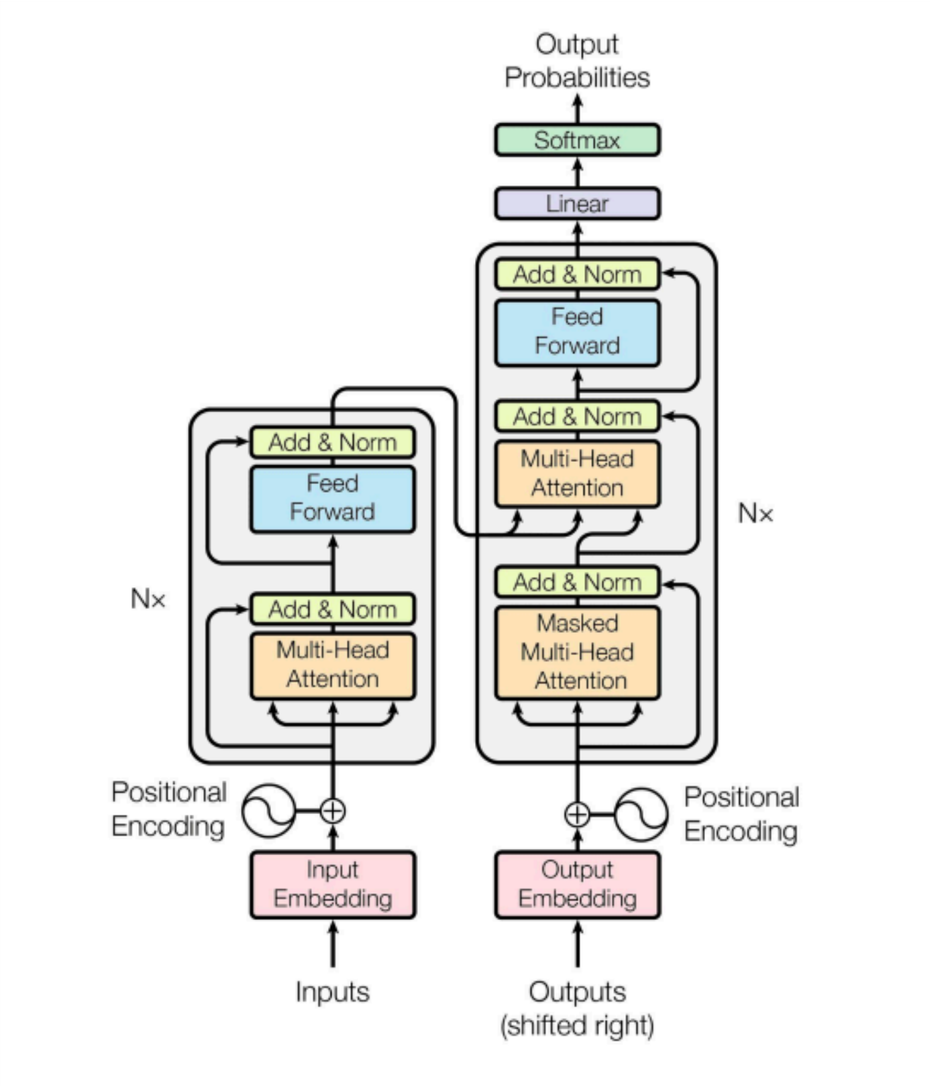
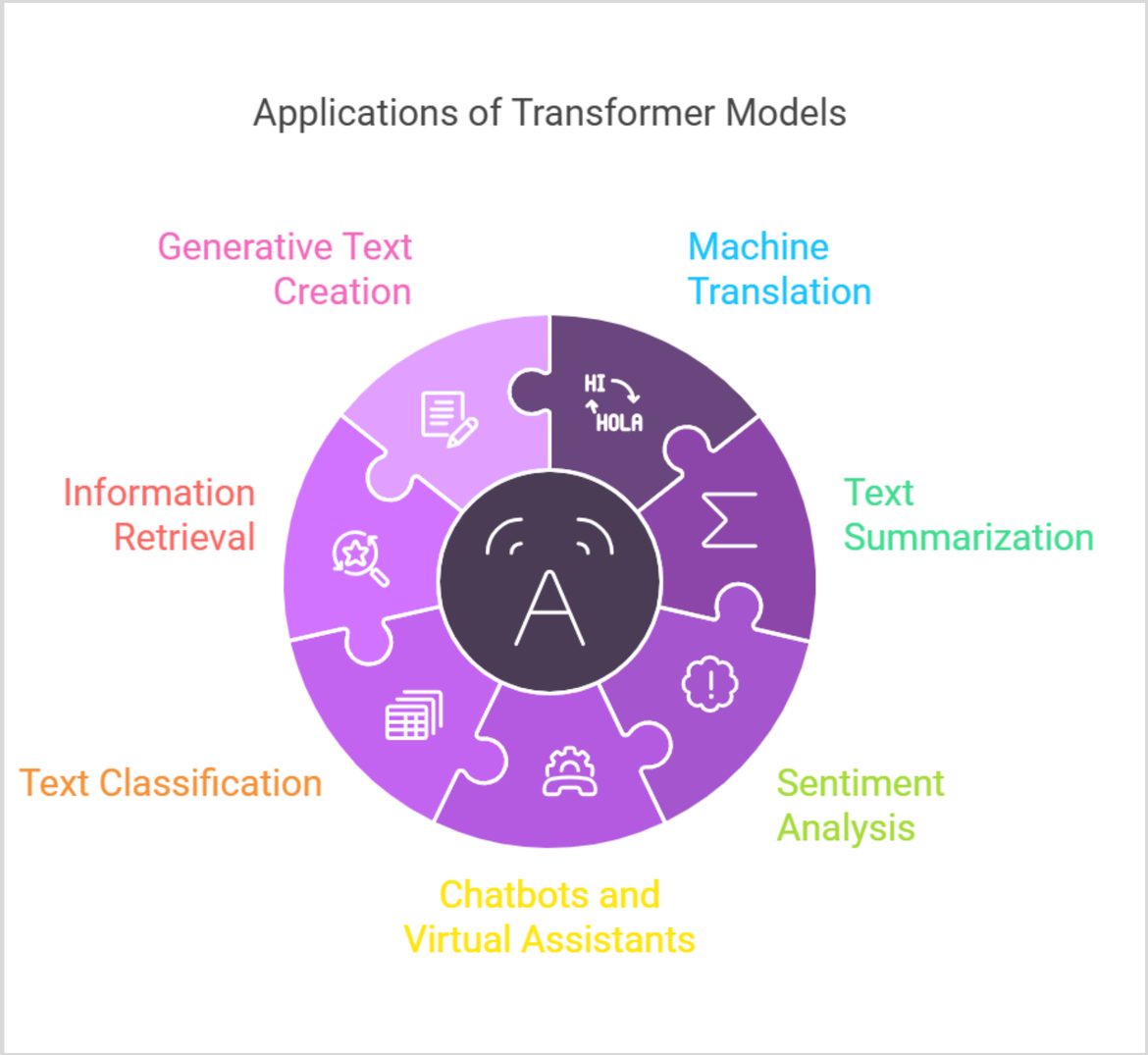


Transformer

معماری ترنسفورمر برای اولین بار در سال ۲۰۱۷ در مقاله‌ای با عنوان مشهور "Attention Is All You Need" معرفی شد.

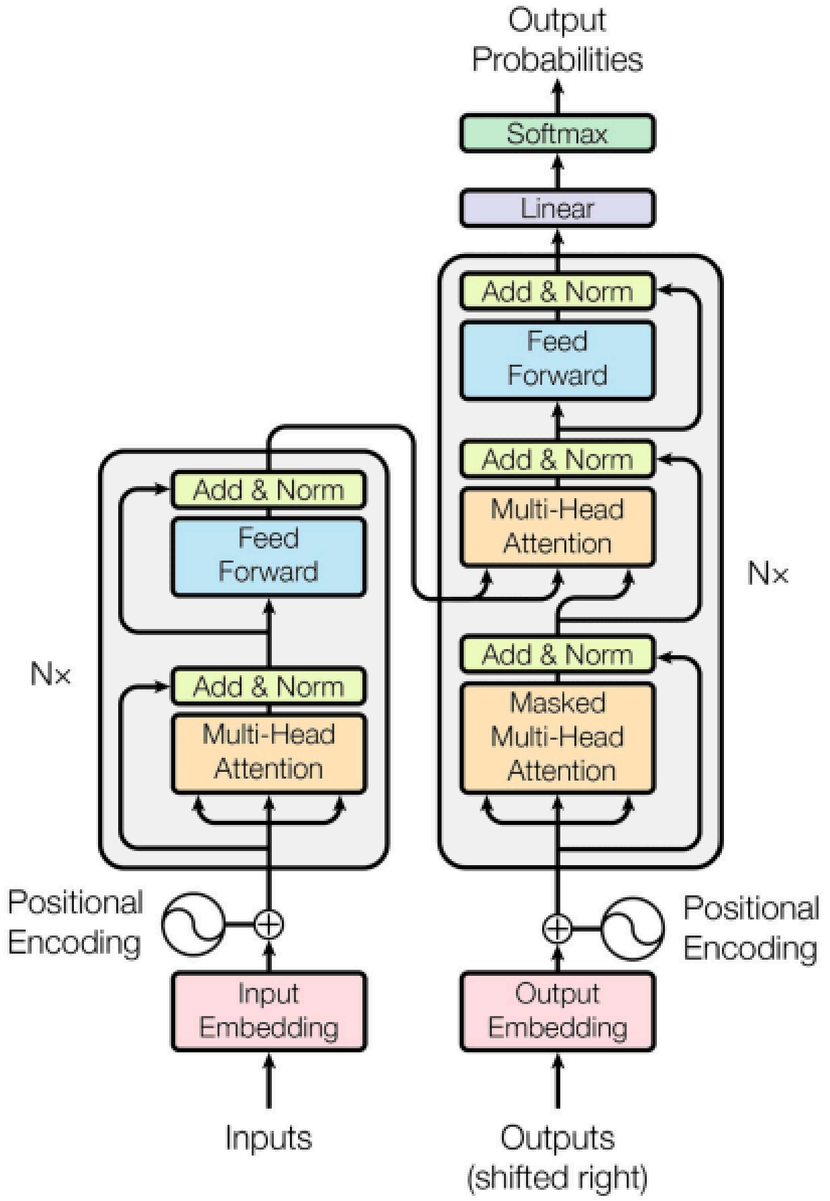
- attention is all you need



- Machine Translation (ترجمه ماشینی)
- Generative Text Creation (تولید متن مولد)
- Text Summarization (خلاصه‌سازی متن)
- Information Retrieval (بازیابی اطلاعات)

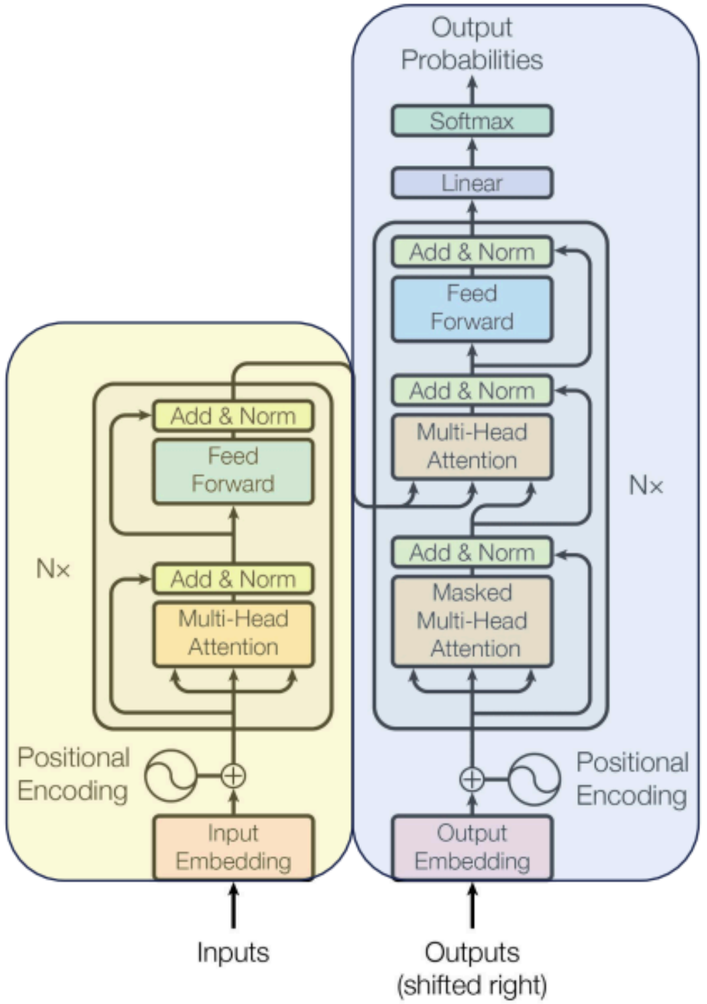
حوزه کاربرد	مدل‌های بنیادی	محصولات و سیستم‌های شاخص
پردازش زبان طبیعی (NLP) و LLMها	BERT، GPT-3/4، T5	**ChatGPT**، **Gemini** (چت‌بات و دستیار مجازی)، **LLaMA**، **Claude**، موتورهای جستجوی معنایی
بینایی کامپیوتر (Computer Vision)	Vision Transformer (ViT)	**DALL-E**، **Midjourney** (تولید تصویر)، سیستم‌های پیشرفته تشخیص تصویر (Image Recognition)
بیوانفورماتیک و پروتئین‌شناسی	معماری‌های ترنسفورمر سفارشی (مانند ESM)	**AlphaFold** (پیش‌بینی ساختار پروتئین)، مدل‌سازی توالی‌های DNA و RNA
سیستم‌های توصیه‌گر	RecSys Transformers	موتورهای توصیه‌گر پیشرفته (مانند نتفلیکس و اسپاتیفای)

Transformer Architecture



BERT
Oct 2018

Representation



GPT
June 2018

Generation

۱. مدل‌های فقط-رمزگذار (Encoder-Only)

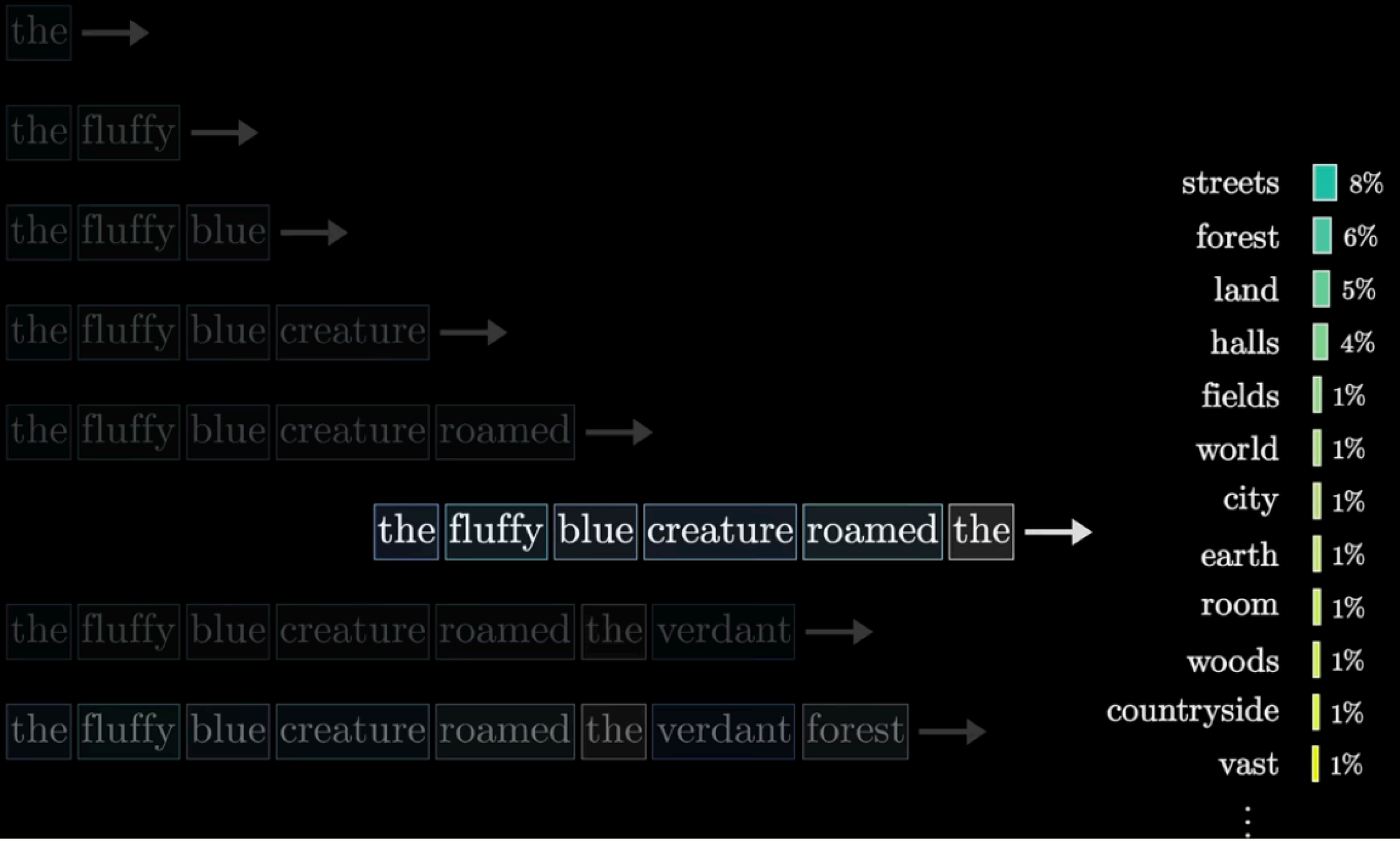
- هدف: فهم دوطرفه و نمایش زمینه‌محور (Bidirectional Understanding).
- مدل‌های شاخص: BERT, ViT (برای تصاویر).
- کاربردها و محصولات:
  - جستجوی معنایی: Google Search.
  - بینایی کامپیوتر: تشخیص تصویر (Google Photos).
  - NLP: تحلیل احساسات، توصیه‌گرها.

۲. مدل‌های فقط-رمزگشا (Decoder-Only)

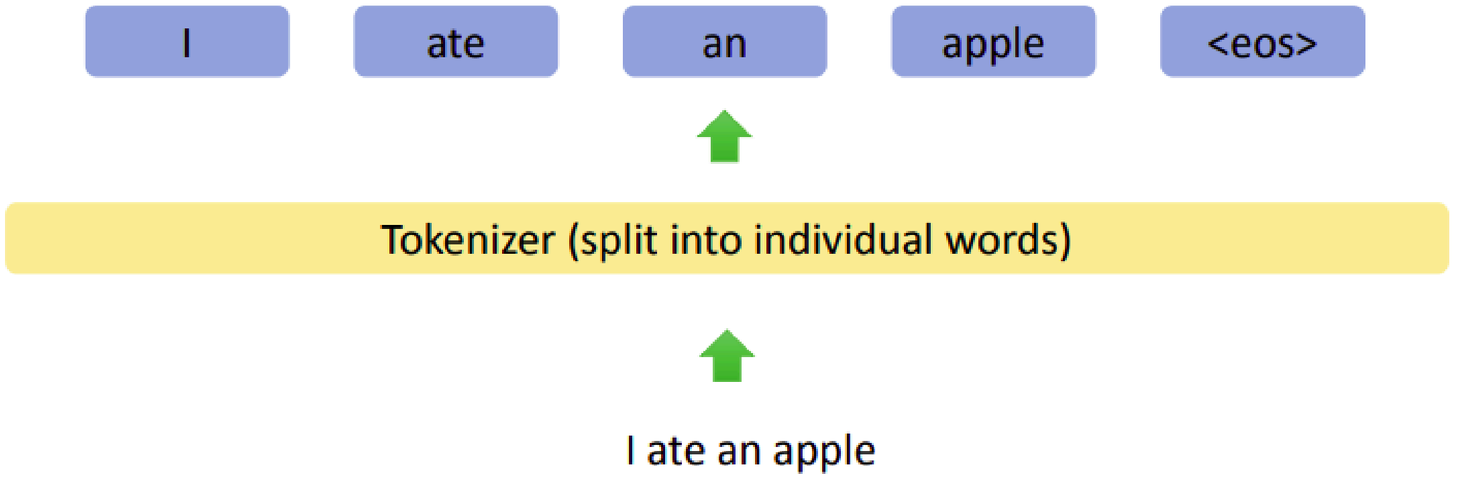
- هدف: تولید محتوای یک‌طرفه و خودبازگشتی (Unidirectional Generation).
- مدل‌های شاخص: GPT, LLaMA, Claude.
- کاربردها و محصولات:
  - چت‌بات‌ها: ChatGPT, Google Gemini.
  - تولید خلاقانه: تولید متن و کد (GitHub Copilot).
  - تولید تصویر: DALL-E, Midjourney.

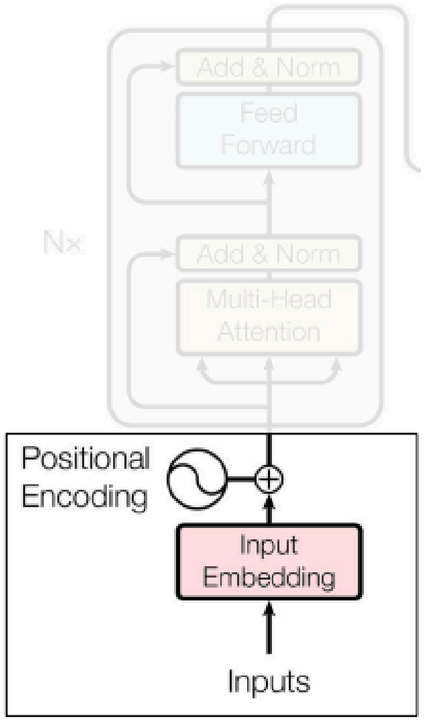
۳. مدل‌های رمزگذار-رمزگشا (Encoder-Decoder)

- هدف: تبدیل توالی به توالی (Sequence-to-Sequence).
- مدل‌های شاخص: T5, BART.
- کاربردها و محصولات:
  - ترجمه ماشینی: Google Translate.
  - خلاصه‌سازی متن.
  - بیوانفورماتیک: AlphaFold (پیش‌بینی ساختار پروتئین).

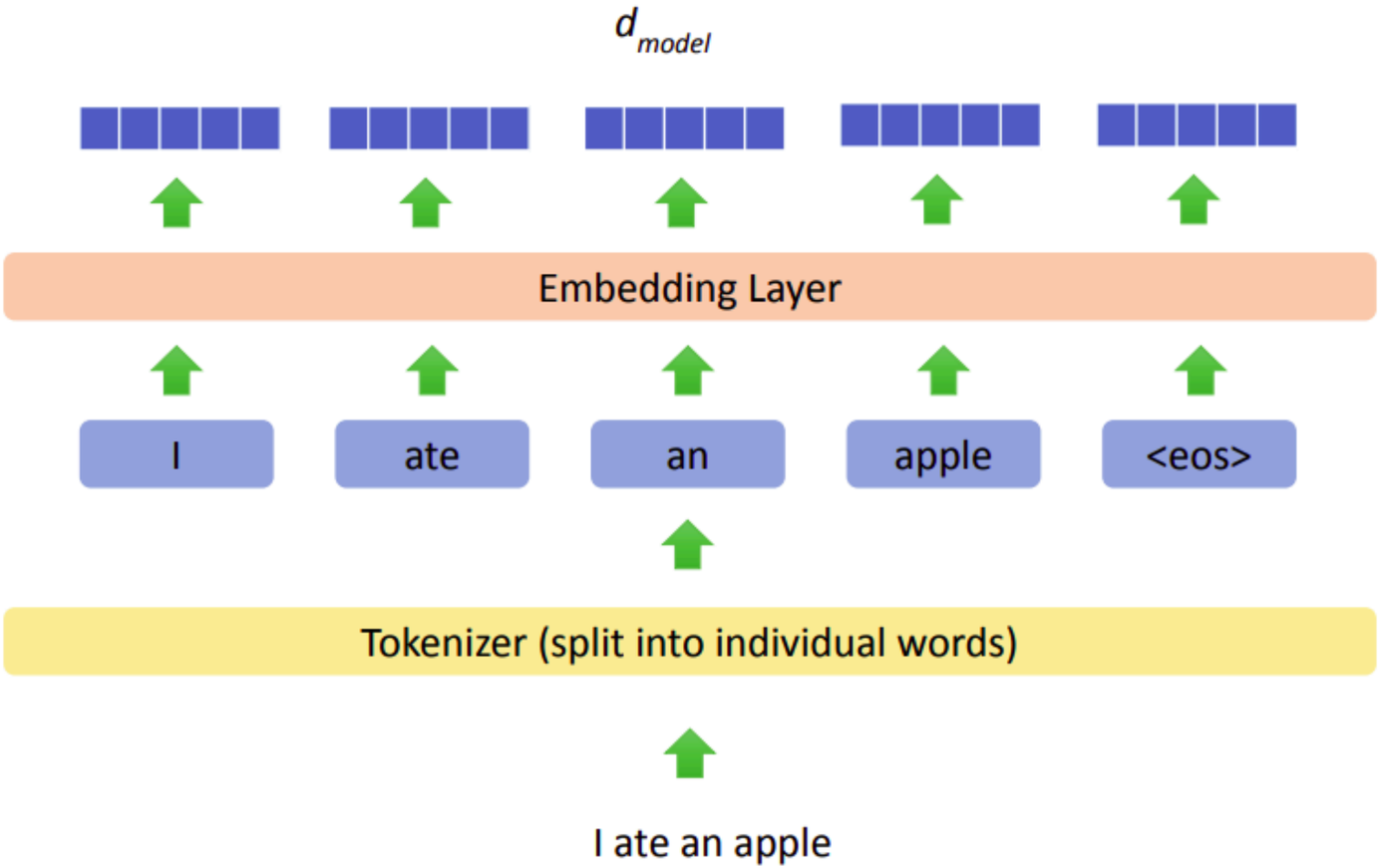

the
the fluffy
the fluffy blue
the fluffy blue creature
the fluffy blue creature roamed
the fluffy blue creature roamed the
the fluffy blue creature roamed the verdant
the fluffy blue creature roamed the verdant forest
streets 8%
forest 6%
land 5%
halls 4%
fields 1%
world 1%
city 1%
earth 1%
room 1%
woods 1%
countryside 1%
vast 1%

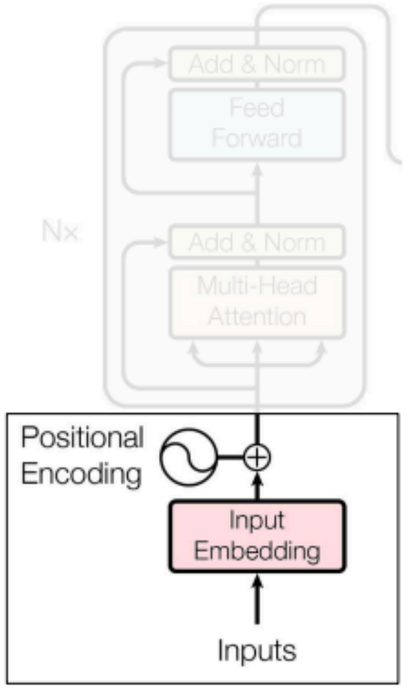
Tokenization





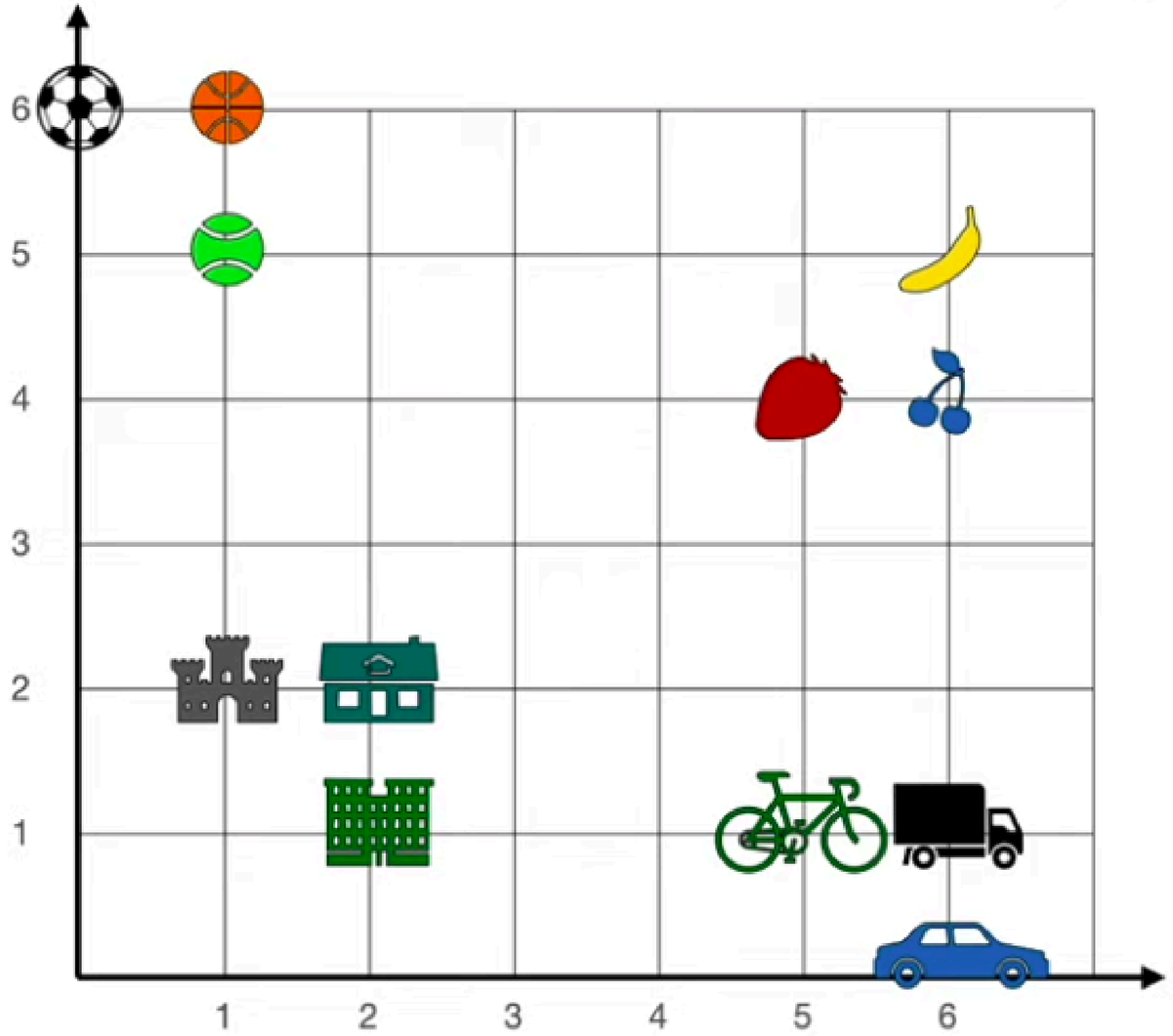
Input Embeddings



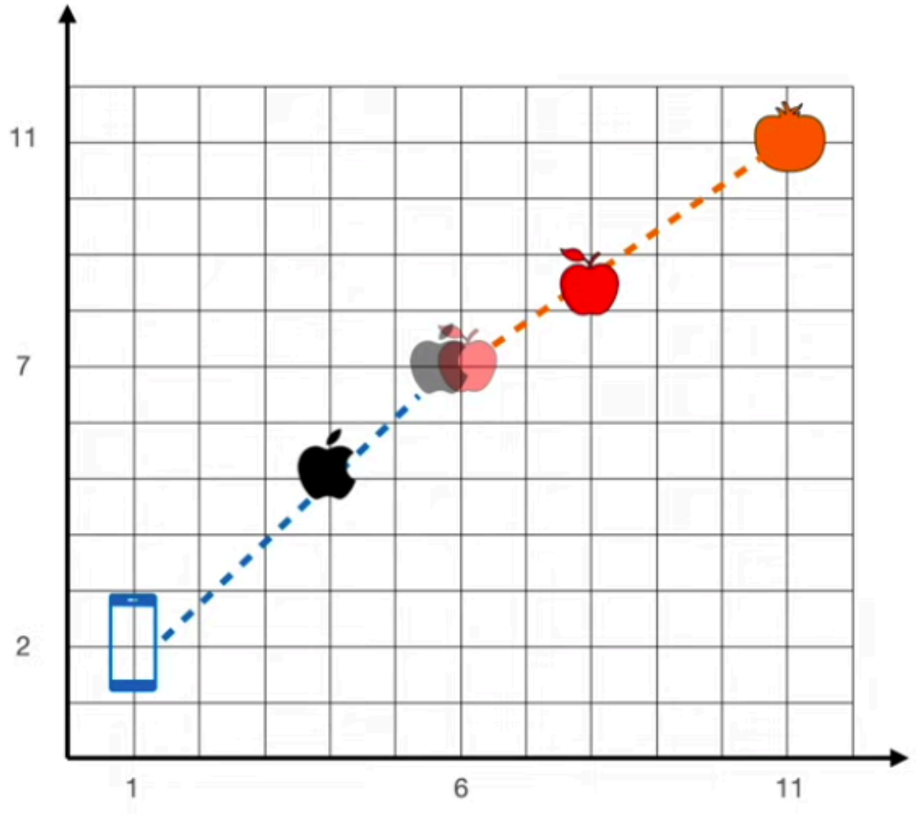


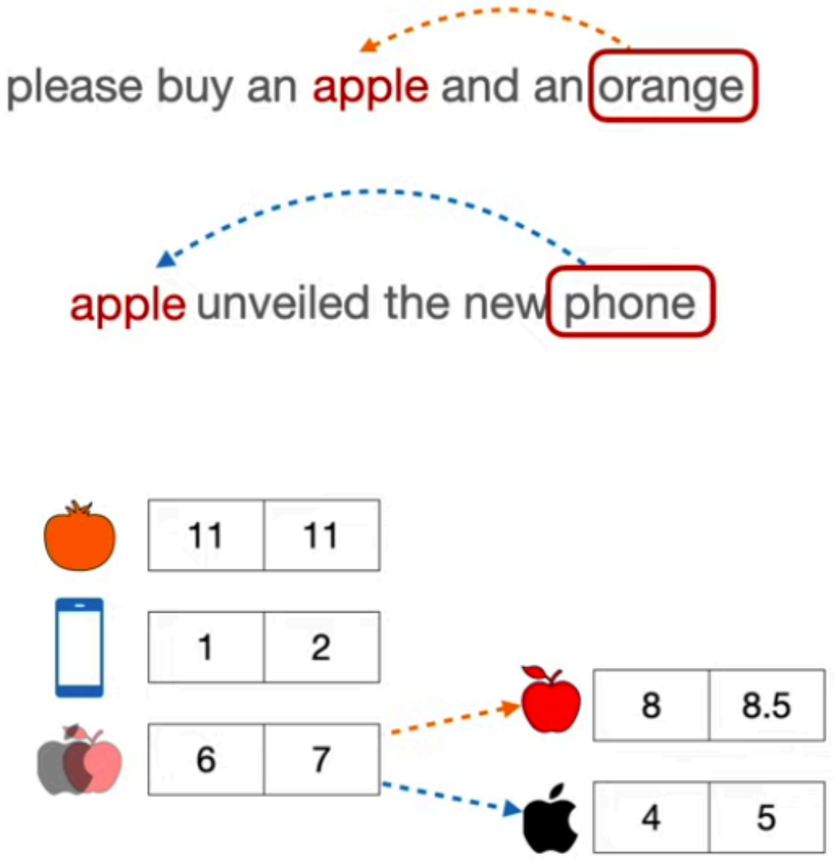
Generate Input Embeddings

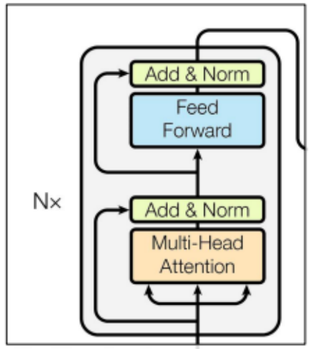
Where would you put the word apple?

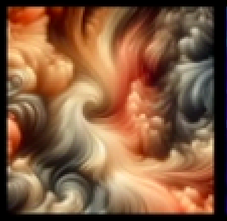
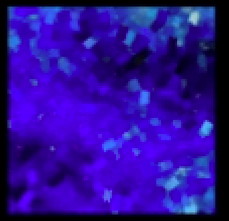
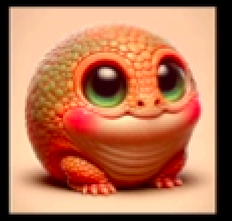
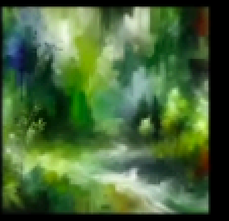
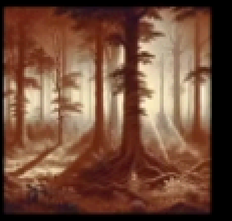


Attention


11
7
2
1
6
11


please buy an apple and an orange
apple unveiled the new phone
11
11
1
2
6
7
8
8.5
4
5


Add & Norm
Feed Forward
Add & Norm
Multi-Head Attention
Nx
Positional Encoding
Input Embedding
Inputs

a	fluffy	blue	creature	roamed	the	verdant	forest
1	2	3	4	5	6	7	8

12,288

6.0	5.6	8.8	1.6	4.5	5.2	0.3	7.2
0.2	5.8	8.0	6.1	7.1	0.5	1.6	3.1
3.0	5.7	7.0	1.2	8.6	2.0	6.2	3.9
6.5	6.5	1.0	8.4	9.7	0.2	5.7	2.1
2.9	6.5	9.1	8.0	8.5	7.9	2.4	1.8
6.1	4.3	7.1	5.6	0.1	2.2	9.2	9.3
4.2	8.9	9.9	4.0	3.6	3.4	6.1	7.3
1.3	3.6	1.5	0.7	7.2	9.2	5.3	4.9
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
3.0	4.3	8.6	6.9	1.7	7.0	5.8	2.3

Query

$$\begin{bmatrix} -3.7 & +3.9 & -2.4 & -6.3 & -9.4 & -8.6 & +3.6 & -0.9 & \cdots & +0.7 \\ +7.9 & +9.7 & -5.6 & +3.2 & -4.7 & -9.5 & +5.1 & -3.6 & \cdots & -2.3 \\ +1.7 & +6.6 & +2.6 & +7.4 & -4.5 & +5.9 & -6.2 & +9.0 & \cdots & +3.7 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ -5.6 & +8.9 & +4.6 & -4.9 & -5.7 & +0.4 & -9.4 & -5.8 & \cdots & -1.5 \end{bmatrix}$$

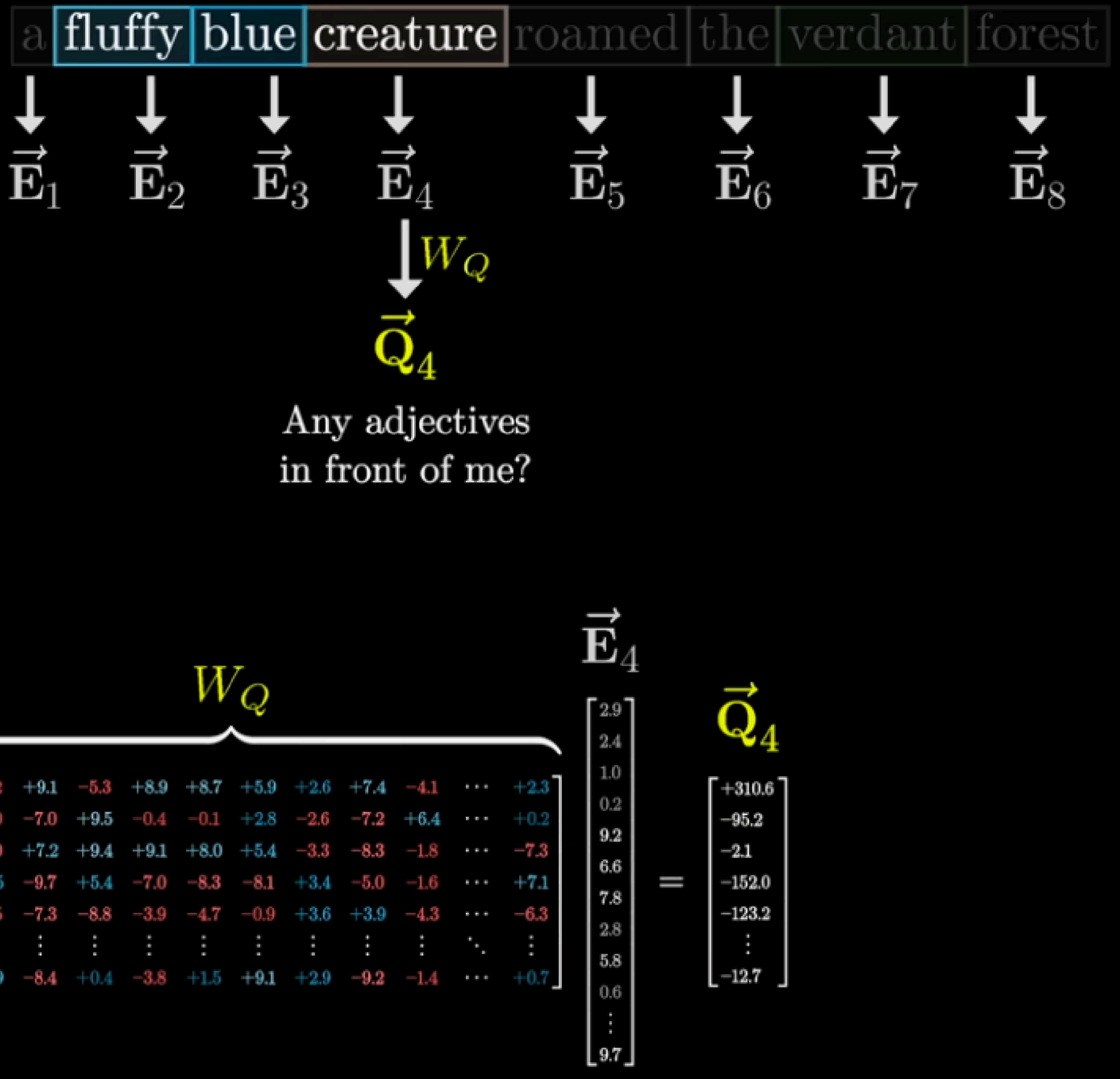
Key

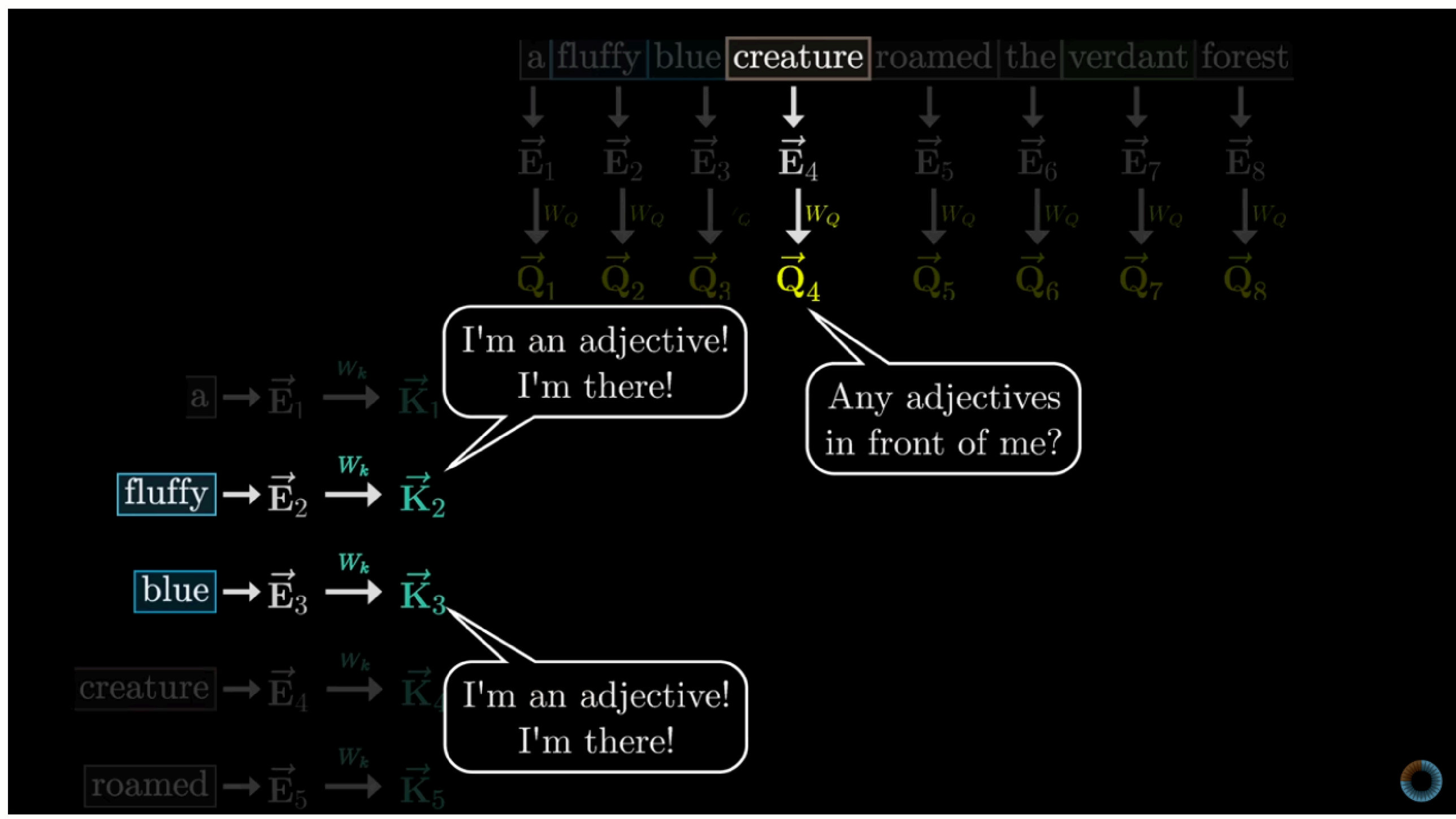
$$\begin{bmatrix} -2.5 & -0.7 & -4.4 & +1.7 & +7.2 & -7.6 & +0.3 & -7.3 & \cdots & +4.3 \\ -2.1 & +1.3 & -6.3 & -7.0 & -0.2 & -2.9 & +8.7 & +5.3 & \cdots & +4.9 \\ +8.0 & -8.2 & +1.0 & +1.7 & +9.1 & -4.1 & -5.1 & -7.9 & \cdots & -9.6 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ +8.5 & +3.4 & +5.6 & -4.3 & +1.7 & -8.6 & -0.3 & +9.5 & \cdots & +7.5 \end{bmatrix}$$

$$\text{Attention}(Q, K, V) = \text{softmax}\left(\frac{K^T Q}{\sqrt{d_k}}\right) V$$

Value

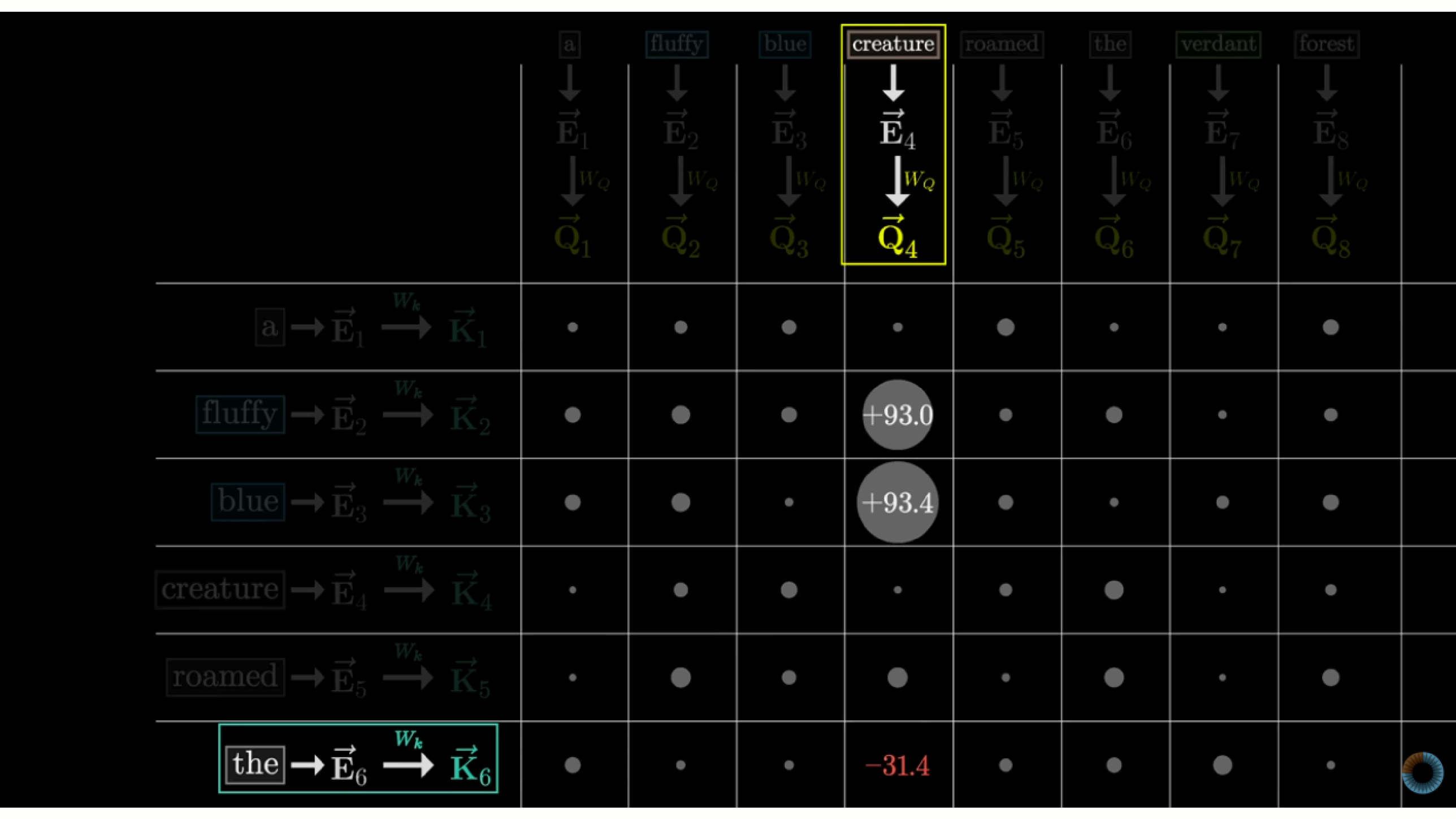
$$\begin{bmatrix} -3.2 & +9.1 & -5.3 & +8.9 & +8.7 & +5.9 & +2.6 & +7.4 & \cdots & -4.1 \\ +6.9 & +2.3 & -9.6 & -3.0 & -7.0 & +9.5 & -0.4 & -0.1 & \cdots & +2.8 \\ -2.6 & -7.2 & +6.4 & -6.1 & +0.2 & -5.5 & -8.0 & +7.2 & \cdots & +9.4 \\ +9.1 & +8.0 & +5.4 & -3.3 & -8.3 & -1.8 & -5.3 & -7.3 & \cdots & -8.8 \\ +4.5 & -9.7 & +5.4 & -7.0 & -8.3 & -8.1 & +3.4 & -5.0 & \cdots & -1.6 \\ +1.1 & +7.1 & +4.5 & -4.5 & -7.3 & -8.8 & -3.9 & -4.7 & \cdots & -0.9 \\ +3.6 & +3.9 & -4.3 & -2.4 & -6.3 & +5.7 & -8.8 & +3.9 & \cdots & +5.5 \\ +5.5 & -4.8 & -2.5 & +1.7 & -4.5 & -2.6 & -6.0 & -0.8 & \cdots & -9.0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ +5.9 & -8.4 & +0.4 & -3.8 & +1.5 & +9.1 & +2.9 & -9.2 & \cdots & -1.4 \end{bmatrix}$$


a fluffy blue creature roamed the verdant forest
$\vec{\mathbf{E}}_1$ $\vec{\mathbf{E}}_2$ $\vec{\mathbf{E}}_3$ $\vec{\mathbf{E}}_4$ $\vec{\mathbf{E}}_5$ $\vec{\mathbf{E}}_6$ $\vec{\mathbf{E}}_7$ $\vec{\mathbf{E}}_8$
W_Q
$\vec{\mathbf{Q}}_4$
Any adjectives in front of me?
W_Q
$\vec{\mathbf{E}}_4$
$\vec{\mathbf{Q}}_4$

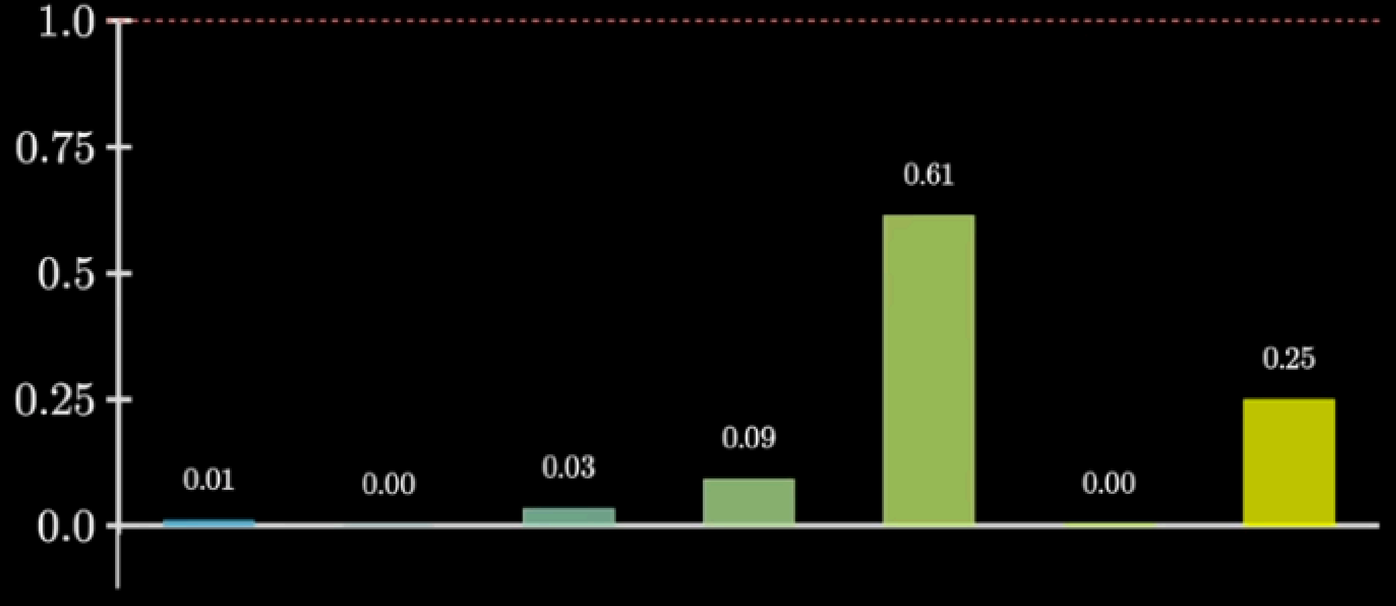

a fluffy blue creature roamed the verdant forest
$\vec{E}_1$ $\vec{E}_2$ $\vec{E}_3$ $\vec{E}_4$ $\vec{E}_5$ $\vec{E}_6$ $\vec{E}_7$ $\vec{E}_8$
W_Q
$\vec{Q}_1$ $\vec{Q}_2$ $\vec{Q}_3$ $\vec{Q}_4$ $\vec{Q}_5$ $\vec{Q}_6$ $\vec{Q}_7$ $\vec{Q}_8$
I'm an adjective! I'm there!
Any adjectives in front of me?
a → $\vec{E}_1$ W_k $\vec{K}_1$
fluffy → $\vec{E}_2$ W_k $\vec{K}_2$
blue → $\vec{E}_3$ W_k $\vec{K}_3$
creature → $\vec{E}_4$ W_k $\vec{K}_4$
roamed → $\vec{E}_5$ W_k $\vec{K}_5$
I'm an adjective! I'm there!

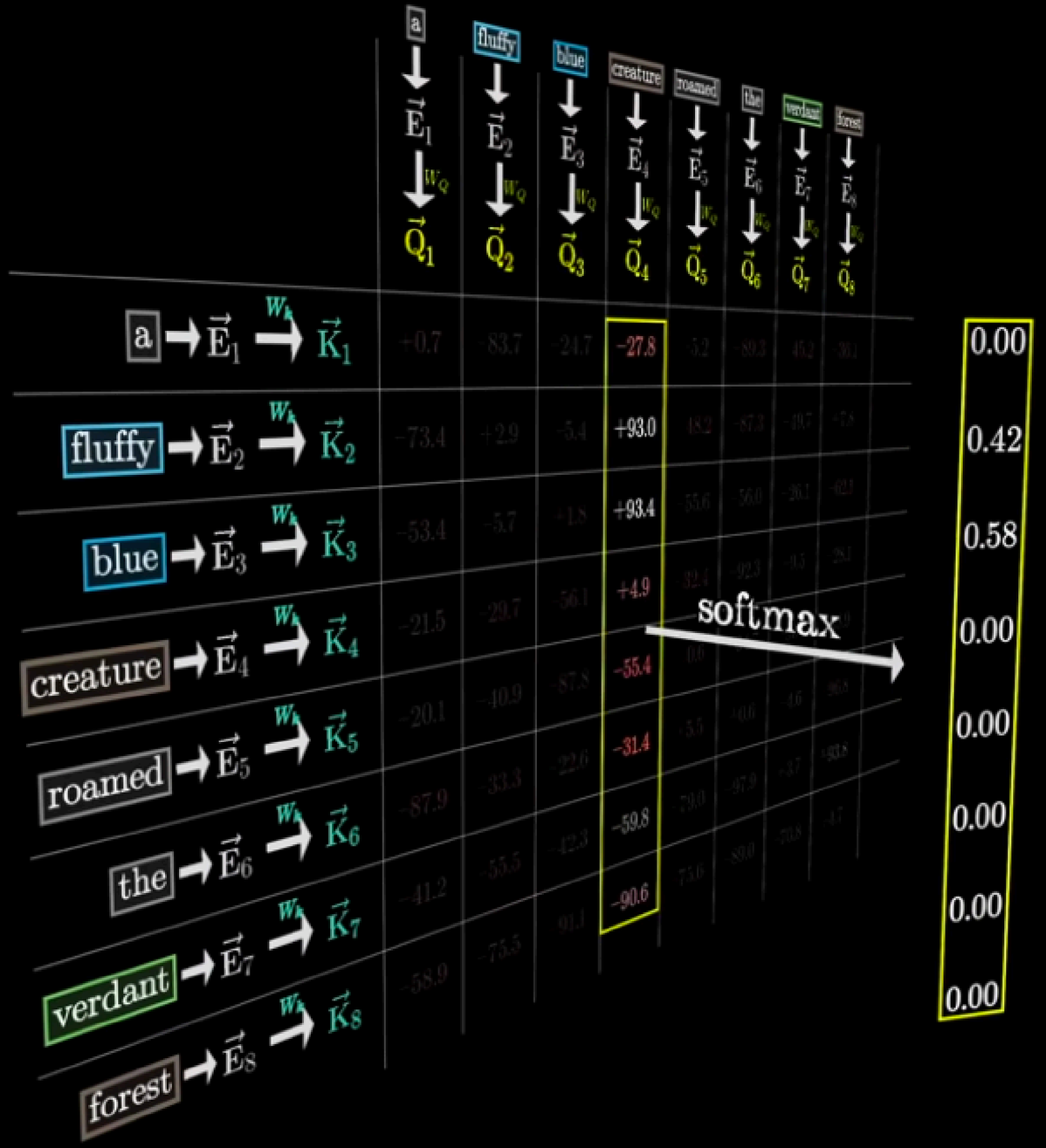
	a	fluffy	blue	creature	roamed	the	verdant	forest
	$\vec{E}_1 \xrightarrow{W_Q} \vec{Q}_1$	$\vec{E}_2 \xrightarrow{W_Q} \vec{Q}_2$	$\vec{E}_3 \xrightarrow{W_Q} \vec{Q}_3$	$\vec{E}_4 \xrightarrow{W_Q} \vec{Q}_4$	$\vec{E}_5 \xrightarrow{W_Q} \vec{Q}_5$	$\vec{E}_6 \xrightarrow{W_Q} \vec{Q}_6$	$\vec{E}_7 \xrightarrow{W_Q} \vec{Q}_7$	$\vec{E}_8 \xrightarrow{W_Q} \vec{Q}_8$
a $\to \vec{E}_1 \xrightarrow{W_K} \vec{K}_1$	$\vec{K}_1 \cdot \vec{Q}_1$	$\vec{K}_1 \cdot \vec{Q}_2$	$\vec{K}_1 \cdot \vec{Q}_3$	$\vec{K}_1 \cdot \vec{Q}_4$	$\vec{K}_1 \cdot \vec{Q}_5$	$\vec{K}_1 \cdot \vec{Q}_6$	$\vec{K}_1 \cdot \vec{Q}_7$	$\vec{K}_1 \cdot \vec{Q}_8$
fluffy $\to \vec{E}_2 \xrightarrow{W_K} \vec{K}_2$	$\vec{K}_2 \cdot \vec{Q}_1$	$\vec{K}_2 \cdot \vec{Q}_2$	$\vec{K}_2 \cdot \vec{Q}_3$	$\vec{K}_2 \cdot \vec{Q}_4$	$\vec{K}_2 \cdot \vec{Q}_5$	$\vec{K}_2 \cdot \vec{Q}_6$	$\vec{K}_2 \cdot \vec{Q}_7$	$\vec{K}_2 \cdot \vec{Q}_8$
blue $\to \vec{E}_3 \xrightarrow{W_K} \vec{K}_3$	$\vec{K}_3 \cdot \vec{Q}_1$	$\vec{K}_3 \cdot \vec{Q}_2$	$\vec{K}_3 \cdot \vec{Q}_3$	$\vec{K}_3 \cdot \vec{Q}_4$	$\vec{K}_3 \cdot \vec{Q}_5$	$\vec{K}_3 \cdot \vec{Q}_6$	$\vec{K}_3 \cdot \vec{Q}_7$	$\vec{K}_3 \cdot \vec{Q}_8$
creature $\to \vec{E}_4 \xrightarrow{W_K} \vec{K}_4$	$\vec{K}_4 \cdot \vec{Q}_1$	$\vec{K}_4 \cdot \vec{Q}_2$	$\vec{K}_4 \cdot \vec{Q}_3$	$\vec{K}_4 \cdot \vec{Q}_4$	$\vec{K}_4 \cdot \vec{Q}_5$	$\vec{K}_4 \cdot \vec{Q}_6$	$\vec{K}_4 \cdot \vec{Q}_7$	$\vec{K}_4 \cdot \vec{Q}_8$
roamed $\to \vec{E}_5 \xrightarrow{W_K} \vec{K}_5$	$\vec{K}_5 \cdot \vec{Q}_1$	$\vec{K}_5 \cdot \vec{Q}_2$	$\vec{K}_5 \cdot \vec{Q}_3$	$\vec{K}_5 \cdot \vec{Q}_4$	$\vec{K}_5 \cdot \vec{Q}_5$	$\vec{K}_5 \cdot \vec{Q}_6$	$\vec{K}_5 \cdot \vec{Q}_7$	$\vec{K}_5 \cdot \vec{Q}_8$
the $\to \vec{E}_6 \xrightarrow{W_K} \vec{K}_6$	$\vec{K}_6 \cdot \vec{Q}_1$	$\vec{K}_6 \cdot \vec{Q}_2$	$\vec{K}_6 \cdot \vec{Q}_3$	$\vec{K}_6 \cdot \vec{Q}_4$	$\vec{K}_6 \cdot \vec{Q}_5$	$\vec{K}_6 \cdot \vec{Q}_6$	$\vec{K}_6 \cdot \vec{Q}_7$	$\vec{K}_6 \cdot \vec{Q}_8$
verdant $\to \vec{E}_7 \xrightarrow{W_K} \vec{K}_7$	$\vec{K}_7 \cdot \vec{Q}_1$	$\vec{K}_7 \cdot \vec{Q}_2$	$\vec{K}_7 \cdot \vec{Q}_3$	$\vec{K}_7 \cdot \vec{Q}_4$	$\vec{K}_7 \cdot \vec{Q}_5$	$\vec{K}_7 \cdot \vec{Q}_6$	$\vec{K}_7 \cdot \vec{Q}_7$	$\vec{K}_7 \cdot \vec{Q}_8$
forest $\to \vec{E}_8 \xrightarrow{W_K} \vec{K}_8$	$\vec{K}_8 \cdot \vec{Q}_1$	$\vec{K}_8 \cdot \vec{Q}_2$	$\vec{K}_8 \cdot \vec{Q}_3$	$\vec{K}_8 \cdot \vec{Q}_4$	$\vec{K}_8 \cdot \vec{Q}_5$	$\vec{K}_8 \cdot \vec{Q}_6$	$\vec{K}_8 \cdot \vec{Q}_7$	$\vec{K}_8 \cdot \vec{Q}_8$

	a $\vec{E}_1 \xrightarrow{W_Q} \vec{Q}_1$	fluffy $\vec{E}_2 \xrightarrow{W_Q} \vec{Q}_2$	blue $\vec{E}_3 \xrightarrow{W_Q} \vec{Q}_3$	creature $\vec{E}_4 \xrightarrow{W_Q} \vec{Q}_4$	roamed $\vec{E}_5 \xrightarrow{W_Q} \vec{Q}_5$	the $\vec{E}_6 \xrightarrow{W_Q} \vec{Q}_6$	verdant $\vec{E}_7 \xrightarrow{W_Q} \vec{Q}_7$	forest $\vec{E}_8 \xrightarrow{W_Q} \vec{Q}_8$
a $\vec{E}_1 \xrightarrow{W_K} \vec{K}_1$	+0.7	−83.7	−24.7	−27.8	−5.2	−89.3	−45.2	−36.1
fluffy $\vec{E}_2 \xrightarrow{W_K} \vec{K}_2$	−73.4	+2.9	−5.4	+93.0	−48.2	−87.3	−49.7	+7.8
blue $\vec{E}_3 \xrightarrow{W_K} \vec{K}_3$	−53.4	−5.7	+1.8	+93.4	−55.6	−56.0	−26.1	−62.1
creature $\vec{E}_4 \xrightarrow{W_K} \vec{K}_4$	−21.5	−29.7	−56.1	+4.9	−32.4	−92.3	−9.5	−28.1
roamed $\vec{E}_5 \xrightarrow{W_K} \vec{K}_5$	−20.1	−40.9	−87.8	−55.4	+0.6	−64.7	−96.7	−18.9
the $\vec{E}_6 \xrightarrow{W_K} \vec{K}_6$	−87.9	−33.3	−22.6	−31.4	+5.5	+0.6	−4.6	−96.8
verdant $\vec{E}_7 \xrightarrow{W_K} \vec{K}_7$	−41.2	−55.5	−42.3	−59.8	−79.0	−97.9	+3.7	+93.8
forest $\vec{E}_8 \xrightarrow{W_K} \vec{K}_8$	−58.9	−75.5	−91.1	−90.6	−75.6	−89.0	−70.8	+4.7


a
fluffy
blue
creature
roamed
the
verdant
forest
$\vec{E}_1$ $\vec{E}_2$ $\vec{E}_3$ $\vec{E}_4$ $\vec{E}_5$ $\vec{E}_6$ $\vec{E}_7$ $\vec{E}_8$
W_Q
$\vec{Q}_1$ $\vec{Q}_2$ $\vec{Q}_3$ $\vec{Q}_4$ $\vec{Q}_5$ $\vec{Q}_6$ $\vec{Q}_7$ $\vec{Q}_8$
a → $\vec{E}_1$ W_k → $\vec{K}_1$
fluffy → $\vec{E}_2$ W_k → $\vec{K}_2$
blue → $\vec{E}_3$ W_k → $\vec{K}_3$
creature → $\vec{E}_4$ W_k → $\vec{K}_4$
roamed → $\vec{E}_5$ W_k → $\vec{K}_5$
the → $\vec{E}_6$ W_k → $\vec{K}_6$
+93.0
+93.4
−31.4

creature	roamed	the	verdant	forest
$\vec{E}_4$	$\vec{E}_5$	$\vec{E}_6$	$\vec{E}_7$	$\vec{E}_8$
W_Q	W_Q	W_Q	W_Q	W_Q
$\vec{Q}_4$	$\vec{Q}_5$	$\vec{Q}_6$	$\vec{Q}_7$	$\vec{Q}_8$
−27.8	−5.2	−89.3	−45.2	−36.1
+93.0	We want these to			
+93.4	act like weights			
+4.9	−32.4	−92.3	−9.5	−28.1
−55.4	+0.6	−64.7	−96.7	−18.9
−31.4	+5.5	+0.6	−4.6	−96.8
−59.8	−79.0	−97.9	+3.7	+93.8
−90.6	−75.6	−89.0	−70.8	+4.7



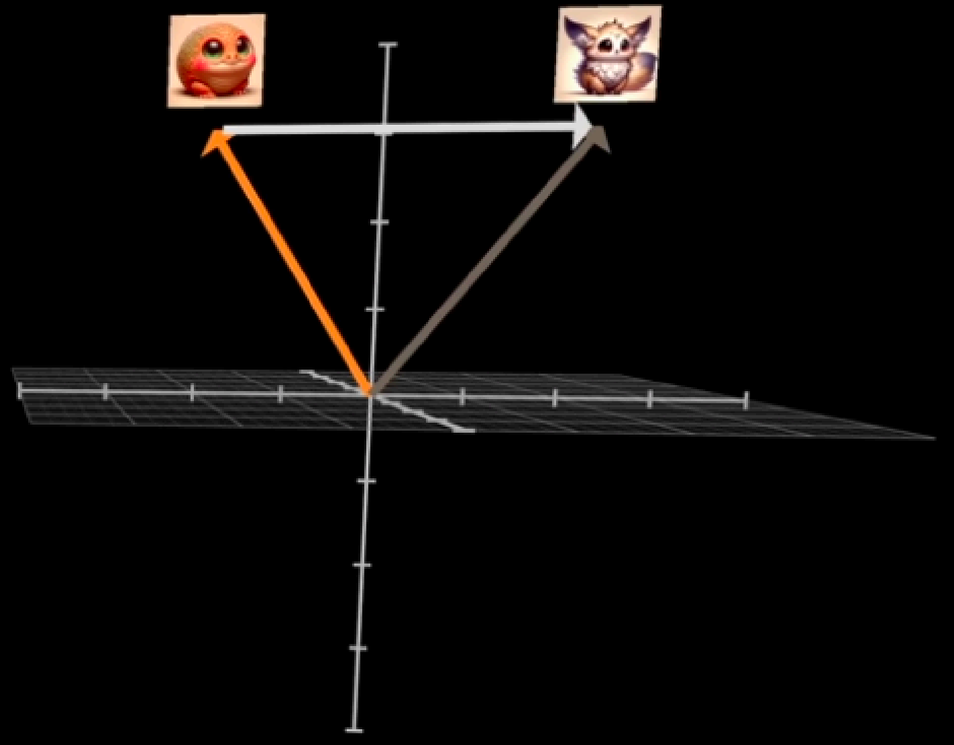

a
fluffy
blue
creature
roamed
the
verdant
forest
$\vec{E}_1$ $\vec{E}_2$ $\vec{E}_3$ $\vec{E}_4$ $\vec{E}_5$ $\vec{E}_6$ $\vec{E}_7$ $\vec{E}_8$
W_Q
$\vec{Q}_1$ $\vec{Q}_2$ $\vec{Q}_3$ $\vec{Q}_4$ $\vec{Q}_5$ $\vec{Q}_6$ $\vec{Q}_7$ $\vec{Q}_8$
W_K
$\vec{K}_1$ $\vec{K}_2$ $\vec{K}_3$ $\vec{K}_4$ $\vec{K}_5$ $\vec{K}_6$ $\vec{K}_7$ $\vec{K}_8$
-27.8
+93.0
+93.4
+4.9
-55.4
-31.4
-59.8
-90.6
softmax
0.00
0.42
0.58
0.00
0.00
0.00
0.00
0.00

$$\text{Attention}(Q, K, V) = \text{softmax}\left(\boxed{\frac{K^T Q}{\sqrt{d_k}}}\right) V$$

	Q_1	Q_2	Q_3	Q_4	Q_5	$\cdots$	Q_n
K_1	$\frac{Q_1 \cdot K_1}{\sqrt{d_k}}$	$\frac{Q_2 \cdot K_1}{\sqrt{d_k}}$	$\frac{Q_3 \cdot K_1}{\sqrt{d_k}}$	$\frac{Q_4 \cdot K_1}{\sqrt{d_k}}$	$\frac{Q_5 \cdot K_1}{\sqrt{d_k}}$	$\cdots$	$\frac{Q_n \cdot K_1}{\sqrt{d_k}}$
K_2	$\frac{Q_1 \cdot K_2}{\sqrt{d_k}}$	$\frac{Q_2 \cdot K_2}{\sqrt{d_k}}$	$\frac{Q_3 \cdot K_2}{\sqrt{d_k}}$	$\frac{Q_4 \cdot K_2}{\sqrt{d_k}}$	$\frac{Q_5 \cdot K_2}{\sqrt{d_k}}$	$\cdots$	$\frac{Q_n \cdot K_2}{\sqrt{d_k}}$
K_3	$\frac{Q_1 \cdot K_3}{\sqrt{d_k}}$	$\frac{Q_2 \cdot K_3}{\sqrt{d_k}}$	$\frac{Q_3 \cdot K_3}{\sqrt{d_k}}$	$\frac{Q_4 \cdot K_3}{\sqrt{d_k}}$	$\frac{Q_5 \cdot K_3}{\sqrt{d_k}}$	$\cdots$	$\frac{Q_n \cdot K_3}{\sqrt{d_k}}$
K_4	$\frac{Q_1 \cdot K_4}{\sqrt{d_k}}$	$\frac{Q_2 \cdot K_4}{\sqrt{d_k}}$	$\frac{Q_3 \cdot K_4}{\sqrt{d_k}}$	$\frac{Q_4 \cdot K_4}{\sqrt{d_k}}$	$\frac{Q_5 \cdot K_4}{\sqrt{d_k}}$	$\cdots$	$\frac{Q_n \cdot K_4}{\sqrt{d_k}}$
K_5	$\frac{Q_1 \cdot K_5}{\sqrt{d_k}}$	$\frac{Q_2 \cdot K_5}{\sqrt{d_k}}$	$\frac{Q_3 \cdot K_5}{\sqrt{d_k}}$	$\frac{Q_4 \cdot K_5}{\sqrt{d_k}}$	$\frac{Q_5 \cdot K_5}{\sqrt{d_k}}$	$\cdots$	$\frac{Q_n \cdot K_5}{\sqrt{d_k}}$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\cdots$	$\vdots$

fluffy creature

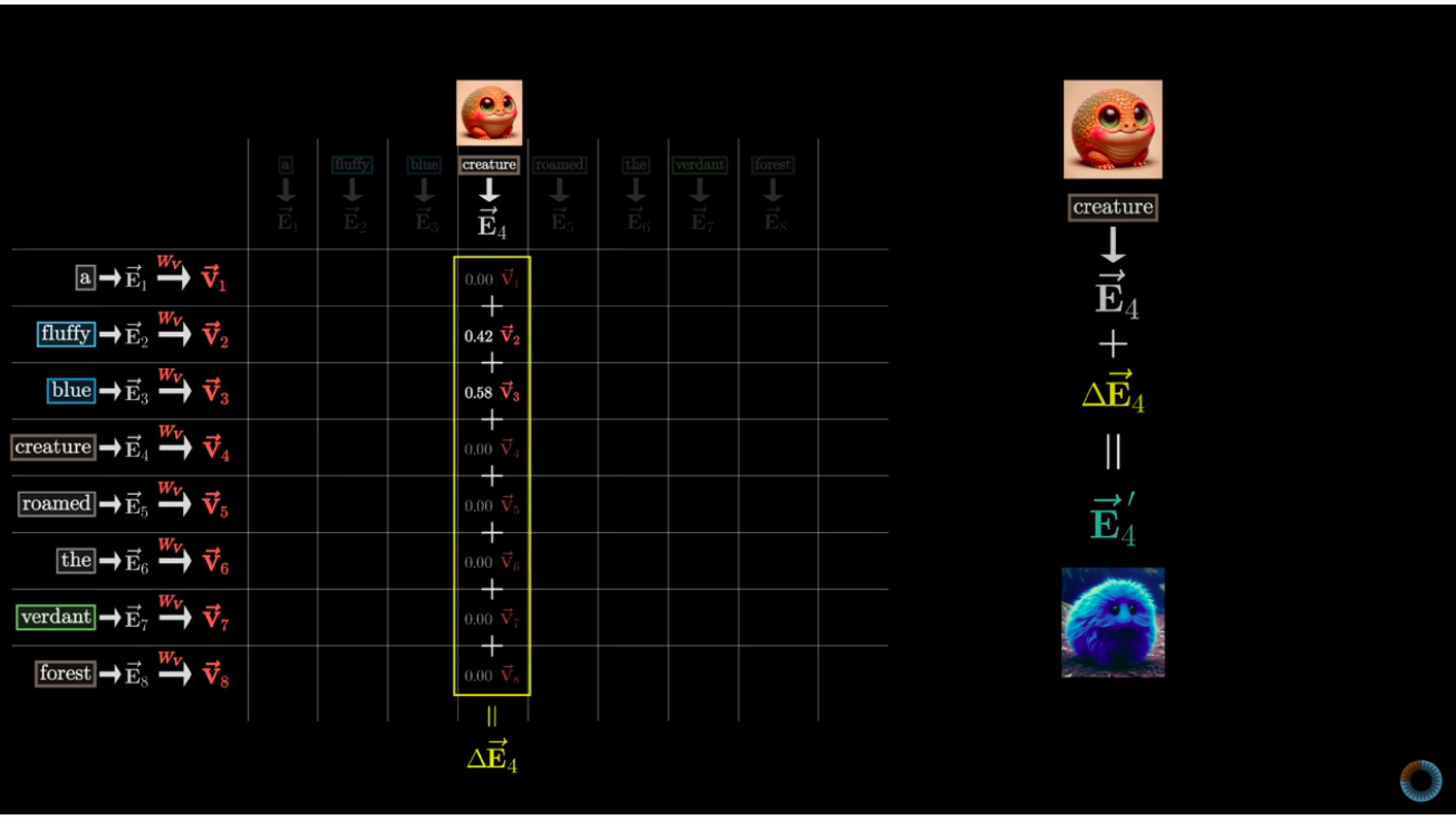
$$\begin{bmatrix} +9.2 \\ -2.3 \\ +5.8 \\ +0.6 \\ +1.3 \\ +8.4 \\ \vdots \\ -8.2 \end{bmatrix} \qquad \begin{bmatrix} -7.6 \\ +2.8 \\ -7.1 \\ +8.8 \\ +0.4 \\ -1.7 \\ \vdots \\ -4.7 \end{bmatrix}$$



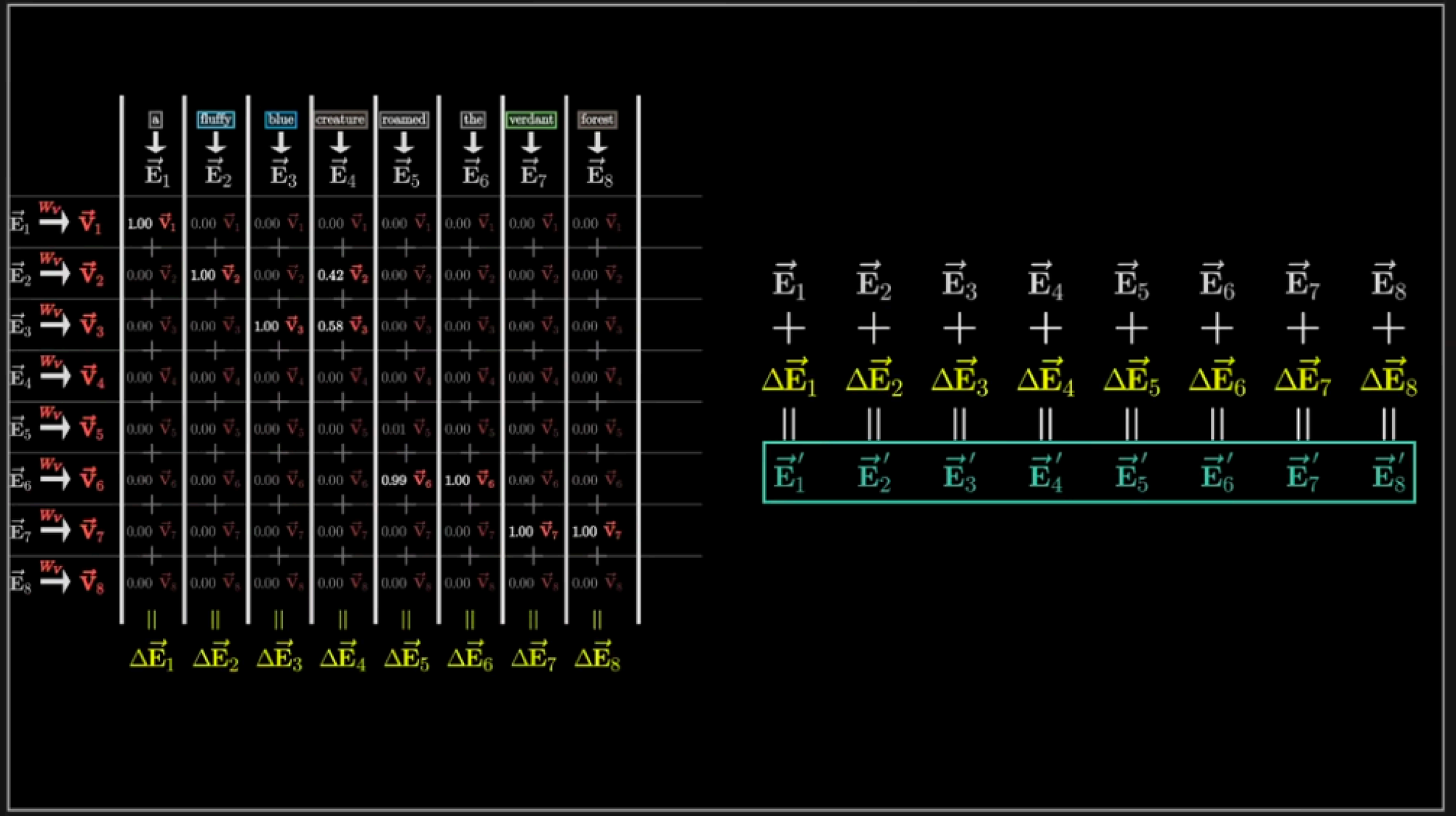
$$W_V$$

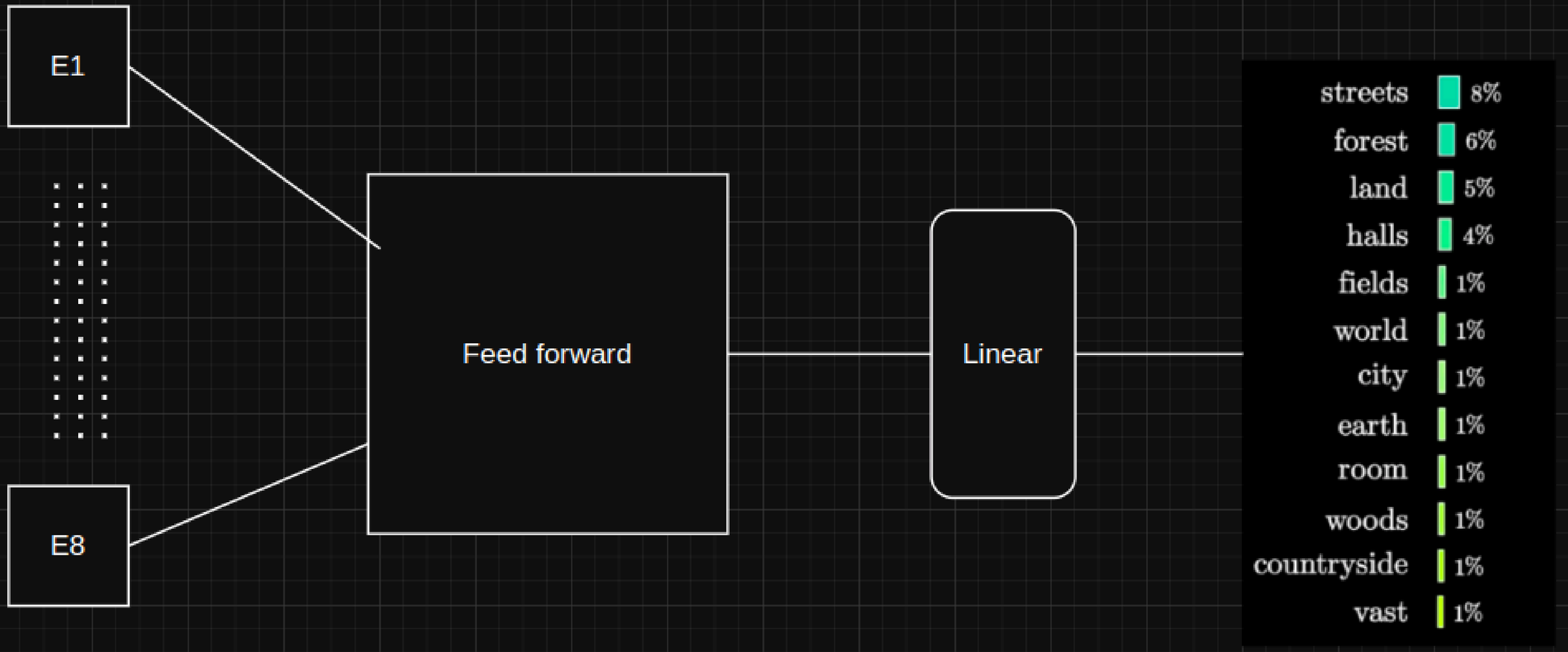
$$\begin{bmatrix} -3.6 & -1.7 & -8.6 & +3.8 & +1.3 & -4.6 & \cdots & -8.0 \\ +1.5 & +8.5 & -3.6 & +3.3 & -7.3 & +4.3 & \cdots & -6.3 \\ +1.7 & -9.5 & +6.5 & -9.8 & +3.5 & -4.6 & \cdots & +9.2 \\ -5.0 & +1.5 & +1.8 & +1.4 & -5.5 & +9.0 & \cdots & +6.9 \\ +3.9 & -4.0 & +6.2 & -2.0 & +7.5 & +1.6 & \cdots & +3.8 \\ +4.5 & +0.0 & +9.0 & +2.9 & -1.5 & +2.1 & \cdots & -3.9 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ +1.5 & +3.0 & +3.0 & -1.4 & +7.9 & -2.6 & \cdots & +7.8 \end{bmatrix}$$

Value Matrix

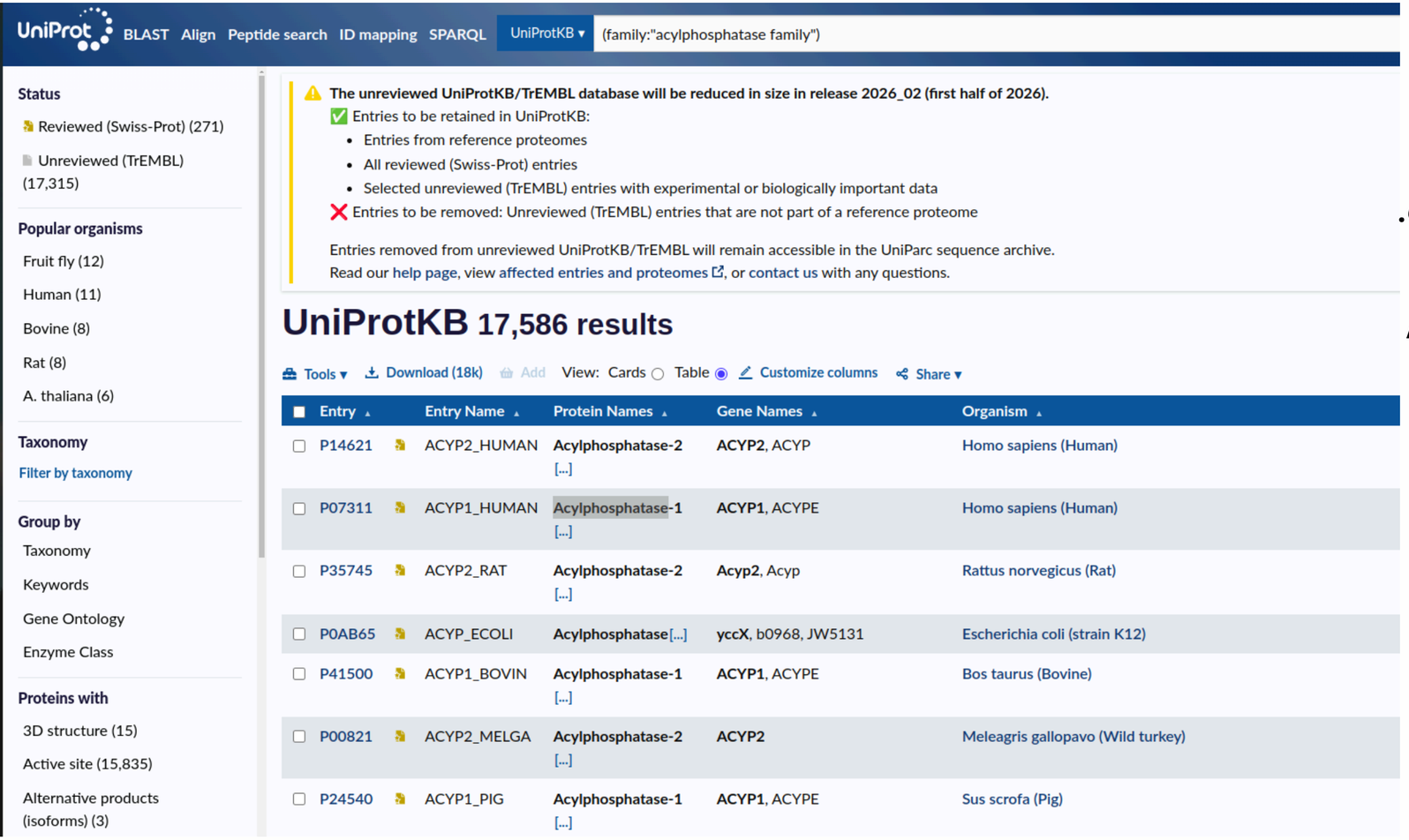

a
fluffy
blue
creature
roamed
the
verdant
forest
$\vec{E}_1$ $\vec{E}_2$ $\vec{E}_3$ $\vec{E}_4$ $\vec{E}_5$ $\vec{E}_6$ $\vec{E}_7$ $\vec{E}_8$
a → $\vec{E}_1$ W_V → $\vec{V}_1$
fluffy → $\vec{E}_2$ W_V → $\vec{V}_2$
blue → $\vec{E}_3$ W_V → $\vec{V}_3$
creature → $\vec{E}_4$ W_V → $\vec{V}_4$
roamed → $\vec{E}_5$ W_V → $\vec{V}_5$
the → $\vec{E}_6$ W_V → $\vec{V}_6$
verdant → $\vec{E}_7$ W_V → $\vec{V}_7$
forest → $\vec{E}_8$ W_V → $\vec{V}_8$
0.00 $\vec{V}_1$
+
0.42 $\vec{V}_2$
+
0.58 $\vec{V}_3$
+
0.00 $\vec{V}_4$
+
0.00 $\vec{V}_5$
+
0.00 $\vec{V}_6$
+
0.00 $\vec{V}_7$
+
0.00 $\vec{V}_8$
=
$\Delta\vec{E}_4$
creature
$\vec{E}_4$
+
$\Delta\vec{E}_4$
=
$\vec{E}_4'$

One head of attention




E1
E8
Feed forward
Linear
streets 8%
forest 6%
land 5%
halls 4%
fields 1%
world 1%
city 1%
earth 1%
room 1%
woods 1%
countryside 1%
vast 1%

تولید توالی آمینواسیدها برای ساخت پروتئین با استفاده از مدل Transformer



uniprot

- معرفی UniProt:
پایگاه دادهٔ جامع پروتئین‌ها که شامل توالی، ساختار و عملکرد آن‌ها در موجودات مختلف است.
- دیتاست پروژه:
توالی‌های آمینواسیدی آنزیم Acylphosphatase استخراج‌شده از پایگاه UniProt.
- کاربرد:
کمک به طراحی و درک بهتر عملکرد آنزیم‌ها و تولید پروتئین‌های مصنوعی.
- هدف مدل:
تولید توالی‌های جدید آمینواسیدی مشابه Acylphosphatase با استفاده از مدل Transformer.