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DeFacto
Deep Fact Validation
O'Hara's first major film was Alfred Hitchcock directed "Jamaica Inn" which was released in 1939, she had previously ...
Architecture of Deep Fact Validation

Natural Language Representation of Input Triple

Jamaica Inn
Alfred Hitchcock
director
BOA Pattern Library

Search Engine

Trustworthiness

Fact Confirmation

Proof Scoring

TRUE

FALSE
... "master of suspense" Sir Alfred Hitchcock, director of *Vertigo* (1958) ...

In the 1959 *Alfred Hitchcock* film *North by Northwest*, Cary Grant ...

*Jamaica Inn*, directed by *Alfred Hitchcock*, starring Charles ...

*Biutiful* is a drama film *directed by* Alejandro González Iñárritu.
Training BOA for DeFacto

- Select Top-60 owl:ObjectProperties in DBpedia
- 7,75M out of 9,99M triples ≈ 78%
- Manually annotate 10 (very frequent) patterns per relation
  - patterns should not be too generic »arg₁ ‘s “ arg₂« and not too specific »arg₁ in the Italian region arg₂«
- 10 fold cross-validation with F₁ = 0.732
Automatic Search Query Generation

“Jamaica Inn” & “under director” & “Alfred Hitchcock”

“Alfred Hitchcock” & “the director of” & “Jamaica Inn”

“Alfred Hitchcock” & “the director of the” & “Jamaica Inn”

“Jamaica Inn” & “written and directed by” & “Alfred Hitchcock”

“Jamaica Inn” & “by filmmaker” & “Alfred Hitchcock”
Architecture of Deep Fact Validation

Jamaica Inn
Director Alfred Hitchcock
BOA Pattern Library

Natural Language Representation of Input Triple

Trustworthiness
Proof Scoring
Fact Confirmation

Image from coursera.org
Proof Search and Confirmation

... Alfred J. Hitchcock, the director of “Jamaica Inn” ...

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>BOA Pattern</td>
<td>1</td>
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<tr>
<td>BOA Score</td>
<td>0.87</td>
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<tr>
<td>Token Distance</td>
<td>5</td>
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<tr>
<td>Wordnet Expansion</td>
<td>0.9</td>
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<tr>
<td>Total Occurrence</td>
<td>12</td>
</tr>
<tr>
<td>Page Title</td>
<td>0.5 &amp; 0.7</td>
</tr>
<tr>
<td>End of Sentence</td>
<td>0</td>
</tr>
<tr>
<td>Phrase and Property</td>
<td>the director of</td>
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</table>

<table>
<thead>
<tr>
<th>Classifier</th>
<th>P</th>
<th>R</th>
<th>F1</th>
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</thead>
<tbody>
<tr>
<td>Logistic Regression</td>
<td>0.769</td>
<td>0.769</td>
<td>0.769</td>
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<tr>
<td>Naïve Bayes</td>
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<td>0.624</td>
<td>0.564</td>
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<tr>
<td>SVM</td>
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<td>0.822</td>
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</tr>
<tr>
<td>RBF Network</td>
<td>0.735</td>
<td>0.717</td>
<td>0.718</td>
</tr>
</tbody>
</table>
Architecture of Deep Fact Validation

- Natural Language Representation of Input Triple
  - Jamaica Inn
  - Alfred Hitchcock
director
  - BOA Pattern Library

- Search Engine

- Trustworthiness
- Proof Scoring

- Fact Confirmation
  - TRUE
  - FALSE

Image from coursera.org
Trustworthiness Analysis of Webpages

- determine similarity to input triple
- compare topics for query with search results
- relying on approach from Nakamura et al. (2007)
  - extended approach to work for two search terms
Trustworthiness Features

✦ Topic Majority in the Web
  • Number of webpages with similar topics to current page

✦ Topic Majority in the Search Results
  • Number of search results similar to the search results that are to be evaluated

✦ Topic Coverage: rate of topic terms appearing in the page

✦ PageRank: the Google Page Rank for the current page
Architecture of Deep Fact Validation

Natural Language Representation of Input Triple

- Jamaica Inn
- Alfred Hitchcock
- director

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TRUE

FALSE

Image from coursera.org
Features for Deep Fact Validation - Part I

• extend score for single proof to score for website

\[ scw(w) = 1 - \prod_{pr \in prw(w)} (1 - fc(pr)) \]

• 2 features for each trustworthiness feature \( f \)

\[ F_{f_{\text{sum}}}(t) = \sum_{w \in s(t)} (f(w) \cdot scw(w)) \quad F_{f_{\text{max}}}(t) = \max_{w \in s(t)} (f(w) \cdot scw(w)) \]

• number of proofs, total hit count, domain/range
Evaluation

✧ **Goal:** Can we effectively distinguish between true and false facts?

✧ Top 60 most used owl:ObjectProperties from DBpedia

✧ We need positive and negative training data for supervised machine learning
Data Generation - Positive Data

- Randomly select 10 triples for each property
- Manually check each fact with web search
- 473 out of 600 were considered true
Data Generation - Subject

Class Y

Property X

rdfs:domain

Class Z

rdfs:range

Individual of Class Y

rdf:type

Individual of Class Z

rdf:type

Another Individual of Class Y

rdf:type

Property X

Individual of Class Z

rdf:type
Data Generation - Object

Class Y

Property X

Class Z

Individual of Class Y

Individual of Class Z

Another Individual of Class Z

Property X

rdfs:domain

rdfs:range

rdf:type
Data Generation - Subject-Object

- Class Y
  - rdfs:domain: Property X
  - rdf:type: Individual of Class Y
  - rdf:type: Another Individual of Class Y

- Property X
  - rdfs:range: Class Z
  - rdf:type: Another Individual of Class Z

- Class Z
  - rdf:type: Individual of Class Z
  - rdf:type: Another Individual of Class Z

- Individual of Class Y
  - rdf:type: Another Individual of Class Y
Data Generation - Property

Class Y \(\text{rdfs:domain} \) Property X \(\text{rdfs:range} \) Class Z

Individual of Class Y \(\text{rdf:type} \) Property X \(\text{rdf:type} \) Individual of Class Z

Individual of Class Y \(\text{rdf:type} \) Another Property \(\text{rdf:type} \) Individual of Class Z
Data Generation - Random

Class Y

Property X

Class Z

rdfs:domain
rdfs:range

Individual of Class Y

Individual of Class Z

rdfs:range

Another Individual of Class Y

Another Individual of Class Z

Property X

Another Property

rdf:type

rdf:type

rdf:type
Data Generation - 20% Mix

- Another Individual of Class Y
  - Property X
  - Individual of Class Z

- Individual of Class Y
  - Property X
  - Another Individual of Class Z

- Another Individual of Class Y
  - Property X
  - Another Individual of Class Z

- Individual of Class Y
  - Another Property
  - Individual of Class Z

- Another Individual of Class Y
  - Another Property
  - Another Individual of Class Z

- Another Individual of Class Y
  - Another Property
  - Another Individual of Class Z

20% of each
Evaluation Results

- Logistic Regression
- Naïve Bayes
- SVM
- J48
- RBF Network

For each category:
- Subject
- Object
- Subject-Object
- Property
- Random
- 20% Mix

6%
Discussion of Results

- 82.6% to 87.6% for J48 on 5 standard test sets and 78.8% for 20% mix
- easiest dataset random, hardest dataset 20% mix
- true facts are very challenging ➔ trackback of wikipedia facts very difficult
- DeFacto performs better for more popular facts
- training & test sets and source code are available online
Demo

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**BOOtstrapping the datA web.**

The goal behind BOA is to use the Data Web as background knowledge for the extraction of natural language patterns that represent predicates found in natural language text. This knowledge is finally fed back into the Data Web with closing the loop.

This is a first GUI version of BOA:

1. Select a corpus on the left side
2. Select a property in the tree
3. View the patterns
4. Click on a pattern to see the details!

**The BOA Architecture:**

![Diagram of BOA architecture]
Conclusion & Future Work

✦ DeFacto is able to check validity of facts using the Web as corpus, export provenance as RDF (PROV-O)
✦ F₁ of about 0.842 on DBpedia facts (J48, all test sets)
✦ extend DeFacto to work with multiple languages
✦ add support for datatype properties
✦ search for negative evidence
✦ create natural language input interface
Thank you! Questions?

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