Human Associations in the Semantic Web and DBpedia

Jörn Hees

2016-09-15
DBpedia Community Meeting Leipzig
Jörn Hees

• PhD Student at DFKI & TU Kaiserslautern

• Blog: Setting up a Linked Data mirror from RDF dumps (DBpedia, Freebase, Wikidata, LinkedGeoData, …) with Virtuoso

• RDFLib maintainer (Python)

• http://joernhees.de

• https://w3id.org/associations
Outline

• Background
• My Research
  • Human Association Datasets
  • Graph Pattern Learning
• Discussion
Outline

• Background

• My Research
  • Human Association Datasets
  • Graph Pattern Learning

• Discussion
What are Human Associations?

- Mental connections between concepts
- What's the first thing that comes to your mind when thinking about ...?
- Example:
  - Dog
What are Human Associations?

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- What's the first thing that comes to your mind when thinking about ...?
- Example:
  - Dog: Cat, collar, leash, walk, fur, bark
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- Example:
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  - House
What are Human Associations?

• Mental connections between concepts
• What's the first thing that comes to your mind when thinking about ... ?
• Example:
  • Dog: Cat, collar, leash, walk, fur, bark
  • House: Roof, door, window, flat, live
Example: DBpedia:Dog
Example: DBpedia:Dog

• **Basic information** (description, types)

---

### About: Dog

An Entity of Type: animal, from Named Graph: [http://dbpedia.org](http://dbpedia.org), within Data Space: [dbpedia.org](http://dbpedia.org)

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The domestic dog (Canis lupus familiaris) is a subspecies of the gray wolf (Canis lupus), a member of the Canidae family of the mammalian order Carnivora. The term “domestic dog” is generally used for both domesticated and feral varieties. The domestic dog is the first domesticated animal and has been the most widely kept working, hunting, and pet animal in human history (citation needed). The word “dog” can also refer to the male of a canine species, as opposed to the word “bitch” which refers to the female of the species. Recent studies of “well-preserved remains of a dog-like canid from the Razboinichya Cave” in the Altai Mountains of southern Siberia concluded that a particular instance of early wolf domestication approximately 33,000 years ago did not result in modern dog lineages, possibly because of climate disruption during the Last Glacial Maximum. The authors postulate that at least several such incipient events have occurred. A study of fossil dogs and wolves in Belgium, Ukraine, and Russia tentatively dates domestication from 14,000 years ago to more than 31,700 years ago. Another recent study has found support for claims of dog domestication between 14,000 and 16,000 years ago, with a range between 9,000 and 34,000 years ago, depending on mutation rate assumptions. Dogs’ value to early human hunter-gatherers led to them quickly becoming ubiquitous across world cultures. Dogs perform many roles for people, such as hunting, herding, pulling loads, protection, assisting police and military, companionship, and, more recently, aiding handicapped individuals. This impact on human society has given them the nickname “man’s best friend” in the Western world. In some cultures, however, dogs are also a source of meat. In 2001, there were estimated to be 400 million dogs in the world. Most breeds of dogs are at most a few hundred years old, having been artificially selected for particular morphologies and behaviors by people for specific functional roles. Through this selective breeding, the dog has developed into hundreds of varied breeds, and shows more behavioral and morphological variation than any other land mammal. For example, height measured to the withers ranges from 15.2 centimetres (6.0 in) in the Chihuahua to about 76 cm (30 in) in the Irish Wolfhound; color varies from white through grays (usually called “blue”) to black, and browns from light (tan) to dark (“red” or “chocolate”) in a wide variation of patterns; coats can be short or long, coarse-haired to wool-like, straight, curly, or smooth. It is common for most breeds to shed this coat.

---

### Property Value

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbpedia-owl:abstract</td>
<td>The domestic dog (Canis lupus familiaris) is a subspecies of the gray wolf (Canis lupus), a member of the Canidae family of the mammalian order Carnivora. The term “domestic dog” is generally used for both domesticated and feral varieties. The domestic dog is the first domesticated animal and has been the most widely kept working, hunting, and pet animal in human history (citation needed). The word “dog” can also refer to the male of a canine species, as opposed to the word “bitch” which refers to the female of the species. Recent studies of “well-preserved remains of a dog-like canid from the Razboinichya Cave” in the Altai Mountains of southern Siberia concluded that a particular instance of early wolf domestication approximately 33,000 years ago did not result in modern dog lineages, possibly because of climate disruption during the Last Glacial Maximum. The authors postulate that at least several such incipient events have occurred. A study of fossil dogs and wolves in Belgium, Ukraine, and Russia tentatively dates domestication from 14,000 years ago to more than 31,700 years ago. Another recent study has found support for claims of dog domestication between 14,000 and 16,000 years ago, with a range between 9,000 and 34,000 years ago, depending on mutation rate assumptions. Dogs’ value to early human hunter-gatherers led to them quickly becoming ubiquitous across world cultures. Dogs perform many roles for people, such as hunting, herding, pulling loads, protection, assisting police and military, companionship, and, more recently, aiding handicapped individuals. This impact on human society has given them the nickname “man’s best friend” in the Western world. In some cultures, however, dogs are also a source of meat. In 2001, there were estimated to be 400 million dogs in the world. Most breeds of dogs are at most a few hundred years old, having been artificially selected for particular morphologies and behaviors by people for specific functional roles. Through this selective breeding, the dog has developed into hundreds of varied breeds, and shows more behavioral and morphological variation than any other land mammal. For example, height measured to the withers ranges from 15.2 centimetres (6.0 in) in the Chihuahua to about 76 cm (30 in) in the Irish Wolfhound; color varies from white through grays (usually called “blue”) to black, and browns from light (tan) to dark (“red” or “chocolate”) in a wide variation of patterns; coats can be short or long, coarse-haired to wool-like, straight, curly, or smooth. It is common for most breeds to shed this coat.</td>
</tr>
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<td>dbpedia-owl:uid</td>
<td>606813442 (xsd:integer)</td>
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</table>
Example: DBpedia:Dog

• **Basic information** *(description, types)*

• **Categorisation** *(categories & types)*

<table>
<thead>
<tr>
<th>dcterms:subject</th>
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<tbody>
<tr>
<td>category:Cosmopolitan_species</td>
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<td>category:Mammals_with_sequenced_genomes</td>
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<td>category:Model_organisms</td>
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<tr>
<td>category:Scavengers</td>
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<tr>
<td>category:Dogs</td>
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<table>
<thead>
<tr>
<th>rdf:type</th>
</tr>
</thead>
<tbody>
<tr>
<td>owl:Thing</td>
</tr>
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<td>duf:Organism</td>
</tr>
<tr>
<td>dbpedia-owl:Animal</td>
</tr>
<tr>
<td>dbpedia-owl:Eukaryote</td>
</tr>
<tr>
<td>dbpedia-owl:Mammal</td>
</tr>
<tr>
<td>dbpedia-owl:Species</td>
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</tr>
<tr>
<td><a href="http://umbel.org/umbel/rc/BiologicalLivingObject">http://umbel.org/umbel/rc/BiologicalLivingObject</a></td>
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<td><a href="http://umbel.org/umbel/rc/EukaryoticCell">http://umbel.org/umbel/rc/EukaryoticCell</a></td>
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<tr>
<td><a href="http://umbel.org/umbel/rc/Mammal">http://umbel.org/umbel/rc/Mammal</a></td>
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</table>
Example: DBpedia:Dog

• Basic information (description, types)

• Categorisation (categories & types)

• Links to other datasets (also Freebase)
Example: DBpedia:Dog

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- **Wiki-page-links** (377 for Dog)
Example: DBpedia:Dog

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• **Categorisation** (categories & types)
• **Links to other datasets** (also Freebase)
• **Inverse links** (redirects, link from other datasets)
• **Wiki-page-links** (377 for Dog)
• **Associations?**
  • Dog:  
    Cat (√), collar (✗), leash (✗), walk (✗), fur (√), bark (✗)
Outline

- Background
- My Research
  - Human Association Datasets
  - Graph Pattern Learning
- Discussion
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My Research

• Research Question:
  - Is it possible to learn patterns for Human Associations from Linked Data?
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My Research

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• Goal:
  • Given an input node predict the output node(s) we would associate
Research Question:

Is it possible to learn patterns for Human Associations from Linked Data?

Dataset of "Semantic Associations" needed
My Research

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Edinburgh Associative Thesaurus

- Association corpus (1973) G. Kiss, C. Armstrong, R. Milroy, J. Piper
  - For each stimulus asked 100 ppl for a response
  - Strong responses became stimuli of next round
Edinburgh Associative Thesaurus

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- ~ 790 K associations (free text)
- Graph: (|V| = 23 K, |E| = 325 K)
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  • For each stimulus asked 100 ppl for a response
  • Strong responses became stimuli of next round
• \( \sim 790 \text{ K associations} \) (free text)
• Graph: \( |V| = 23 \text{ K, } |E| = 325 \text{ K} \)
  • \( \sim 5000 \) strong associations (>19x)
  • \( \sim 167.4 \text{ K raw associations} \)
Edinburgh Associative Thesaurus

**Examples:**

<table>
<thead>
<tr>
<th>dog</th>
<th>cat</th>
<th>man</th>
<th>woman</th>
<th>bank</th>
<th>money</th>
</tr>
</thead>
<tbody>
<tr>
<td>dog</td>
<td>57</td>
<td>woman 66</td>
<td>man 59</td>
<td>money 25</td>
<td>cash 7</td>
</tr>
<tr>
<td>cat</td>
<td>5</td>
<td>strong 3</td>
<td>sex 5</td>
<td>book 7</td>
<td>bags 7</td>
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<td>collar</td>
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<td>girl 5</td>
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<td>pounds 6</td>
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<td>mouse</td>
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<td>hole 2</td>
<td>female 3</td>
<td>manager 6</td>
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</tr>
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<td>3</td>
<td>boy 2</td>
<td>child 2</td>
<td>clerk 5</td>
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<td>tom</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Edinburgh Associative Thesaurus

- Difficulty: Free text
- Mapping to Semantic Entities
  
  "dog" - "cat"
Edinburgh Associative Thesaurus

- Difficulty: Free text
- Mapping to Semantic Entities

"dog" - "cat"
Edinburgh Associative Thesaurus

- Difficulty: Free text
- Mapping to Semantic Entities
  - "pupil" - "school"
  - Semi-Automatic Mapping Approach
  - 727 verified "Semantic Associations"
Associations & Linked Data

ASSOCIATIONS & LINKED DATA

A research project to connect Human Associations and the Semantic Web

(drag / scroll to interact)
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Data Analysis

• Local Linked Data Endpoint:
  • Central Datasets
  • ~8 G triples
  • SPARQL Queries
Data Analysis

• Local Linked Data Endpoint:
  • Central Datasets
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  • SPARQL Queries
• Scalability Issues
First Analysis

• Node Degrees:
• Avg: 3643

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<tr>
<th>Node</th>
<th>Degree</th>
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<td>dbp:Animal</td>
<td>400624</td>
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• Node Degrees:
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  • Would cause bias!

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First Analysis

- Node Degrees:
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- Exclude in-links?
  - Directionality depends on modelling!

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Graph Pattern Learning

- First idea: Shortest paths
  - Many false positives (associations)
  - Problems with high degrees
    - Super-nodes (owl:Thing, countries, cities)
    - Everything is connected with paths of length 2 ;)

![Diagram](image-url)
Graph Pattern Learning

• First idea: Shortest paths
  • Many false positives (associations)
  • Problems with high degrees
    • Super-nodes (owl:Thing, countries, cities)
      • Everything is connected with paths of length 2 ;)
  • Problems due to modelling
    • Nearly linear parts / chains
      • (owl:sameAs, freebase, temporal properties)
Good Graph Patterns?

• How often is a response reached? \text{max}
• How many other nodes are reached? \text{min}
• How many nodes need to be expanded? \text{min}
• How long does a query take? \text{min}
Graph Pattern Learning

- Idea: Shortest *paths*
Graph Pattern Learning

- Idea: Shortest paths
- Idea: Constrained Subgraphs
  - Don't model cost as hops, but number of expanded nodes
    - Property based look-ahead
    - Prefer keeping the search corridor narrow
  - "Spreading activation" like
Graph Pattern Learning

- Genetic algorithm (genetic programming)
  - Individuals: SPARQL BGP patterns
Graph Pattern Learning

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- Mutation:
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  • Mating: Exchange of triples & unifying variables
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  - Mating: Exchange of triples & unifying variables
  - Fitness function: Good pattern?
Learned Graph Patterns

https://w3id.org/associations
Stats about this graph pattern

<table>
<thead>
<tr>
<th>Metric</th>
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<tbody>
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</tbody>
</table>
Info from BabelNet
Info from WikiData
Info from BabelNet
Evaluation

• How good are the learned patterns?
  • Difficult to evaluate directly

• Indirect objective approach:
  • Are they good for prediction?
  • Training/Test set split
  • Clustered similar GPs
  • Given a stimulus from the test set, what’s the rank of the true response in the prediction results?
Evaluation Results
<table>
<thead>
<tr>
<th></th>
<th>Recall@1</th>
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<th>Recall@3</th>
<th>Recall@4</th>
<th>Recall@5</th>
<th>Recall@10</th>
<th>MAP</th>
<th>NDCG</th>
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</thead>
<tbody>
<tr>
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<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.042</td>
<td>0.097</td>
<td>0.029</td>
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<tr>
<td>outdeg out</td>
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<td>0.167</td>
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<tr>
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<td>pagerank in</td>
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<td>0.292</td>
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<td>pagerank out</td>
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<td>0.097</td>
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<td>0.167</td>
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<td>0.069</td>
<td>0.083</td>
<td>0.111</td>
<td>0.046</td>
<td>0.095</td>
</tr>
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Summary

• **Goal**
  Learning Graph Patterns for Associations

• **Datasets**

• **Graph Pattern Learning**
Discussion

Thanks for your attention

Questions?

https://w3id.org/associations