

Feature extraction and embedding models

Dirk Wulff & Zak Hussain



MAX PLANCK INSTITUTE
FOR HUMAN DEVELOPMENT



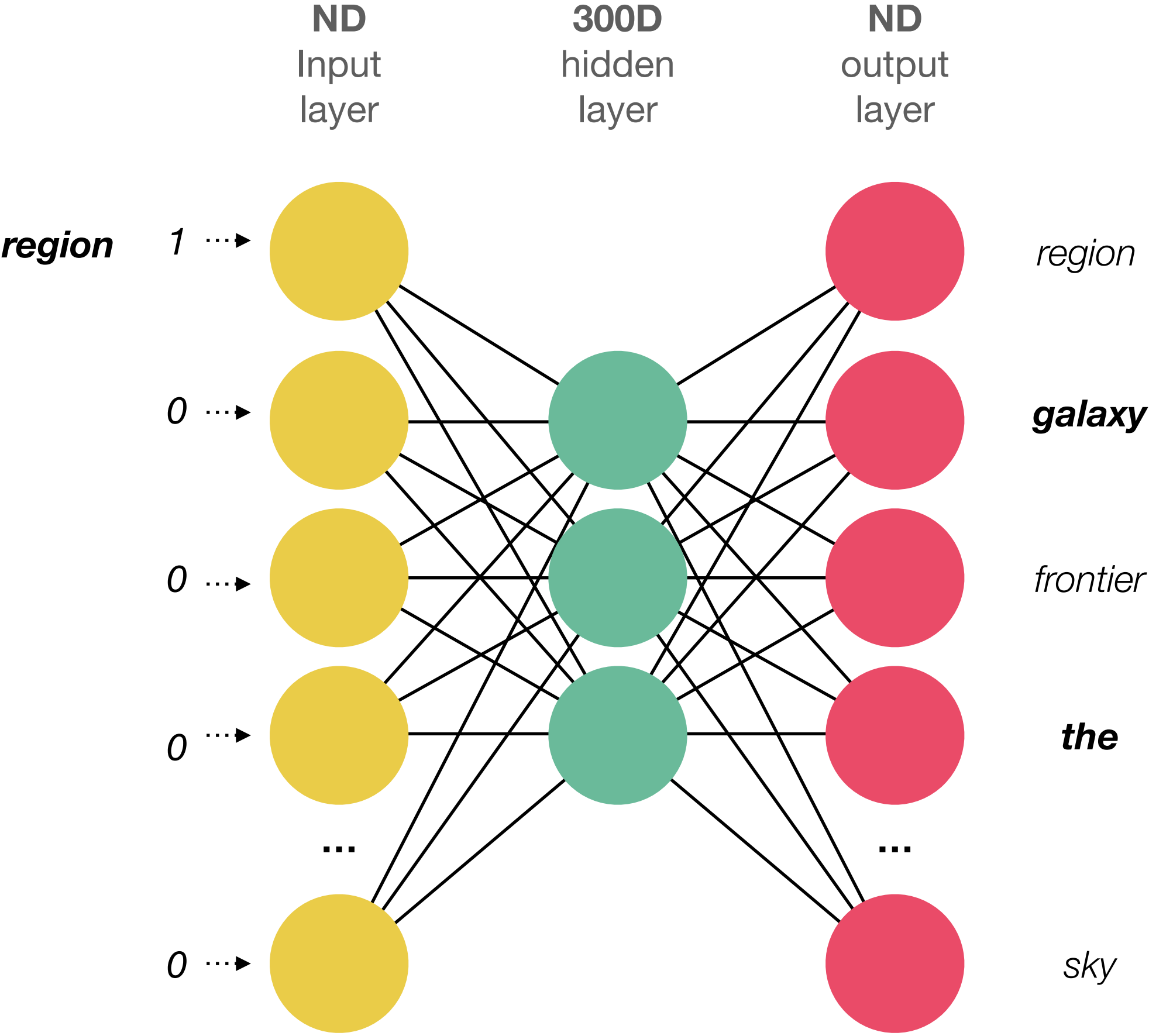


**“You’ll know
a word by
the company
that it
keeps!”**

John Rupert Firth
Linguist
1890-1960

Word embedding

word2vec



"You're on your way, Kelvin. Good luck!" Moddard's voice sounded as close as before.

A wide slit opened at eye-level, and I could see the stars. The Prometheus was orbiting in the region of Alpha in Aquarius and I tried in vain to orient myself; a glittering dust filled my porthole. I could not recognize a single constellation; in **this region of the galaxy** the sky was unfamiliar to me. I waited for the moment when I would pass near the first distinct star, but I was unable to isolate any one of them. Their brightness was fading; they receded, merging into a vague, purplish glimmer, the sole indication of the distance I had already travelled. My body rigid, sealed in its pneumatic envelope, I was knifing through space with the impression of standing still in the void, my only distraction the steadily mounting heat.

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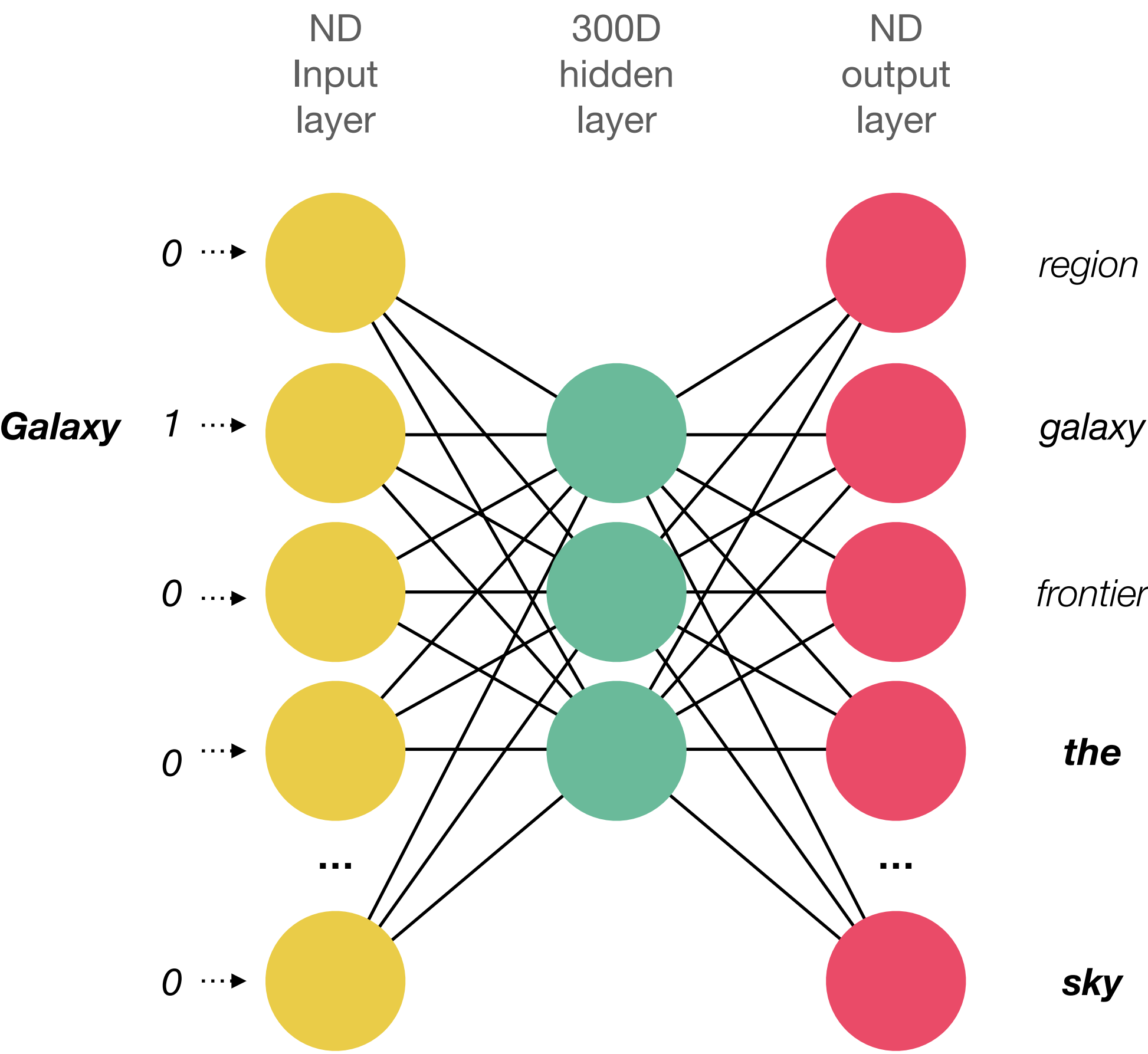
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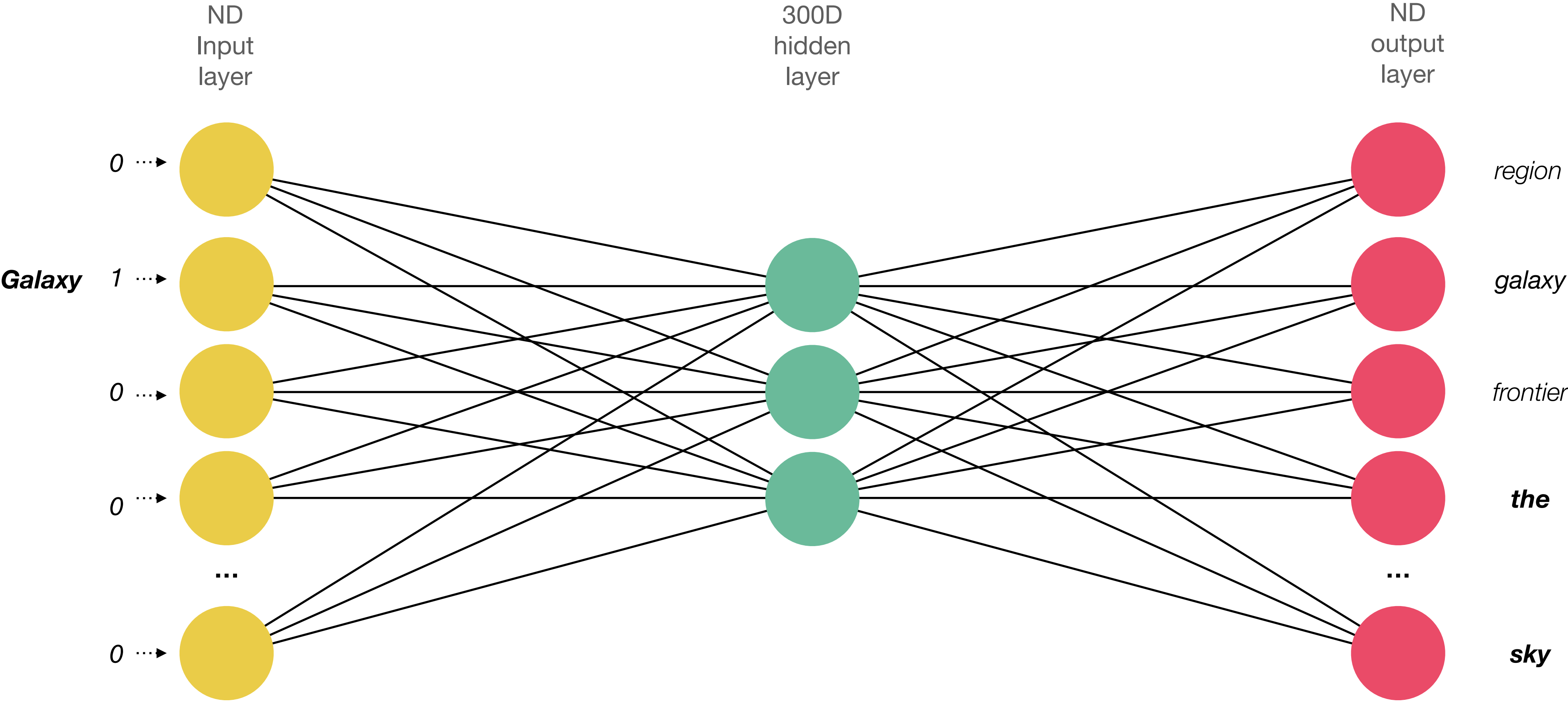
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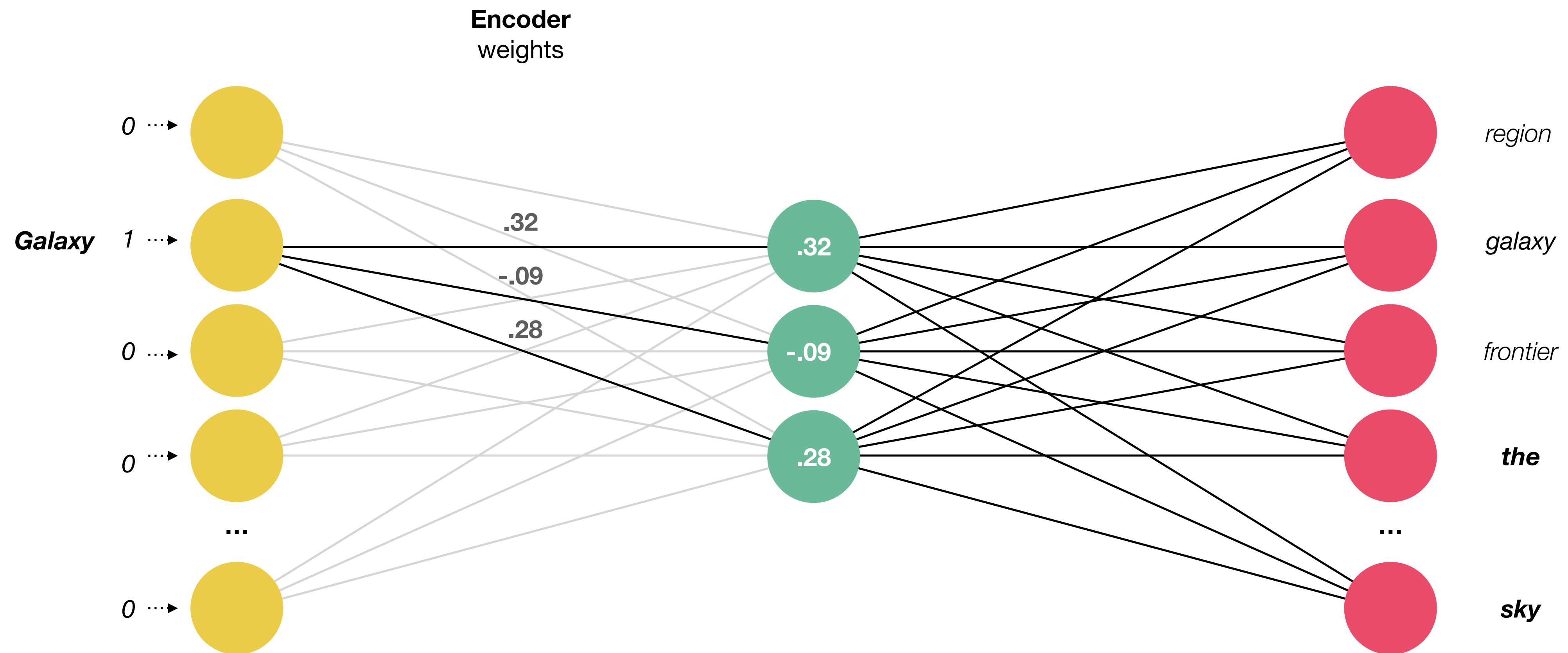
Word embedding

word2vec



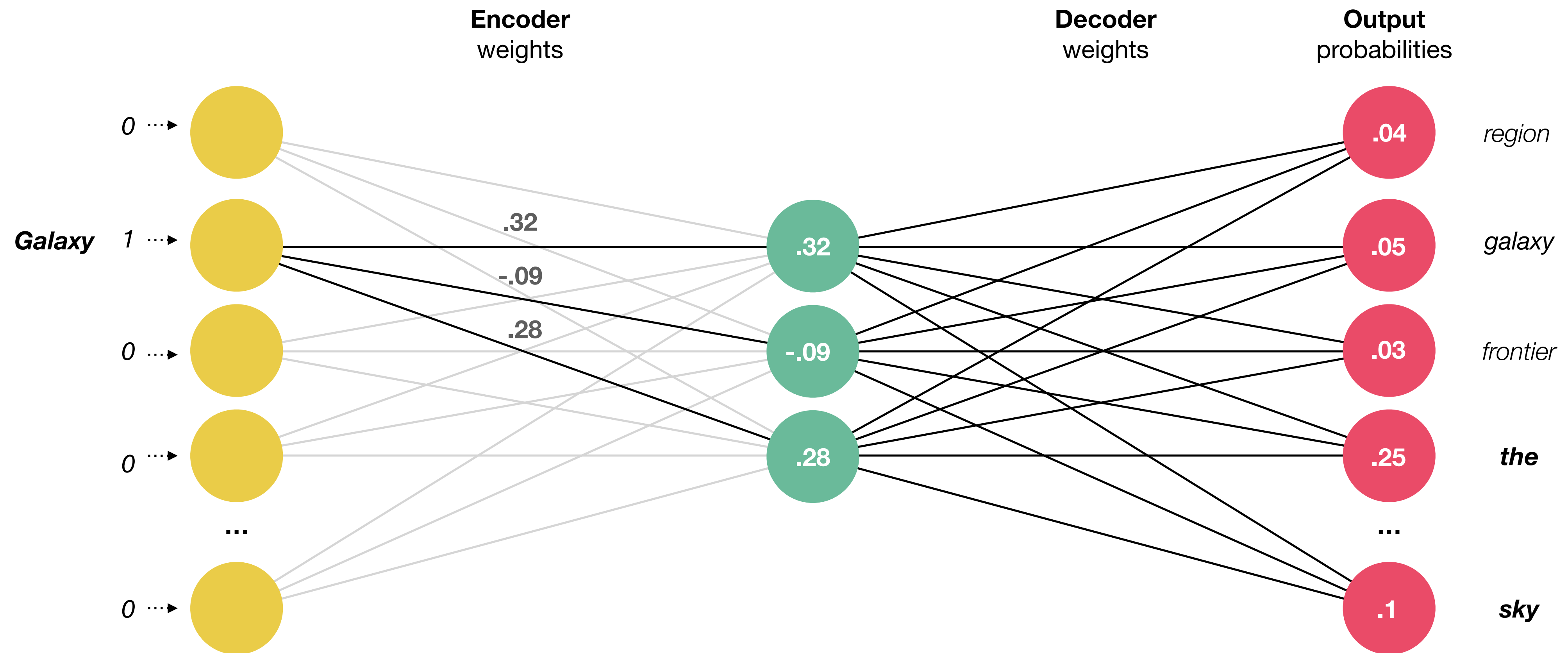
Word embedding

“A good language model encodes words with similar output similarly”



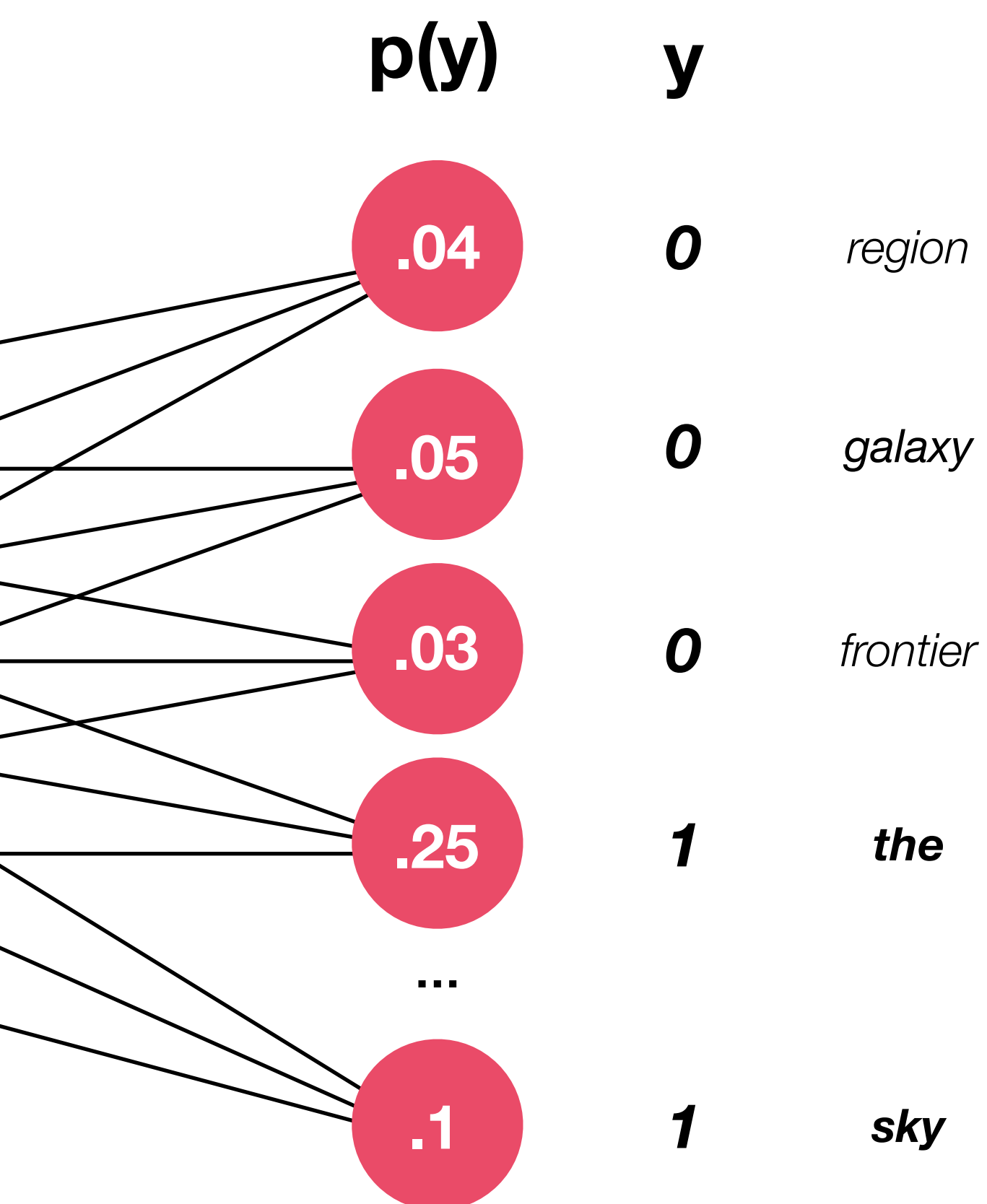
Word embedding

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Error signal

and gradient descent



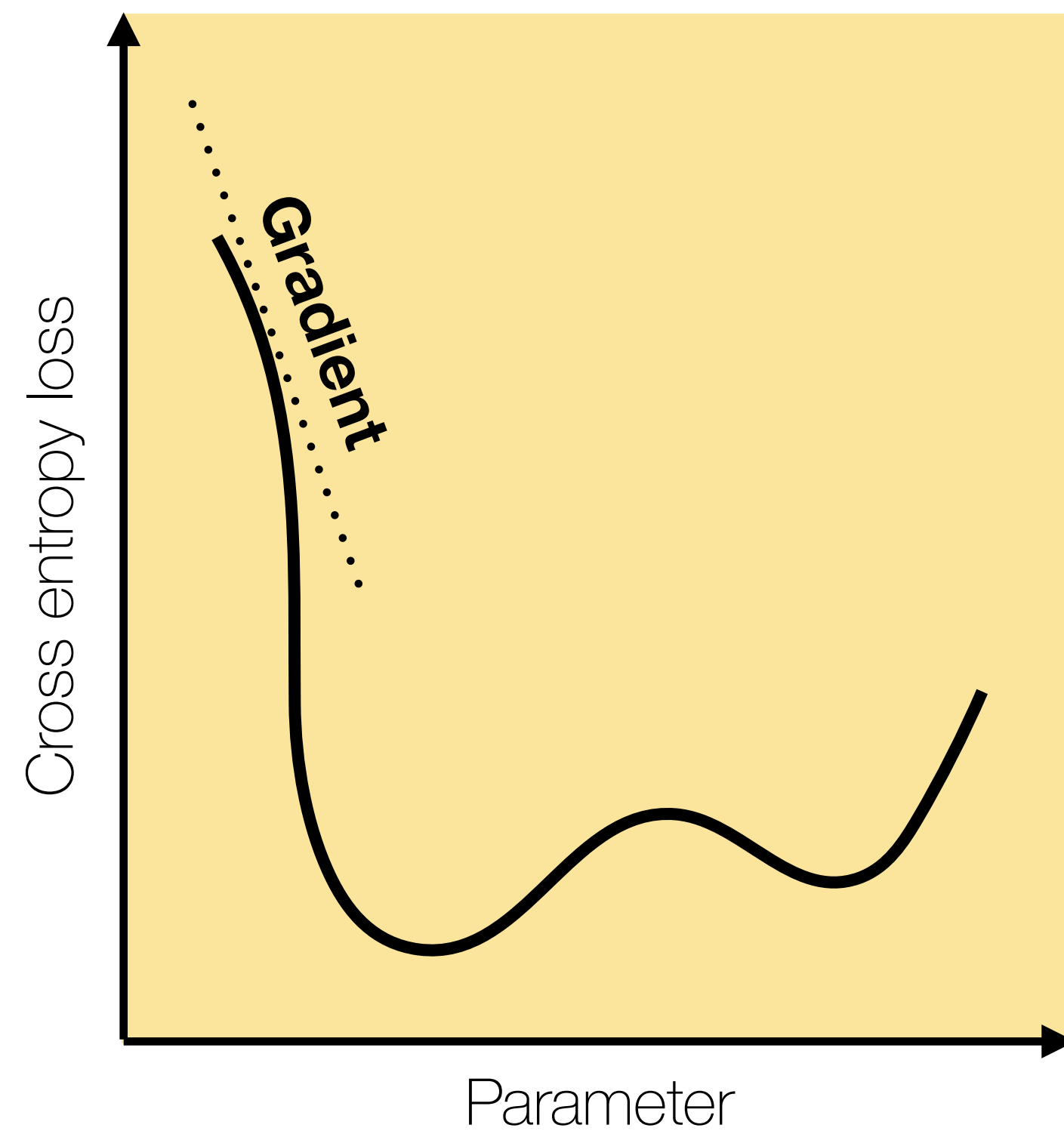
Sum over context **contexts** Sum over context **words** **Criterion**
 0 if word is absent
 1 if word is present **Model prediction**
 Softmax probability

$$-\sum_i \sum_j y_{ij} \log p(y_{ij})$$

Cross entropy loss

Error signal

and gradient descent



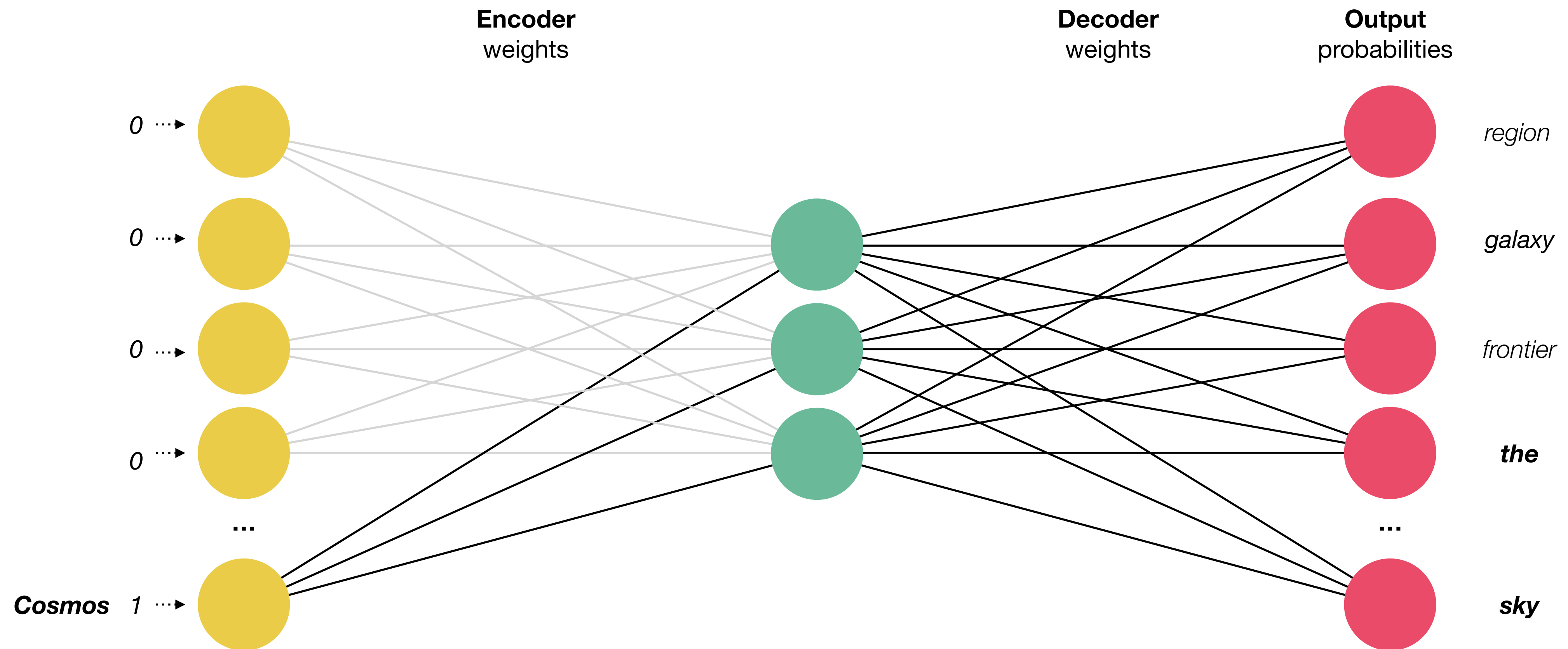
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Cross entropy loss

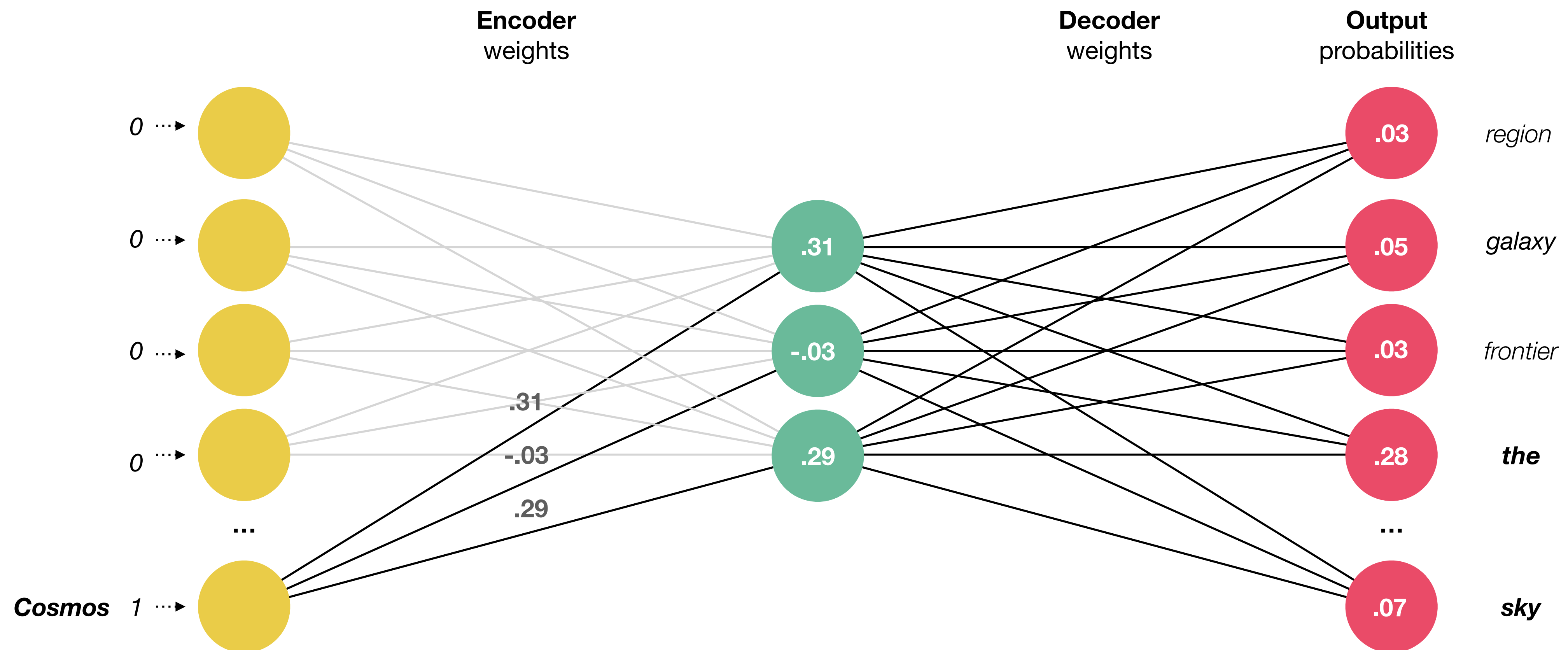
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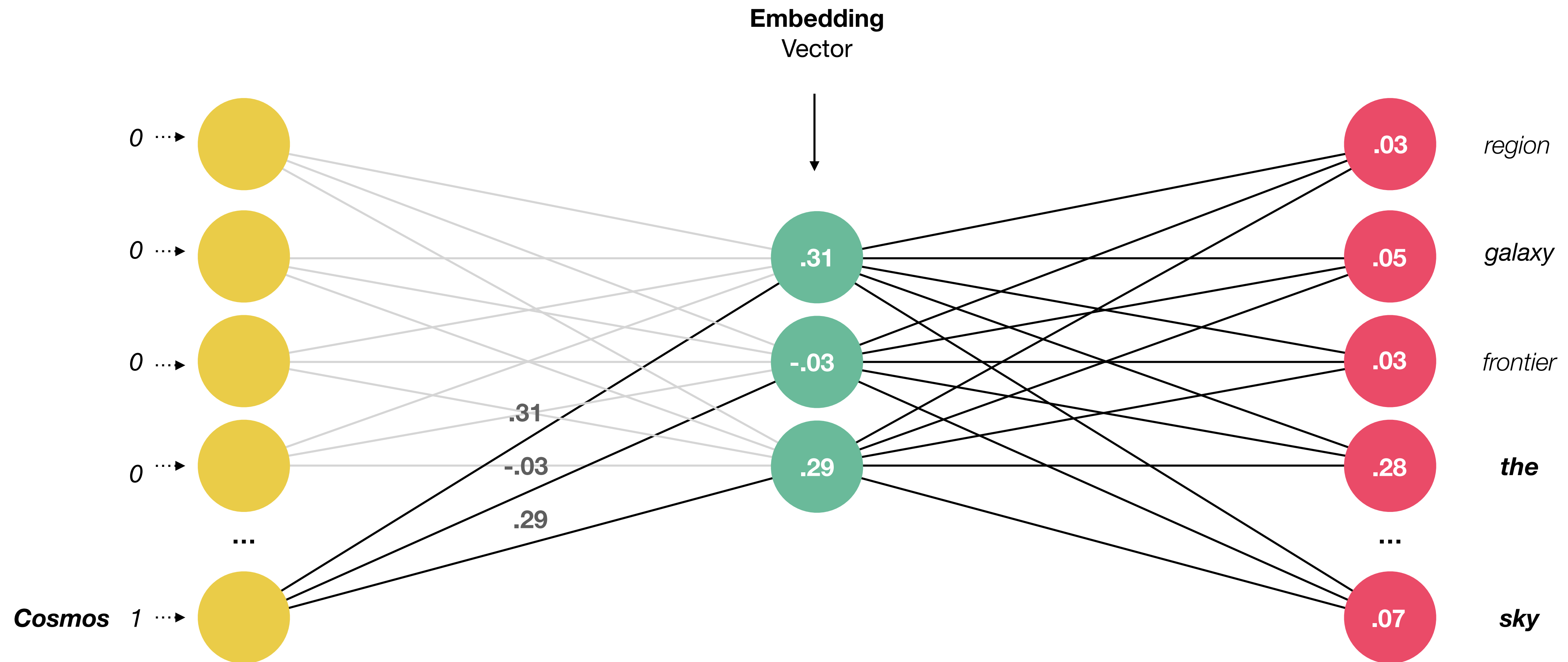
Word embedding

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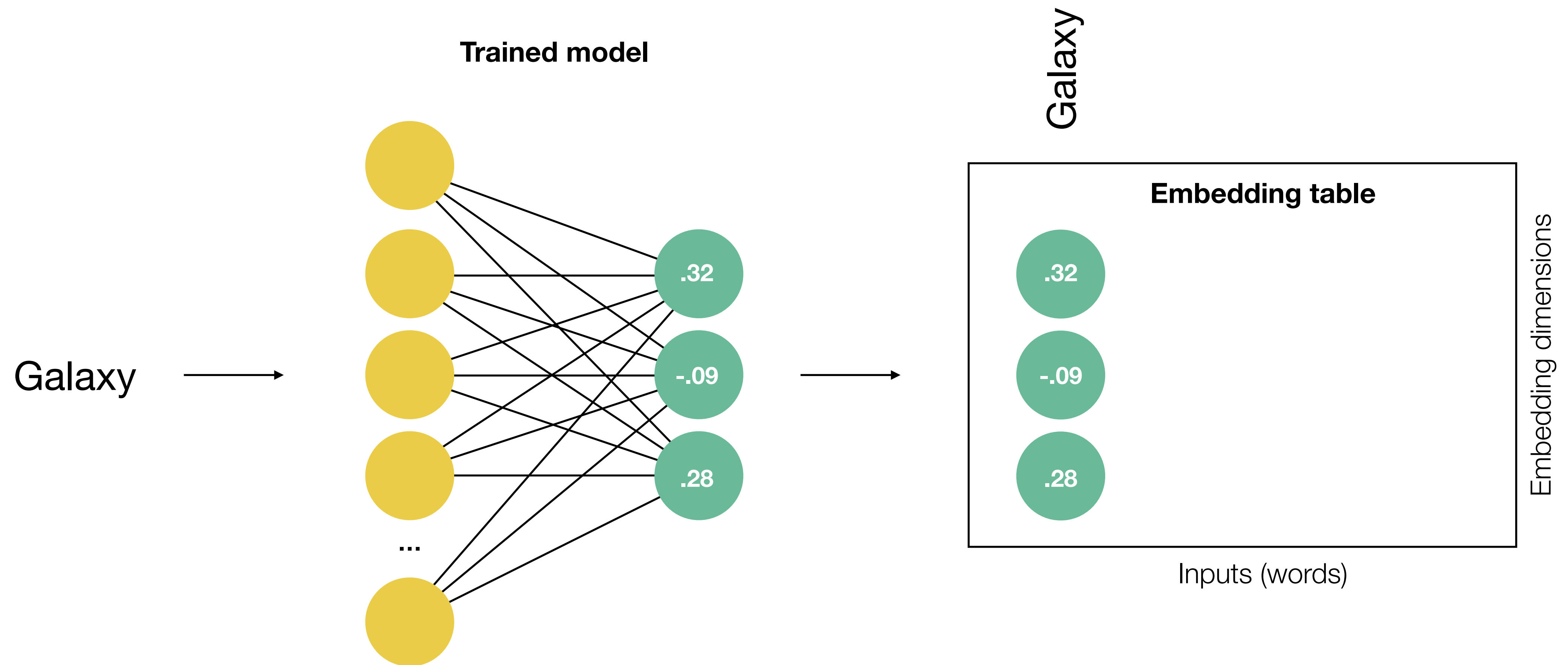
Word embedding

Embeddings = hidden activations (typically right before the output)



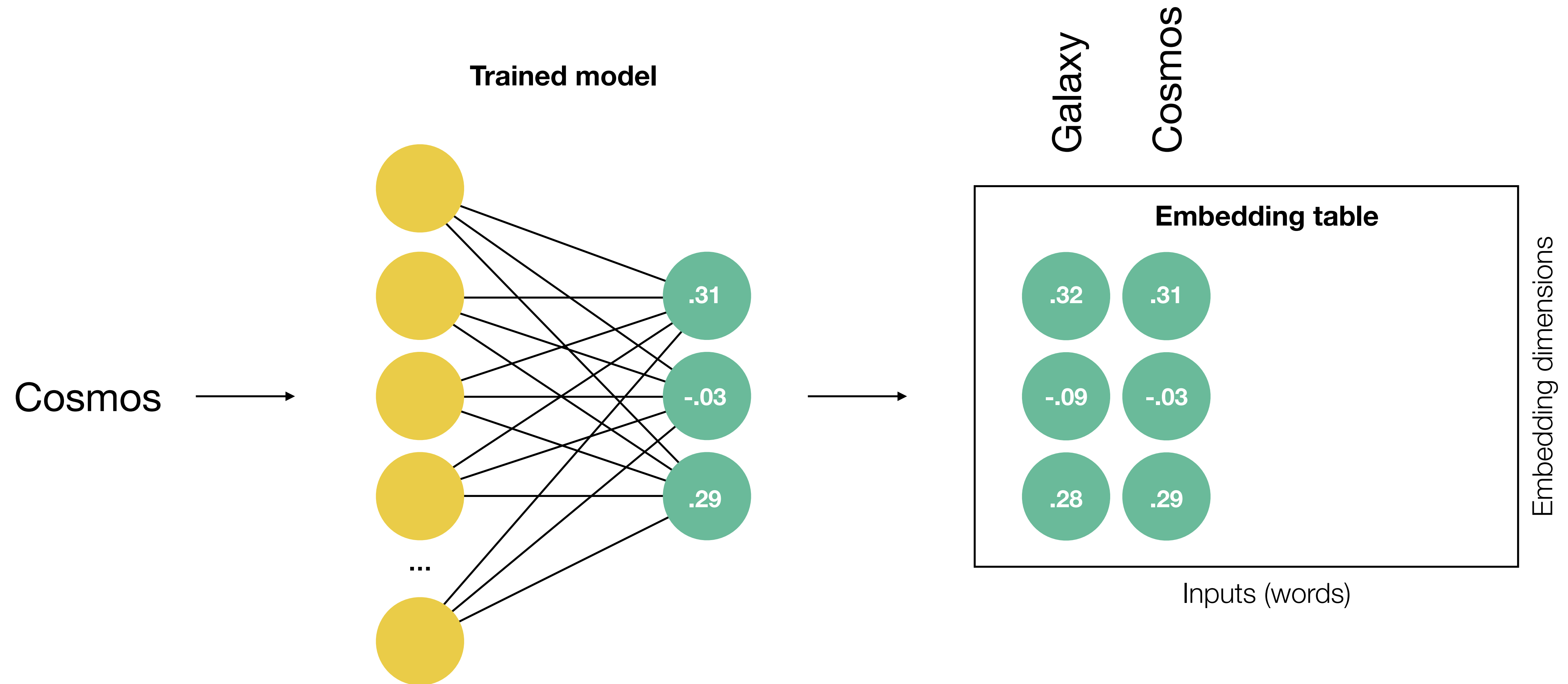
Generating embeddings

or recording hidden activations



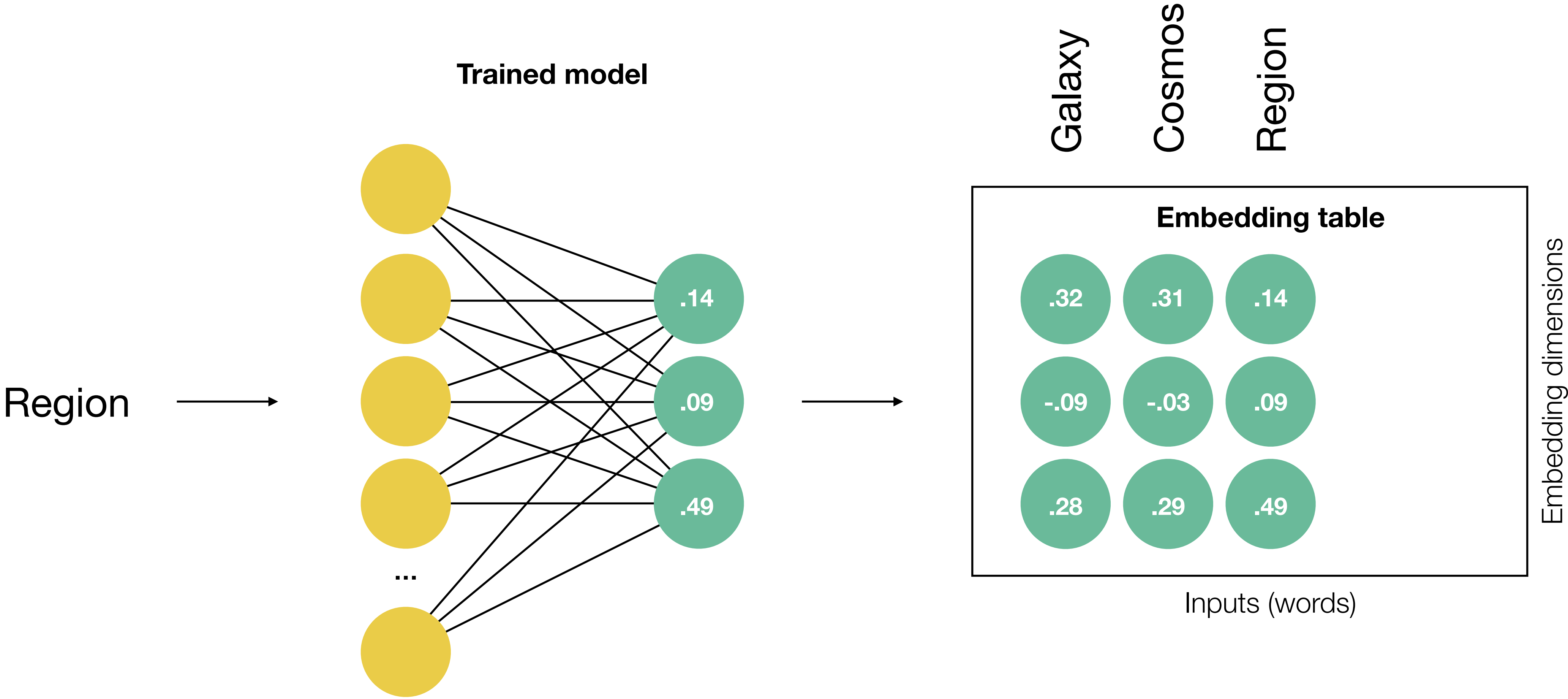
Generating embeddings

or recording hidden activations



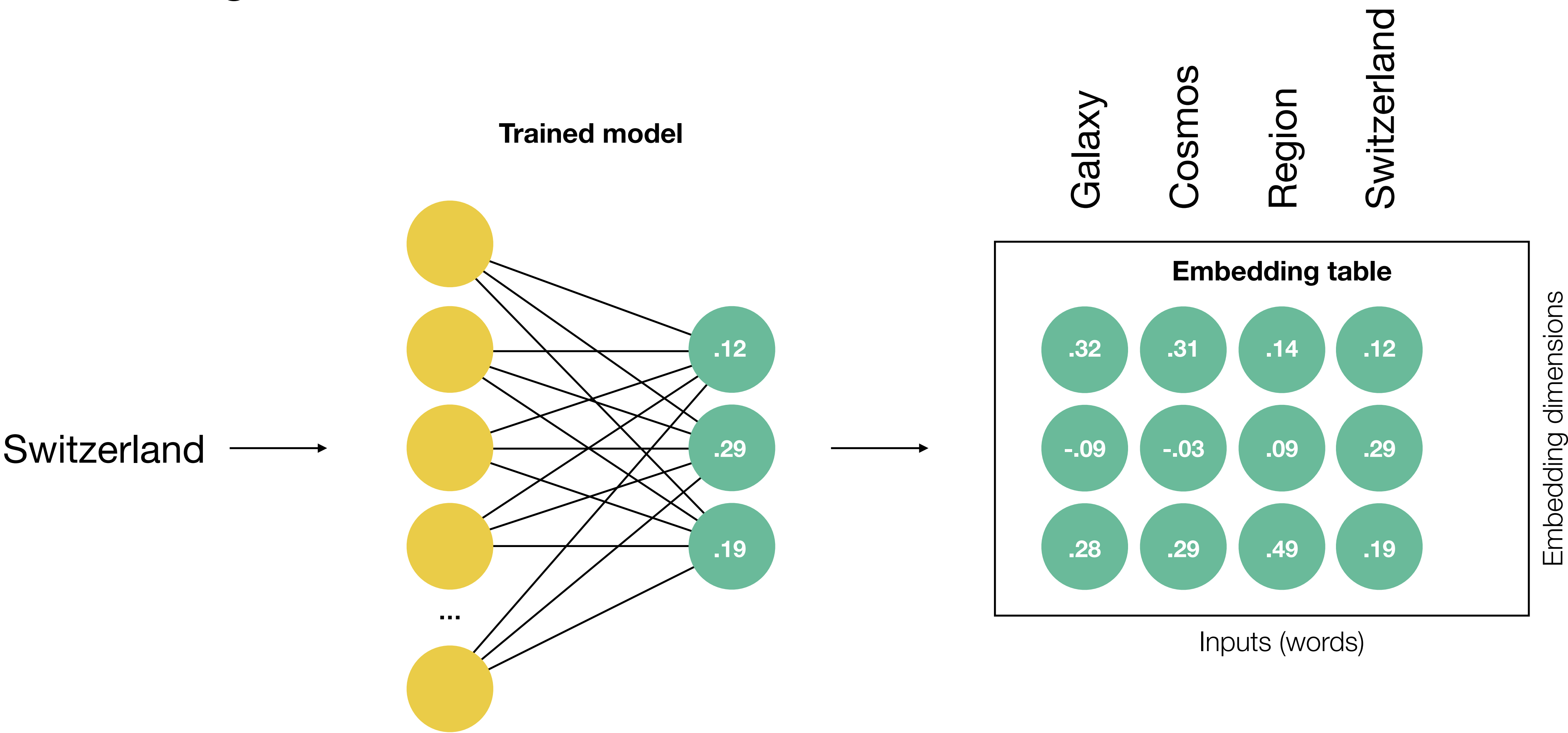
Generating embeddings

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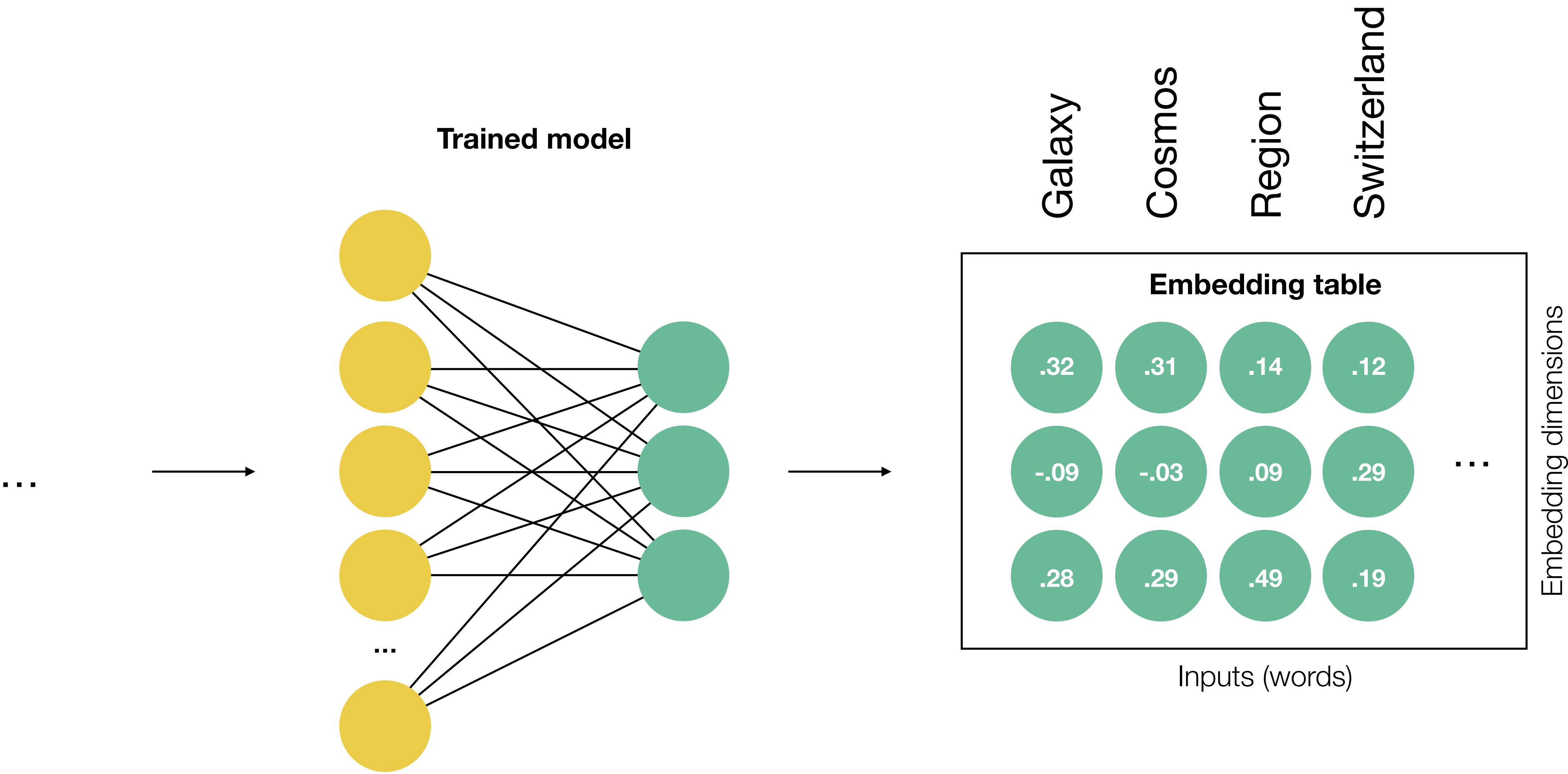
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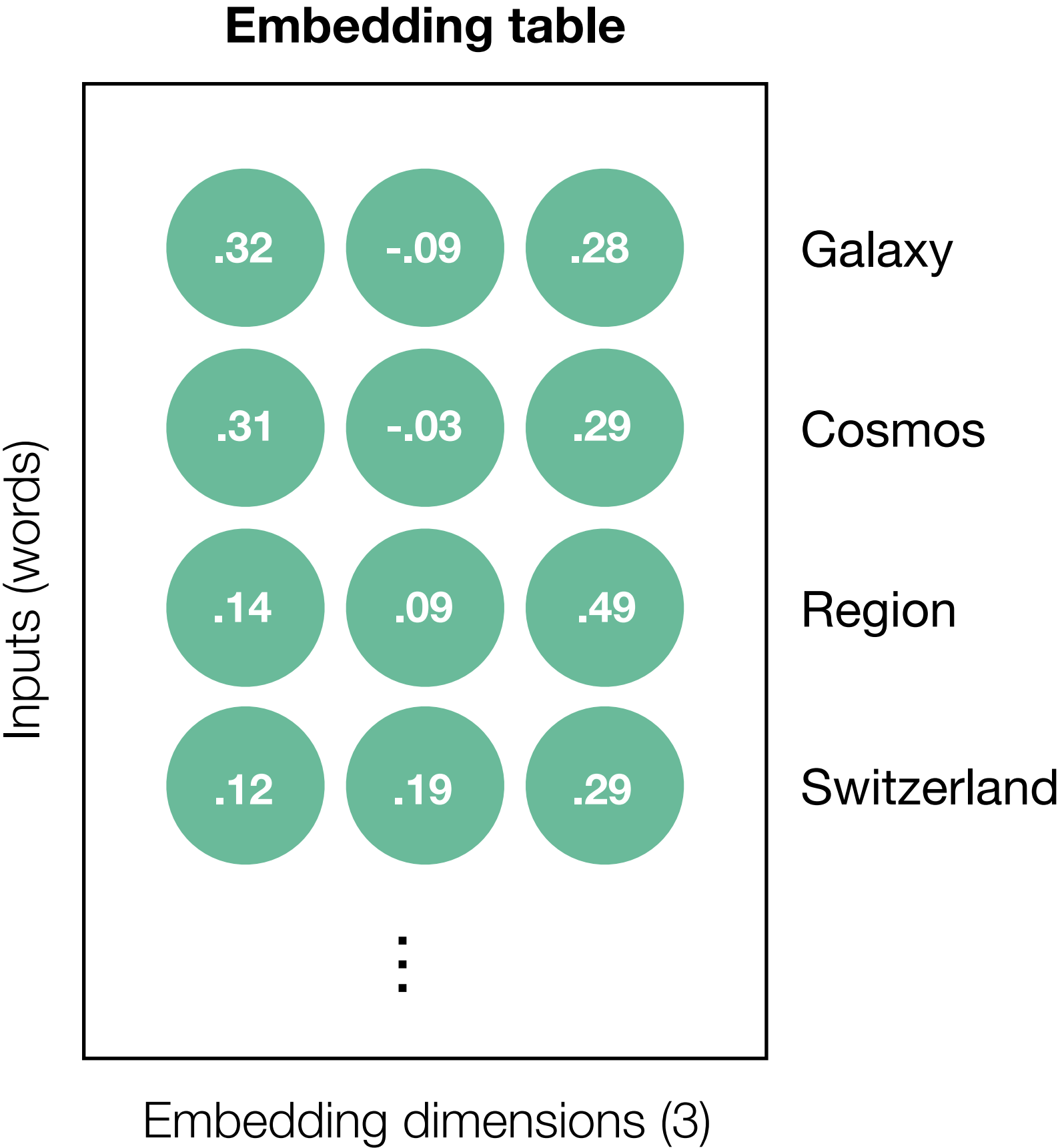
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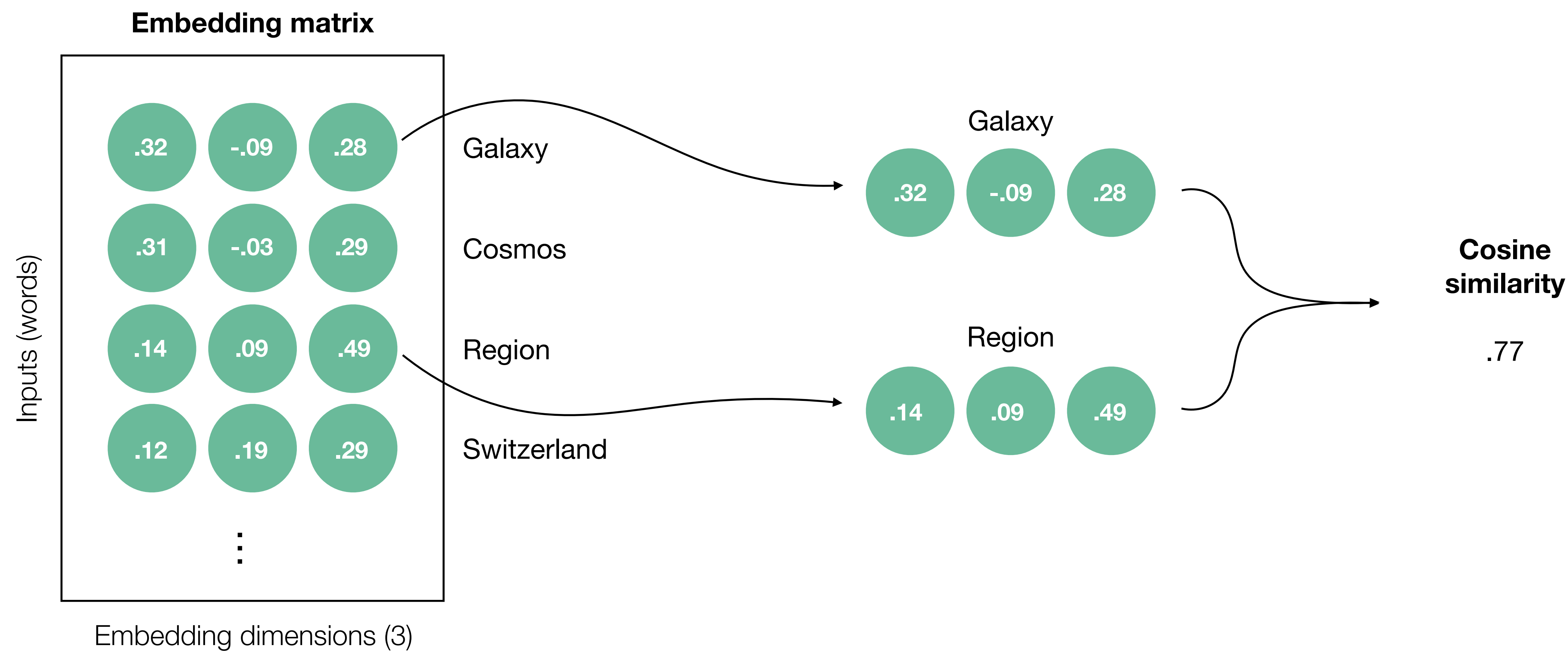
Comparing embeddings

Using cosine similarity



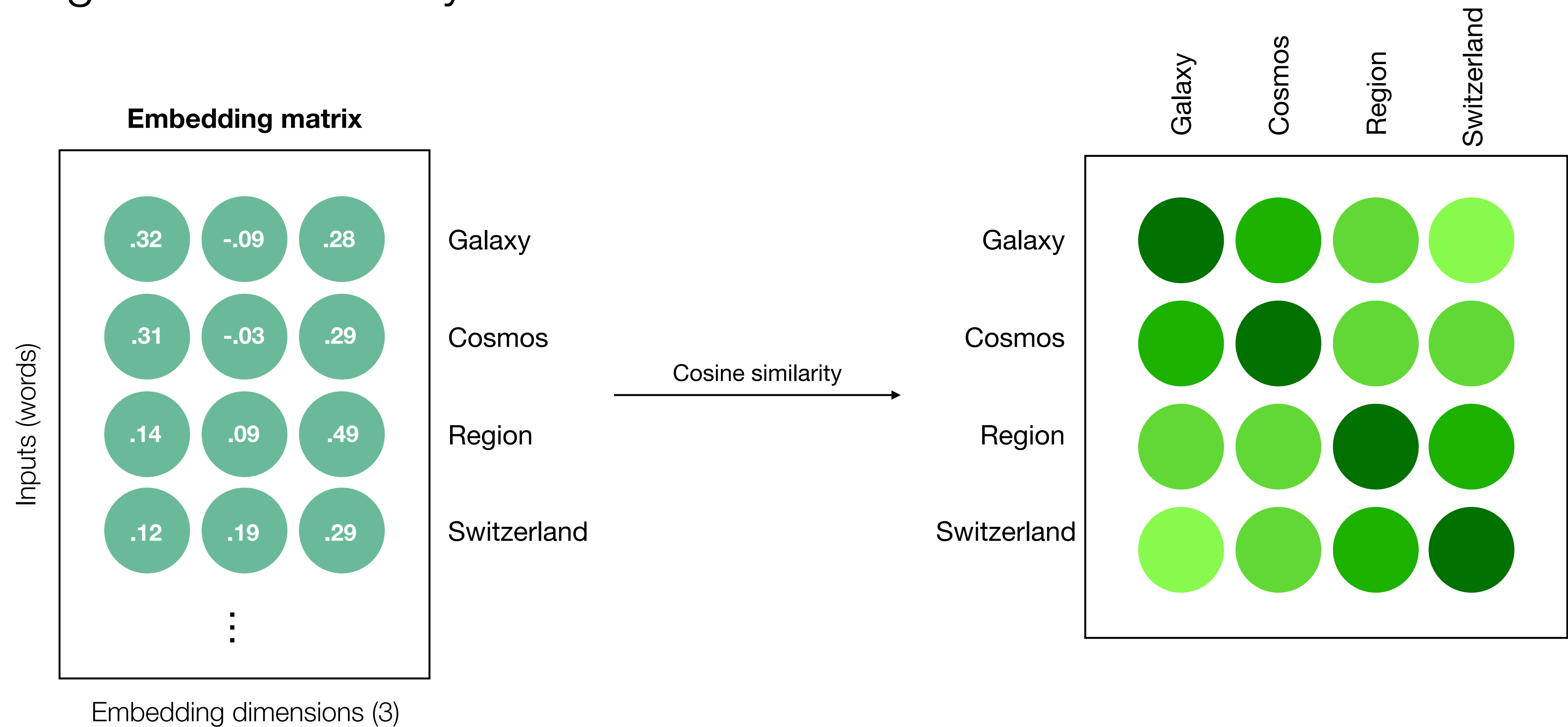
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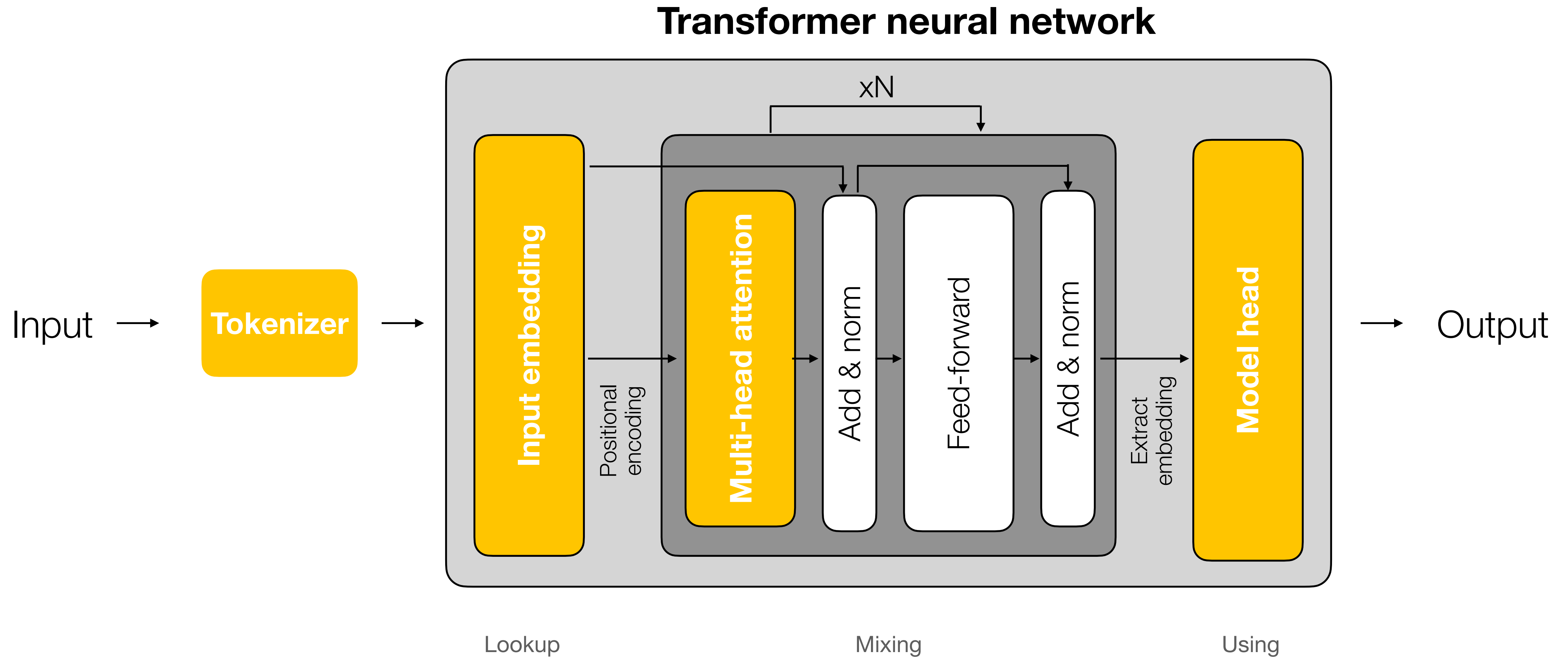
Comparing embeddings

Using cosine similarity



Transformer

Architecture



Transformer

Tokenization

Sentence

'This was it, the descent.'



Tokenizer



'[CLS]', 'this', 'was', 'it', ',', 'the', 'descent', '.', '[SEP]'

"You're on your way, Kelvin. Good luck!" Moddard's voice sounded as close as before.

A wide slit opened at eye-level, and I could see the stars. The `_Prometheus_` was orbiting in the region of Alpha in Aquarius and I tried in vain to orient myself; a glittering dust filled my porthole. I could not recognize a single constellation; in this region of the galaxy the sky was unfamiliar to me. I waited for the moment when I would pass near the first distinct star, but I was unable to isolate any one of them. Their brightness was fading; they receded, merging into a vague, purplish glimmer, the sole indication of the distance I had already travelled. My body rigid, sealed in its pneumatic envelope, I was knifing through space with the impression of standing still in the void, my only distraction the steadily mounting heat.

Suddenly, there was a shrill, grating sound, like a steel blade being drawn across a sheet of wet glass. **This was it, the descent.** If I had not seen the figures racing across the dial, I would not have noticed the change in direction. The stars having vanished long since, my gaze was swallowed up on the pale reddish glow of infinity. I could hear my heart thudding heavily. I could feel the coolness from the air-conditioning on my neck, although my face seemed to be on fire. I regretted not having caught a glimpse of the `_Prometheus_`, but the ship must have been out of sight by the time the automatic controls had raised the shutter of my porthole.

The capsule was shaken by a sudden jolt, then another. The whole vehicle began to vibrate. Filtered through the insulating layers of the outer skins, penetrating my pneumatic cocoon, the vibration reached me, and ran through my entire body. The image of the dial shivered and multiplied, and its phosphorescence spread out in all directions. I felt no fear. I had not undertaken this long voyage only to overshoot my target!

I called into the microphone:

"Station Solaris! Station Solaris! Station Solaris! I think I am leaving the flight-path, correct my course! Station Solaris, this is the `_Prometheus_` capsule. Over."

I had missed the precious moment when the planet first came into view. Now it was spread out before my eyes; flat, and already immense. Nevertheless, from the appearance of its surface, I judged that I was still at a great height above it, since I had passed that imperceptible frontier after which we measure the distance that separates us from a celestial body in terms of altitude. I was falling. Now I had the sensation of falling, even with my eyes closed. (I quickly reopened them: I did not want to miss anything there was to be seen.)

Transformer

Tokenziation

Sentence

'...merging into a vague, purplish glimmer...'



Tokenizer



'merging', 'into', 'a', 'vague', ',', 'pu',
'##rp', '##lish', 'g', '##lim', '##mer'

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Transformer

Tokenziation

Sentence

'you've won 202000 Eur'



Tokenizer



'[CLS]', 'you', "'", 've', 'won', '2020', '##00',
'eu', '##r', '[SEP]'

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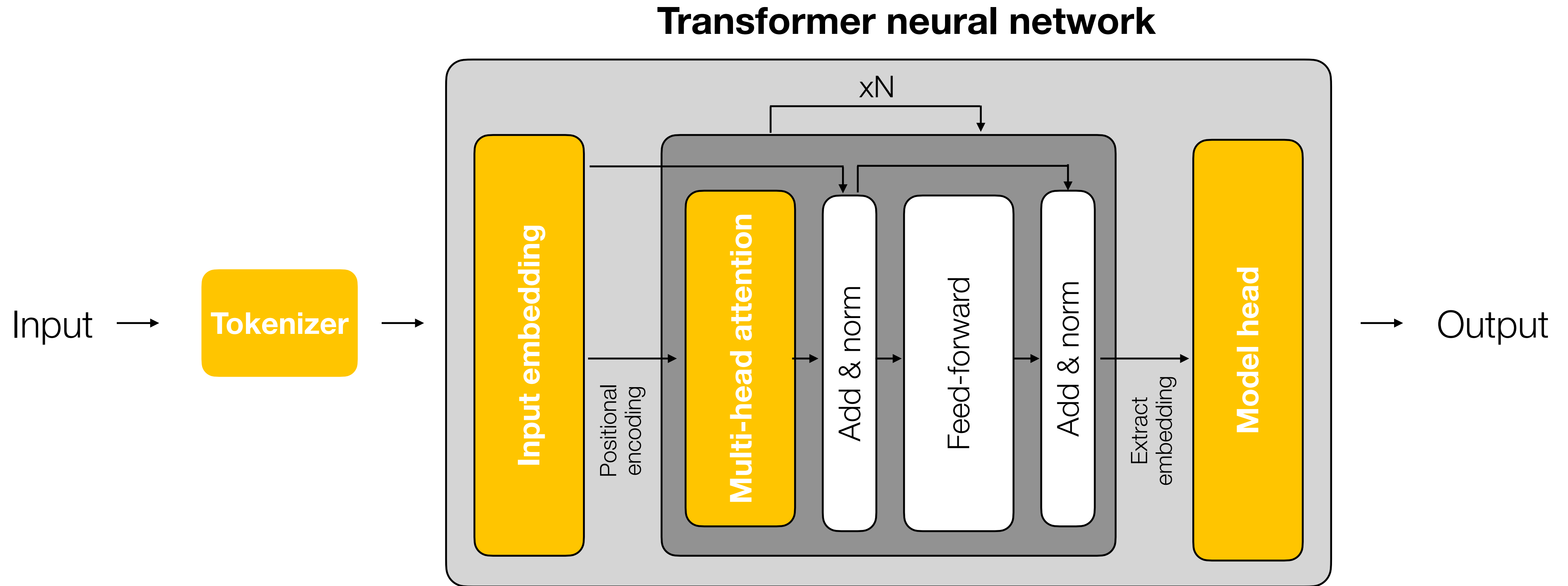
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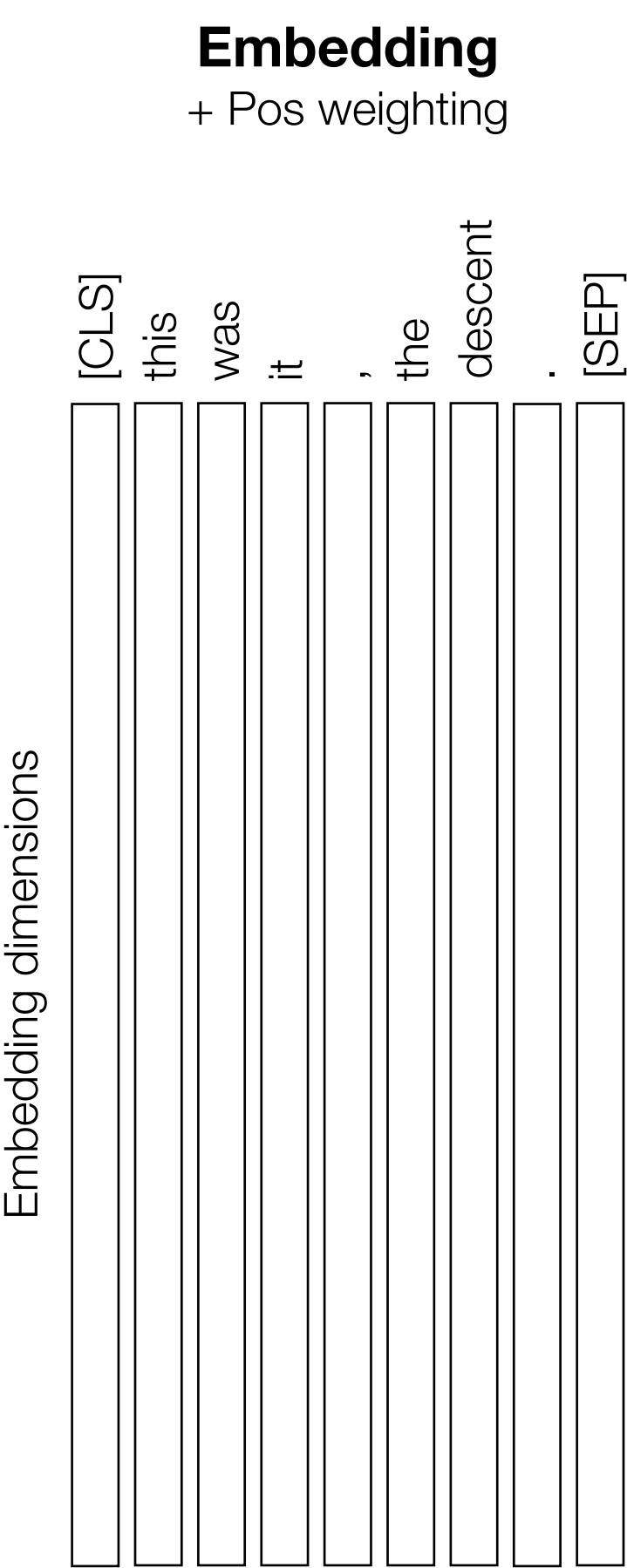
Transformer

Architecture



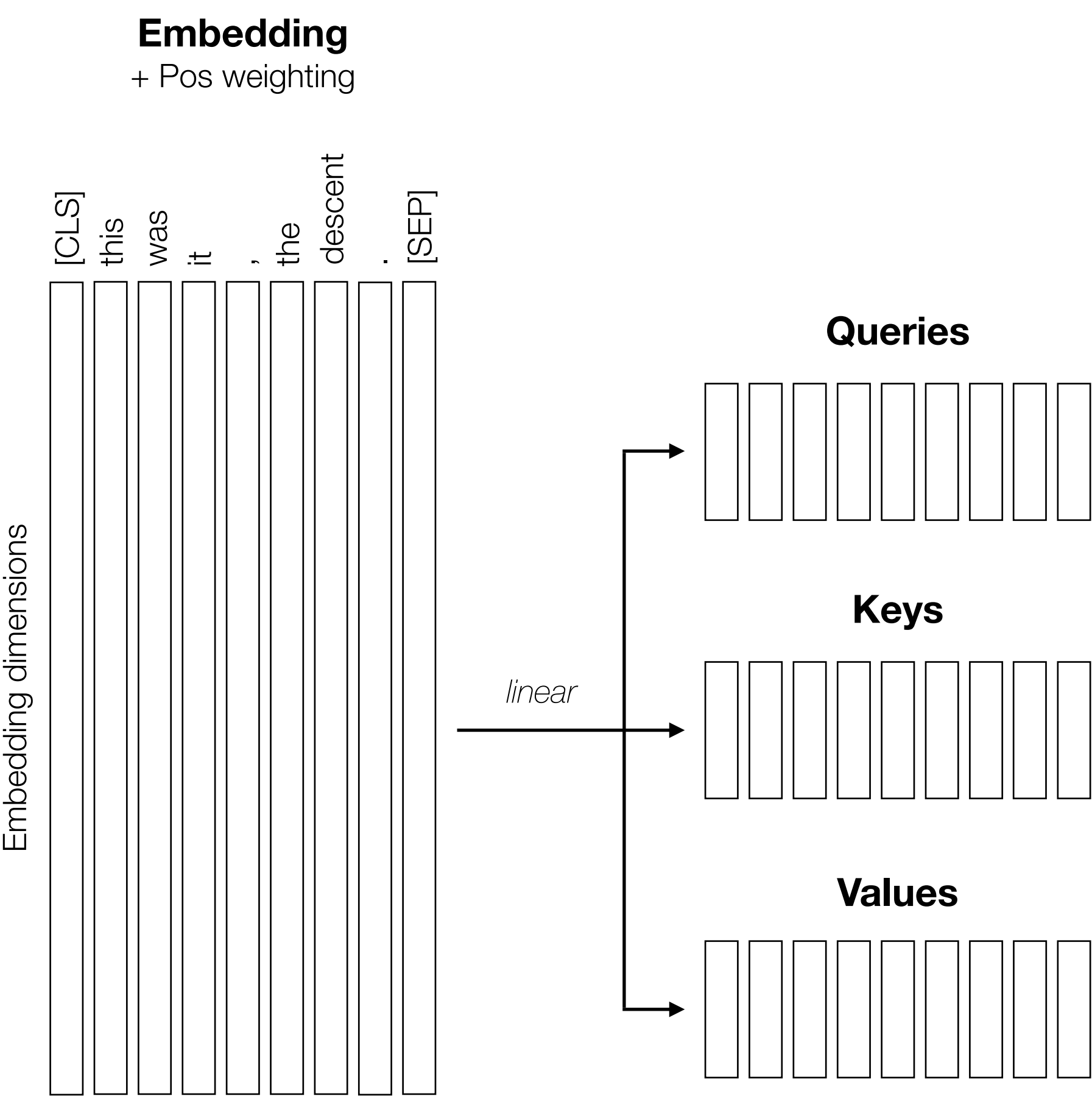
Transformer

Input embeddings



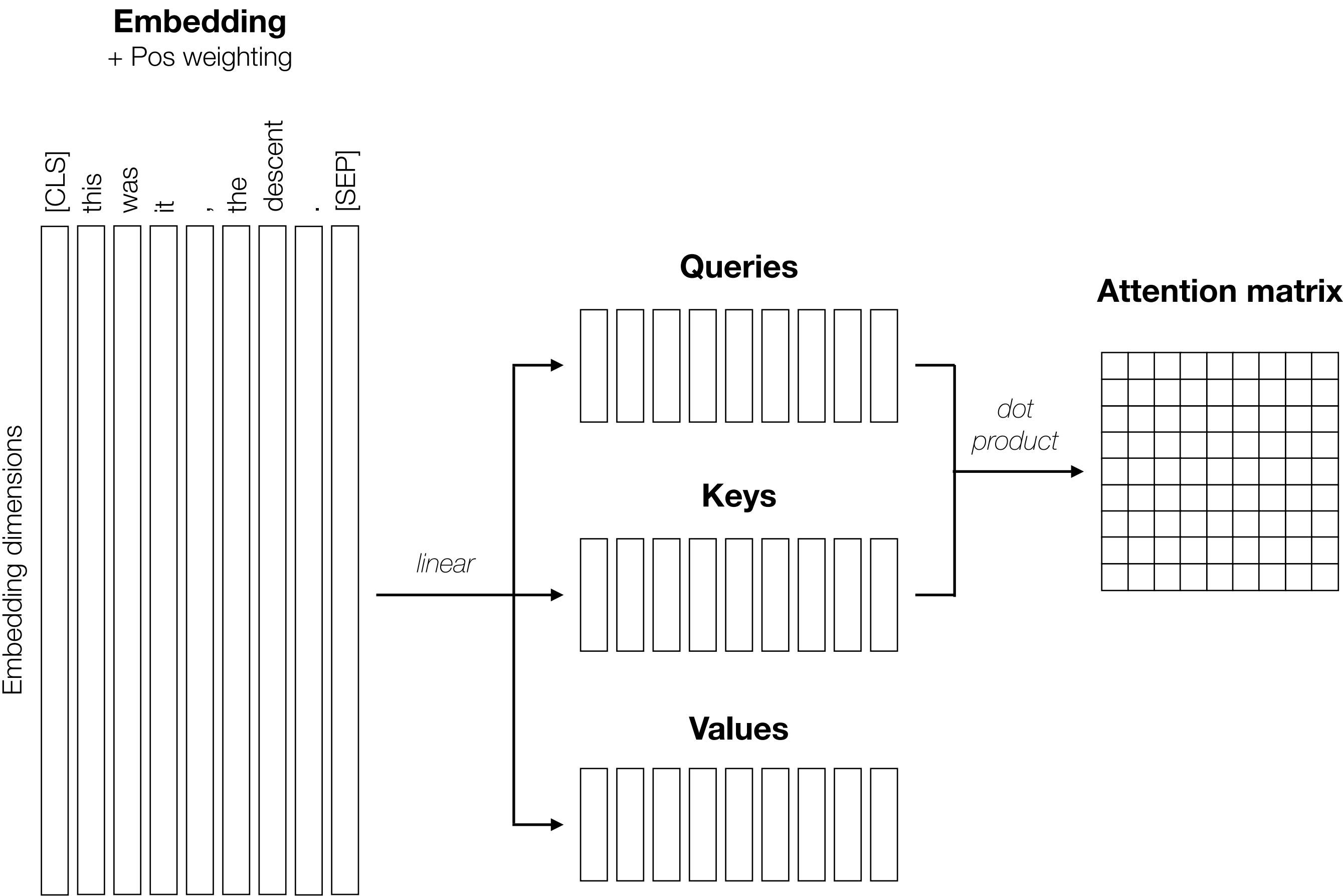
Transformer

Attention



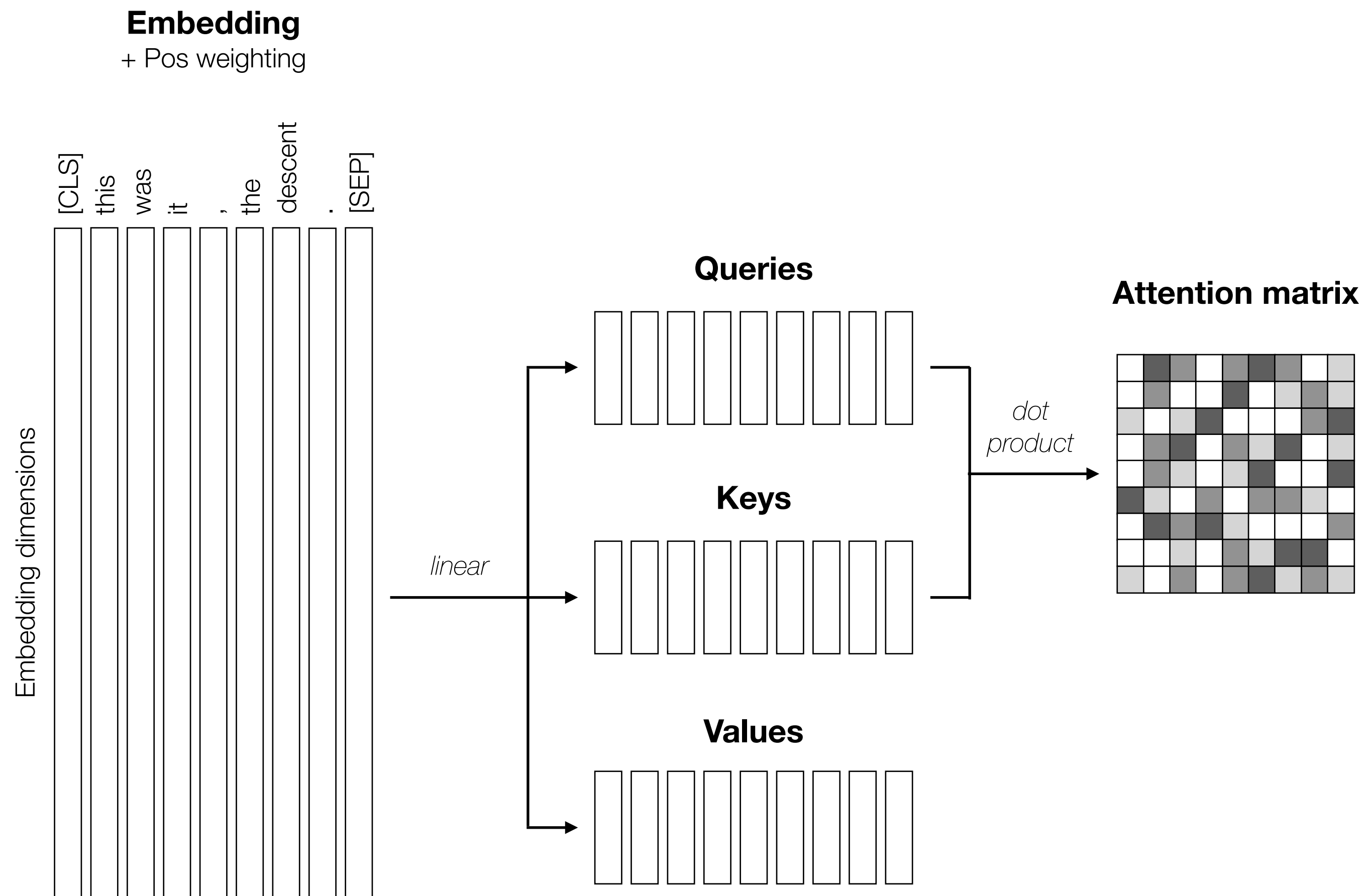
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Attention



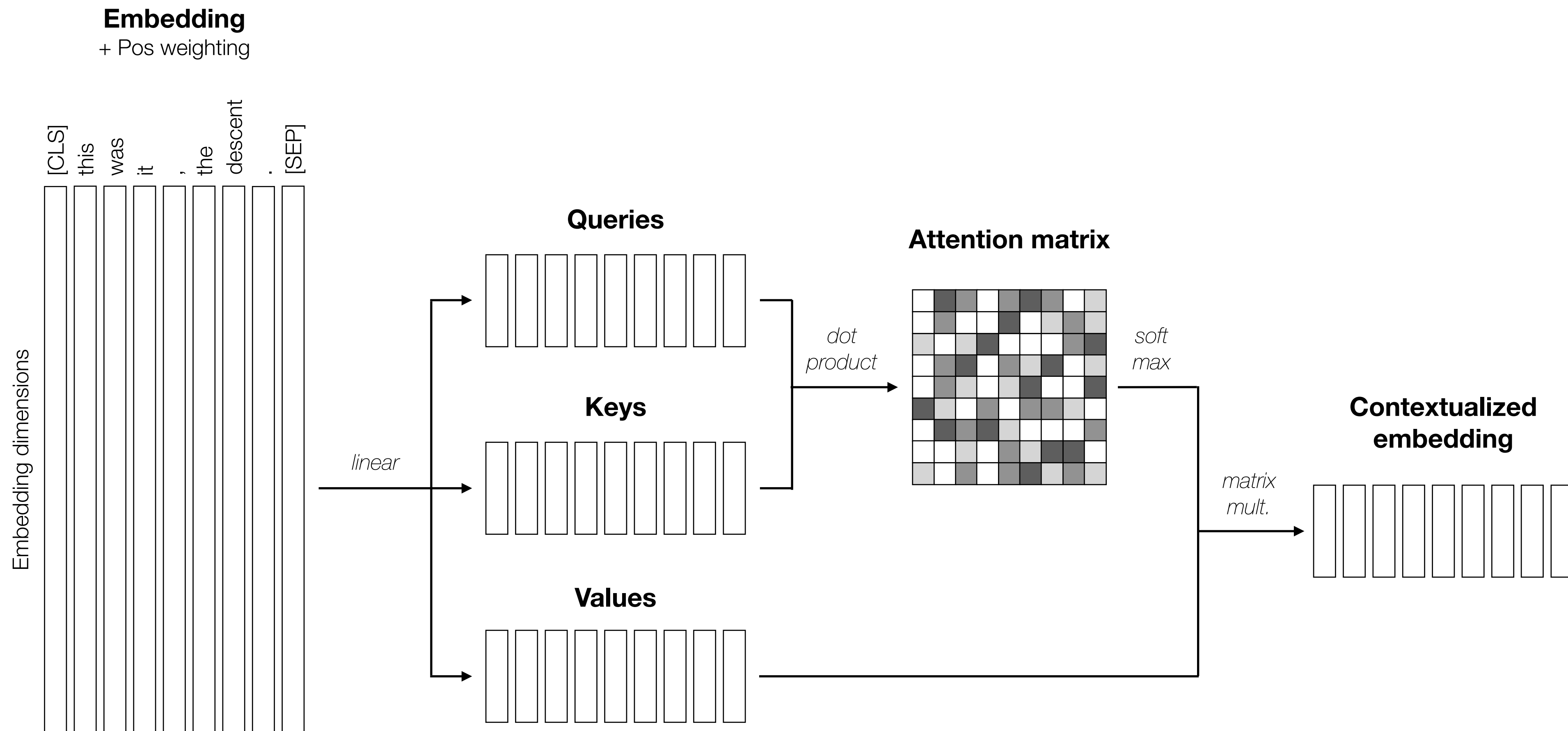
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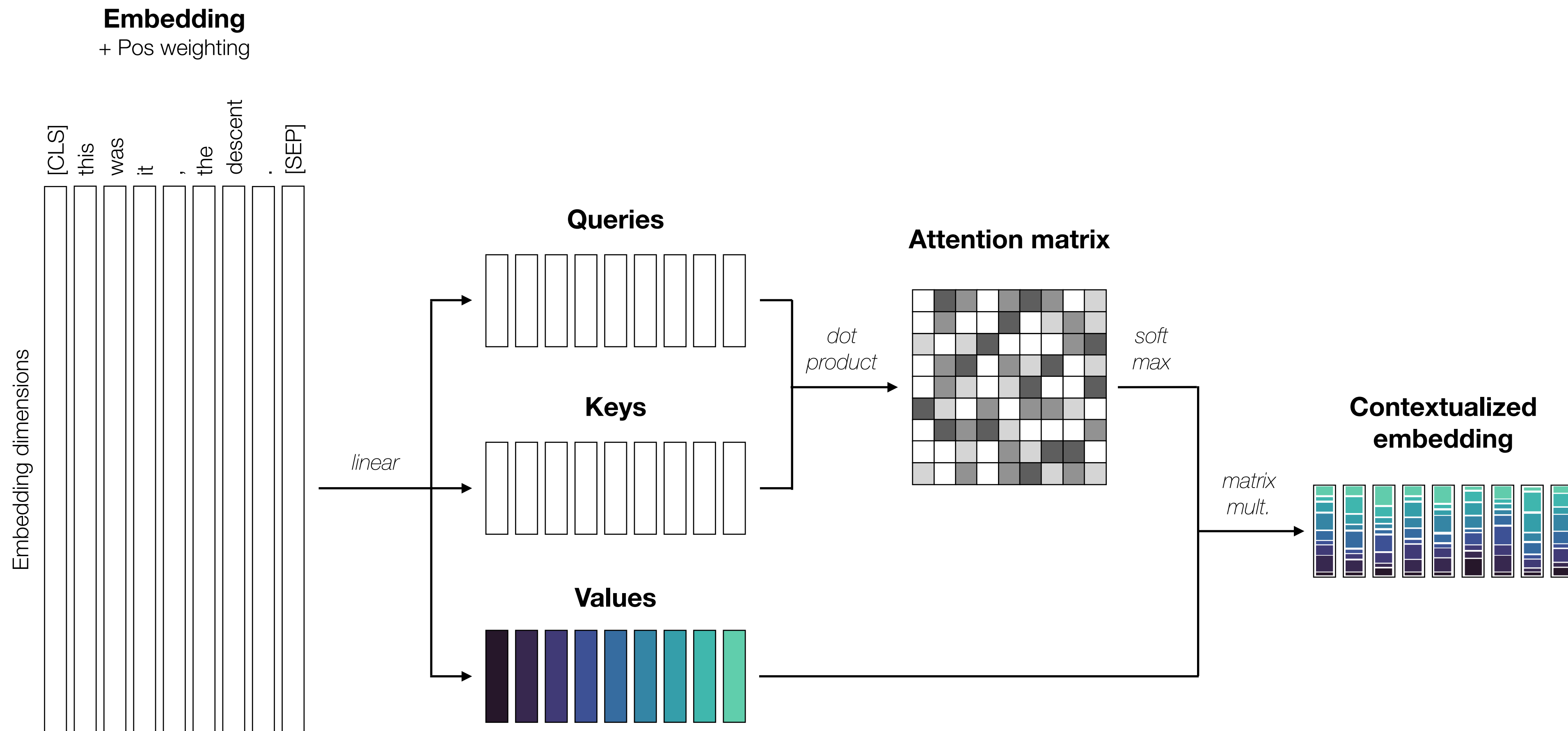
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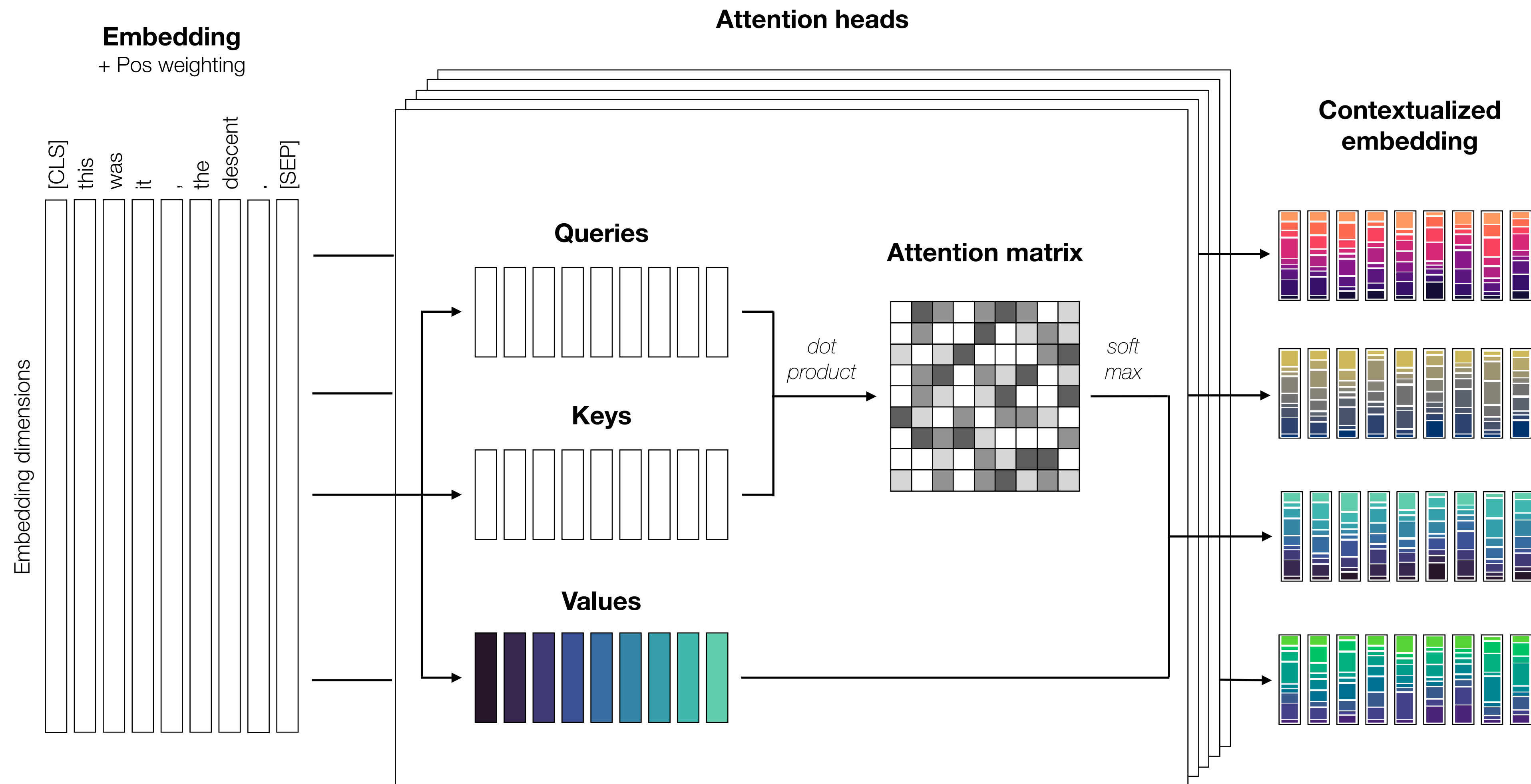
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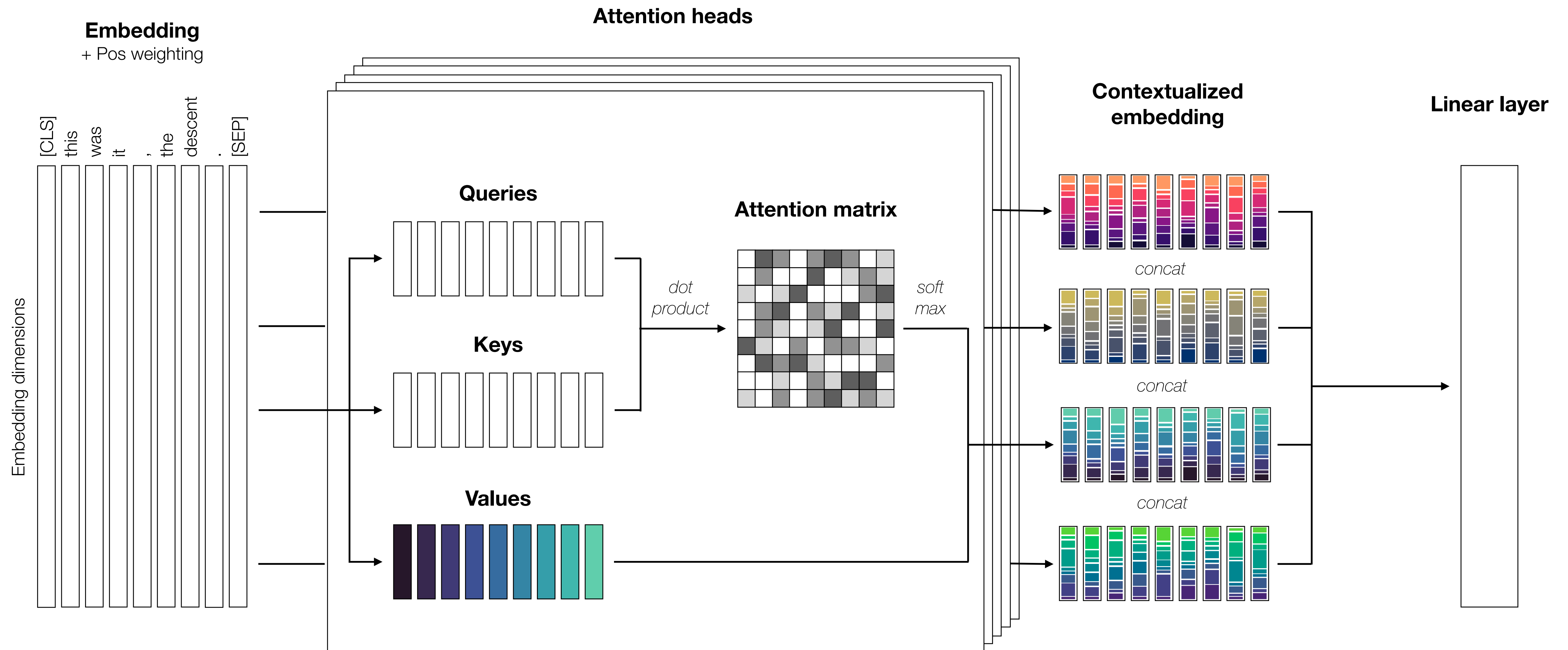
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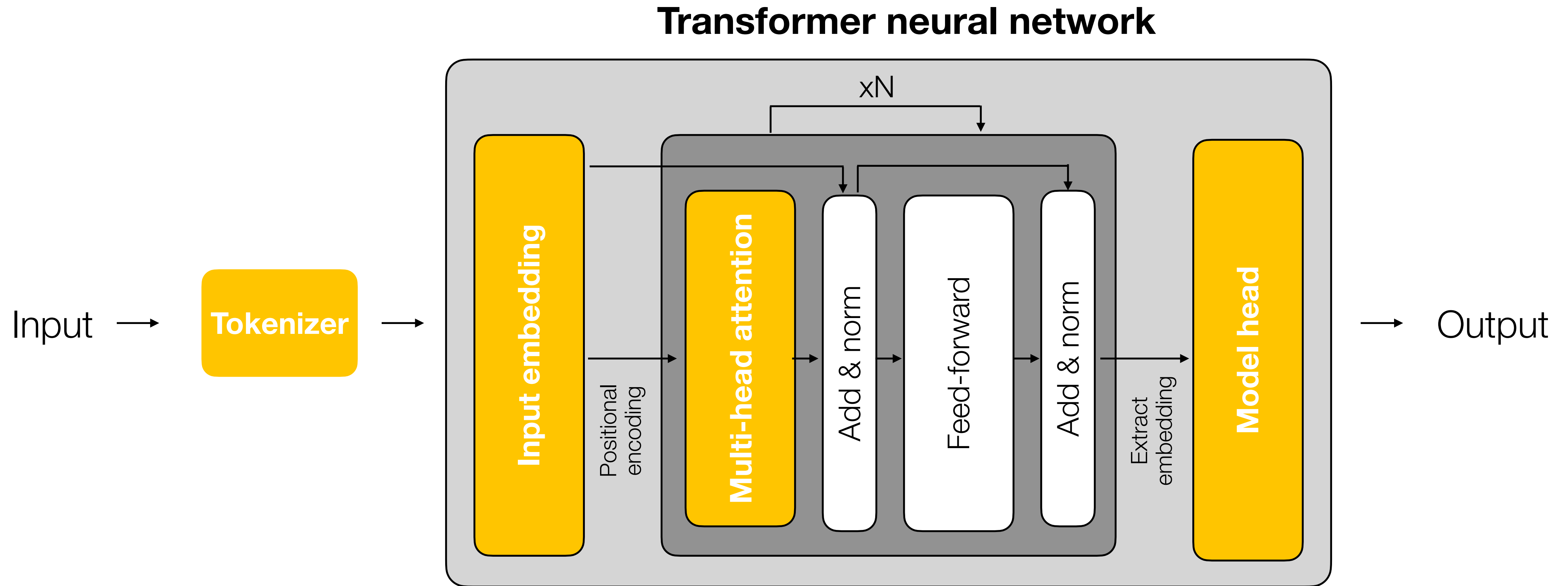
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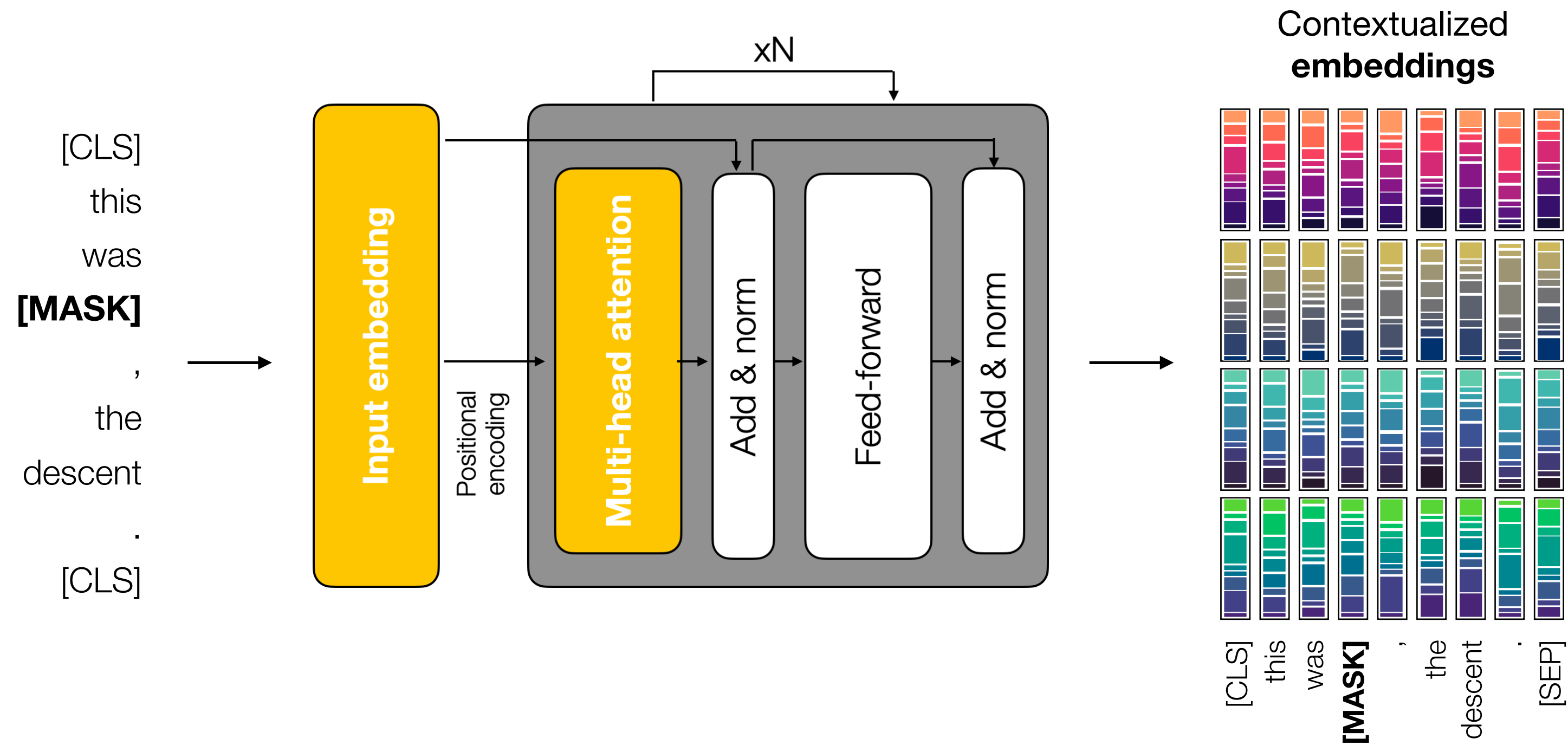
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Architecture



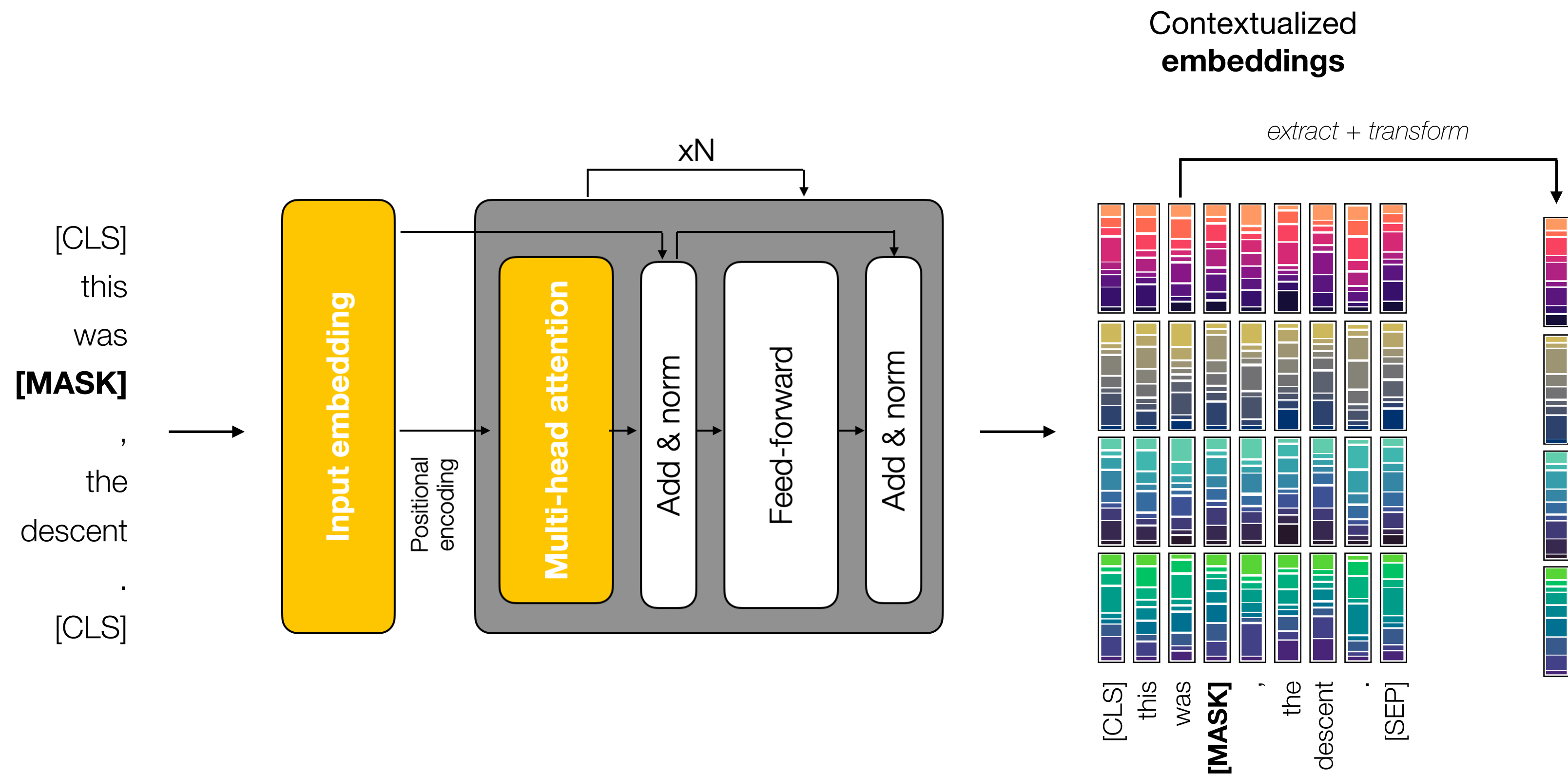
Transformer

Model head for **masked language modeling**



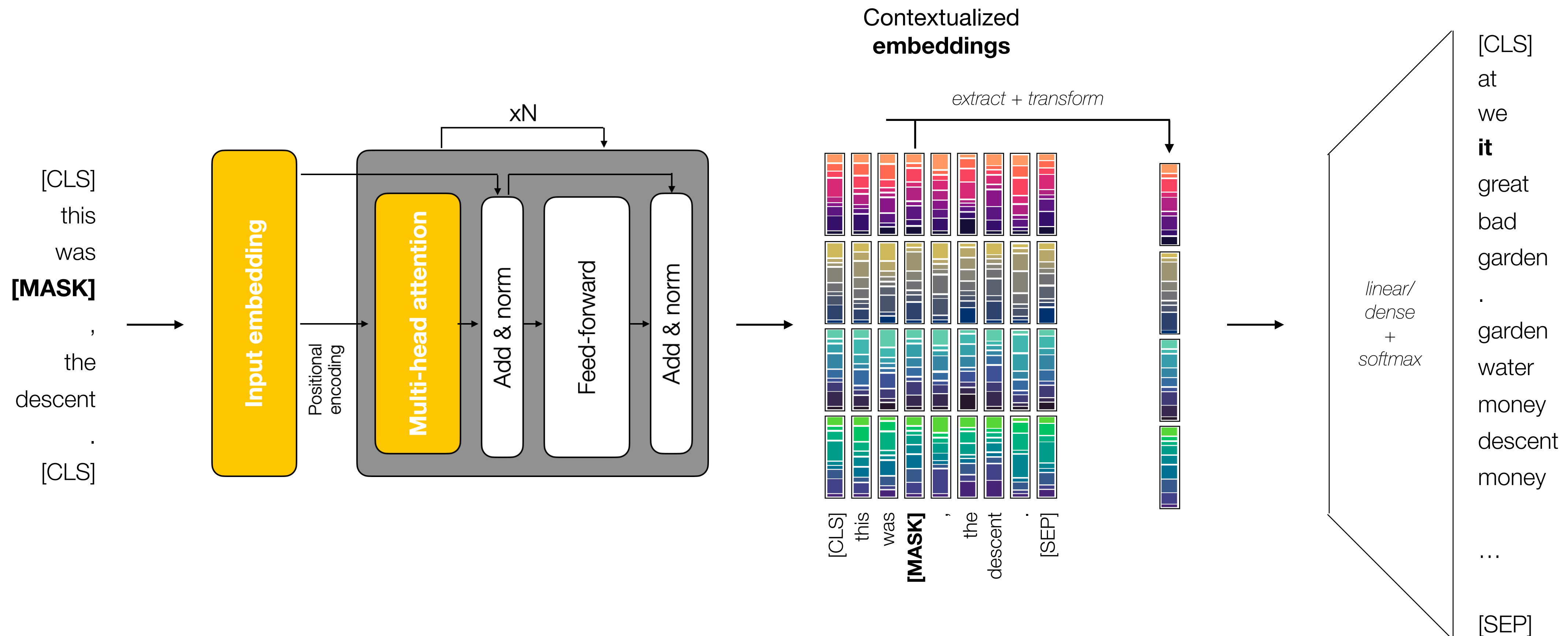
Transformer

Model head for masked language modeling



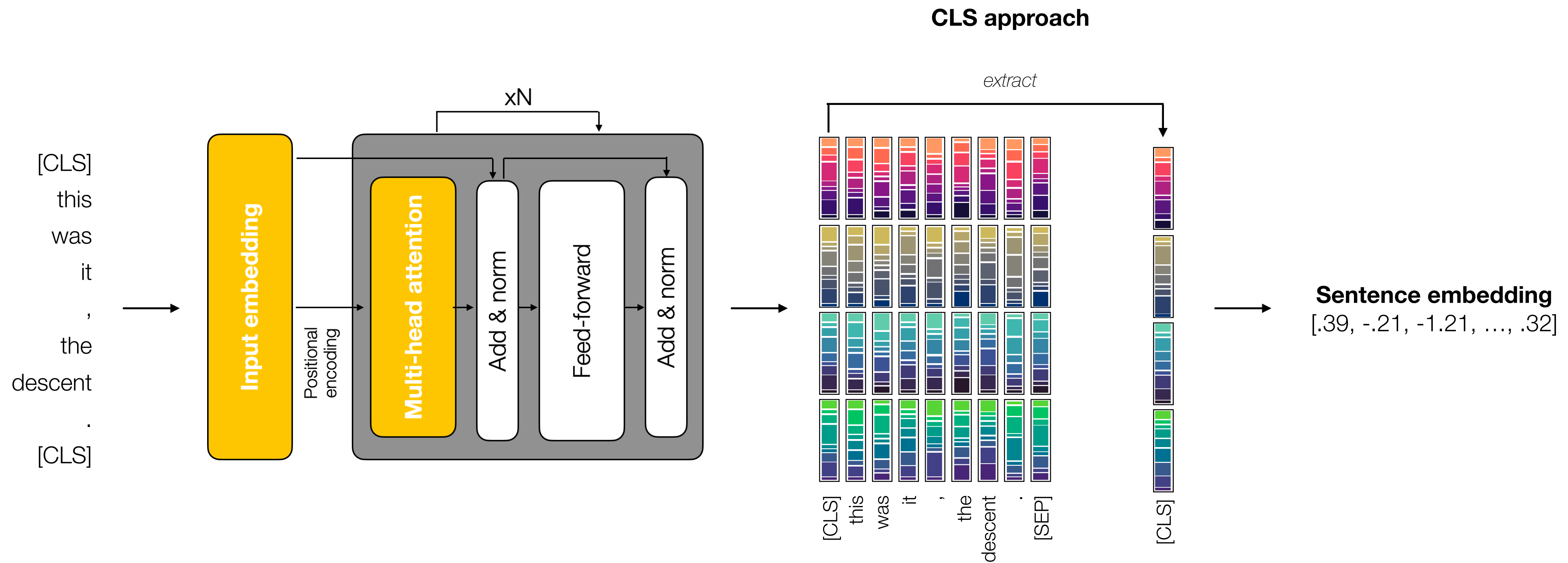
Transformer

Model head for masked language modeling



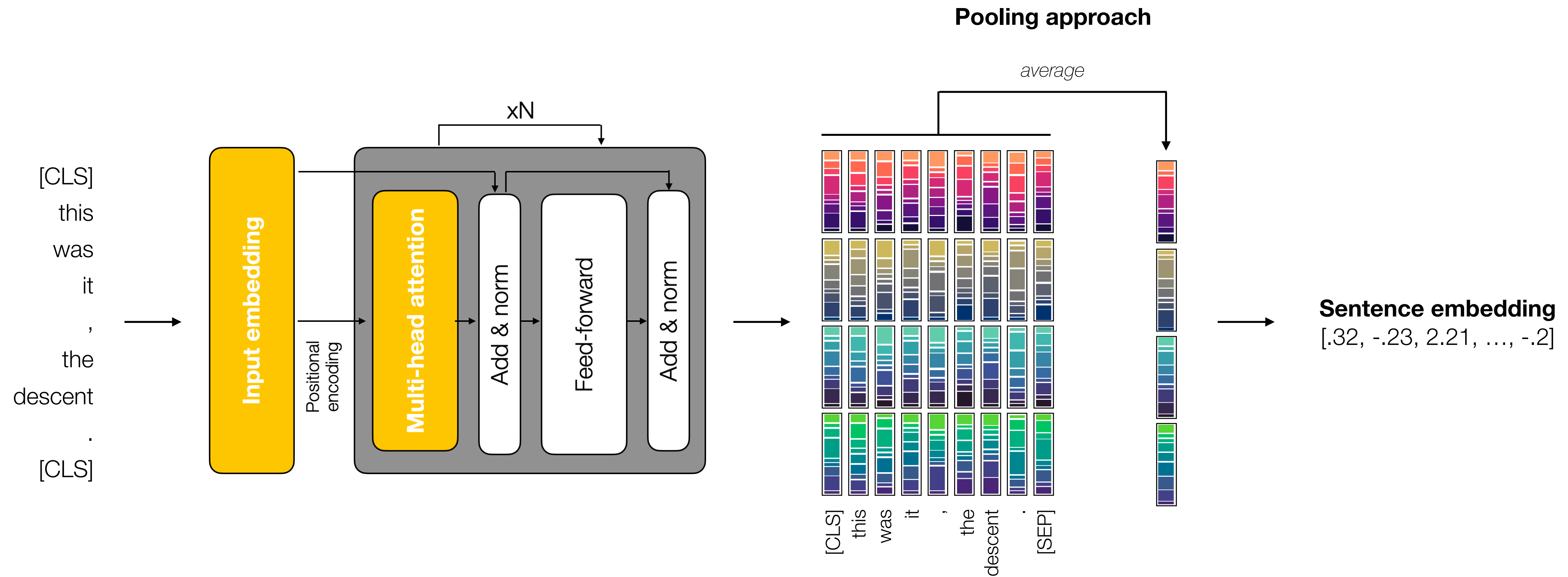
Feature extraction

to generate sentence embeddings



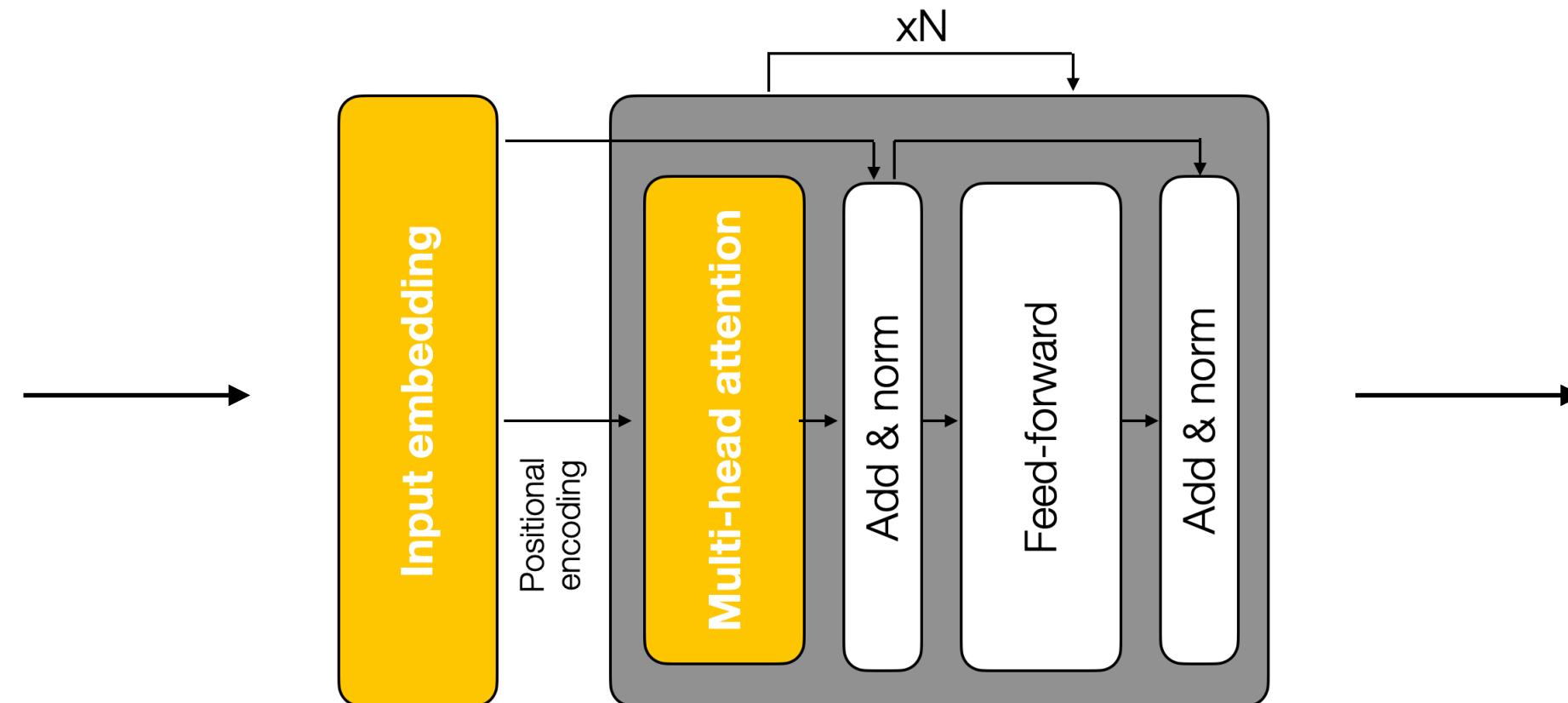
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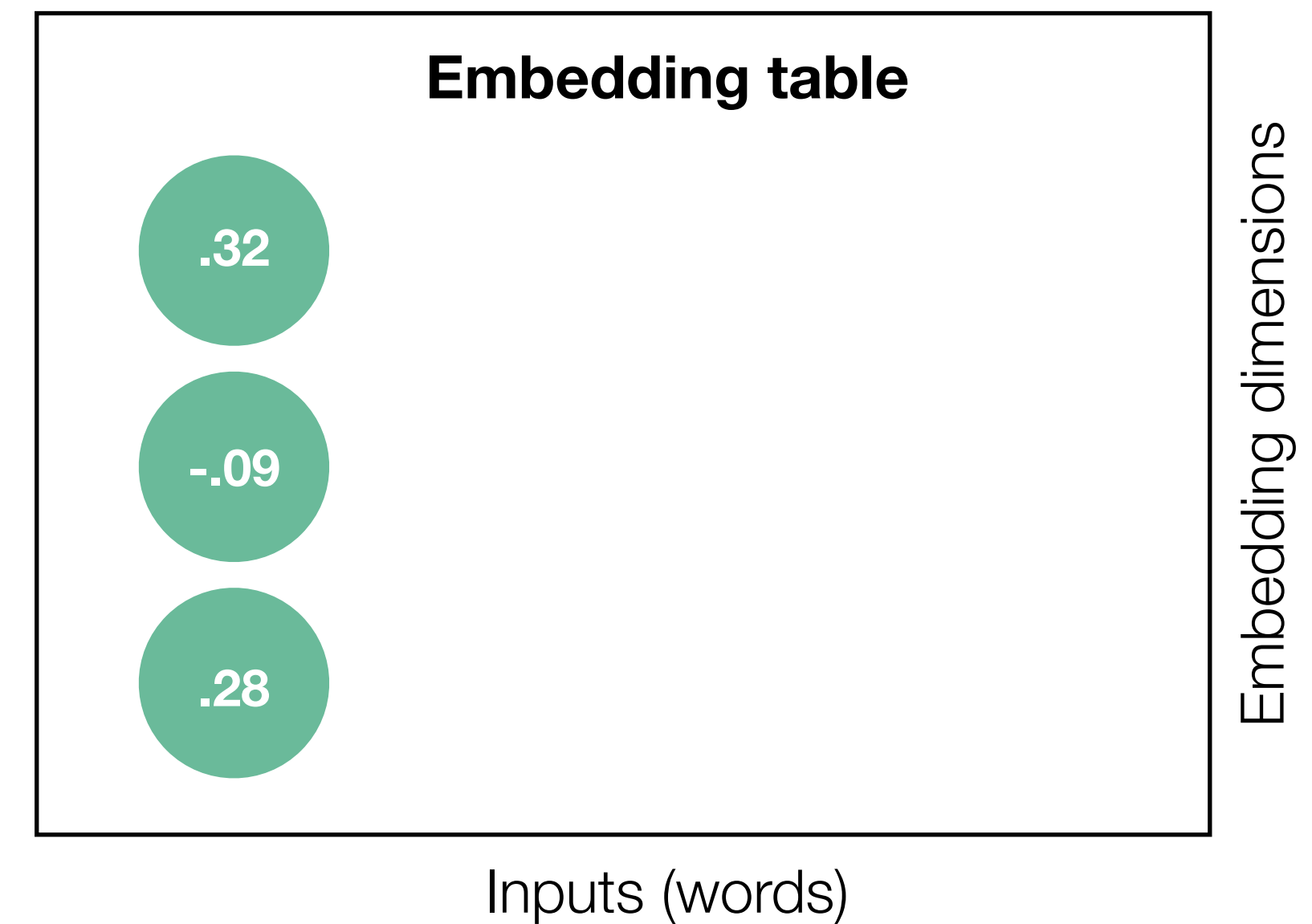


or recording hidden activations

A gender perspective on the global migration of scholars



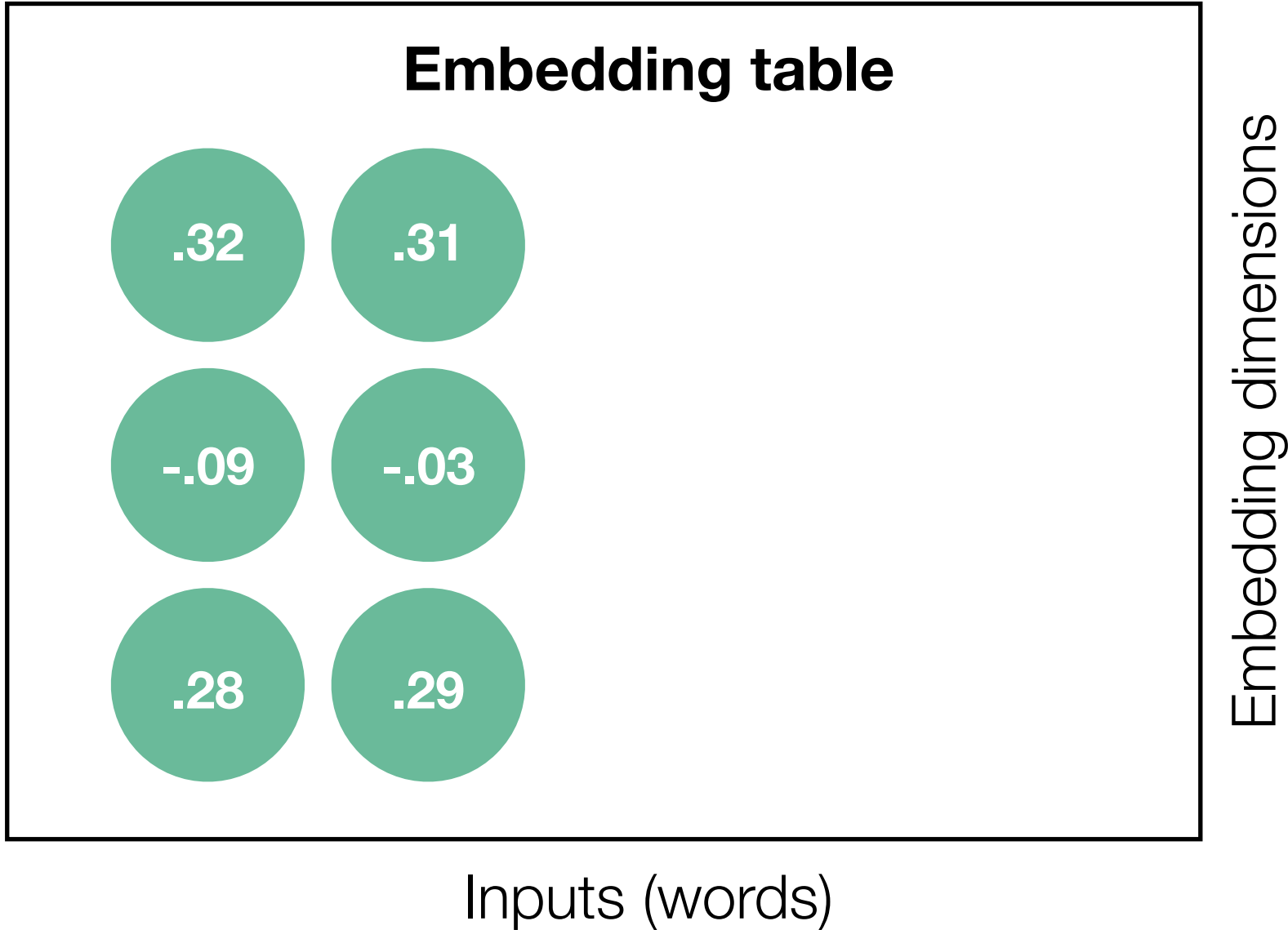
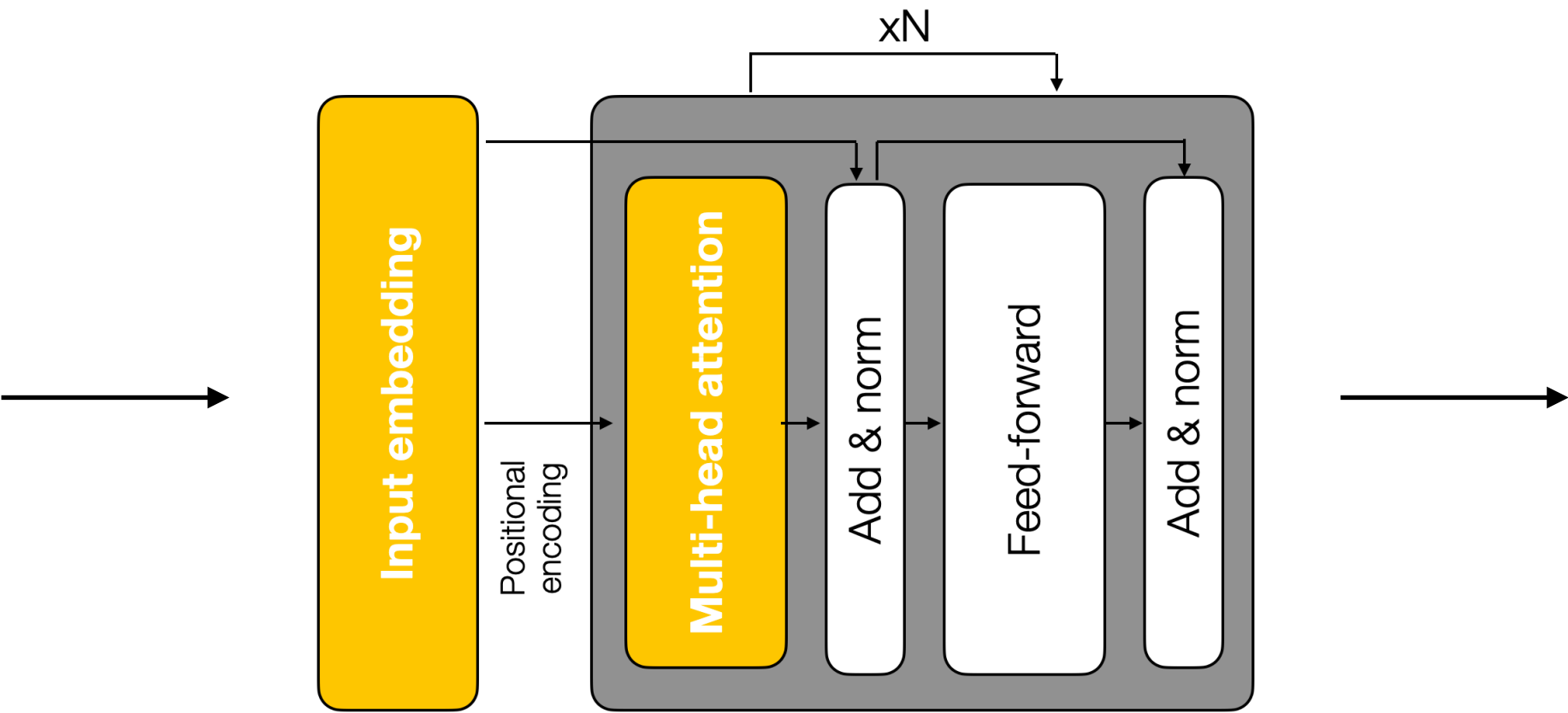
A gender perspective...



Generating embeddings

or recording hidden activations

Authorship and
citation gender
trends in
immunology
and
microbiology

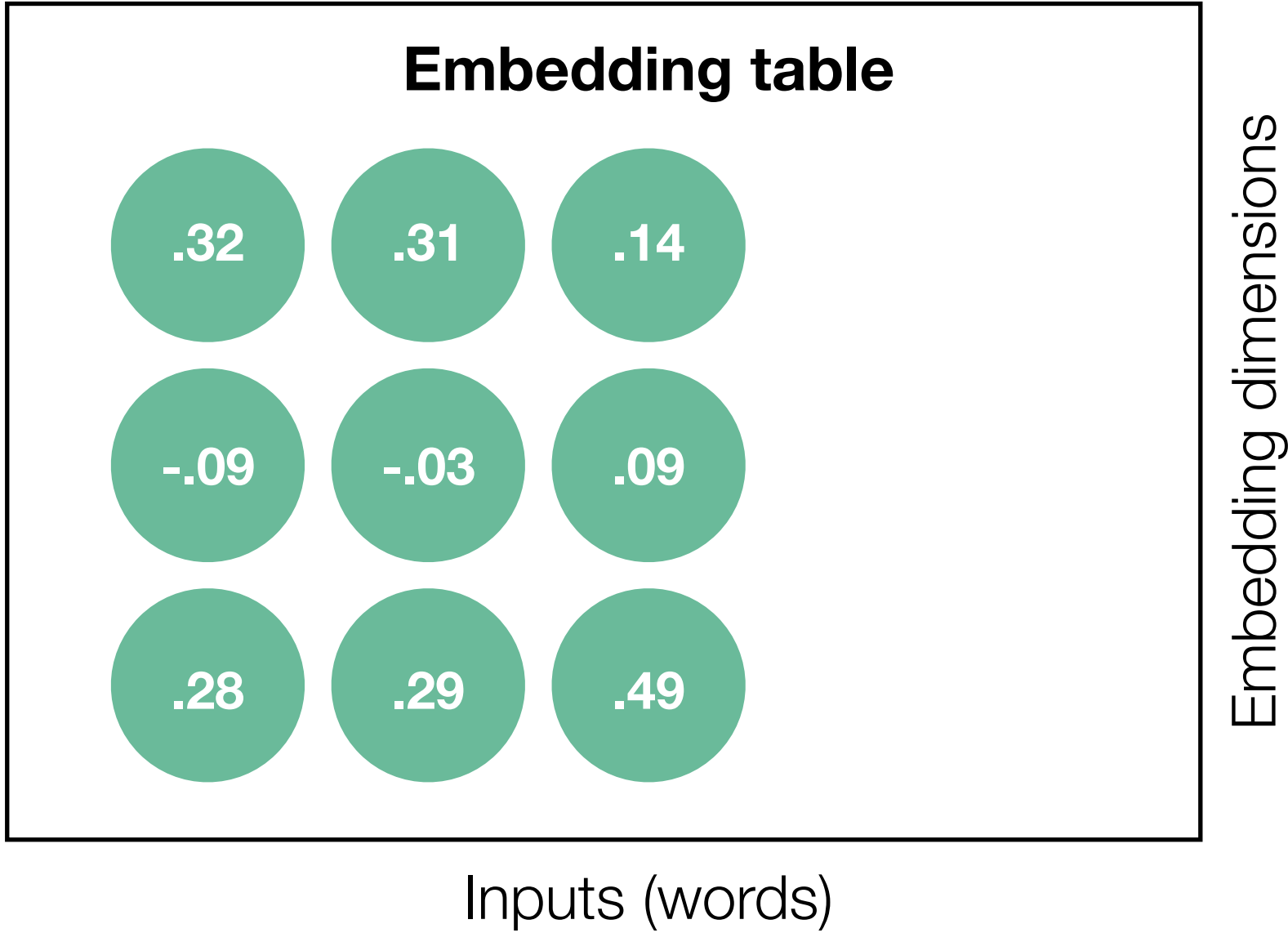
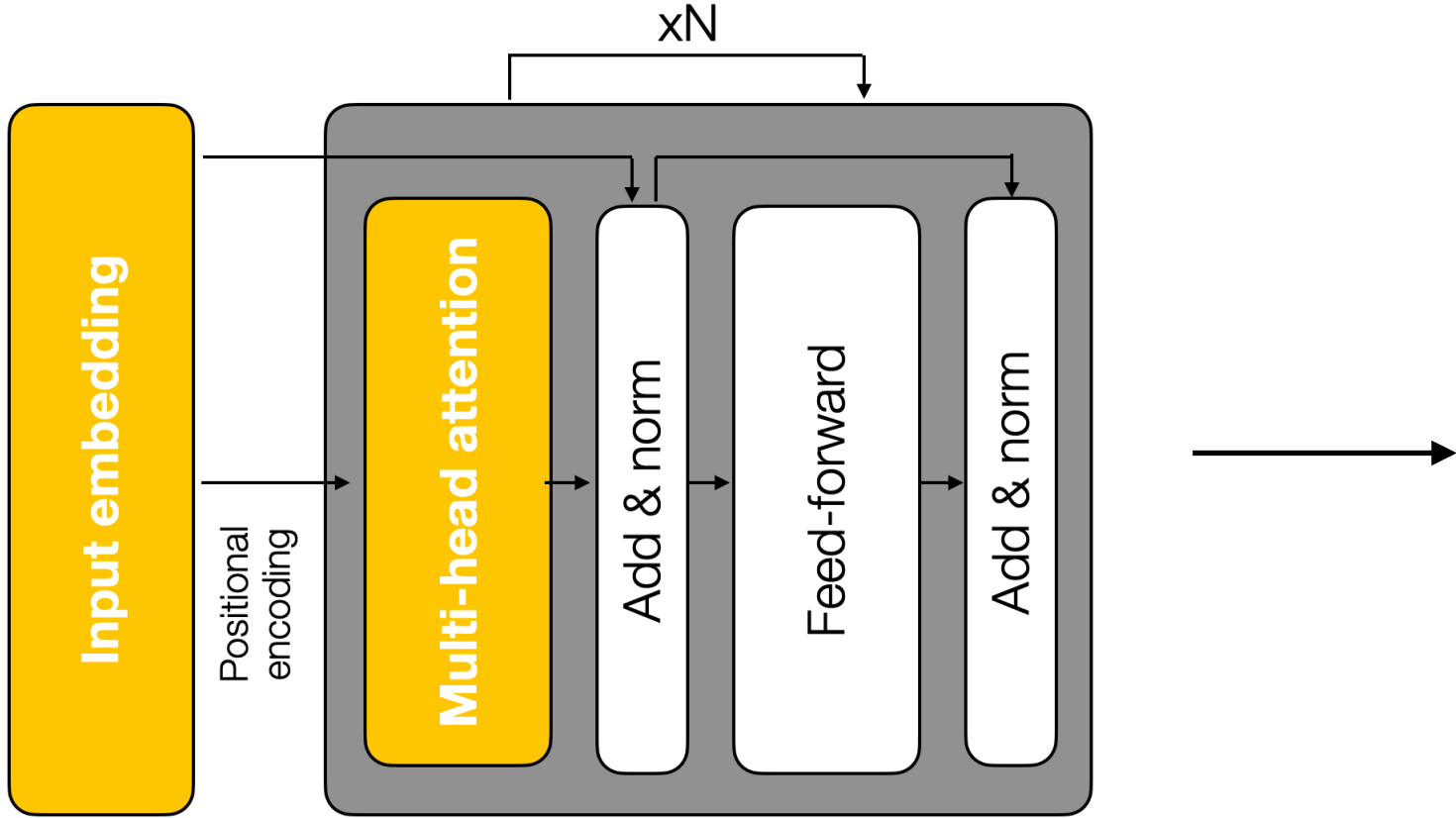


A gender perspective...
Authorship and citation...

Generating embeddings

or recording hidden activations

Toward
metascience via
human-level AI
with
metacognition

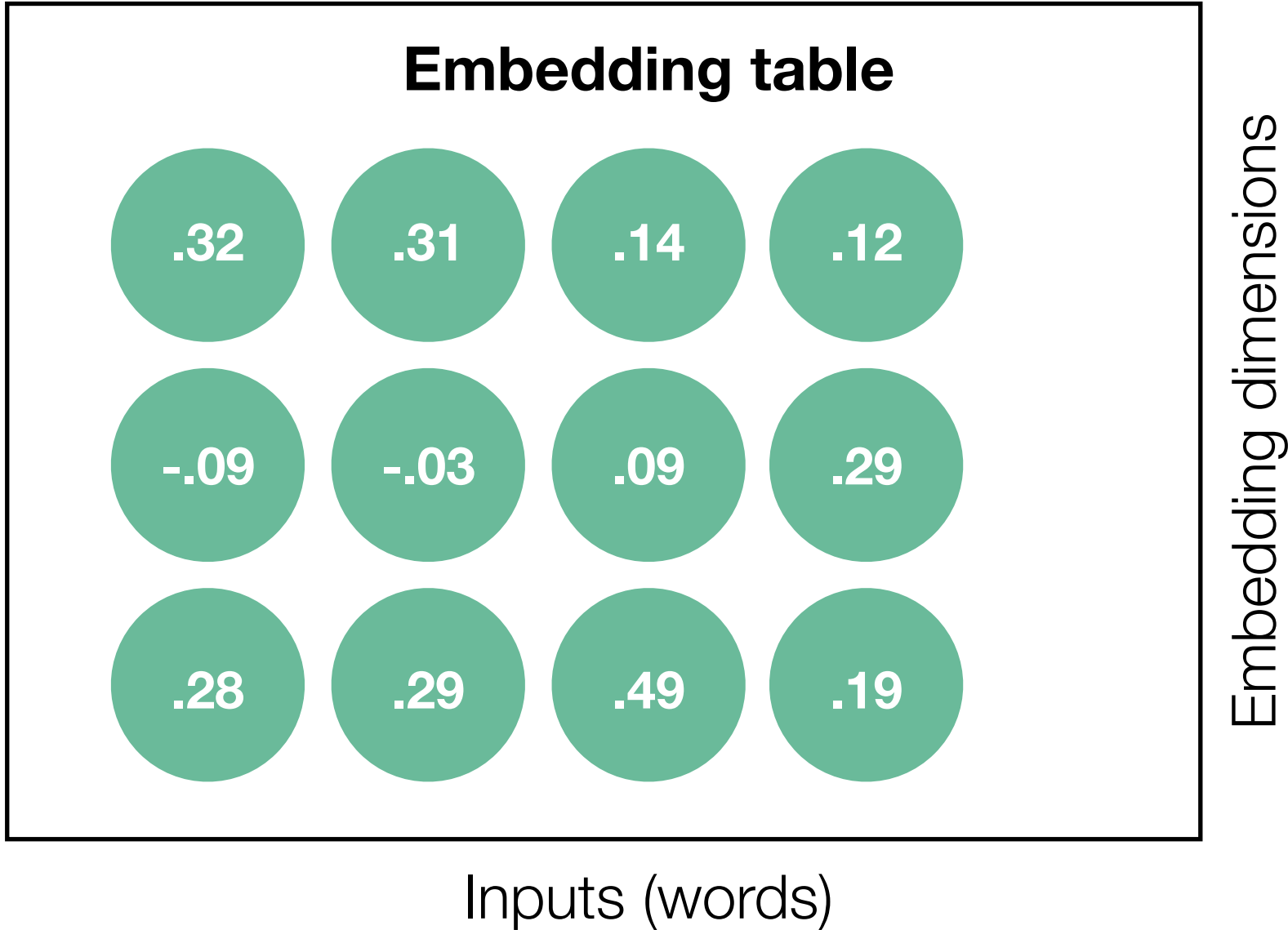
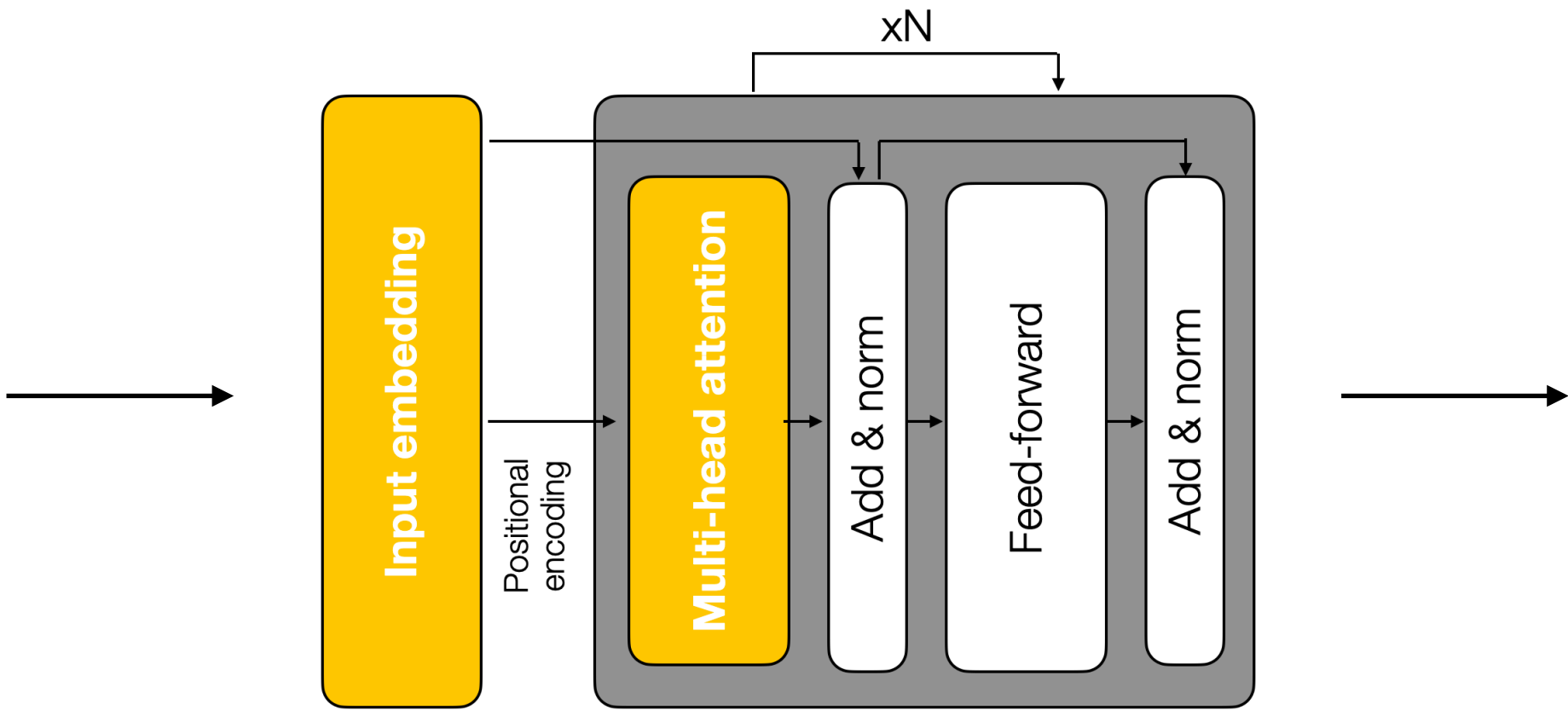


A gender perspective...
Authorship and citation...
Toward metascience...

Generating embeddings

or recording hidden activations

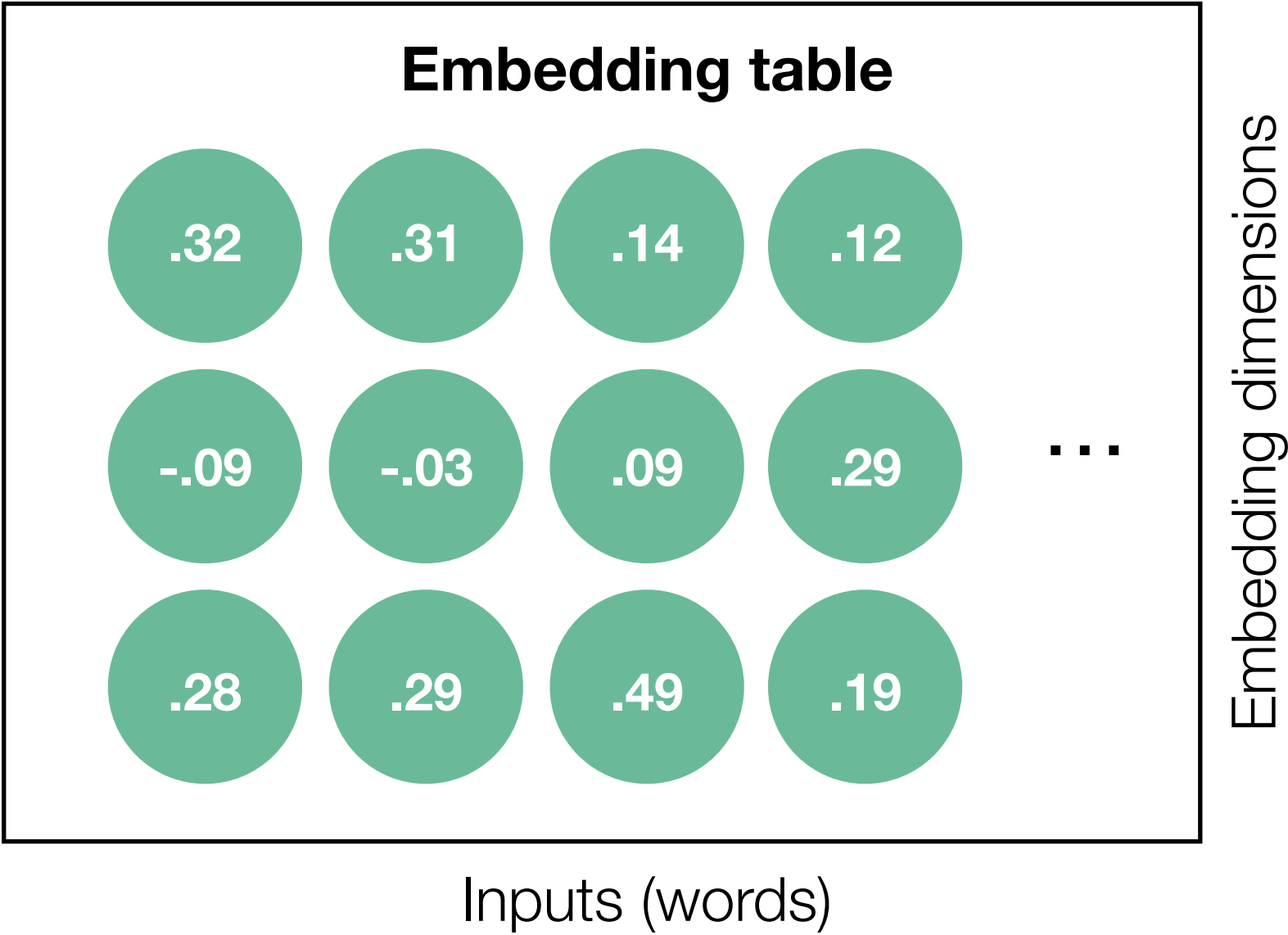
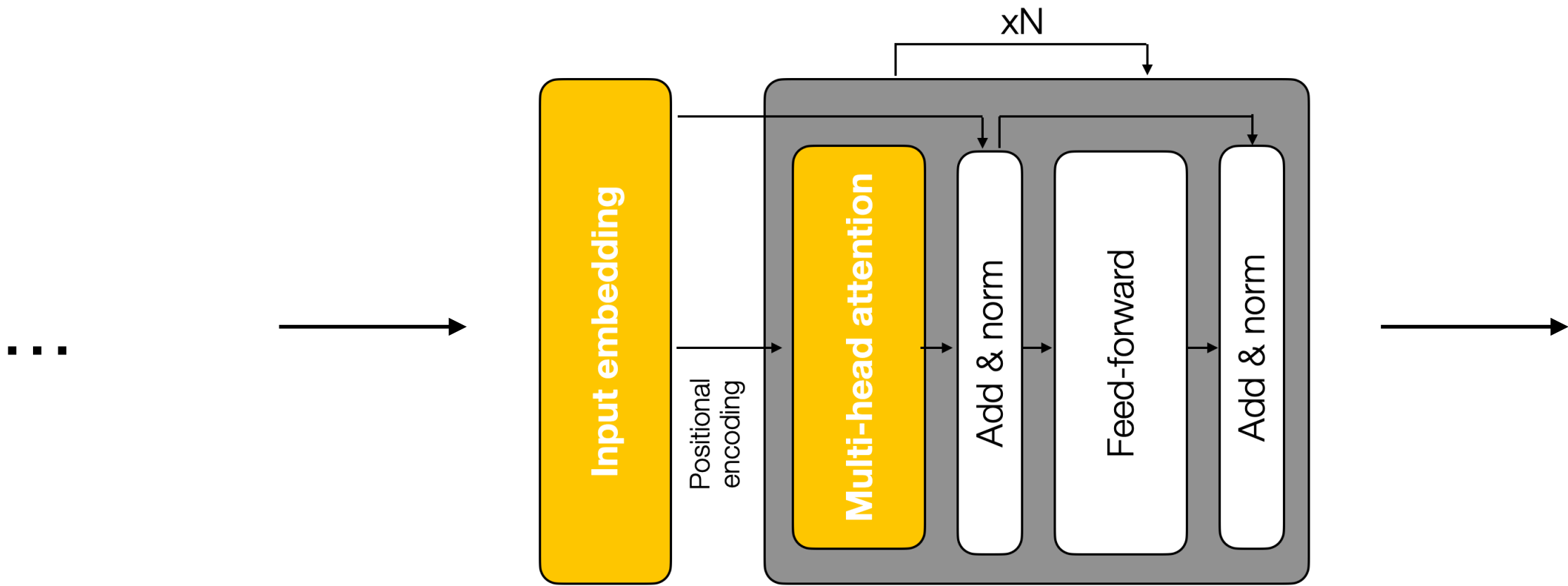
Science
behind AI: the
evolution of
trend, mobility,
and
collaboration



A gender perspective...
Authorship and citation...
Toward metascience...
Science behind AI...

Generating embeddings

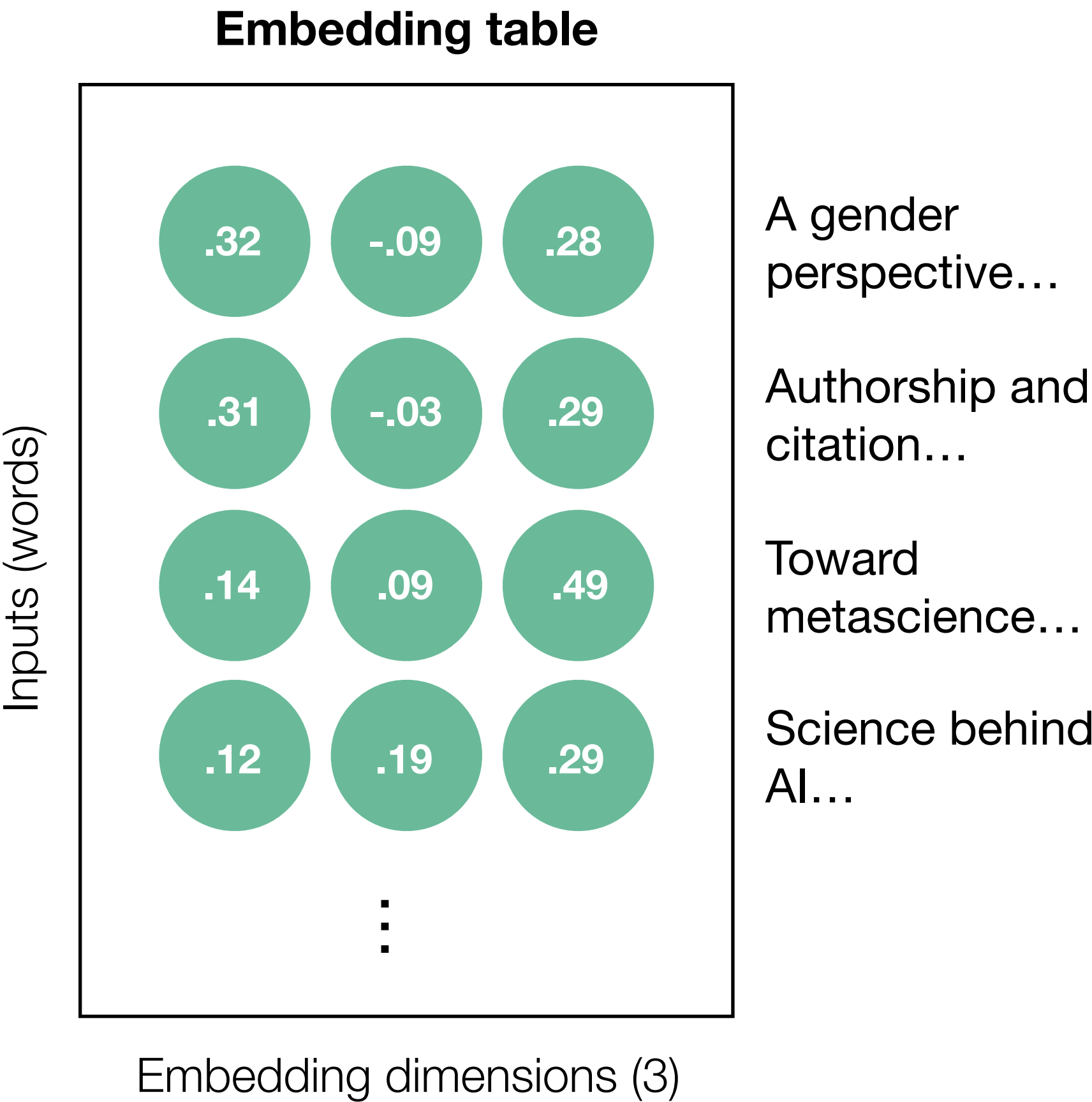
or recording hidden activations



A gender perspective...
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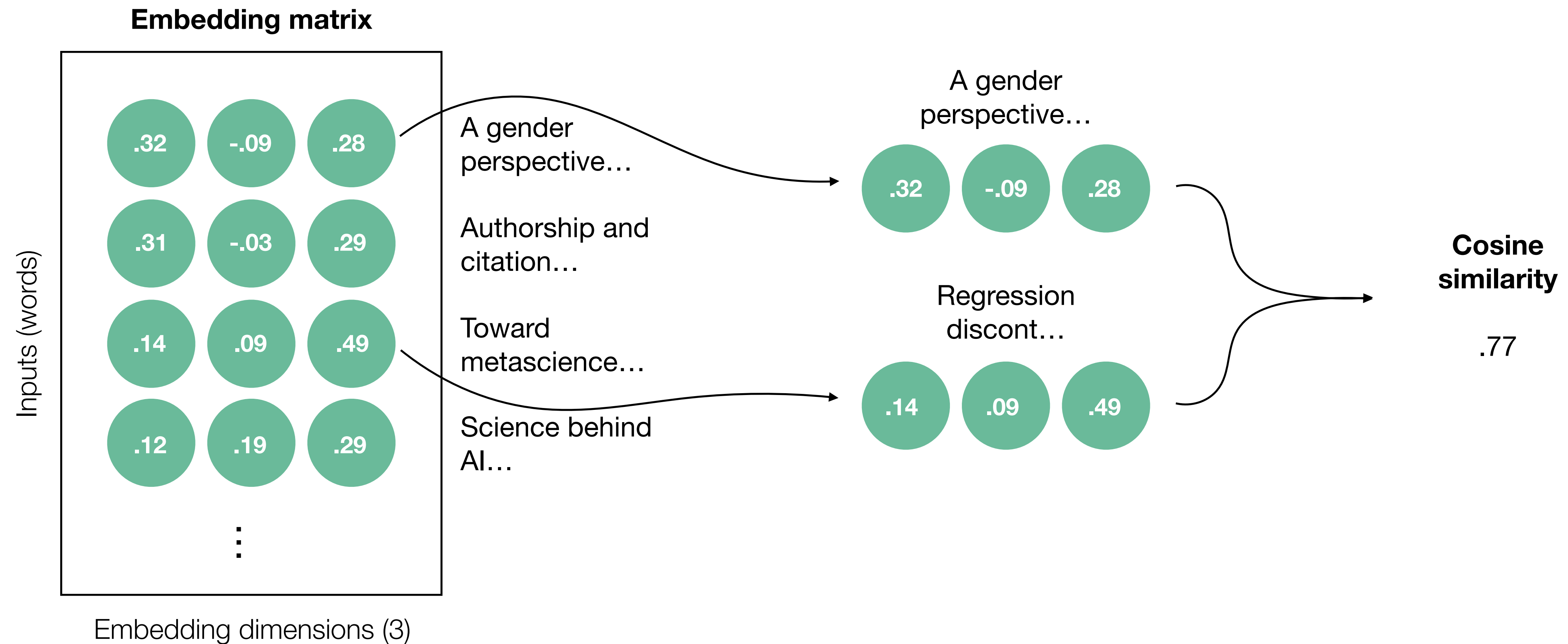
Comparing embeddings

Using cosine similarity



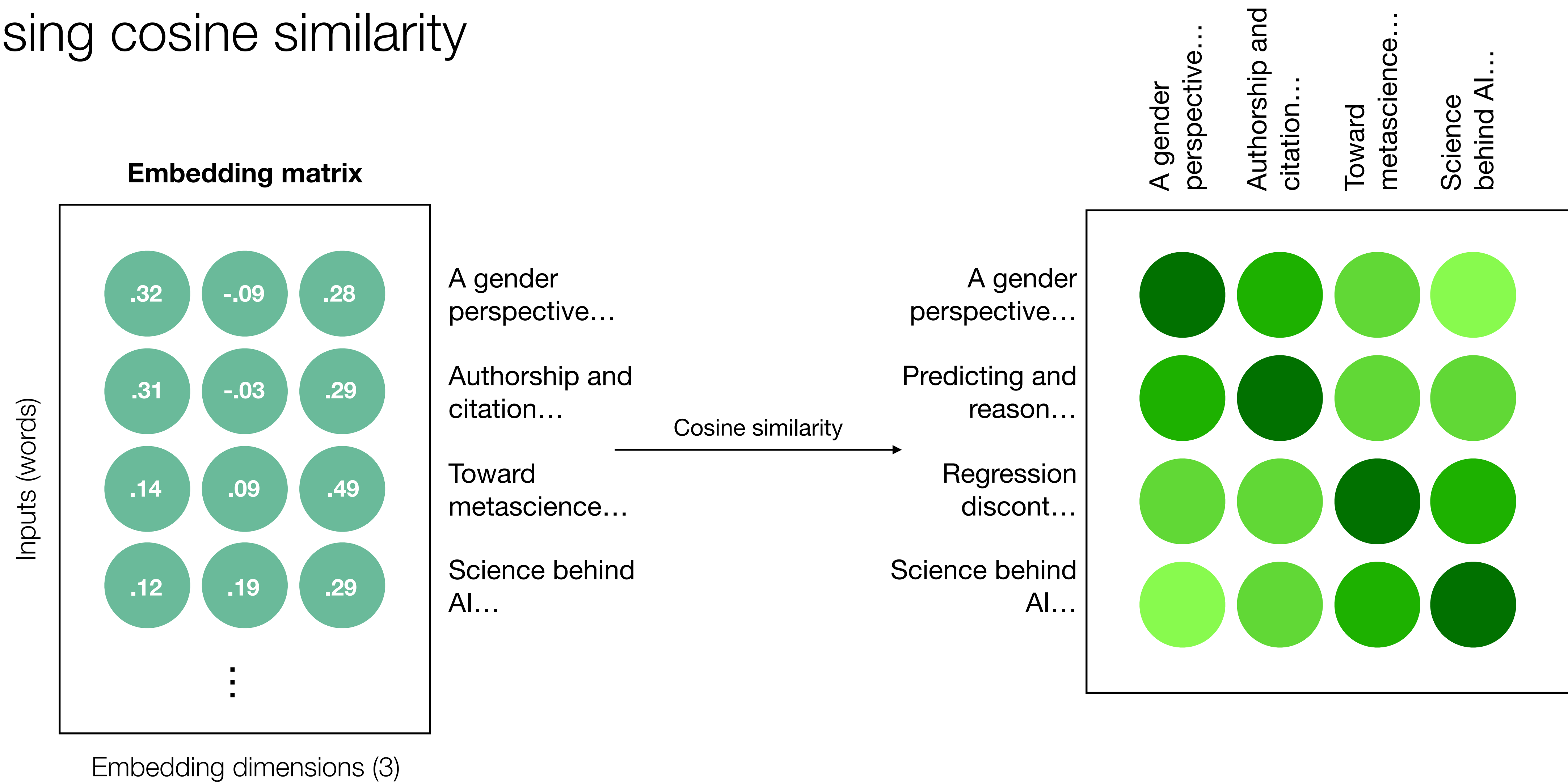
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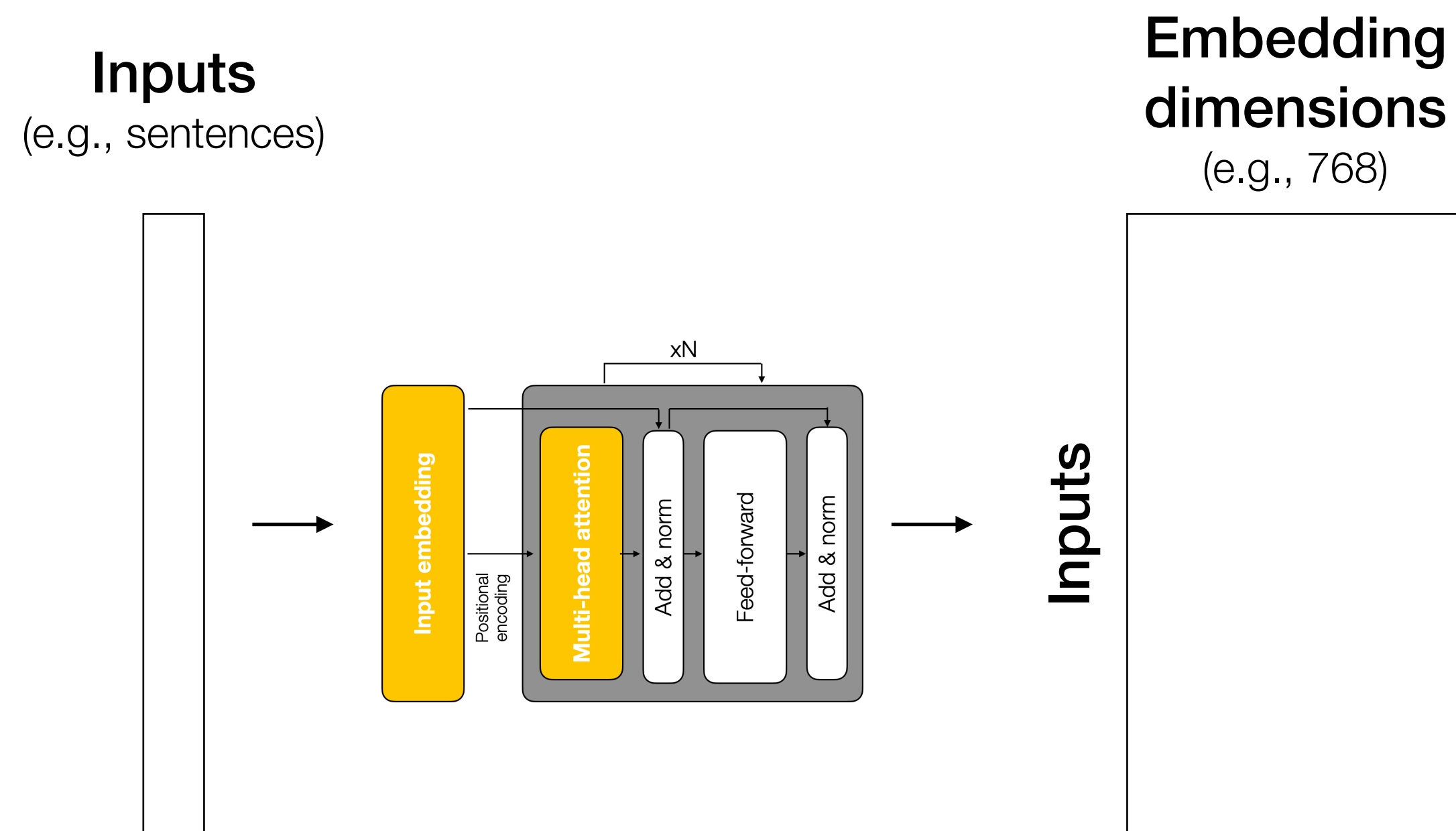
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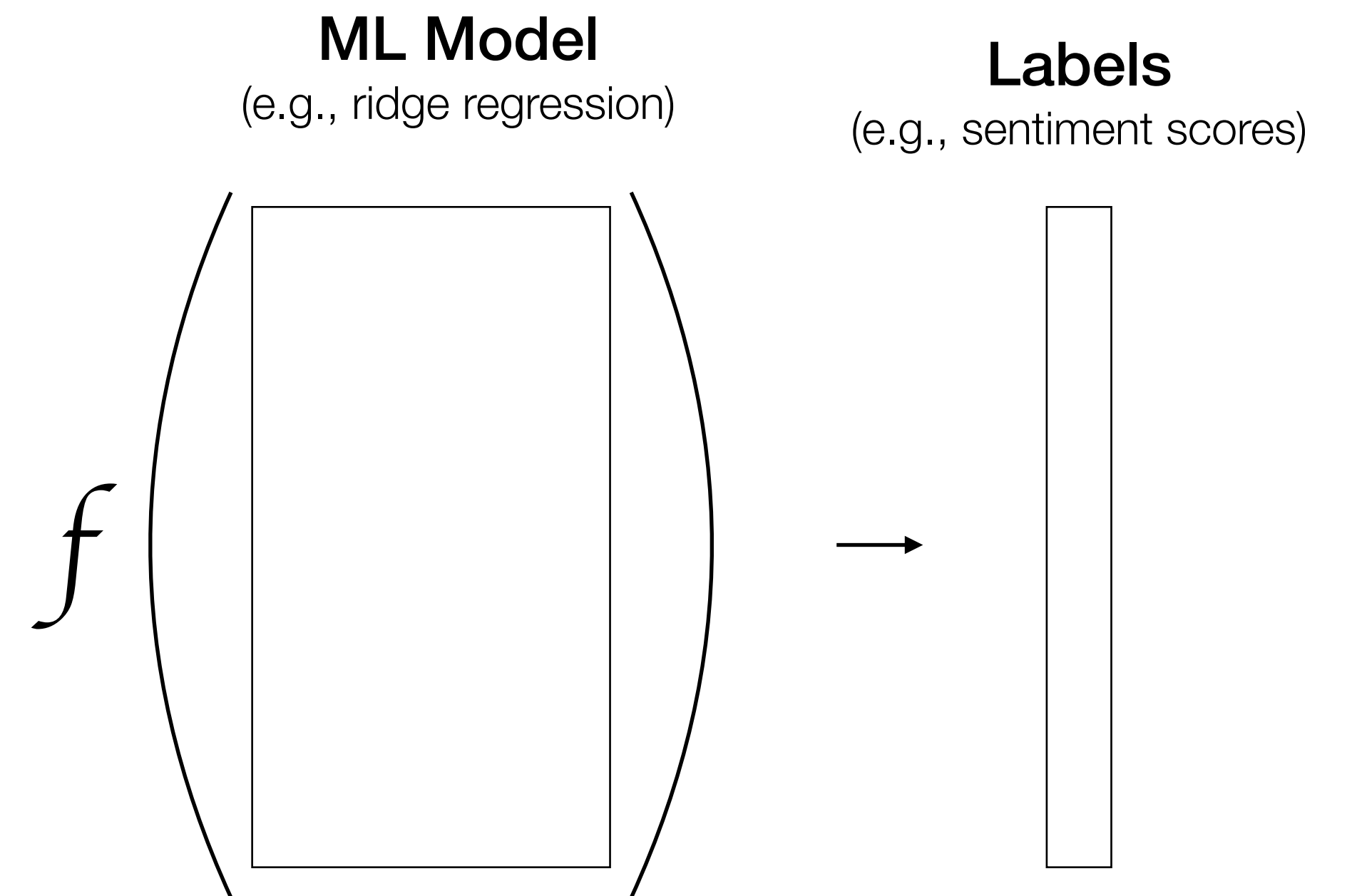
Feature extraction

for regression and classification

Step 1 - feature extraction



Step 2 - train predictive model



Analyzing science of science research

