The Grumpy Linguist's Guide to Distributed Representations of Sentence Meaning

Marco Baroni
Center for Mind/Brain Sciences
University of Trento

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Distributional and distributed word representations
From LSA to Word2Vec

Can we cram the meaning of a whole sentence into a single vector?
I met John who told me that you said that Mary had a good time with her date last night at the sushi place
Composition rules are stable and predictable

*Use/purpose* of utterance might change

**Background: Review**

A very long movie, dull in stretches, with entirely too much focus on meal preparation and igloo construction.

**Background: Planning the evening**

It’s a very long movie, let’s watch it some other time when we don’t need to wake up early.

How to learn general composition rules

*From raw corpora 1: Contexts*

![Diagram](image1)

How to learn general composition rules

*From raw corpora 2: Reconstruction error*

![Diagram](image2)

How to learn general composition rules

*From (minimally) curated data: Translations*

![Diagram](image3)
How to learn general composition rules
From (minimally) curated data: Image captions

▶ A football player is kicking the ball while the opposing fans watch.
▶ A football player kicks the ball during a game with a red shirted crowd looking.
▶ A male wearing a football uniform kicking a football during a football game.
▶ A man punting a football as fans from the opposing team watch in the background.

http://nlp.cs.illinois.edu/HockenmaierGroup/8k-pictures.html

What is sentence meaning anyway?
Continuous or discrete?

A man with no shirt is holding a football.
A football is being held by a man with no shirt.

Four people are walking on the beach.
A group of people is on a beach.

A man is climbing a rope.
A man is coming down a rope.

Nobody is riding a bike.
Two people are riding a bike.

(All high-relatedness sentence pairs from SICK:
http://clic.cimec.unitn.it/composes/sick.html)
What is sentence meaning anyway?

Bringing about new information

Nixon is dead.

It’s a very long movie, dull in stretches, with entirely too much focus on meal preparation and igloo construction.

Two people are riding a bike.
Nobody is riding a bike.

Popular tasks and core sentence meaning

Paraphrasing

A woman cuts up broccoli. A woman is cutting broccoli.
A man plays the keyboard with his nose. The man is playing the piano with his nose.
A woman is slipping in the water-tub. A woman is lying in a raft.
A man is playing a piano. A woman is peeling a potato.

http://research.microsoft.com/en-us/downloads/38cf15fd-b8df-477e-a4e4-a4680caa75af/

Popular tasks and core sentence meaning

Sentiment analysis

http://nlp.stanford.edu/sentiment/treebank.html

Popular tasks and core sentence meaning

Question Answering

This author describes the last Neanderthals being killed by Homo sapiens in his The Inheritors, and a lone British naval officer hallucinates survival on a barren rock in his Pincher Martin. In another of his novels, the title entity speaks to Simon atop a wooden stick; later in that novel, the followers of Jack steal Piggy’s glasses and break the conch shell of Ralph, their former chief. For 10 points, name this British author who described boys on a formerly deserted island in his Lord of the Flies.

A: William Golding

http://cs.umd.edu/~miyyer/qblearn/
A 66-year-old man has been sentenced to life in prison by a French court for murdering seven girls and young women. Michel Fourniret, dubbed the “Ogre of the Ardennes”, had admitted kidnapping and killing his victims between 1987 and 2001.

Michel Fourniret was sentenced to life imprisonment.

Figure from Li and Hovy EMNLP 2014
Doing great without modeling core sentence meaning
Trivializing SICK
relatedness entailment
(Pearson r) (Accuracy)

<table>
<thead>
<tr>
<th>Method</th>
<th>Relatedness</th>
<th>Entailment</th>
</tr>
</thead>
<tbody>
<tr>
<td>adding word vectors</td>
<td>70%</td>
<td>74%</td>
</tr>
<tr>
<td>lexicalized recursive composition</td>
<td>57%</td>
<td>72%</td>
</tr>
<tr>
<td>median of SemEval systems</td>
<td>71%</td>
<td>77%</td>
</tr>
</tbody>
</table>

Pham et al. ACL 2015

Questions as classifiers

A boy and a girl are looking at a woman.

NP performed an action

NP was affected by an action

V took place

an event physically took place PP

an event temporally took place PP

NP performed V

NP was affected by V

NP was physically located PP

Testing core sentence meaning by asking questions
A proposal

A boy and a girl are looking at a woman.

Are a boy and a girl looking at someone? ✓
Is a boy looking at someone? ✓
Are two persons looking at someone? ✓
Is a female person being looked at? ✓
Is a male person being looked at? x

The author of Lord of The Flies received the Nobel prize in 1983.

Did the author of Lord of the Flies receive a prize? ✓
Did William Golding receive a prize? NA
Is Lord of the Flies a book? NA
General setup

A boy and a girl are looking at a woman

A boy and a girl perform.action

CLASSIFIER

TRUE

SAME CLASSIFIER FOR ALL TESTED MODELS?

Intermezzo

BeautEval

Probing sentence vectors for core meaning

Getting arguments right

A boy is looking at a woman in the park.

a boy performed an action ✓

an event physically took place in the park ✓

A kid is barking at a dog.

a kid performed barking ✓

a dog performed barking x

A boy is running in the park.

a young person performed an action ✓

moving took place ✓

an event physically took place outdoors ✓
### Probing sentence vectors for core meaning

#### Relative clauses

The boy we met yesterday in the park is running.

<table>
<thead>
<tr>
<th>Element</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>a boy performed running</td>
<td>✓</td>
</tr>
<tr>
<td>a park performed running</td>
<td>x</td>
</tr>
</tbody>
</table>

#### Conjunctions

A man is holding a baby and singing.

<table>
<thead>
<tr>
<th>Element</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>a man performed singing</td>
<td>✓</td>
</tr>
<tr>
<td>a baby performed singing</td>
<td>x</td>
</tr>
</tbody>
</table>

A man and a woman are singing.

<table>
<thead>
<tr>
<th>Element</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>a man performed an action</td>
<td>✓</td>
</tr>
<tr>
<td>two persons performed an action</td>
<td>✓</td>
</tr>
</tbody>
</table>

That man is either singing or shouting at us.

<table>
<thead>
<tr>
<th>Element</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>a man performed singing</td>
<td>x</td>
</tr>
</tbody>
</table>

#### Sentence-internal anaphora

A lioness with a cub is grooming herself.

<table>
<thead>
<tr>
<th>Element</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>a lioness was affected by grooming</td>
<td>✓</td>
</tr>
</tbody>
</table>

The cub of a lioness is grooming herself.

<table>
<thead>
<tr>
<th>Element</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>a lioness was affected by grooming</td>
<td>x</td>
</tr>
</tbody>
</table>

#### Minimal pairs

A boy started/refused to run.

<table>
<thead>
<tr>
<th>Element</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>running took place</td>
<td>✓</td>
</tr>
</tbody>
</table>

Three turtles are laying on/next to a log and a fish is swimming beneath it.

<table>
<thead>
<tr>
<th>Element</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>a fish was physically located under three turtles</td>
<td>✓/x</td>
</tr>
</tbody>
</table>

(Bransford et al. CogPsy 1972)
Building the data set

- Sentence extraction from corpora (noisy)
  - Det Adj? Noun that !Verb+ Verb !Verb*
  - The boy that we met yesterday
  - is running in the park

- Automated question generation (noisy)

- Validation with subjects