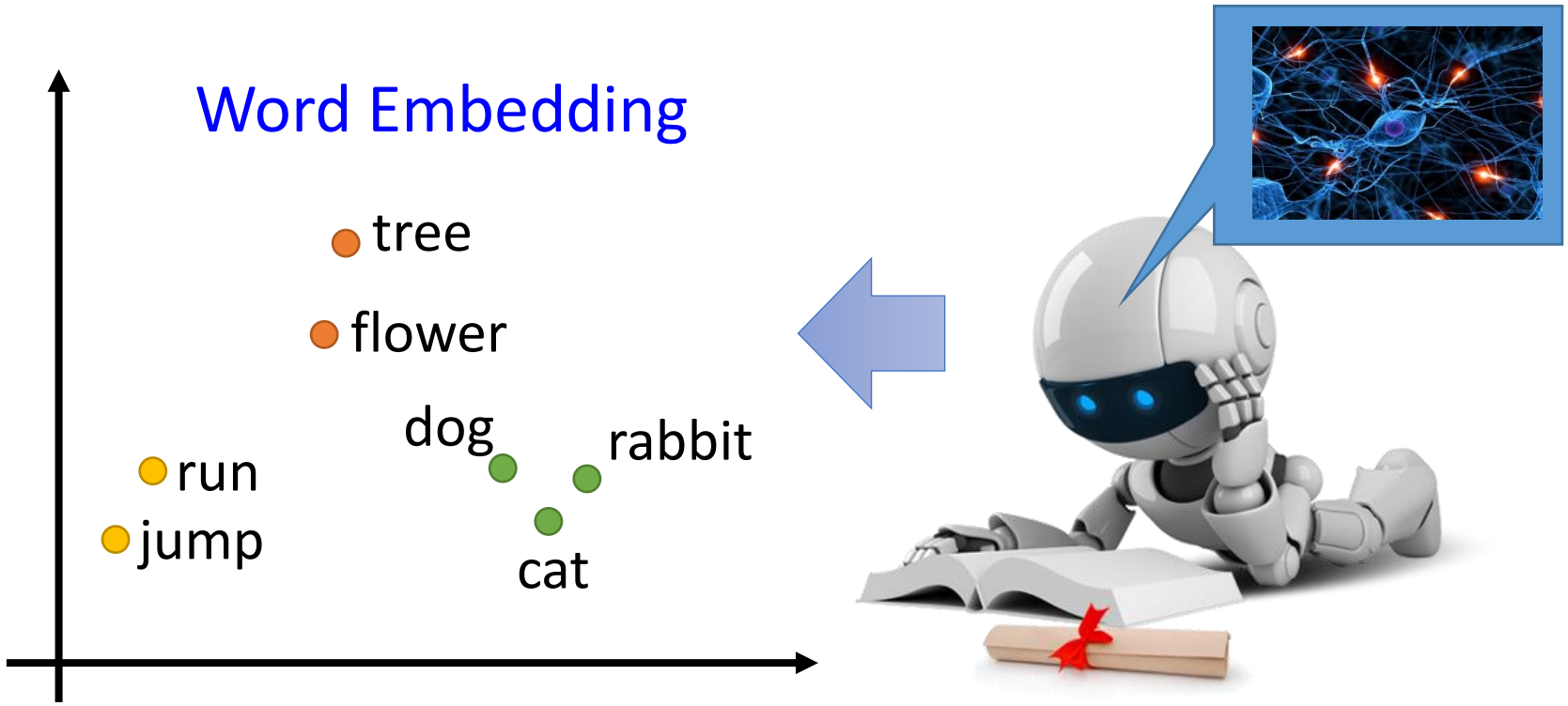
Unsupervised Learning: Word Embedding

Word Embedding是dimension reduction的一个好且广为人知的应用。

Word Embedding

- Machine learns the meaning of words from reading a lot of documents without supervision



1 1-of-N Encoding

apple = [1 0 0 0 0]

bag = [0 1 0 0 0]

cat = [0 0 1 0 0]

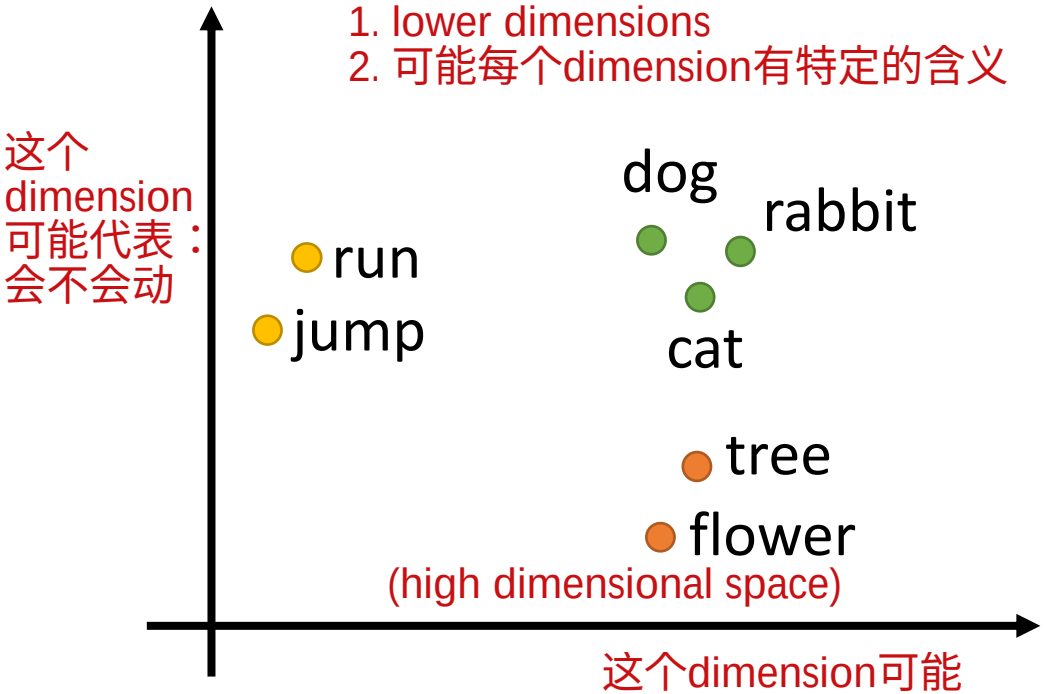
dog = [0 0 0 1 0]

elephant = [0 0 0 0 1]

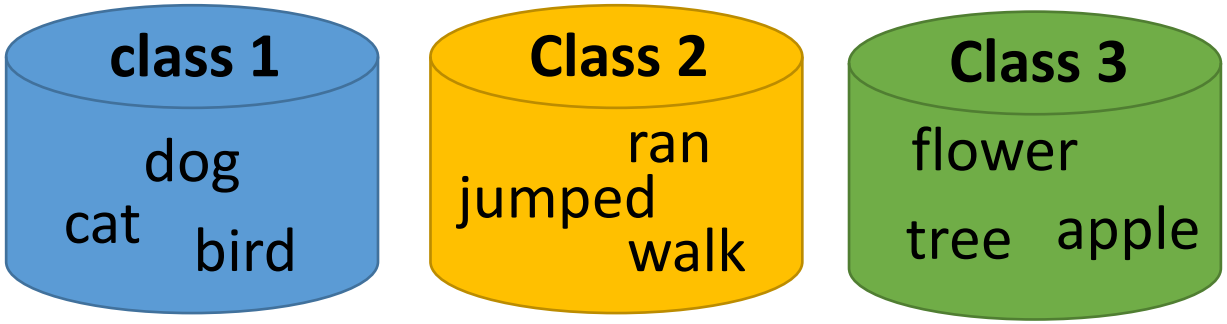
1. # of dimensions = # of words
2. vectors are not informative

3 Word Embedding

1. lower dimensions
2. 可能每个dimension有特定的含义



2 Word Class



How about auto-encoder? 不行

Word Embedding

- Machine learns the meaning of words from reading a lot of documents without supervision → unsupervised
- A word can be understood by its context

蔡英文、馬英九 are something very similar

You shall know a word by the company it keeps

馬英九 520宣誓就職

蔡英文 520宣誓就職

How to exploit the context?

1 • **Count based**

- If two words w_i and w_j frequently co-occur, $V(w_i)$ and $V(w_j)$ would be close to each other
- E.g. Glove Vector: http://nlp.stanford.edu/projects/glove/

$V(w_i) . V(w_j)$ ⟷ $N_{i,j}$

Inner product

Number of times w_i and w_j in the same document

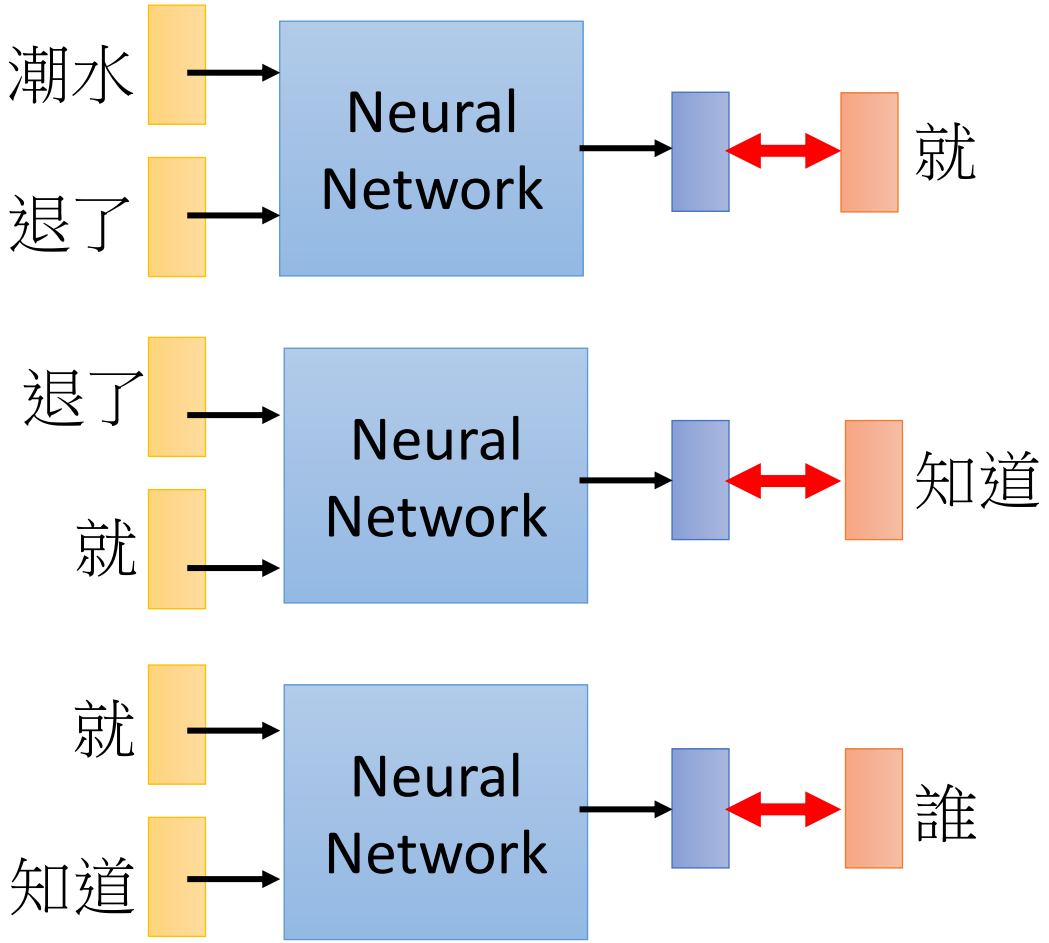
2 • **Prediction based**

Prediction-based – Training

Collect data:

潮水 退了 就 知道 誰 …
不爽 不要 買…
公道價 八萬 一…
……

Minimizing cross entropy



Prediction-based - 推文接話

推 louisee :話說十幾年前我念公立國中時,老師也曾做過這種事,但

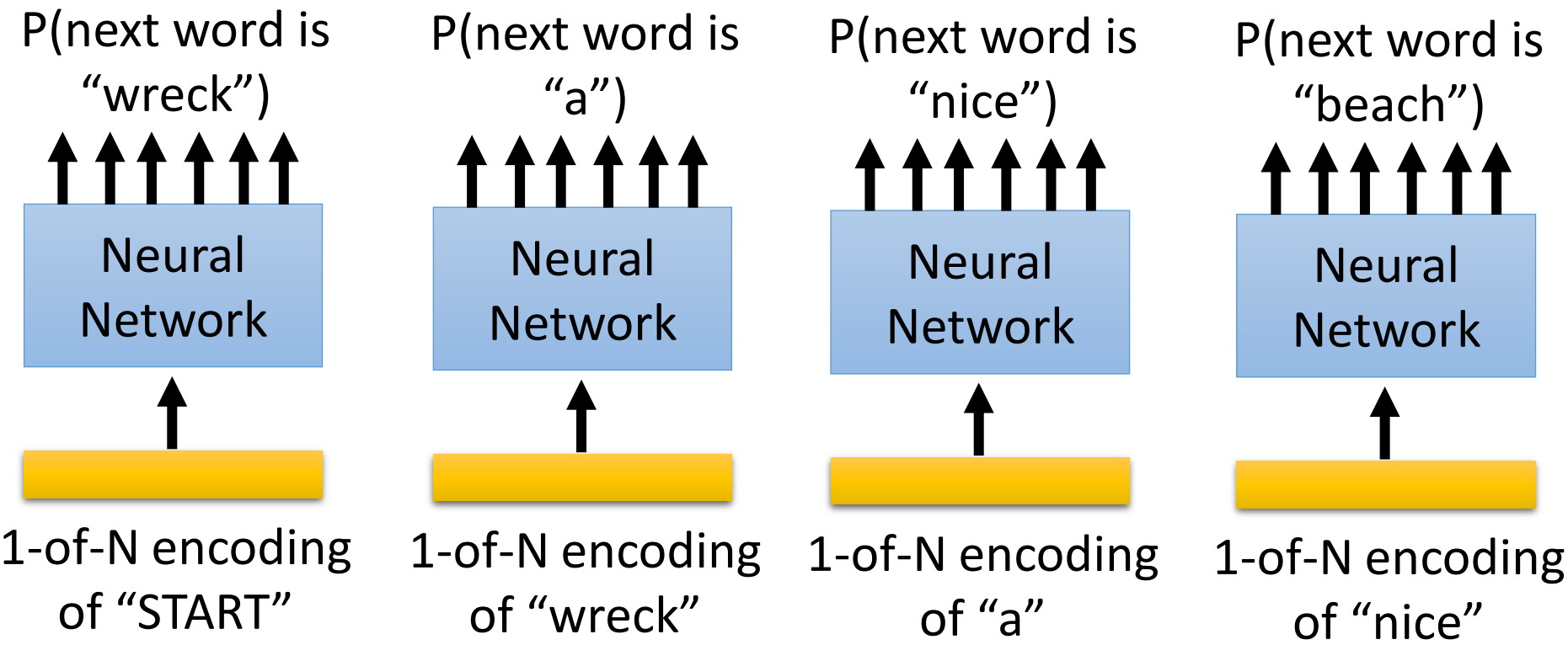
https://www.ptt.cc/bbs/Teacher/M.1317226791.A.558.html

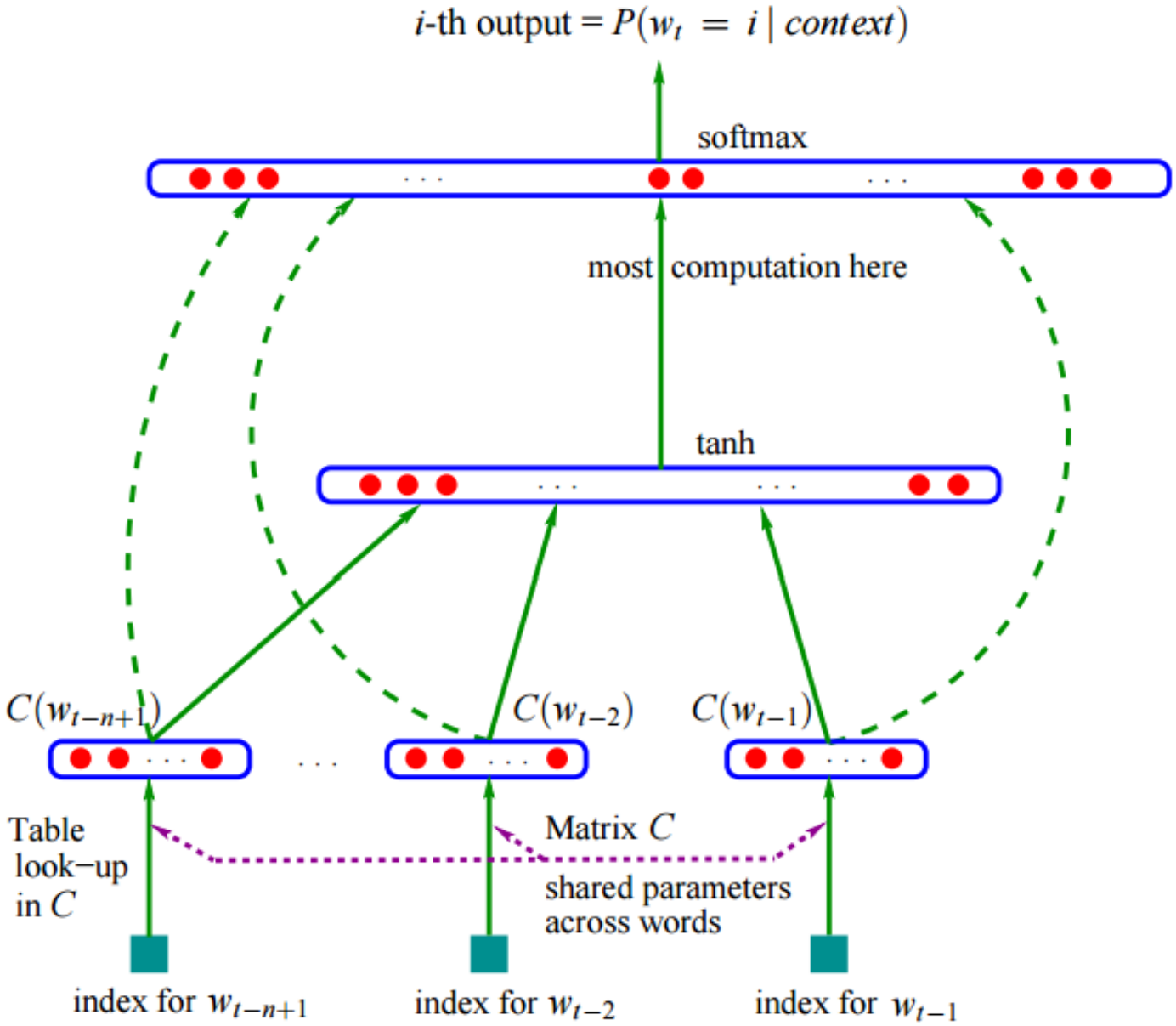
推 AO56789: 我同學才扯好不好，他有一次要交家政料理報告
→ AO56789:其中一個是要寫一樣水煮料理的食譜，他居然給我寫

著名簽名檔 (出處不詳)

Prediction-based – Language Modeling

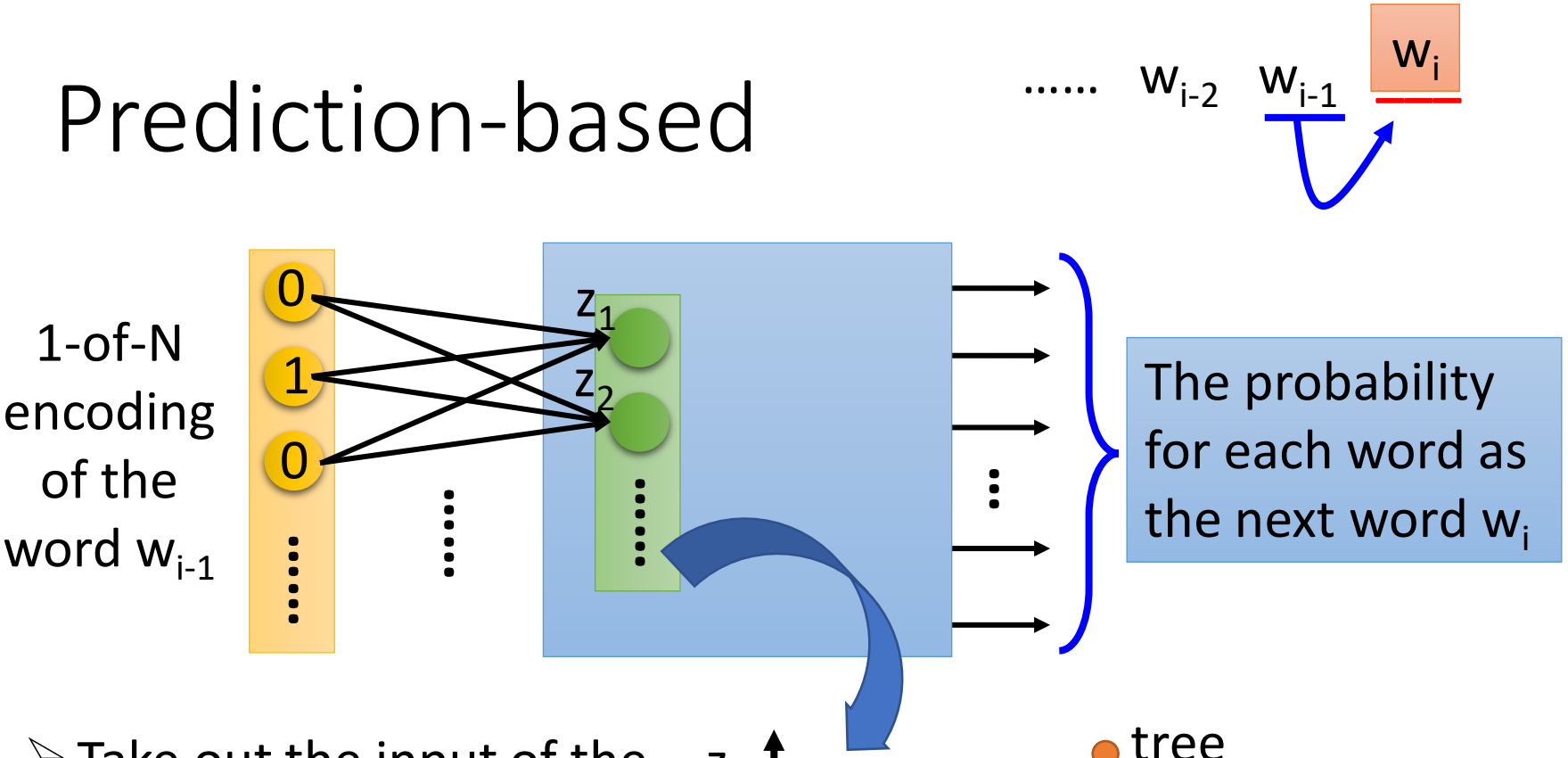
P("wreck a nice beach")
=P(wreck|START)P(a|wreck)P(nice|a)P(beach|nice)
P(b|a): the probability of NN predicting the next word.



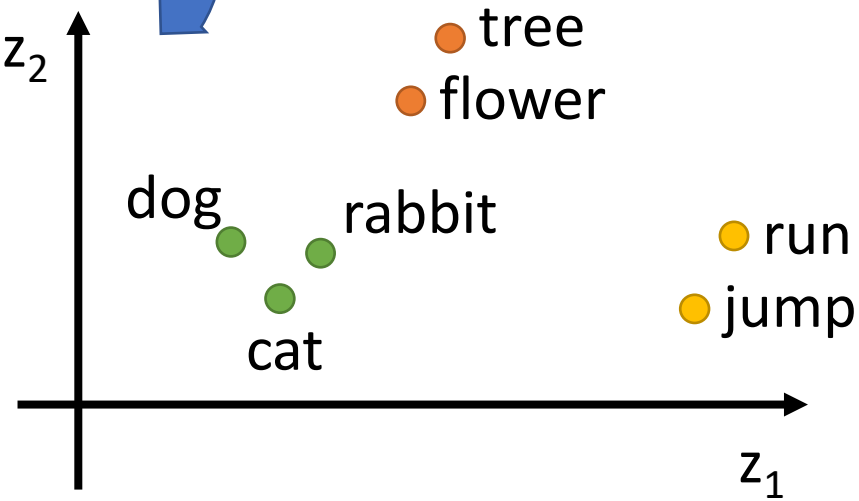


Bengio, Y., Ducharme, R., Vincent, P., & Jauvin, C. (2003). A neural probabilistic language model. *Journal of machine learning research*, *3*(Feb), 1137-1155.

Prediction-based

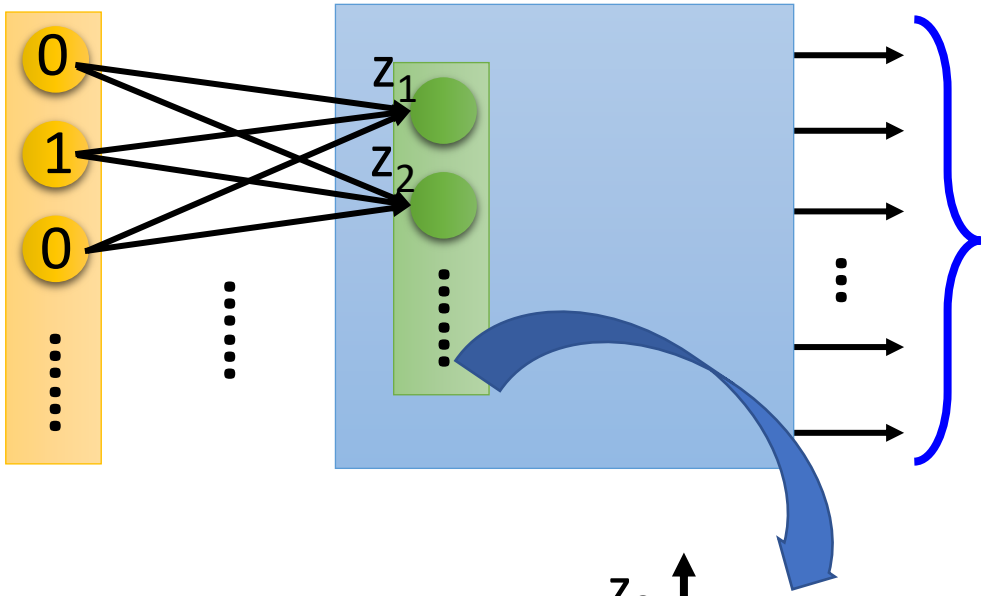


- Take out the input of the neurons in the first layer
- Use it to represent a word w
- Word vector, word embedding feature: V(w)



Prediction-based

You shall know a word by the company it keeps



蔡英文
or
馬英九

The probability for each word as the next word w_i

"宣誓就職" should have large probability

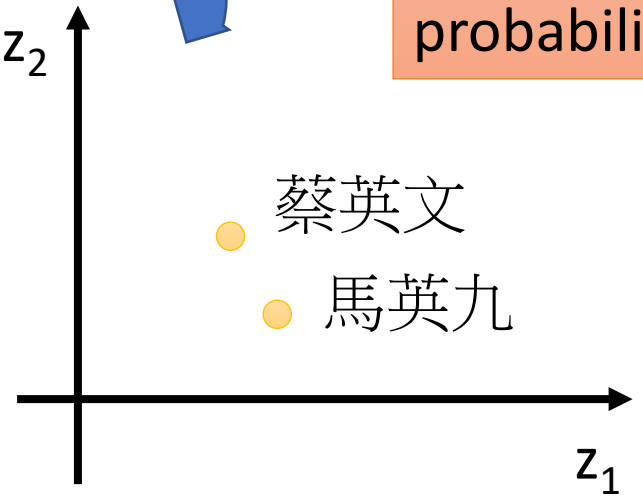
Training text:

…… 蔡英文 宣誓就職 ……

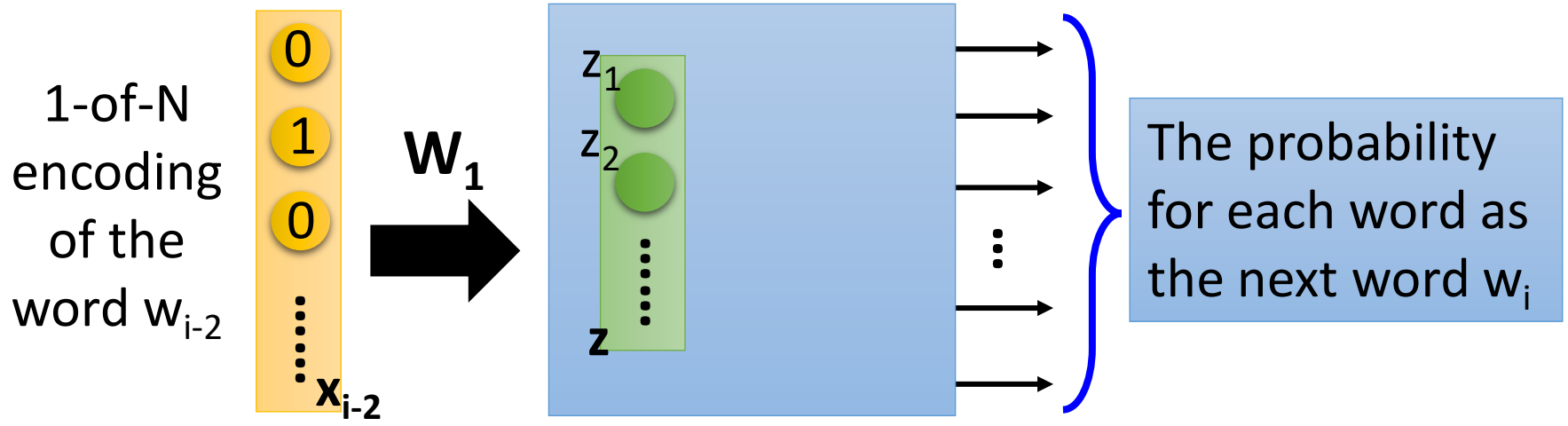
w_{i-1} w_i

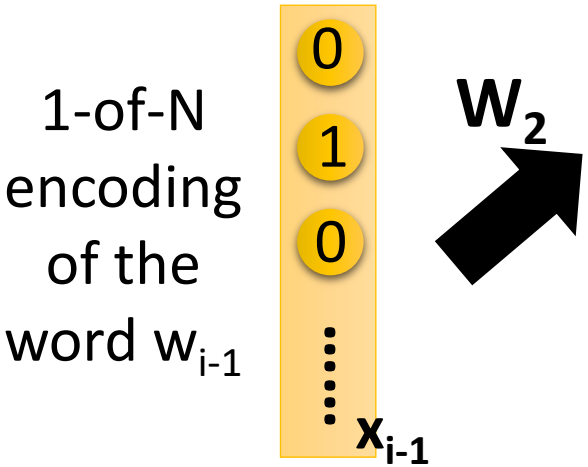
…… 馬英九 宣誓就職 ……

w_{i-1} w_i



Prediction-based – Sharing Parameters





The length of $\mathbf{x}_{i-1}$ and $\mathbf{x}_{i-2}$ are both $|V|$.

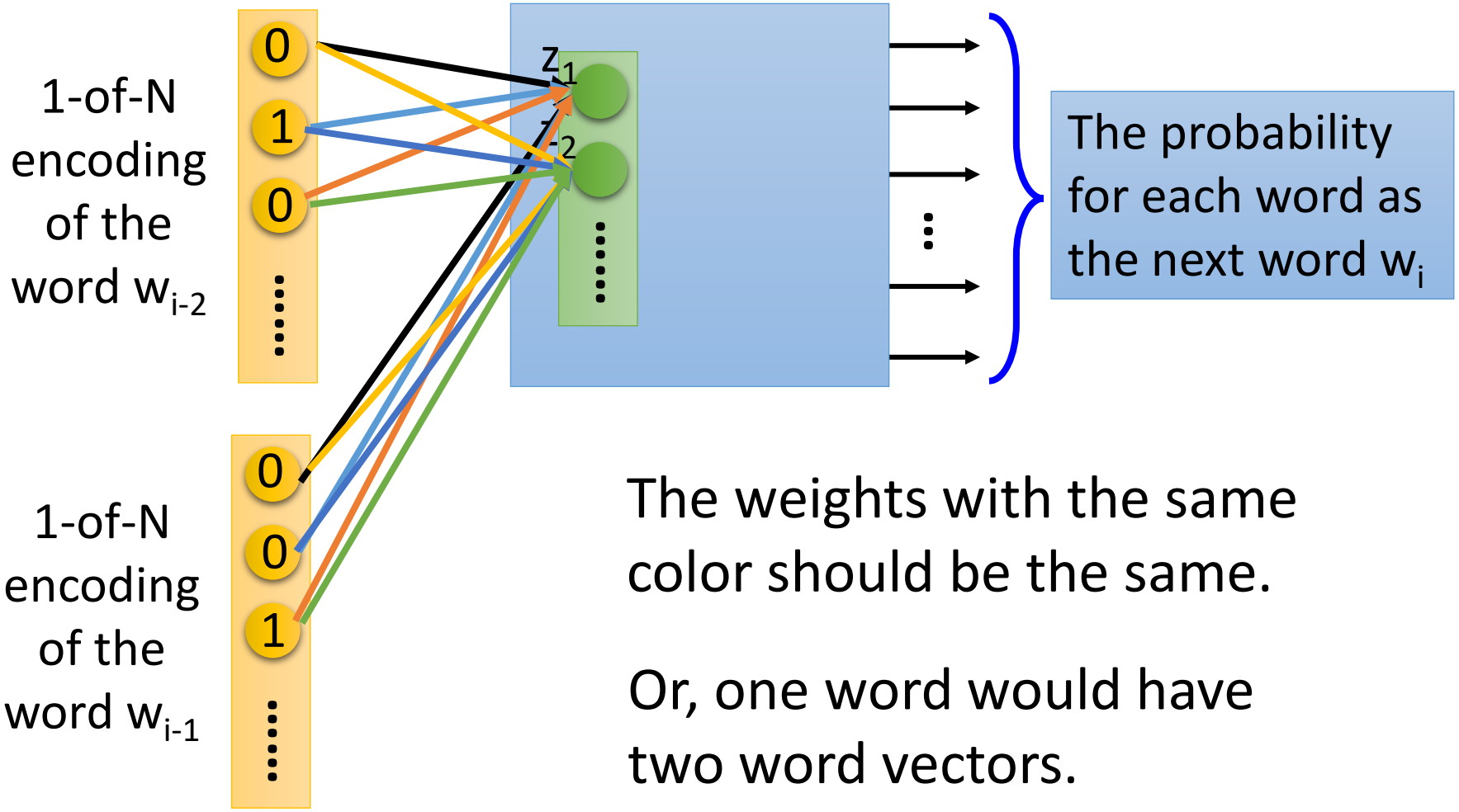
The length of $\mathbf{z}$ is $|Z|$.

$$\mathbf{z} = \mathbf{W}_1 \mathbf{x}_{i-2} + \mathbf{W}_2 \mathbf{x}_{i-1}$$

The weight matrix $\mathbf{W}_1$ and $\mathbf{W}_2$ are both $|Z|X|V|$ matrices.

$$\mathbf{W}_1 = \mathbf{W}_2 = \mathbf{W} \Rightarrow \mathbf{z} = \mathbf{W}(\mathbf{x}_{i-2} + \mathbf{x}_{i-1})$$

Prediction-based – Sharing Parameters

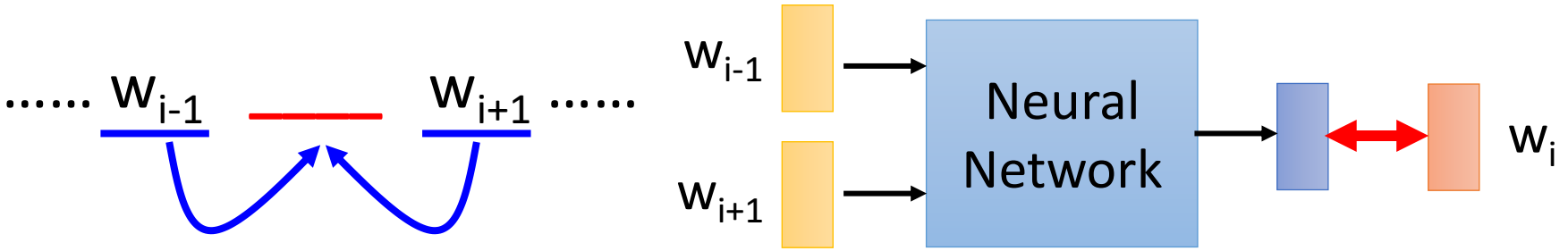


The weights with the same color should be the same.

Or, one word would have two word vectors.

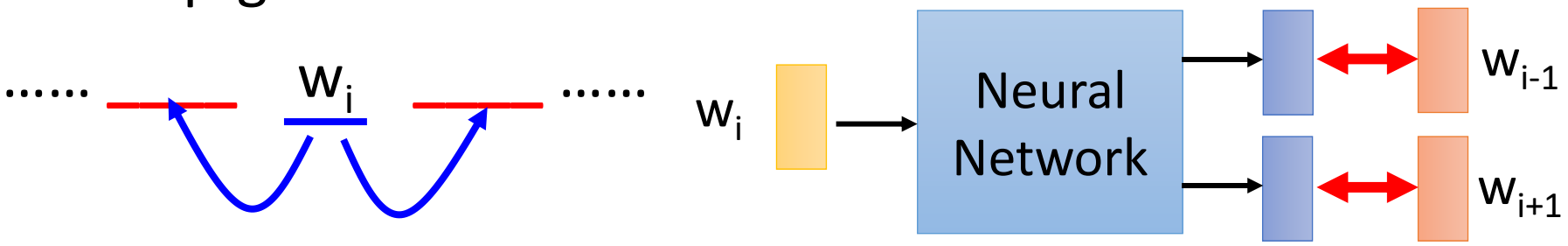
Prediction-based – Various Architectures

- Continuous bag of word (CBOW) model



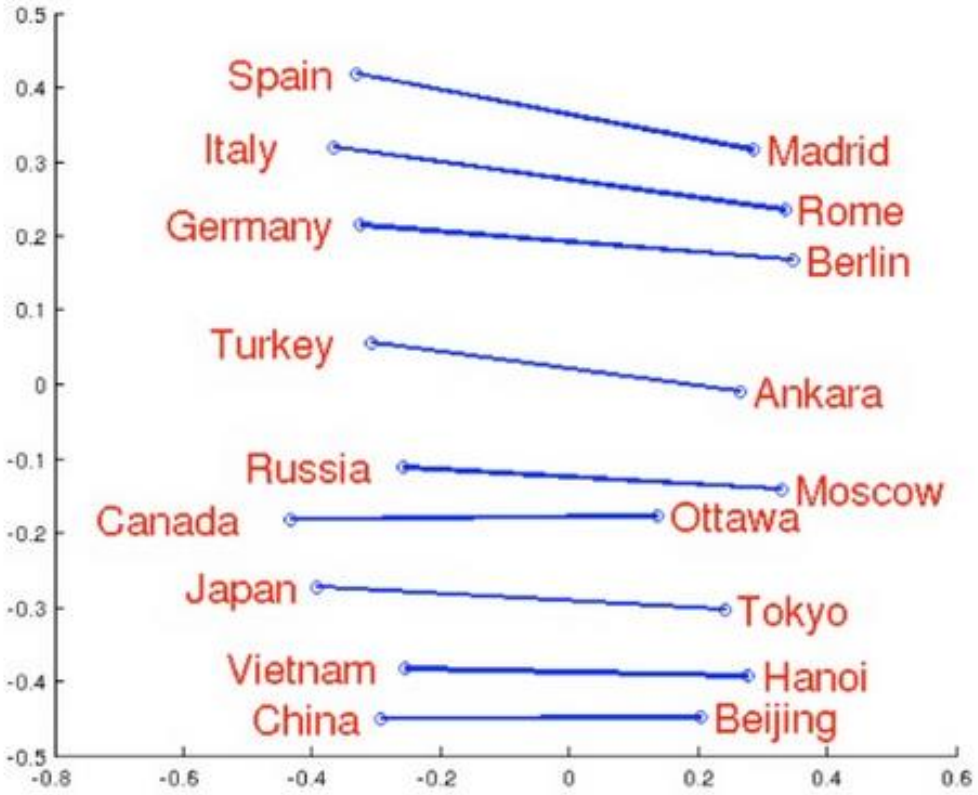
predicting the word given its context

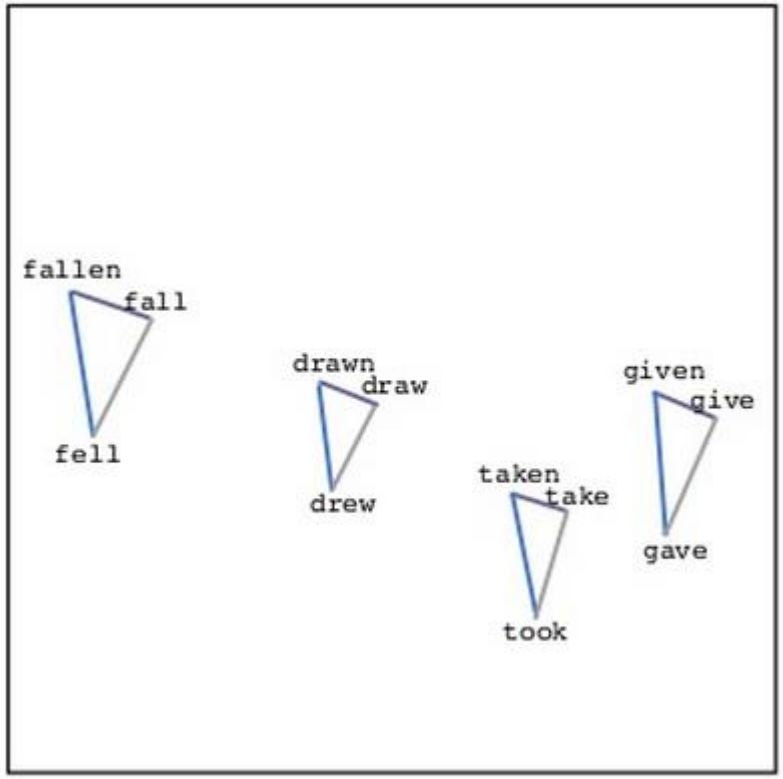
- Skip-gram



predicting the context given a word

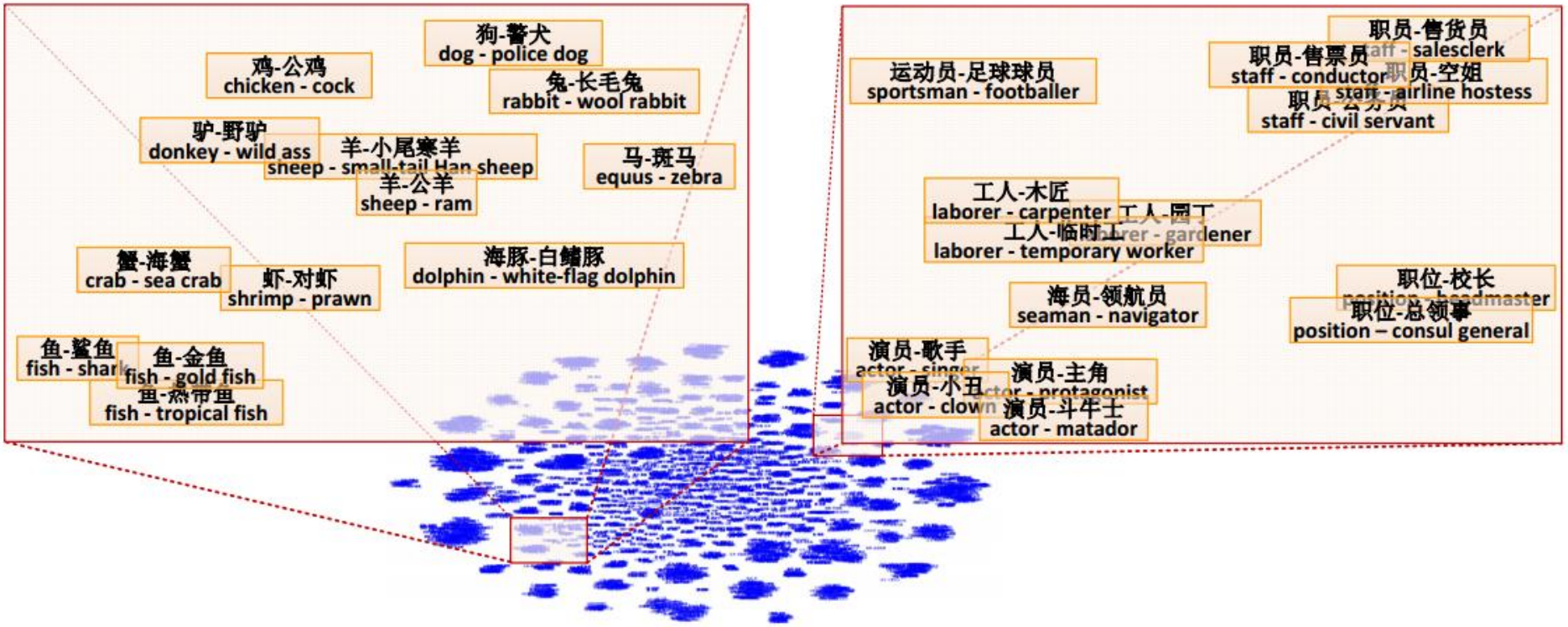
Word Embedding





Source: http://www.slideshare.net/hustwj/cikm-keynotenov2014

Word Embedding



Fu, Ruiji, et al. "Learning semantic hierarchies via word embeddings."*Proceedings of the 52th Annual Meeting of the Association for Computational Linguistics: Long Papers*. Vol. 1. 2014.

Word Embedding

- Characteristics

$$V(Germany) \approx V(Berlin) - V(Rome) + V(Italy)$$

$$V(hotter) - V(hot) \approx V(bigger) - V(big)$$

$$V(Rome) - V(Italy) \approx V(Berlin) - V(Germany)$$

$$V(king) - V(queen) \approx V(uncle) - V(aunt)$$

- Solving analogies

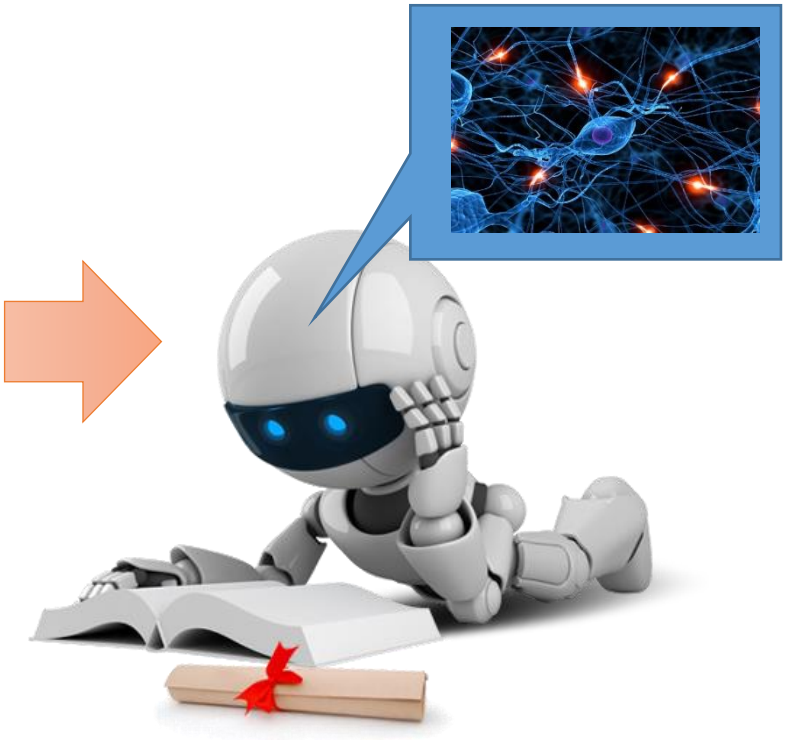
Rome : Italy = Berlin : ?

Compute $V(Berlin) - V(Rome) + V(Italy)$

Find the word w with the closest V(w)

Demo

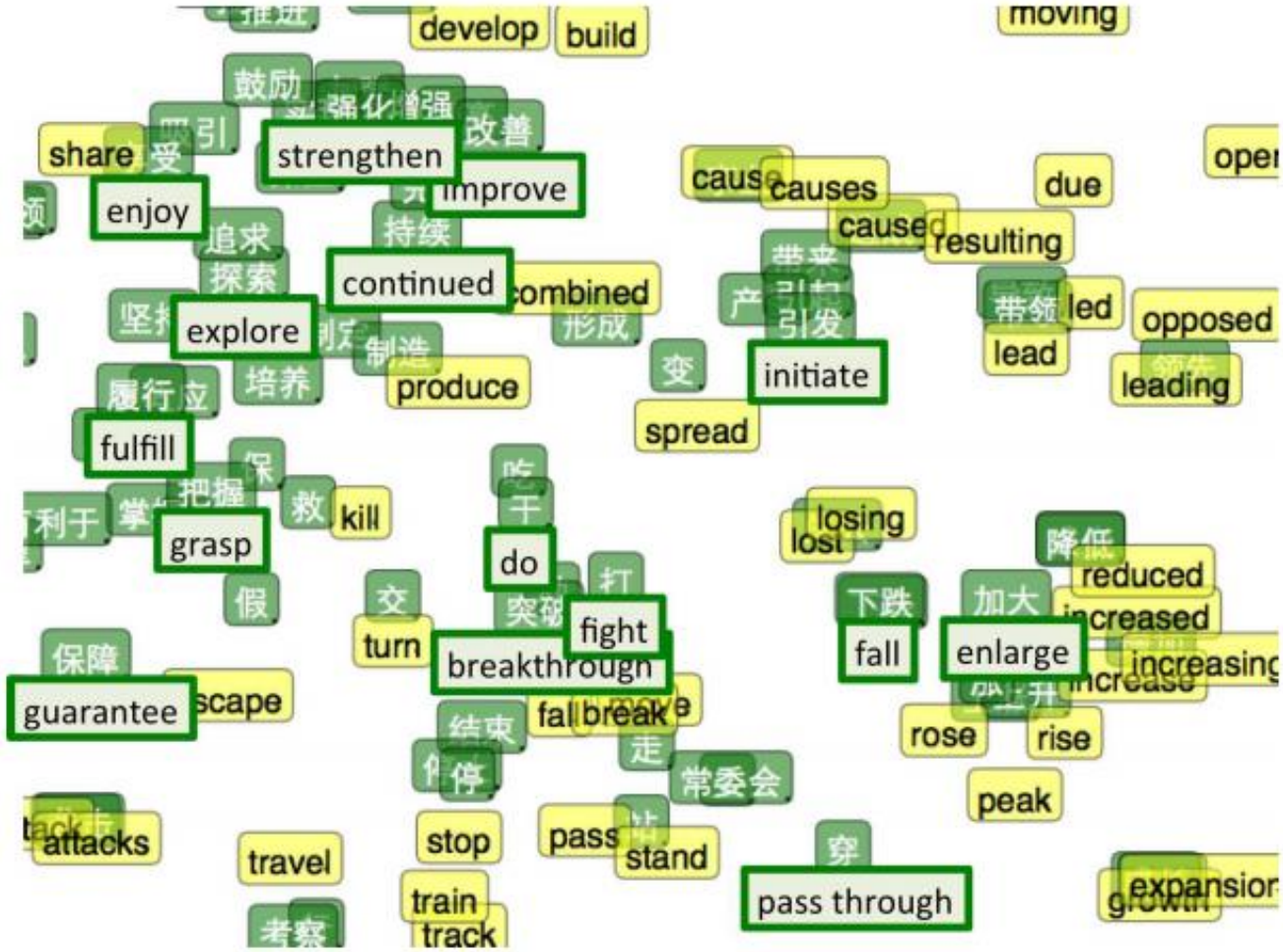
- Machine learns the meaning of words from reading a lot of documents without supervision



Demo

- Model used in demo is provided by 陳仰德
  - Part of the project done by 陳仰德、林資偉
  - TA: 劉元銘
  - Training data is from PTT (collected by 葉青峰)

Multi-lingual Embedding



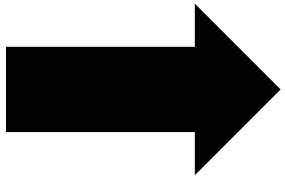
Bilingual Word Embeddings for Phrase-Based Machine Translation, Will Zou, Richard Socher, Daniel Cer and Christopher Manning, EMNLP, 2013

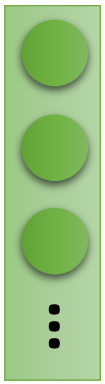
Document Embedding

- word sequences with different lengths → the vector with the same length
  - The vector representing the meaning of the word sequence
  - A word sequence can be a document or a paragraph

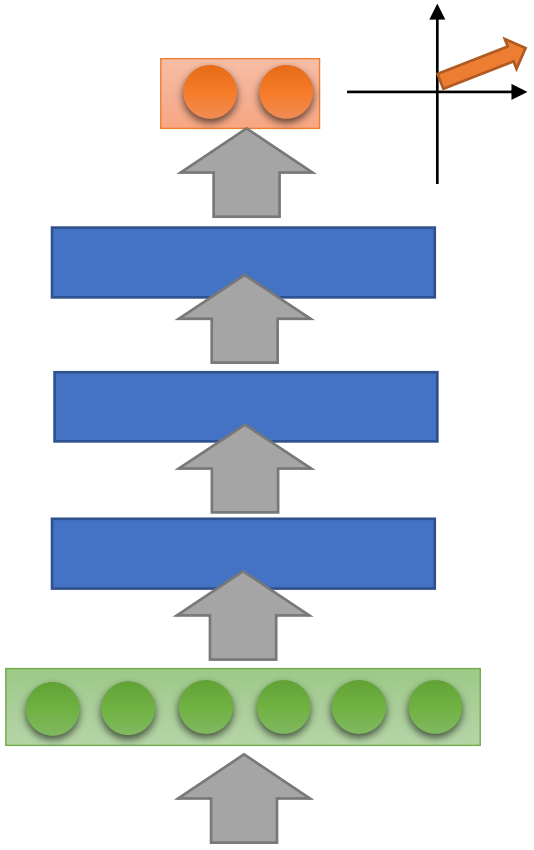
word sequence

(a document or paragraph)

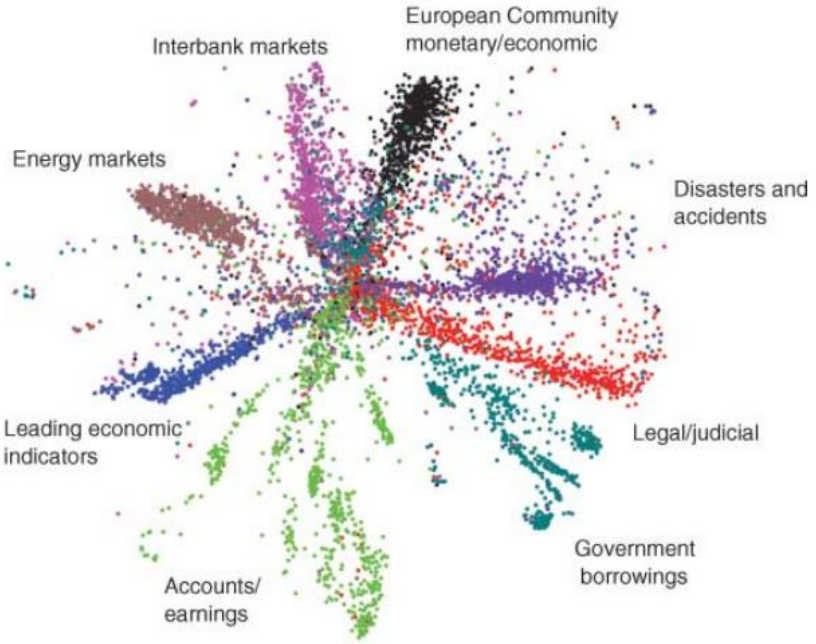




Semantic Embedding



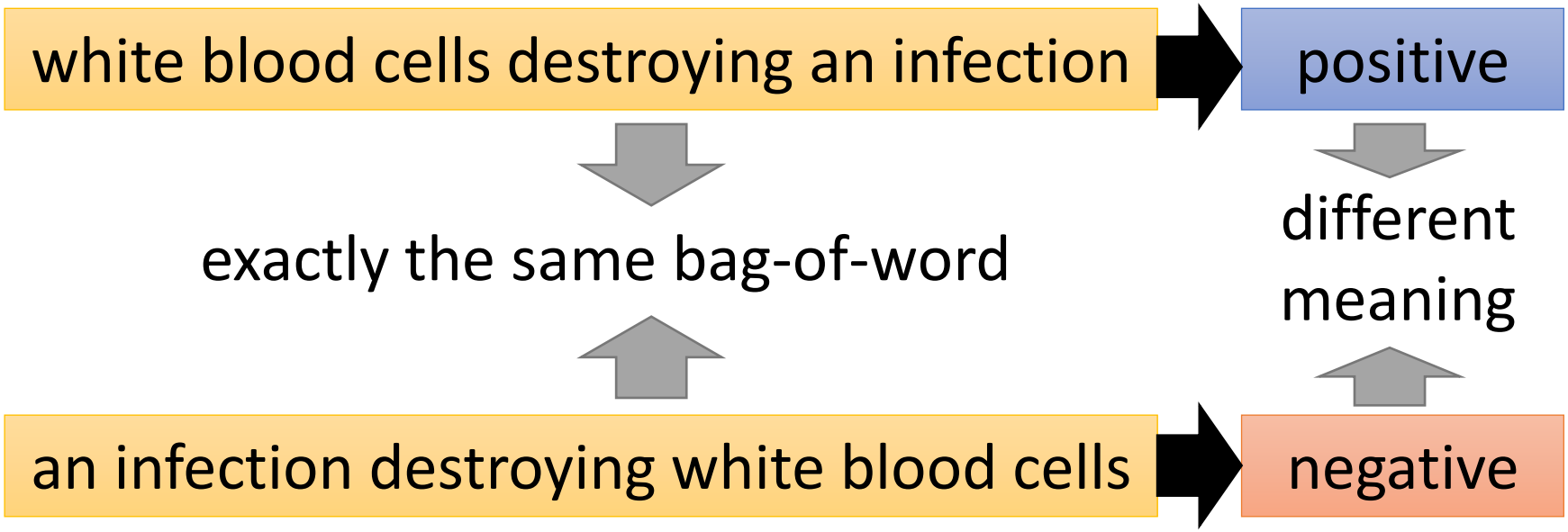
Bag-of-word



Reference: Hinton, Geoffrey E., and Ruslan R. Salakhutdinov. "Reducing the dimensionality of data with neural networks." *Science* 313.5786 (2006): 504-507

Beyond Bag of Word

- To understand the meaning of a word sequence, the order of the words can not be ignored.



Beyond Bag of Word

- ***Paragraph Vector***: Le, Quoc, and Tomas Mikolov. "Distributed Representations of Sentences and Documents.“ ICML, 2014
- ***Seq2seq Auto-encoder***: Li, Jiwei, Minh-Thang Luong, and Dan Jurafsky. "A hierarchical neural autoencoder for paragraphs and documents." arXiv preprint, 2015
- ***Skip Thought***: Ryan Kiros, Yukun Zhu, Ruslan Salakhutdinov, Richard S. Zemel, Antonio Torralba, Raquel Urtasun, Sanja Fidler, “Skip-Thought Vectors” arXiv preprint, 2015.

Acknowledgement

- 感謝 John Chou 發現投影片上的錯字