

Feature representation

LS-1

... x_{t-3} x_{t-2} x_{t-1} x_t x_{t+1} x_{t+2} x_{t+3} ...

Vocabulary : $X = I(N) = N \begin{bmatrix} 1 & & & \\ & \ddots & & \\ & & \ddots & \\ & & & 1 \end{bmatrix}$

ith word = { 0, 0, 0, ..., i, 0, 0 ..., 0 }

CENTER WORD = λ_m

$$D = \left\{ X_w^{(1)}, X_c^{(1)} \quad \dots \dots \quad X_w^{(m)}, X_c^{(m)} \right\}$$

The diagram illustrates the context window for a word X_t . On the left, a box contains four words: X_{t-1} , X_t , X_{t+1} , and X_{t+2} . An arrow points from this box to a larger bracket on the right, which encloses the words X_{t-1} , X_t , and X_{t+1} . The bracket is labeled "CONTEXT WINDOW * 2". Below the bracket, the words are labeled "EXAMPLES PER CENTER WORD."

Word2Vec

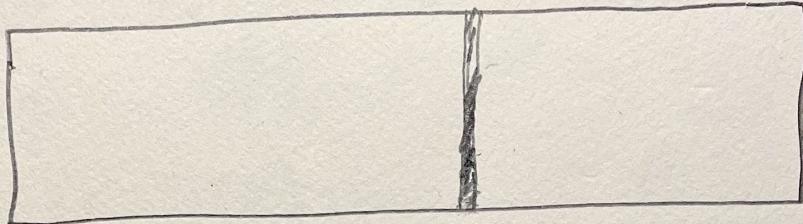
L7-2

CENTER word projection

$$U \in \mathbb{R}^{K \times N}$$

$x_w \in \{0, 1\}^N \Rightarrow x_w \cdot U \Rightarrow u_w \Rightarrow$ w^m column vector from U !!!

$$U =$$



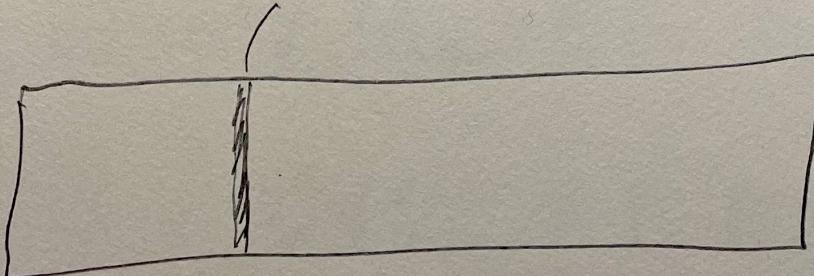
$\hookrightarrow w^m$ column
= EMBEDDING for
CENTER word w

Context word projection

$$V \in \mathbb{R}^{K \times N}$$

c^m context word EMBEDDING V_c

$$V =$$



$u_w^\top \cdot V_c \Rightarrow$ Large for $x_{w,c}$ if w, c appears in D

$u_w^\top \cdot V_c \Rightarrow$ Small or Neg. If w, c does not appear in D

WORD2VEC ALGORITHM

L5-3

STEP 1

RANDOMLY INITIALIZE $U, V \in \mathbb{R}^{K \times N}$

STEP 2

for $X_w, X_c \in D$ do:

(a) Select u_w from X_w

(b) Compute $u_w^T V \in \mathbb{R}^N$

$$(c) P(X_c | X_w; U, V) = \frac{e^{(u_w^T V)_c}}{\sum_{j=1}^N e^{(u_w^T V)_j}} \in [0, 1]^N$$

$$(d) NLL(U, V | X_w, X_c) = -X_c \cdot \log P_{X_c | X_w}$$

$$= P_{X_c | X_w}$$

(e) GRADIENT OF NLL:

$$\nabla_{U_w} \text{NLL} = V \cdot (P_{X_c | X_w} - X_c)^T \in \mathbb{R}^{K \times 1}$$

$$\nabla_V \text{NLL} = u_w^T \cdot (P_{X_c | X_w} - X_c) \in \mathbb{R}^{K \times N}$$

(f) UPDATE STEP: LEARNING RATE $0.1 \rightarrow 0.0001$

loop

$$U_w = U_w - \eta \nabla_{U_w} \text{NLL} \Rightarrow \text{UPDATES } U^{\text{TH}} \text{ COLUMN OF } U$$

$$V = V - \eta \nabla_V \text{NLL} \Rightarrow \text{UPDATES ENTIRE } V \text{ MATRIX!}$$