

CS 383: Machine Learning

Prof Adam Poliak

Fall 2024

11/20/2024

Lecture 26

Announcements – Remaining Assignments

HW07: due Wednesday 11/27

HW08: due Friday 12/06 (might extend this too)

Project Presentations – 12/17 10:00am

Word Representations

Document-Term Matrix

DMT:

- Rows represent a document
- Columns represent a word
- Values represent some feature of word w_i in document d_j

	w_1	w_2	w_3	w_4	w_v
d_1									
d_1									
...									
d_n									10

Document-Term Matrix

We represent each word in our vocabulary as ...
an index in our matrix

	w_1	w_2	w_3	w_4	w_v
d_1									
d_1									
...									
d_n									

One Hot Vector

- Unique vector for each word
- $n-1$ elements in vector are 0
- One element in vector is 1

One hot vector example

a pioneer of computer science for work combining statistics and linguistics, and an advocate for women in the field



One hot vector example

a pioneer of computer science for work combining statistics and linguistics, and an advocate for women in the field

a	?	...	?	...	?	...	?
pioneer	?	...	?	...	?	...	?
science	?	...	?	...	?	...	?
...	?	...	?	...	?	...	?
advocate	?	...	?	...	?	...	?

One hot vector example

a pioneer of computer science for work combining statistics and linguistics, and an advocate for women in the field

a	1	...	0	...	0	...	0
pioneer	?	...	?	...	?	...	?
science	?	...	?	...	?	...	?
...	?	...	?	...	?	...	?
advocate	?	...	?	...	?	...	?

One hot vector example

a pioneer of computer science for work combining statistics and linguistics, and an advocate for women in the field

a	1	...	0	...	0	...	0
pioneer	0	...	1	...	0	...	0
science	?	...	?	...	?	...	?
...	?	...	?	...	?	...	?
advocate	?	...	?	...	?	...	?

One hot vector example

a pioneer of computer science for work combining statistics and linguistics, and an advocate for women in the field

a	1	...	0	...	0	...	0
pioneer	0	...	1	...	0	...	0
science	0	...	0	...	1	...	0
...	?	...	?	...	?	...	?
advocate	?	...	?	...	?	...	?

One hot vector example

a pioneer of computer science for work combining statistics and linguistics, and an advocate for women in the field

a	1	...	0	...	0	...	0
pioneer	0	...	1	...	0	...	0
science	0	...	0	...	1	...	0
...	0	...	0	...	0	...	1
advocate	0	...	0	...	0	...	1

One hot vector example

a pioneer of computer science for work combining statistics and linguistics, and an advocate for women in the field

	a	...	pioneer	...	science	...	advocate
a	1	...	0	...	0	...	0
pioneer	0	...	1	...	0	...	0
science	0	...	0	...	1	...	0
...	0	...	0	...	0	...	1
advocate	0	...	0	...	0	...	1

Issues with one-hot vector

- Sparse
 - Lots of 0's
- Very big
 - As big as vocabulary
- Doesn't capture any meaning of the word
 - DTM actually captures some aspects of the documents' meaning
 - We'd like the same for our word representations

**How do we figure out the meaning
of a new word?**

Meaning from Context: Tezguino

A bottle of *tezgüino* is on the table.
Everyone likes *tezgüino*.
Tezgüino makes you drunk.
We make *tezgüino* out of corn.

Lin, ACL 1998; Nida, 1975 p.167

Meaning from Context: Tezguino

A bottle of *tezguino* is on the table.
Everyone likes *tezguino*.
Tezguino makes you drunk.
We make *tezguino* out of corn.



Lin, ACL 1998; Nida, 1975 p.167

Distributional Hypothesis

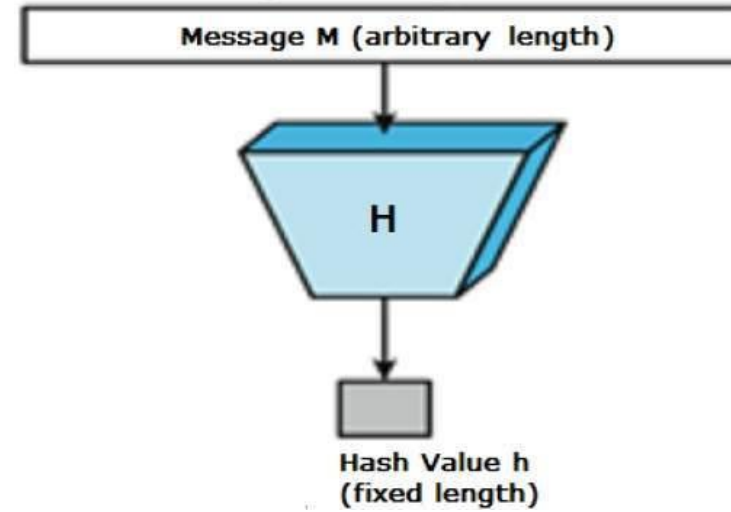
*words with similar contexts
share similar meanings*

(Harris, 1954)

*you shall know a word by
the company it keeps*

(Firth 1957)

Meaning from Context: *Hash*



Meaning from Context: *Hash*

*about to get my hands on some top shelf **hash** but
I have no idea what the **hash** price is in my area.
There is no one that sells **hash** in my area actually.*



Co-occurrence matrix

*about to get my hands on some top shelf **hash** but
I have no idea what the **hash** price is in my area.
There is no one that sells **hash** in my area actually.*

	on	hands	hash	price	actually	area	my
on							
hands							
hash							
price							
actually							
area							
my							

v x v matrix

Co-occurrence matrix

*about to get my hands on some top shelf **hash** but
I have no idea what the **hash** price is in my area.
There is no one that sells **hash** in my area actually.*

Window
size of 2

	on	hands	hash	price	actually	area	my
on							
hands							
hash							
price							
actually							
area							
my						????	

Co-occurrence matrix

*about to get my hands on some top shelf **hash** but
I have no idea what the **hash** price is in **my area**.
There is no one that sells **hash** in **my area** actually.*

Window
size of 2

	on	hands	hash	price	actually	area	my
on							
hands							
hash							
price							
actually							
area							
my						????	

Co-occurrence matrix

*about to get my hands on some top shelf **hash** but
I have no idea what the **hash** price is in **my area**.
There is no one that sells **hash** in **my area** actually.*

Window
size of 2

	on	hands	hash	price	actually	area	my
on							
hands							
hash							
price							
actually							
area							
my						2	

Co-occurrence matrix

*about to get my hands on some top shelf **hash** but
I have no idea what the **hash** price is in **my area**.
There is no one that sells **hash** in **my area** actually.*

Window
size of 2

	on	hands	hash	price	actually	area	my
on							
hands							
hash							
price							
actually							
area							2
my						2	

Co-occurrence matrix

*about to get my hands on some top shelf **hash** but
I have no idea what the **hash price** is in **my area**.
There is no one that sells **hash** in **my area** actually.*

Window
size of 2

	on	hands	hash	price	actually	area	my
on							
hands							
hash							
price			????				
actually							
area							2
my						2	

Co-occurrence matrix

*about to get my hands on some top shelf **hash** but
I have no idea what the **hash price** is in **my area**.
There is no one that sells **hash** in **my area** actually.*

Window
size of 2

	on	hands	hash	price	actually	area	my
on							
hands							
hash							
price			1				
actually							
area							2
my						2	

Co-occurrence matrix

*about to get my hands on some top shelf hash but
I have no idea what the hash price is in my area.
There is no one that sells hash in my area actually.*

Window
size of 2

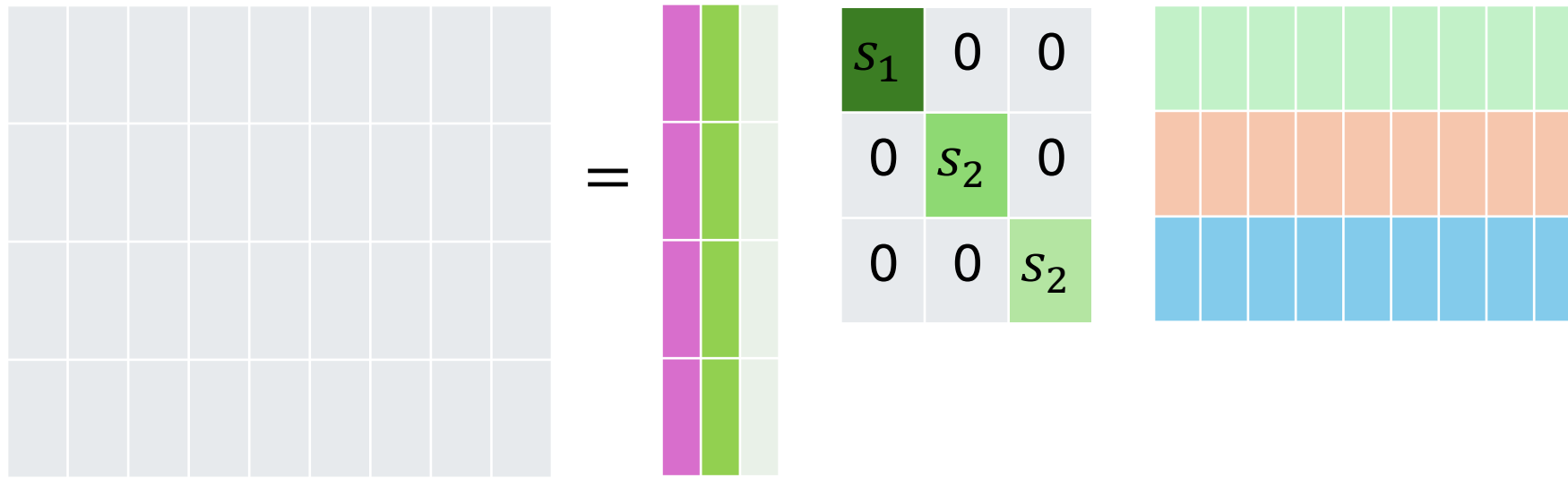
	on	hands	hash	price	actually	area	my
on	0	1	0	0	0	0	0
hands	1	0	0	0	0	0	1
hash	0	0	0	1	0	0	1
price	0	0	1	0	0	0	0
actually	0	0	0	0	0	1	0
area	0	0	0	0	1	0	2
my	0	1	1	0	1	2	0

Issues with co-occurrence matrix

- Large dimensions
- Still sparse
 - Not as much as one-hot but still sparse
- Is meaning captured?
- Solution:
 - Dimensionality Reduction to the rescue

Singular Value Decomposition

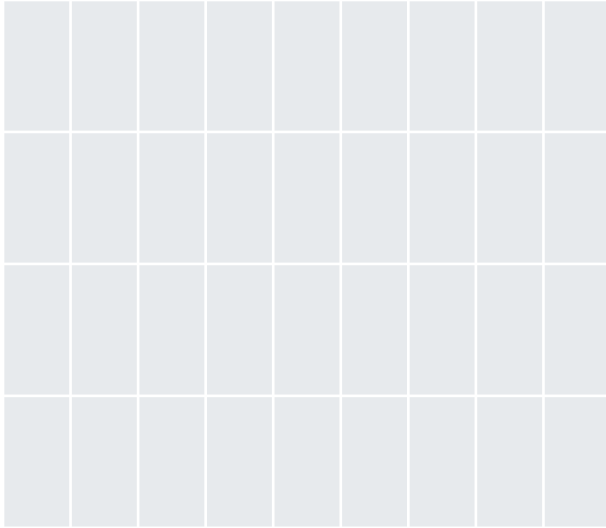
Document Term Matrix



$$\begin{matrix}
 \mathbf{M} \\
 n \times v
 \end{matrix}
 =
 \begin{matrix}
 \mathbf{U} \\
 n \times k
 \end{matrix}
 \begin{matrix}
 \mathbf{S} \\
 k \times k
 \end{matrix}
 \begin{matrix}
 \mathbf{V} \\
 k \times v
 \end{matrix}$$

Singular Value Decomposition

Co-occurrence matrix

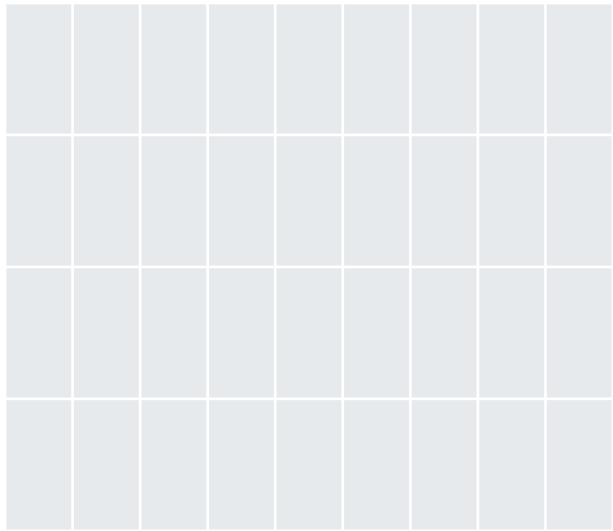


M

$V \times V$

Singular Value Decomposition

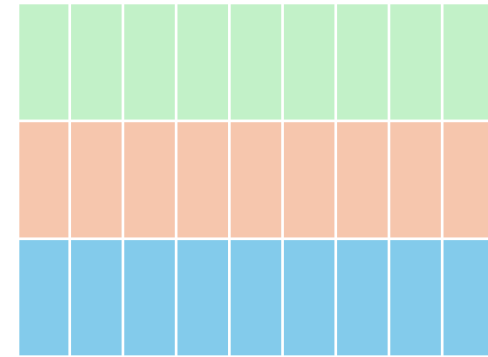
Co-occurrence matrix



=



s_1	0	0
0	s_2	0
0	0	s_2



M
 $v \times v$

=

U
 $v \times k$

S
 $k \times k$

V
 $k \times v$

Word Embeddings

Initialize random vectors

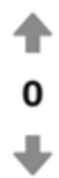


This is a look-up table where each row indicates the list of numbers for a word

Update word embeddings by reading a corpus



Example



Posted by u/SaltyPositive 1 year ago

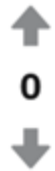


Ziip Disposable Device

Where are all the ziip device posts at?! I recently bought the ziip refilled disposable device and I'm so so unsure on what to make of it, because there is NO hit, but the cloud is dense upon exhaling, but I don't feel a rush and I'm not sure how hard you have to pull(????) it really doesn't feel like I'm pulling at anything at all. I'm posting here because I bought this pod for 7 cad as a substitute for the Juul ones but don't know if I just got a faulty device? Any other similar experiences?

2 Comments Share Save Hide Report

50% Upvoted



Posted by u/SaltyPositive 1 year ago



Ziip Disposable Device

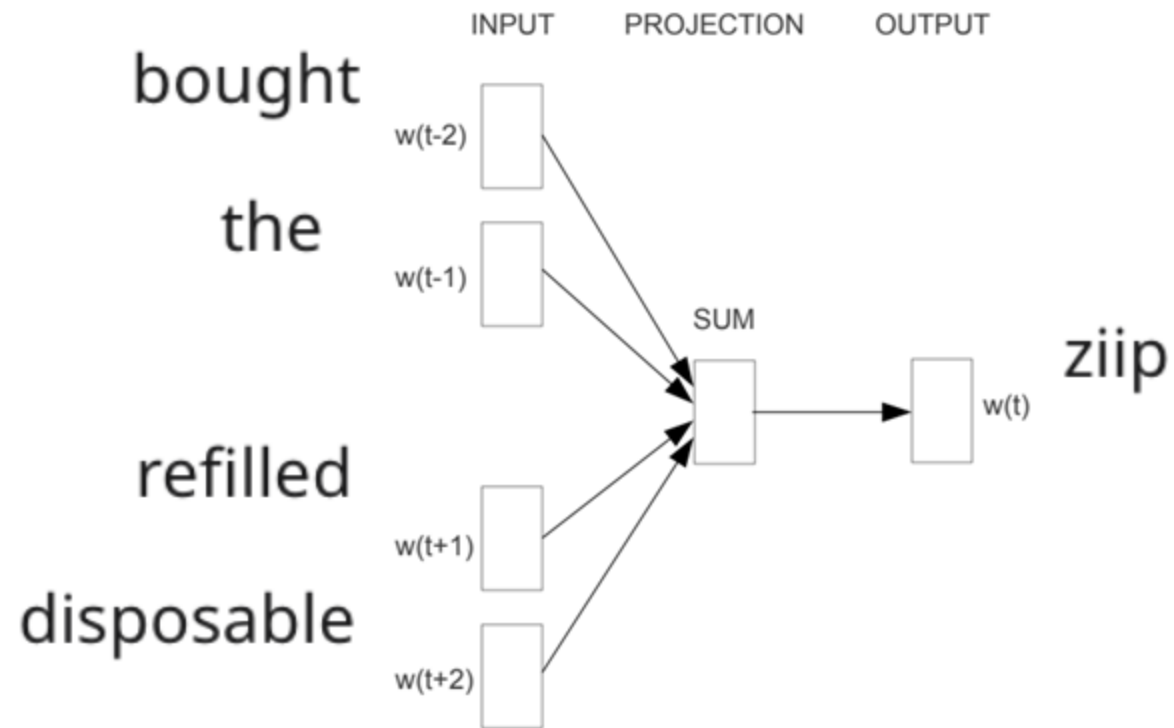
Where are all the ziip device posts at?! I recently bought the [?] refilled disposable device and I'm so so unsure on what to make of it, because there is NO hit, but the cloud is dense upon exhaling, but I don't feel a rush and I'm not sure how hard you have to pull(????) it really doesn't feel like I'm pulling at anything at all. I'm posting here because I bought this pod for 7 cad as a substitute for the Juul ones but don't know if I just got a faulty device? Any other similar experiences?

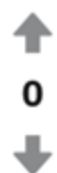
2 Comments Share Save Hide Report

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Continuous Bag of Words (CBOW) (Mikolov et al. 2013)

- Predict a word given its context





Posted by u/SaltyPositive 1 year ago

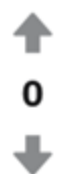


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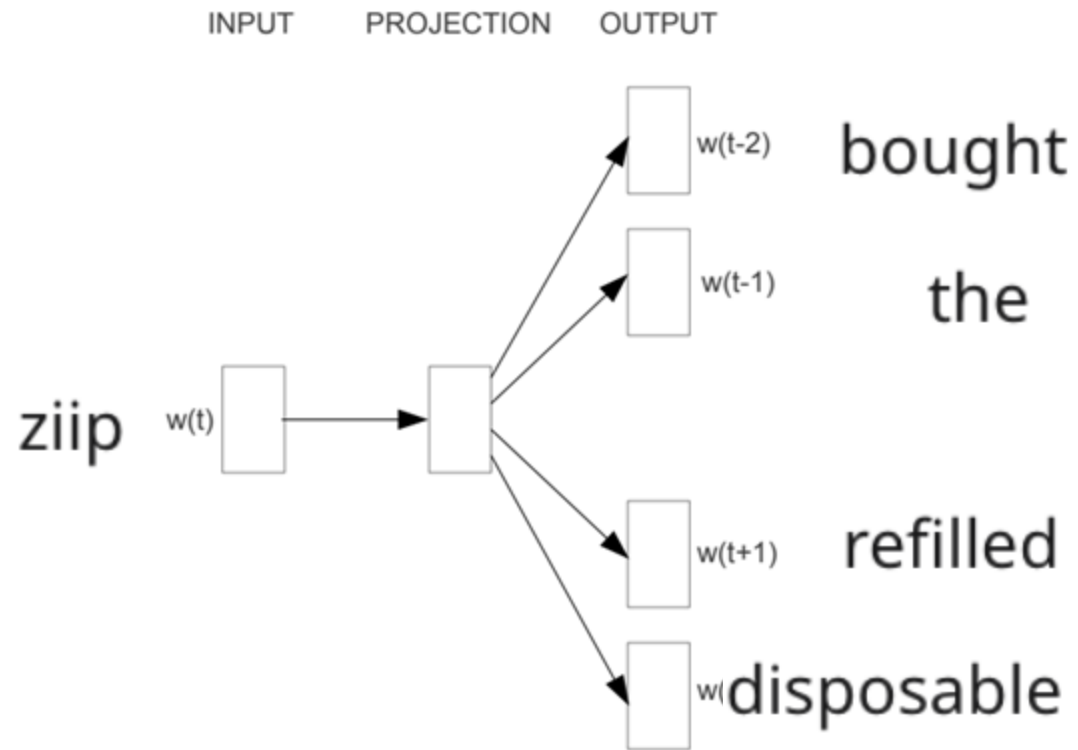
? ziip ?

2 Comments Share Save Hide Report

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Skip-Gram

- Predict the context around a word



Updated Word Embeddings as byproduct of training



After training the neural network, we have updated values in our look-up table

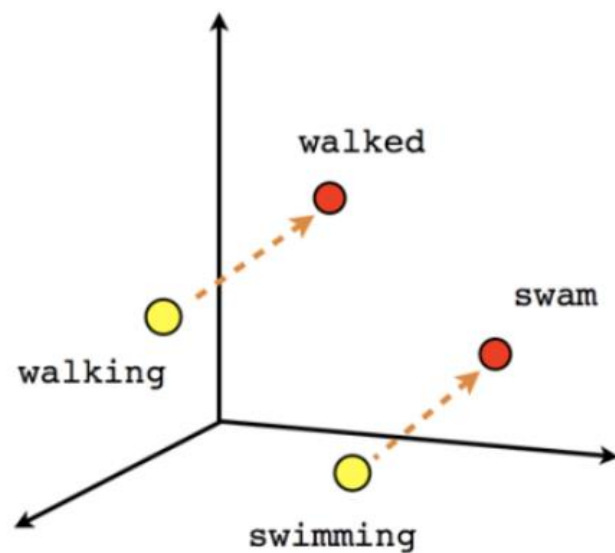
Word Embeddings

a	0.4420	...	0.167	...	0.4838	...	0.2314
pioneer	0.2401	...	0.3732	...	0.9653	...	0.6366
science	0.7532	...	0.3245	...	0.5893	...	0.7772
...	0.2032	...	0.5792	...	0.9302	...	0.4924
advocate	0.3424	...	0.2944	...	0.3923	...	0.3492

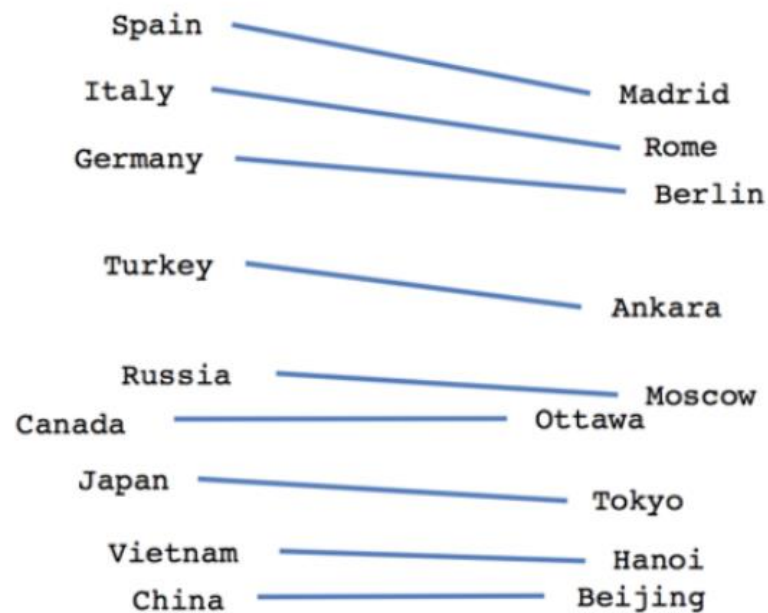
Word2vec: how to learn vectors

- Given the set of positive and negative training instances, and an initial set of embedding vectors
- The goal of learning is to adjust those word vectors such that we:
 - **Maximize** the similarity of the **target word, context word** pairs (w, c_{pos}) drawn from the positive data
 - **Minimize** the similarity of the (w, c_{neg}) pairs drawn from the negative data.

Word Embeddings Preserve Meaning



Verb tense

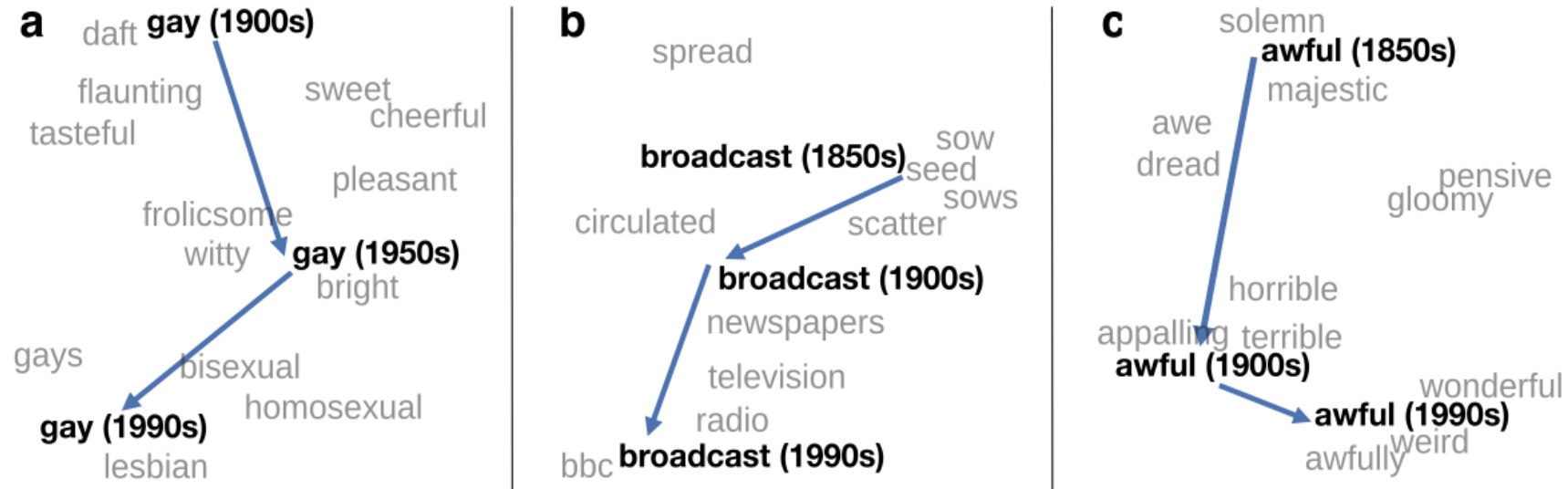


Country-Capital

Embeddings as a window onto historical semantics

Train embeddings on different decades of historical text to see meanings shift

~30 million books, 1850-1990, Google Books data



William L. Hamilton, Jure Leskovec, and Dan Jurafsky. 2016. Diachronic Word Embeddings Reveal Statistical Laws of Semantic Change. Proceedings of ACL.

Embeddings reflect cultural bias!

Bolukbasi, Tolga, Kai-Wei Chang, James Y. Zou, Venkatesh Saligrama, and Adam T. Kalai. "Man is to computer programmer as woman is to homemaker? debiasing word embeddings." In *NeurIPS*, pp. 4349-4357. 2016.

- Ask “Paris : France :: Tokyo : x”
 - x = Japan
- Ask “father : doctor :: mother : x”
 - x = nurse
- Ask “man : computer programmer :: woman : x”
 - x = homemaker

Algorithms that use embeddings as part of e.g., hiring searches for programmers, might lead to bias in hiring

Historical embedding as a tool to study cultural biases

Garg, N., Schiebinger, L., Jurafsky, D., and Zou, J. (2018). Word embeddings quantify 100 years of gender and ethnic stereotypes. *Proceedings of the National Academy of Sciences* 115(16), E3635–E3644.

- Compute a **gender or ethnic bias** for each adjective: e.g., how much closer the adjective is to "woman" synonyms than "man" synonyms, or names of particular ethnicities
- Embeddings for **competence** adjective (*smart, wise, brilliant, resourceful, thoughtful, logical*) are biased toward men, a bias slowly decreasing 1960-1990
- Embeddings for **dehumanizing** adjectives (barbaric, monstrous, bizarre) were biased toward Asians in the 1930s, bias decreasing over the 20th century.
- These match the results of old surveys done in the 1930s