Anchor-Text

WIKIPEDIAThe Free Encyclopedia

True Positive Sample

False Positive Sample
Evaluation - Performance

- 5-fold cross validation over the automatically extracted dataset

<table>
<thead>
<tr>
<th>Method</th>
<th>P</th>
<th>R</th>
<th>F₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp Role Dictionary</td>
<td>0.82</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>CRF-based Role Annotator</td>
<td><strong>0.94</strong></td>
<td>0.97</td>
<td><strong>0.95</strong></td>
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</table>

- The dictionary filters out the true negative samples but not the samples with ambiguous surface forms which may refer to a person name or a role (e.g. Pope)
### Evaluation - Robustness

- Trained on the automatically extracted dataset (wikipedia) tested on the manually created dataset (New York Times)

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<td>Temp Role Dictionary</td>
<td>0.66</td>
<td>1</td>
<td>0.79</td>
</tr>
<tr>
<td>ANNIE Gazetteer</td>
<td>0.55</td>
<td>0.72</td>
<td>0.62</td>
</tr>
<tr>
<td>CRF-based Role Annotator</td>
<td><strong>0.80</strong></td>
<td>0.93</td>
<td><strong>0.86</strong></td>
</tr>
</tbody>
</table>

- Dictionary: Cannot differentiate the “Alexander Pope” and “Pope Francis”
- Role Annotator: learns patterns like “<PERSON> Pope” → Not a Role
Evaluation - Feature Ablation

- 5-fold cross validation over the automatically extracted dataset (Wikipedia)

<table>
<thead>
<tr>
<th>Feature Group</th>
<th>P</th>
<th>R</th>
<th>F₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Features</td>
<td>0.90</td>
<td>0.95</td>
<td>0.92</td>
</tr>
<tr>
<td>Contextual Features</td>
<td>0.72</td>
<td>0.27</td>
<td>0.39</td>
</tr>
<tr>
<td>External Features</td>
<td>0.82</td>
<td>1</td>
<td>0.90</td>
</tr>
<tr>
<td>All Features</td>
<td>0.94</td>
<td>0.97</td>
<td>0.95</td>
</tr>
<tr>
<td>All Features (25% Dictionary size reduction)</td>
<td>0.94</td>
<td>0.92</td>
<td><strong>0.93</strong></td>
</tr>
</tbody>
</table>
Conclusion and Future Steps

● Definition of the task of temporal role annotation
● Proposed a structured prediction approach for the annotation of temporal roles
● Constructed two high quality ground-truth datasets for this task

● Next Steps
  ● Experiment with more Role categories
  ● Enrich the ground truth
  ● Experiment with more features
  ● Continue with the subsequent step of disambiguating the temporal roles to the corresponding named entities
Thank You!

Code and Data: https://github.com/ISE-AIFB/RoleTagger


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Twitter account: @mairy10u
Related Work

● NER
  ● NER approached are optimized to label surface forms that link to a NE class (PERSON, ORGANIZATION, PLACE... )

● NED/EL
  ●

● Dictionaries and Gazetteers [1]
  ● Domain dependent
  ● Manual effort
  ● Do not scale
  ● Suffer in terms of recall