Applied Deep Learning

Word Representations

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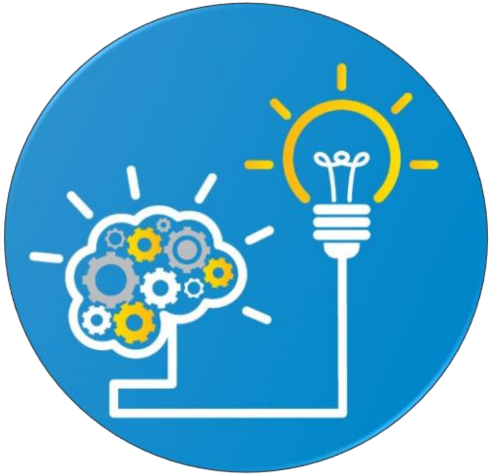
Meaning Representations

- Definition of “Meaning”
  - the idea that is represented by a word, phrase, etc.
  - the idea that a person wants to express by using words, signs, etc.
  - the idea that is expressed in a work of writing, art, etc.

Meaning Representations in Computers

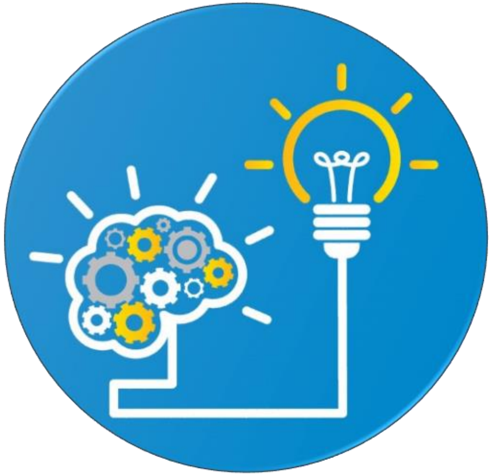
Knowledge-Based Representation



Corpus-Based Representation

Meaning Representations in Computers

Knowledge-Based Representation



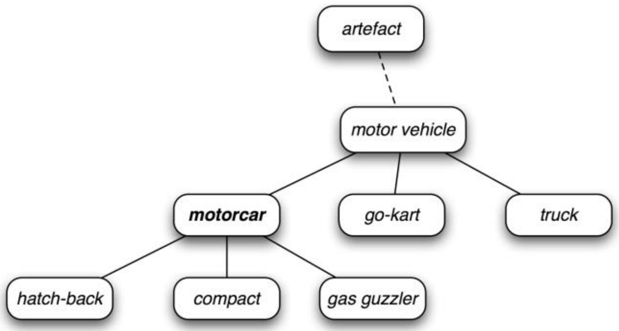
Corpus-Based Representation

Knowledge-Based Representation

- Hypernyms (is-a) relationships of WordNet

```
from nltk.corpus import wordnet as wn
panda = wn.synset('panda.n.01')
hyper = lambda s: s.hypernyms()
list(panda.closure(hyper))
```

```
[Synset('procyonid.n.01'),
Synset('carnivore.n.01'),
Synset('placental.n.01'),
Synset('mammal.n.01'),
Synset('vertebrate.n.01'),
Synset('chordate.n.01'),
Synset('animal.n.01'),
Synset('organism.n.01'),
Synset('living_thing.n.01'),
Synset('whole.n.02'),
Synset('object.n.01'),
Synset('physical_entity.n.01'),
Synset('entity.n.01')]
```



Issues:
- newly-invented words
- subjective
- annotation effort
- difficult to compute word similarity

Meaning Representations in Computers

Knowledge-Based Representation

Corpus-Based Representation

Corpus-Based Representation

- Atomic symbols: ***one-hot*** representation

car [0 0 0 0 0 0 1 0 0 … 0]

car

Issues: difficult to compute the similarity (i.e. comparing “car” and “motorcycle”)

[0 0 0 0 0 0 1 0 0 … 0] AND [0 0 1 0 0 0 0 0 0 … 0] = 0

car motorcycle

Idea: words with similar meanings often have similar neighbors

Corpus-Based Representation

- Neighbor-based representation
  - Co-occurrence matrix constructed via neighbors
  - Neighbor definition: full document v.s. windows

full document
word-document co-occurrence matrix gives general topics
→ "Latent Semantic Analysis"

windows
context window for each word
→ capture syntactic (e.g. POS) and semantic information

Window-Based Co-occurrence Matrix

- Example
  - Window length=1
  - Left or right context
  - Corpus:

    I love AI.
    I love deep learning.
    I enjoy learning.

similarity > 0

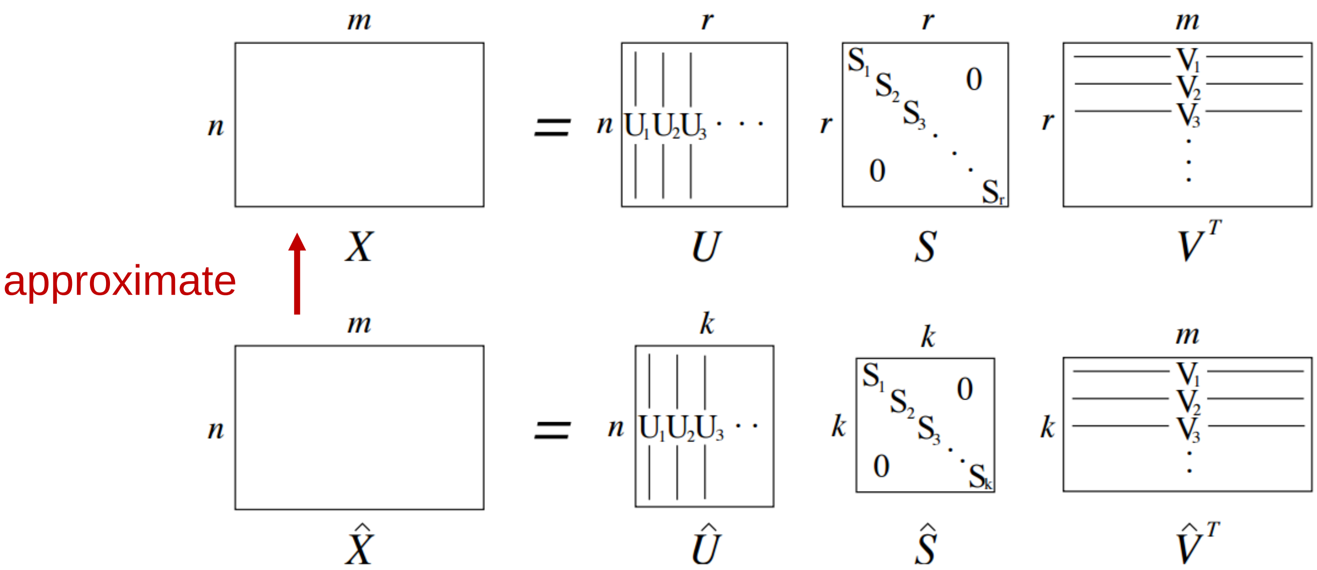
Counts	I	love	enjoy	AI	deep	learning
I	0	2	1	0	0	0
love	2	0	0	1	1	0
enjoy	1	0	0	0	0	1
AI	0	1	0	0	0	0
deep	0	1	0	0	0	1
learning	0	0	1	0	1	0

Issues:
- matrix size increases with vocabulary
- high dimensional
- sparsity → poor robustness

Idea: low dimensional word vector

Low-Dimensional Dense Word Vector

- Method 1: dimension reduction on the matrix
- Singular Value Decomposition (SVD) of co-occurrence matrix X



Low-Dimensional Dense Word Vector

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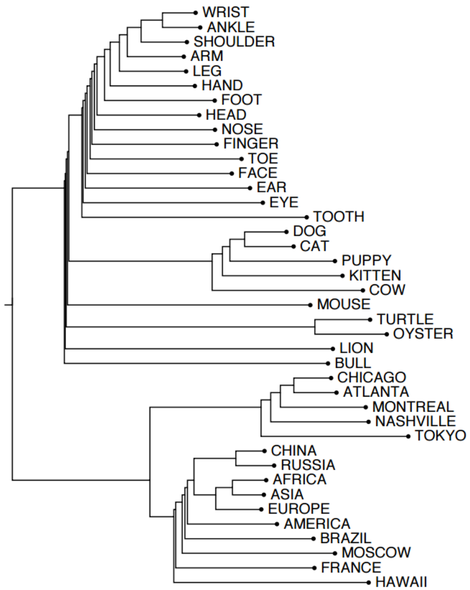
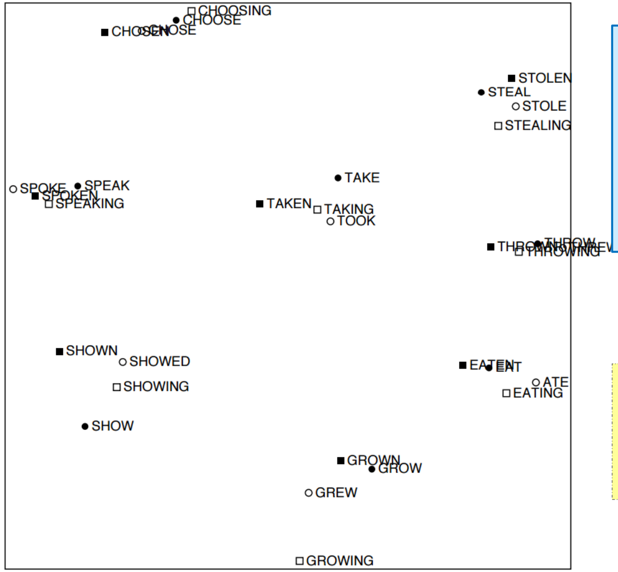
- Singular Value Decomposition (SVD) of co-occurrence matrix X



semantic relations



syntactic relations

Issues:

- computationally expensive: $O(mn^2)$ when $n<m$ for $n \times m$ matrix
- difficult to add new words

Idea: directly learn low-dimensional word vectors

Rohde et al., "An Improved Model of Semantic Similarity Based on Lexical Co-Occurrence," 2005.

Low-Dimensional Dense Word Vector

- Method 2: directly learn low-dimensional word vectors
  - Learning representations by back-propagation. (Rumelhart et al., 1986)
  - A neural probabilistic language model (Bengio et al., 2003)
  - NLP (almost) from Scratch (Collobert & Weston, 2008)
  - Recent and most popular models: word2vec (Mikolov et al. 2013) and Glove (Pennington et al., 2014)
    - As known as “Word Embeddings”

Summary

- Knowledge-based representation
- Corpus-based representation
  - Atomic symbol
  - Neighbors
    - High-dimensional sparse word vector
    - Low-dimensional dense word vector
      - Method 1 – dimension reduction
      - Method 2 – direct learning