Building a default knowledge base of objects (and other stories of robots)

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Outline

Introduction: Granny Annie and the Robot

Part I: Where are my things?

Part II: Default Knowledge by frames

Epilogue: What are objects, anyway?
Granny Annie and the Robot

Granny Annie

Bob
Granny Annie and the Robot
Granny Annie and the Robot
Granny Annie and the Robot
Part I: Where are my things?

Goal: Learn Semantic Relations

Ingredients: Natural Language

Distributional Semantics (Word Space Models)

Linked Open Data (DBpedia)
Vector Space Model

**Question**

Is it legal to fit a washing machine in the bathroom?

Hi all, I would like to fit a washing machine in the bathroom. The power cable will be fed through a small hole in the wall with the outlet socket on the outside of the bathroom and the machine will be +1200mm from the edge of the bath and 500mm from the toilet. My question is, is this legal?

*Asked by: edward_88  29th Dec, 2012  Electrical*
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**Vector Space Model**

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**Co-occurrence matrix**

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<tr>
<th></th>
<th>Washing_machine</th>
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<tbody>
<tr>
<td>Bathroom</td>
<td>5</td>
<td>2</td>
</tr>
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<td>Bedroom</td>
<td>0</td>
<td>1</td>
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**Vector Space Model**

**QUESTION**
Is it legal to fit a washing machine in the bathroom?

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**Singular value decomposition**

\[
M = U \Sigma V^* 
\]

**Low-rank approximation**

\[
U_k \Sigma_k V_k^* = M_k 
\]
Vector Space Model

bn:00008995n Bathroom -0.03750793 0.06731935 -0.02334246 -0.02009913 0.02251291 0.07689607 0.01527985 -0.10780967 0.18232885 0.1234034 -0.0520944 -0.25805958 0.12200121 -0.04875973 -0.03544397 -0.03841146 0.00970973 ...

bn:00007365n Washing_machine -0.00911299 0.11549547 -0.04274256 -0.04274256 0.03672424 -0.06627292 0.13761881 0.01171631 -0.08721243 0.08270955 0.13095092 -0.00137408 -0.16226186 0.0422162 0.0545828 -0.01007292 0.10094466 -0.05663372 0.09864459 0.10167608 7.534e-05 0.08067719 0.05527394

Cosine similarity:

\[
\frac{A \cdot B}{\|A\| \|B\|} = \frac{\sum_{i=1}^{n} A_i B_i}{\sqrt{\sum_{i=1}^{n} A_i^2} \sqrt{\sum_{i=1}^{n} B_i^2}}
\]
**Vector Space Model**

\[
\text{sim}(\text{Bathroom}, \text{Washing\_machine}) = \cos(\alpha) \approx 0.71
\]

\[
\text{sim}(\text{Bathroom}, \text{Ashtray}) = \cos(\beta) \approx 0.37
\]
Vector Space Model

José Camacho-Collados, Mohammad Taher Pilehvar and Roberto Navigli.

Nasari: Integrating explicit knowledge and corpus statistics for a multilingual representation of concepts and entities.

Artificial Intelligence 240, Elsevier, 2016, pp.567-57
Object Detection
Object Detection

$q_1, \ldots, q_n$ observed objects in the query

$o_1, \ldots, o_m$ candidate object

\[
\text{likelihood} (o_i) = \prod_{j=i}^{n} \text{relatedness} (o_i, q_j)
\]
## Objects Detection

### Candidate objects

<table>
<thead>
<tr>
<th>Query objects</th>
<th>Tea_cosy</th>
<th>Pitcher_(container)</th>
<th>Mug</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerator</td>
<td>.473</td>
<td>.544</td>
<td>.522</td>
</tr>
<tr>
<td>Sink</td>
<td>.565</td>
<td>.693</td>
<td>.621</td>
</tr>
<tr>
<td>Sugar_bowl_(dishware)</td>
<td>.555</td>
<td>.600</td>
<td>.627</td>
</tr>
<tr>
<td>Teabox</td>
<td>.781</td>
<td>.466</td>
<td>.602</td>
</tr>
<tr>
<td>Instant_coffee</td>
<td>.821</td>
<td>.575</td>
<td>.796</td>
</tr>
<tr>
<td>Electric_water_boiler</td>
<td>.503</td>
<td>.559</td>
<td>.488</td>
</tr>
<tr>
<td>product</td>
<td>.048</td>
<td>.034</td>
<td>.047</td>
</tr>
</tbody>
</table>
Objects Detection

First results at ECAI 2016

Application-driven evaluation at ICRA 2016

Funded by ALOOF and STRANDS
Objects and Rooms

Distributional Relational Hypothesis

If two entities are semantically related, the natural relation that comes from their respective types is highly likely to occur.

```
Entity 1 ________________________ Entity 2

Type 1       Semantic Relation      Type 2

Entity 1 ________________________ Entity 2

Semantic Similarity
```
Objects and Rooms

Distributional Relational Hypothesis

For example, the location relation that holds between an object and a room is represented in a distributional space if the entities representing the object and the room are highly associated.

\[ \text{Object} \xrightarrow{\text{isLocatedAt}} \text{Room} \]

\[ \text{Entity 1} \xrightarrow{\text{Semantic Similarity}} \text{Entity 2} \]
Objects and Rooms

Distributional representation of entities from NASARI, aligned to DBpedia

Similarity to **Dishwasher**

<table>
<thead>
<tr>
<th>Location</th>
<th>Cosine Similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen</td>
<td>.803</td>
</tr>
<tr>
<td>Air_shower_(room)</td>
<td>.788</td>
</tr>
<tr>
<td>Utility_room</td>
<td>.763</td>
</tr>
<tr>
<td>Bathroom</td>
<td>.758</td>
</tr>
<tr>
<td>Furnace_room</td>
<td>.749</td>
</tr>
</tbody>
</table>
Objects and Rooms

A word space model of entity **lexicalizations**

Skip-gram NN-based model from Amazon reviews (83M)

$$\text{vector(public toilet)} = \text{vector(public)} + \text{vector(toilet)}$$

<table>
<thead>
<tr>
<th>public_toilet</th>
<th>paper_towel</th>
<th>Cosine Similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>restrooms</td>
<td>towels</td>
<td>0.636</td>
</tr>
<tr>
<td>toilets</td>
<td>paper</td>
<td>0.531</td>
</tr>
<tr>
<td>restroom</td>
<td>dishtowel</td>
<td>0.525</td>
</tr>
<tr>
<td>toilet</td>
<td>papertowel</td>
<td>0.519</td>
</tr>
<tr>
<td>public</td>
<td>napkin</td>
<td>0.505</td>
</tr>
</tbody>
</table>

Best Neighbors

Similarity to **Dishwasher**
Objects and Rooms

www.CrowdFlower.com

20 rooms (Category:Rooms)

100 objects (Category:Domestic_Implement*)

2,000 pairs annotated:

- 2: unexpected
- 1: unusual
- 1: plausible
- 2: expected
Objects and Rooms

www.CrowdFlower.com

object:
Toothbrush

The toothbrush is an oral hygiene instrument used to clean the teeth and gums that consists of a head of tightly clustered bristles mounted on a handle, which facilitates the cleansing of hard-to-reach areas of the mouth.

room:
Classroom

A classroom or schoolroom is a room in which classes are held.

How likely is it to find this object in this room?

- unexpected
- unusual
- plausible
- usual
Objects and Rooms

Data collected: https://project.inria.fr/alooof/data/
12,767 valid judgments
455 untrusted
At least 5 judgment per pair
Average agreement 64.74%
Distribution 37%/30%/24%/9%
86 USD
# Objects and Rooms

## Evaluation

<table>
<thead>
<tr>
<th>Method</th>
<th>Precision at 1</th>
<th>Precision at 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location Frequency</td>
<td>.000</td>
<td>.008</td>
</tr>
<tr>
<td>Link Frequency</td>
<td>.280</td>
<td>.260</td>
</tr>
<tr>
<td>NASARI-sim</td>
<td>.390</td>
<td>.380</td>
</tr>
<tr>
<td>SkipGram-sim</td>
<td>.350</td>
<td>.400</td>
</tr>
</tbody>
</table>
Objects and Rooms

Automatically built knowledge base

336 dbc:Domestic Implements
199 dbc:Rooms

Similarity > 0.570 corresponding to best precision
931 object-location pairs (879 new ones!)
Objects and Rooms

Results at **EKAW 2016**
Submission to **Semantic Web Journal**

Data at:
https://project.inria.fr/aloof/data/
Part II: Default Knowledge by Frames

Goal: Learn Typical Situations

Ingredients: Natural Language

Frame Semantics (FrameNet)

Linked Open Data (DBpedia, WordNet, FrameBase)
Default Knowledge

Loose operational definition

Knowledge that Bob can use when it doesn't know about its current environment.

Example:

dbr:Spoon deko:locatedAt dbr:Kitchen
Frame Semantics

Cutting

Definition:
An **AGENT** cuts a **ITEM** into **ITEMS** using an **INSTRUMENT** (which may or may not be expressed).

At the ceremony, **AGENT** cut **ITEM** into **ITEMS** using **INSTRUMENT** for a long time.

FEs:

Core:

**AGENT:** The **AGENT** is the person cutting the **ITEM** into **ITEMS**.

**INSTRUMENT:** The **INSTRUMENT** is the tool used for cutting.

**ITEM:** The **ITEM** is the object being cut.

**ITEMS** are the parts of the original **ITEM** which are the result of the cutting.

Non-Core:

**PROCEDURE:** The **PROCEDURE** with which the **ITEM** is being cut into **ITEMS**.

**INSTRUMENT:** The **INSTRUMENT** is used to cut the **ITEM**.

**MANNER:** The **MANNER** in which the **ITEM** is being cut into **ITEMS**.

**STATE:** An act of the **STATE** that accomplishes the slicing.

**STATE:** The **STATE** of the **ITEM** being sliced into **ITEMS**.

**LOCATIVE:** Where the slicing takes place.

**STATE:** The **STATE** for which the slicing is taking place.

**STATE:** The **STATE** of the **ITEM** being sliced into **ITEMS**.

**TIME:** The time when the slicing occurs.
KNEWS

Knowledge Extraction with Semantics

Text (Natural Language) → Semantic Parsing → Discourse Representation Structure → Semantic Roles

Word Sense Disambiguation → WordNet Synsets → FrameNet Frames → Alignment → RDF Triples

Entity Linking → DBPedia Entities
"The robot should ask if it should serve more."

(Curran, Clark and Bos 2007)

http://babelnet.org/
KNEWS

Link words to entities in Babelnet (Navigli and Ponzetto, 2012)

http://babelfy.org
The robot is driving the car.
The robot is driving the car.
Demo: http://gingerbeard.alwaysdata.net/knews/

Source code: https://github.com/valeriobasile/learningbyreading

Demo at **ECAI 2016**

Paper at **INLG 2016**
DeKO KB

Default Knowledge about Objects

First version: collection of frame instances

1) Collect text
2) Extract frame instances
3) ???
4) Infer default knowledge

Poster at ESWC 2016
DeKO Corpus

Intermediate Stories : 1.198
Beginner Stories : 426
UVCS Stories : 29
Total Stories : 1.653
Total Sentences : 34.384
Total Tokens: 282.664
Average Sentence length: 8 words

http://web2.uvcs.uvic.ca/elc/studyzone/
http://www.eslfast.com/
http://www.rong-chang.com/customs/
DeKO RDF

268,958 RDF triples

114,536 Frame instances

666 Frame types
(from 4,215 Wordnet synsets)

222 roles

3830 entities
DeKO Clusters

Hard clustering of frame instances

A boy is eating an apple

A girl is eating a pear

The apple was stolen
DeKO Clusters

Hard clustering of frame instances

A boy is eating an apple

A girl is eating a pear

The apple was stolen
Epilogue: What are objects anyway?

Goal: Identify objects in DBpedia

Ingredients: DBpedia
           Generic Entities
           Wikipedia
           Linguistic features
           Extra-linguistic features
           ?
Epilogue: What are objects anyway?

dbr:Frying_pan
A frying pan, frypan, or skillet is a flat-bottomed pan used for frying, searing, and browning foods.

Is fundamentally different from

dbr:Turin
Turin is a city and an important business and cultural centre in northern Italy, capital of the Piedmont region, located mainly on the left bank of the Po River, in front of Susa Valley and surrounded by the western Alpine arch and by the Superga Hill.
Epilogue: What are objects anyway?

- generic entities
  - objects
  - locations
  - animals
- named entities
  - persons
  - cities
- activities
Epilogue: What are objects anyway?

$dbr:\text{Frying\_pan}$ vs $dbr:\text{Turin}$

- Syntax (determiner?)
- Word form (plural?)
- WordNet synsets
- Word embeddings
- Category in SKOS
- Class in OpenCyC

... 

Problem related to facts vs beliefs
THE END
References

- Jay Young, Valerio Basile, Lars Kunze, Elena Cabrio, Nick Hawes: Towards Lifelong Object Learning by Integrating Situated Robot Perception and Semantic Web Mining. ECAI 2016
- Jay Young, Lars Kunze, Valerio Basile, Elena Cabrio, Nick Hawes and Barbara Caputo: Semantic Web-Mining and Deep Vision for Lifelong Object Discovery. ICRA 2016 (under review)
- Valerio Basile, Soufian Jebbara, Elena Cabrio, Philipp Cimiano: Populating a Knowledge Base with Object-Location Relations using Distributional Semantics. EKAW 2016
- Valerio Basile, Elena Cabrio, Claudia Schon: KNEWS: Using Logical and Lexical Semantics to Extract Knowledge from Natural Language. ECAI 2016