A Language Visualization System

Emre Ünal
Outline

• Introduction & Prior work
• Components
• Implementation
• Conclusion & Future Work
Outline

- Introduction & Prior work
- Components
- Implementation
- Conclusion & Future Work
What is language visualization?
Why are we interested in language visualization?
• A language visualization system
• A question answering module
Prior Work

• SHRDLU
• PUT System
• CarSim
• WordsEye
• DESCRIBER
• CONFUCIUS
Outline

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• Introduction & Prior work

• Components

• Implementation

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Components

- Alice
- WordNet
- CoreNLP
Alice

- 3D programming environment
- Used mostly for educational purposes
- Open source

alice.org
Alice
Why Alice?

- Camera, light
- Model loading, texture mapping
- Model based coordinate systems, model transforms
- Extensive gallery of 3D models (528 in our system)
WordNet

- Large lexical database of English
- Synsets of nouns, verbs, adjectives and adverbs.
- Semantic relations
- Freely available
WordNet

- Main relation is synonymy.
- Synonyms form synsets.
- 117000 synsets.
WordNet

- Synonymy e.g. board - plank
- Antonymy e.g. dry - wet
- Hyponymy e.g. dog - canine
- Hypernymy e.g. canine - dog
- Meronymy e.g. window - building
- Holonymy e.g. building - window
- Troponymy e.g. lisp - talk
- Entailment e.g. snore - sleep
# WordNet

<table>
<thead>
<tr>
<th>Semantic Relation</th>
<th>Syntactic Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synonymy</td>
<td>N, V, Aj, Av</td>
</tr>
<tr>
<td>Antonymy</td>
<td>Aj, Av</td>
</tr>
<tr>
<td>Hyponymy</td>
<td>N</td>
</tr>
<tr>
<td>Hypernymy</td>
<td>N</td>
</tr>
<tr>
<td>Meronymy</td>
<td>N</td>
</tr>
<tr>
<td>Holonymy</td>
<td>N</td>
</tr>
<tr>
<td>Troponymy</td>
<td>V</td>
</tr>
<tr>
<td>Entailment</td>
<td>V</td>
</tr>
</tbody>
</table>

N: Nouns, V: Verbs, Aj: Adjectives, Av: Adverbs

Table 3.1: Semantic Relations in WordNet
CoreNLP

- NLP tools
- Parser, NER, POS tagger, CoRef Resolution
- Open source

nlp.stanford.edu
POS Tagger

<table>
<thead>
<tr>
<th></th>
<th>Penn Treebank Tagset</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CC</strong></td>
<td>Coordinating conjunction</td>
</tr>
<tr>
<td><strong>CD</strong></td>
<td>Cardinal number</td>
</tr>
<tr>
<td><strong>DT</strong></td>
<td>Determiner</td>
</tr>
<tr>
<td><strong>EX</strong></td>
<td>Existential there</td>
</tr>
<tr>
<td><strong>FW</strong></td>
<td>Foreign word</td>
</tr>
<tr>
<td><strong>IN</strong></td>
<td>Prep. or subordinating conj.</td>
</tr>
<tr>
<td><strong>JJ</strong></td>
<td>Adjective</td>
</tr>
<tr>
<td><strong>JJR</strong></td>
<td>Adjective, comparative</td>
</tr>
<tr>
<td><strong>JJS</strong></td>
<td>Adjective, superlative</td>
</tr>
<tr>
<td><strong>LS</strong></td>
<td>List item marker</td>
</tr>
<tr>
<td><strong>MD</strong></td>
<td>Modal</td>
</tr>
<tr>
<td><strong>NN</strong></td>
<td>Noun, singular or mass</td>
</tr>
<tr>
<td><strong>NNS</strong></td>
<td>Noun, plural</td>
</tr>
<tr>
<td><strong>NNP</strong></td>
<td>Proper noun, singular</td>
</tr>
<tr>
<td><strong>NNPS</strong></td>
<td>Proper noun, plural</td>
</tr>
<tr>
<td><strong>PDT</strong></td>
<td>Predeterminer</td>
</tr>
<tr>
<td><strong>POS</strong></td>
<td>Possessive ending</td>
</tr>
<tr>
<td><strong>PRP</strong></td>
<td>Personal pronoun</td>
</tr>
<tr>
<td><strong>PRP$</strong></td>
<td>Possessive pronoun</td>
</tr>
<tr>
<td><strong>RB</strong></td>
<td>Adverb</td>
</tr>
<tr>
<td><strong>RBR</strong></td>
<td>Adverb, comparative</td>
</tr>
<tr>
<td><strong>RBS</strong></td>
<td>Adverb, superlative</td>
</tr>
<tr>
<td><strong>RP</strong></td>
<td>Particle</td>
</tr>
</tbody>
</table>

**Table A.1: Penn Treebank POS Tags**
Parser

- Outputs phrase structure tree
- Stanford dependencies
The cat is on the table.

The / DT cat / NN is / VBZ on / IN the / DT table / NN . /.
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The System
The System

- Language Understanding
- Scene Construction
- Question Answering
The System

Text-to-Scene conversion

Language Understanding

Scene Construction

Question Answering
Language Components

- Nouns
- Adjectives
- Prepositions
Nouns

- Nouns correspond to 3D models
Problems about nouns

• May refer to non-physical entities.

• Might be too general.

• A physical entity can be referred in multiple ways.

• A noun phrase may refer to a single object or a noun can refer to more than one object.
<Synset gloss="warm-blooded egg-laying vertebrates characterized by feathers and forelimbs modified as wings" hint="bird" id="SID-01503061-N">
  <Model path="Animals/Bird1.a2c"/>
  <Model path="Animals/Bluebird.a2c"/>
</Synset>

<Synset gloss="a piece of furniture with shelves for storing books" hint="bookcase" id="SID-02870880-N">
  <Model path="Furniture/Bookcase.a2c"/>
</Synset>
Hypernym - Hyponym relations

- Vehicle
  - Rocket
  - Sled
  - Bike
  - Car
Hypernym - Hyponym relations

Food

... Cheese

... Banana
Adjectives

• Modify properties of models

• Some adjectives cannot be visualized
Adjectives

Model Properties

• Visibility
• Size
• Position
• Orientation
• Color
• Transparency
Adjectives

Model Properties

• Visibility
• Size
• Position
• Orientation
• Color
• Transparency
Adjectives

Model Properties

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## Table C.1: Synset - Scale Map For Size Related Adjectives

<table>
<thead>
<tr>
<th>Adjective Hint</th>
<th>Synset ID</th>
<th>Width, Height, Depth Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>astronomical</td>
<td>SID-01383582-A</td>
<td>(3.0, 3.0, 3.0)</td>
</tr>
<tr>
<td>giant</td>
<td>SID-01385773-A</td>
<td>(2.5, 2.5, 2.5)</td>
</tr>
<tr>
<td>huge</td>
<td>SID-01387319-A</td>
<td>(1.5, 1.5, 1.5)</td>
</tr>
<tr>
<td>big</td>
<td>SID-01382086-A</td>
<td>(1.2, 1.2, 1.2)</td>
</tr>
<tr>
<td>standard</td>
<td>SID-02295998-A</td>
<td>(1.0, 1.0, 1.0)</td>
</tr>
<tr>
<td>small</td>
<td>SID-01391351-A</td>
<td>(0.8, 0.8, 0.8)</td>
</tr>
<tr>
<td>tiny</td>
<td>SID-01392249-A</td>
<td>(0.5, 0.5, 0.5)</td>
</tr>
<tr>
<td>infinitesimal</td>
<td>SID-01393483-A</td>
<td>(0.25, 0.25, 0.25)</td>
</tr>
<tr>
<td>tall</td>
<td>SID-02385102-A</td>
<td>(1.0, 1.1, 1.0)</td>
</tr>
<tr>
<td>short</td>
<td>SID-02386612-A</td>
<td>(1.0, 0.9, 1.0)</td>
</tr>
<tr>
<td>fat</td>
<td>SID-00986027-A</td>
<td>(1.3, 1.0, 1.3)</td>
</tr>
<tr>
<td>thin</td>
<td>SID-00988232-A</td>
<td>(0.8, 1.0, 0.8)</td>
</tr>
</tbody>
</table>
Prepositions

- Spatial relations
- Modify positions of models
Prepositions

Model Properties

• Visibility
• Size
• Position
• Orientation
• Color
• Transparency
Spatial Relations

on
in
in front of
behind
next to
near
above
below
A giant dog is behind the small cat.
A giant dog is behind the small cat.

A/DT giant/JJ dog/NN is/VBZ behind/IN the/DT small/JJ cat/NN ./.
A giant dog is behind the small cat.

A/DT giant/JJ dog/NN is/VBZ behind/IN the/DT small/JJ cat/NN ./.
A giant dog is behind the small cat.

A/DT giant/JJ dog/NN is/VBZ behind/IN the/DT small/JJ cat/NN ./.

Synset ID - 02086723

Synset ID - 02124272
A giant dog is behind the small cat.
A giant dog is behind the small cat.
A giant dog is behind the small cat.
A giant dog is behind the small cat.
A giant dog is behind the small cat.
A giant dog is behind the small cat.
A giant dog is behind the small cat.
There is a room. A sofa is in the room. A table is in front of the sofa. A man is behind the sofa. A toy is on the table. A car is behind the room.
Question Answering

- Position of a model
- Test spatial relation
- Test visibility by another object
Where is the room?
It is in front of the car.

Where is the sofa?
It is in the room, in front of the man, behind the table.

Is toy on the table?
Yes.

Is man in the room?
Yes.

Is car in the room?
No.

Is sofa in front of the table?
No

Can man see the sofa?
Yes.

Can man see the car?
No.
The system is capable of answering questions even though the particular spatial relation is never mentioned in the text.
Conclusions

• A language visualization system design with rich vocabulary and extensive model gallery

• A new way of solving spatial inference problems
Future Work

• Handle verbs
• Animations, path planning, physics engine
• Improve q/a system
• A learning system
Questions