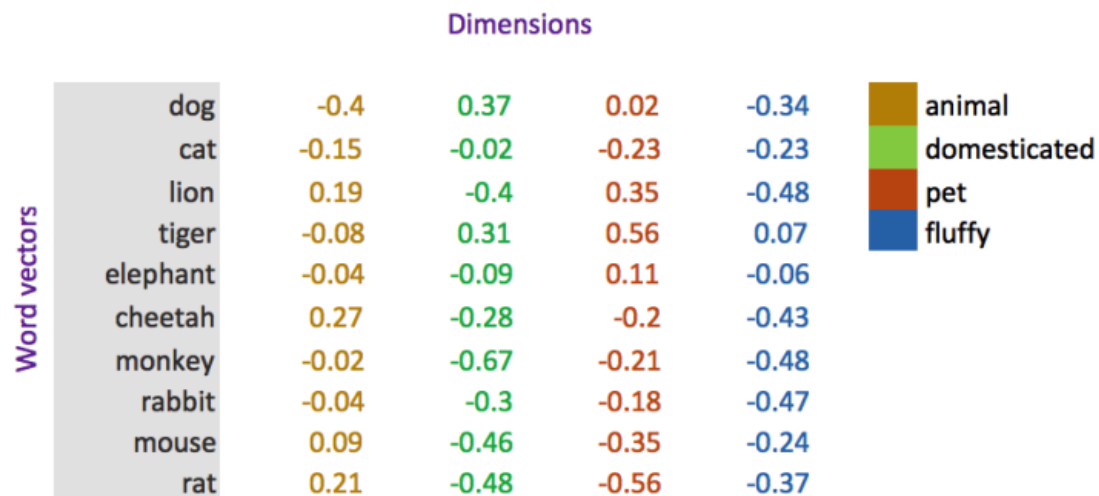


Word representation in machine learning problem

1. Localist representation: One-hot encoding vector, a vector of zeros, excepts the position where the target is in the word pool.
2. **Words vector**: word embeddings or word representations, which are distributed representation. Captures word meanings by a vector of real valued numbers (as opposed to dummy numbers) where each point captures a dimension of the word's meaning and where semantically similar words have similar vectors.



Advantage:

- Relatively smaller dimension
- similar words as similar word vectors, and can be measured mathematically.
- support mathematical operation e.g. King - Man + Women = Queen

How to construct word vector?

SVD method

1. Construct a matrix X:
 - Word to document matrix
 - Window based Co-occurrence Matrix
2. Apply $X = USV^T$

3. Select k columns of U .

disadvantage: computational intensive $\mathcal{O}(N^2)$

Word2vec

Likelihood function:

$$Likelihood = L(\theta) = \prod_{t=1}^T \prod_{-m \leq j \leq m; j \neq 0} P(w_{t+j} | w_t; \theta)$$

Objective function:

$$J(\theta) = -\frac{1}{T} \log L(\theta) = -\frac{1}{T} \sum_{t=1}^T \sum_{-m \leq j \leq m; j \neq 0} \log P(w_{t+j} | w_t; \theta)$$

where

$$P(w_{t+j} | w_t; \theta) = \text{Softmax}(\mu_o^T v_c) = \frac{e^{\mu_o^T v_c}}{\sum_{w \in W} e^{\mu_w^T v_c}}$$

then we can write:

$$J(\theta) = -\frac{1}{T} \sum_{t=1}^T \sum_{o \in V} \log \frac{e^{\mu_o^T v_c}}{\sum_{w \in W} e^{\mu_w^T v_c}}$$

find the derivative

$$\begin{aligned} \frac{\partial J}{\partial v_c} &= \frac{\partial}{\partial v_c} - \frac{1}{T} \sum_{t=1}^T \sum_{o \in V} [u_o^T v_c - \log \sum_{w \in W} e^{u_w^T v_c}] \\ &= -\frac{1}{T} \sum_{t=1}^T \sum_{o \in V} [u_o - \sum_{w \in W} P(u_o | v_c) u_w] \\ \frac{\partial J}{\partial u_o} &= \frac{\partial}{\partial u_o} - \frac{1}{T} \sum_{t=1}^T \sum_{o \in V} [u_o^T v_c - \log \sum_{w \in W} e^{u_w^T v_c}] \\ &= -\frac{1}{T} \sum_{t=1}^T [(1 - P(u_o | v_c)) v_c] \end{aligned}$$

A very good source that explains word2vec in very details can be found [here](#)

