

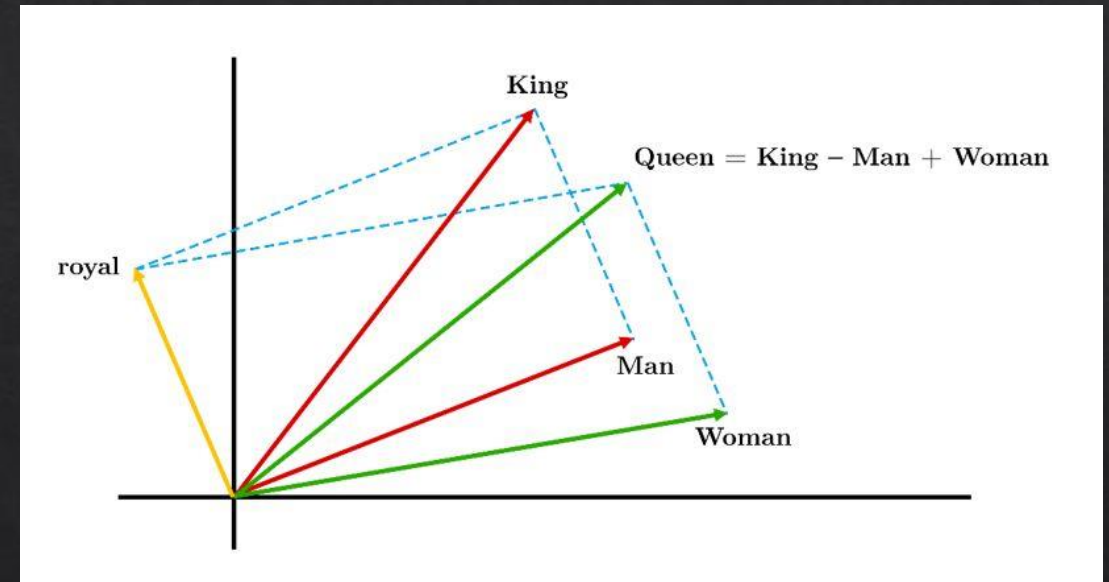
A peek into word embeddings using word2vec

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Word embeddings & Word2Vec

- ◇ Represent words as vectors. (String \rightarrow double[])
 - ◇ Here we have an example.
 - ◇ Basis: $\langle \text{👑}, \text{♀} \rangle$ (instead of the standard $\langle 1, 1 \rangle$)
 - ◇ $\text{Man} = \langle 1, 1 \rangle$
 - ◇ $\text{Woman} = \langle 1, 2 \rangle$
 - ◇ $\text{King} = \langle 2, 1 \rangle$
 - ◇ $\text{Queen} = \text{King} - \text{Man} + \text{Woman}$
 $= \langle 2, 1 \rangle - \langle 1, 1 \rangle + \langle 1, 2 \rangle$
 $= \langle 2, 2 \rangle$



- ◇ The word vectors capture the semantic meanings* of words.
- ◇ In real life applications, the vector spaces usually have much higher dimensions.

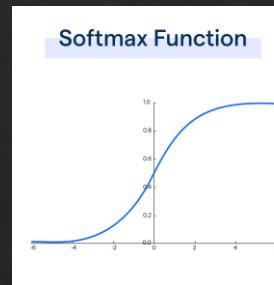
* Semantic meaning: the interpretation or the inherent meaning of a word, phrase, sentence or text within a particular context.

Probability in Word2Vec models

- ◇ CBOW: input Outside context words → output Center word
- ◇ Skip-gram: input Center word → output Outside context words
- ◇ Let's focus on Skip-gram.
- ◇ We calculate the probability in the training of models:

$$P(O = o | C = c) = \frac{e^{\vec{u}_o^T \cdot \vec{v}_c}}{\sum_{w \in \text{Vocab}} e^{\vec{u}_w^T \cdot \vec{v}_c}} \in [0, 1]$$

- ◇ The softmax function gives a probability distribution.
- ◇ Probability of words appearing together in the data → semantic meanings
- ◇ The word vectors are continuously adjusted to maximize the probability.

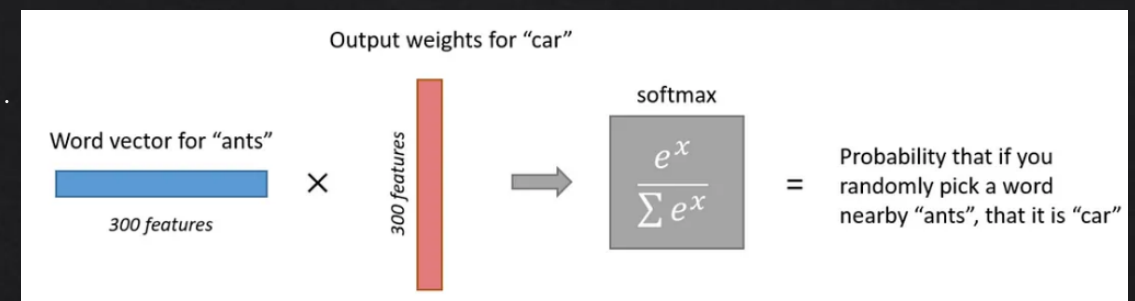
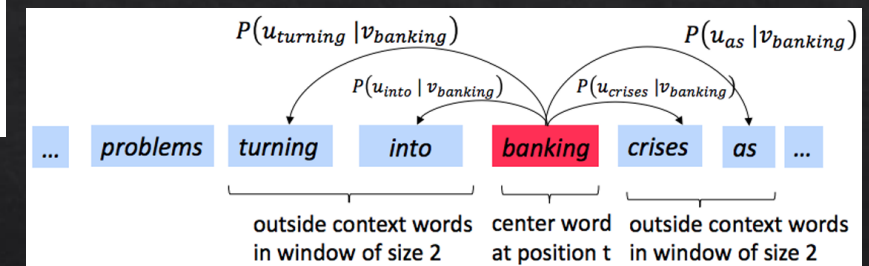
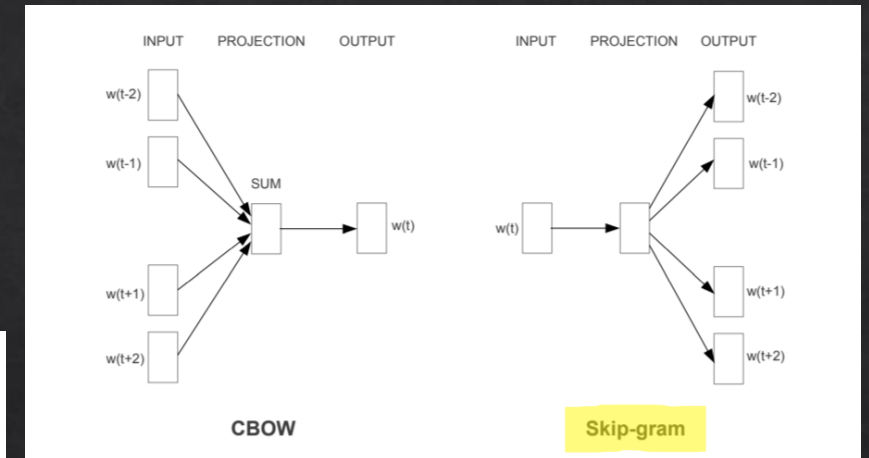
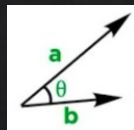


- ◇ The trained models compute the cosine similarity $\cos \theta$

$$\text{Recall that } \cos \theta = \frac{\vec{a} \cdot \vec{b}}{|\vec{a}| |\vec{b}|} = \hat{a} \cdot \hat{b} \in [-1, 1]$$

- ◇ Similarity of the semantic meanings of the words

- ◇ Note that dot products are involved in both the calculations of $\cos \theta$ and P ...



Code implementation

- ◆ Implementing a basic Skip-Gram model:

```
epoch 999 loss = 15919.783211167764
```

```
Top 3 words most similar to 'food' in the essay: ['i_', 'nourish', 'plant-based']
```

- ◆ Using a pre-trained model (word2vec-google-news-300):

```
# Get the analogy
print("Man is to king as woman is to", analogy("man", "king", "woman")) # queen
Man is to king as woman is to queen
```

- ◆ Factors affecting prediction: size of corpus, preprocessing techniques (stop word removal, tokenization), epochs, sampling etc.

```
Most similar words to the word "food":
foods 0.6804922819137573
Food 0.6538903713226318
foodstuffs 0.642582893371582
meals 0.616668701171875
food_stuffs 0.5928642153739929
nourishing_meals 0.5847609043121338
foodstuff 0.5835224986076355
staple_foods 0.5535788536071777
nutritious 0.5466451644897461
meal 0.5433712601661682
```

```
wv.most_similar("good")
[('great', 0.7291510105133057),
 ('bad', 0.7190051078796387),
 ('terrific', 0.6889115571975708),
 ('decent', 0.6837348341941833),
 ('nice', 0.6836092472076416),
 ('excellent', 0.644292950630188),
 ('fantastic', 0.6407778263092041),
 ('better', 0.6120728850364685),
 ('solid', 0.5806034803390503),
 ('lousy', 0.576420247554779)]
```

- ◆ Please visit [the GitHub Repository](https://github.com/yueagar/ESTR2018-project)* to read the more detailed explanation and download the full source code. Thank you.

* Link: <https://github.com/yueagar/ESTR2018-project>

