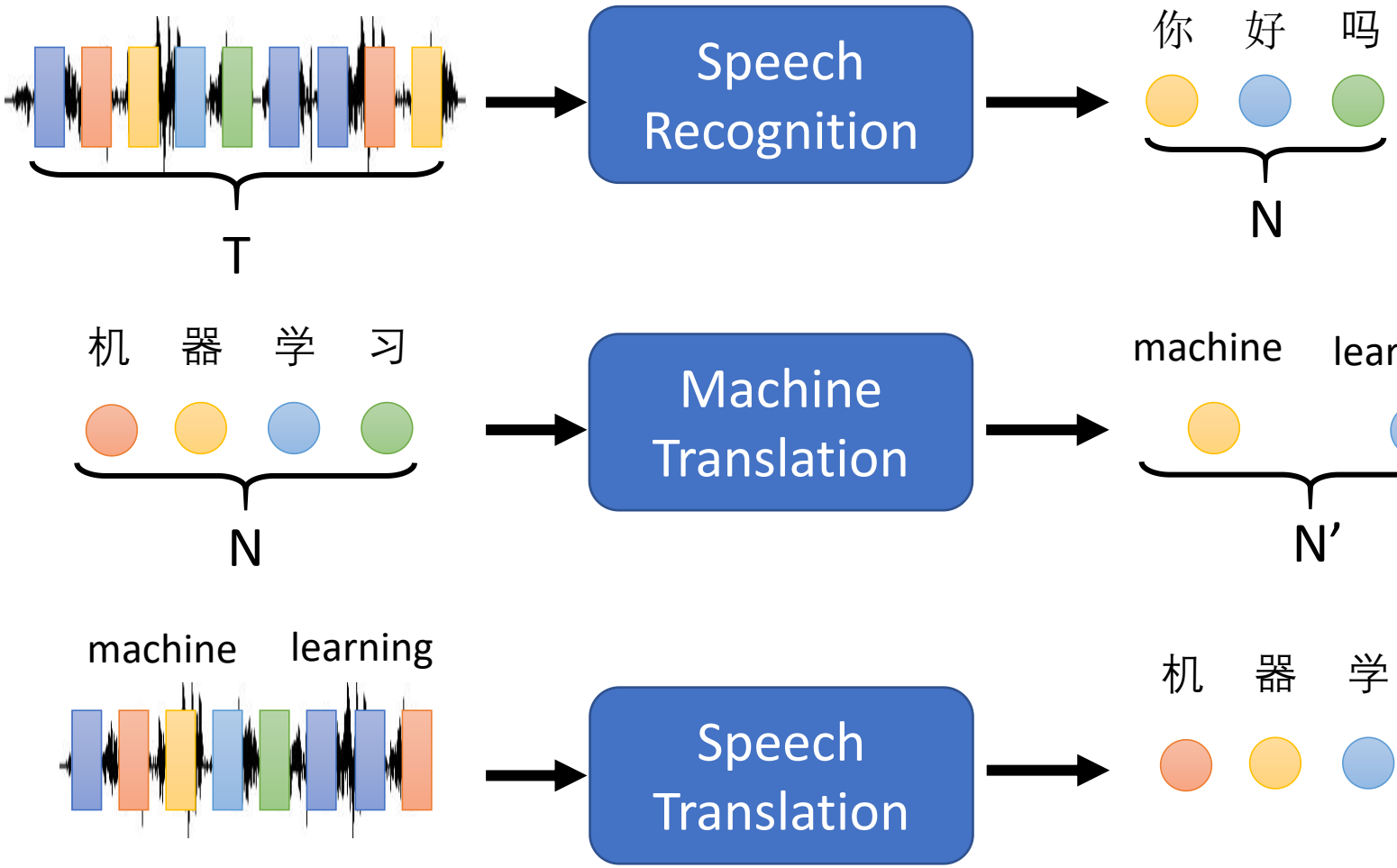
Transformer

Yizhen Lao

Sequence-to-sequence (Seq2seq)

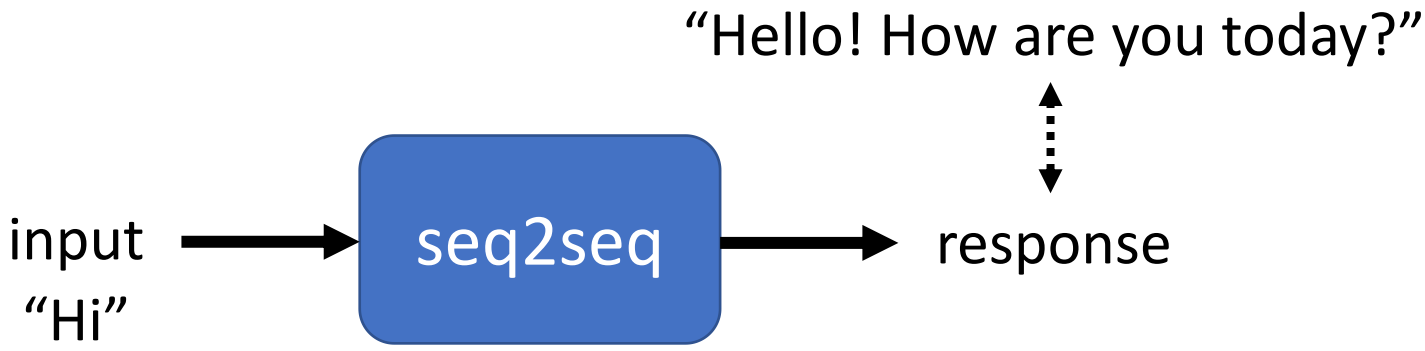
Input a sequence, output a sequence

The output length is determined by model.



Language without text

Seq2seq for Chatbot



Training data:

[PERSON 1:] Hi
[PERSON 2:] Hello ! How are you today ?
[PERSON 1:] I am good thank you , how are you.
[PERSON 2:] Great, thanks ! My children and I were just about to watch Game of Thrones.
[PERSON 1:] Nice ! How old are your children?
[PERSON 2:] I have four that range in age from 10 to 21. You?
[PERSON 1:] I do not have children at the moment.
[PERSON 2:] That just means you get to keep all the popcorn for yourself.
[PERSON 1:] And Cheetos at the moment!
[PERSON 2:] Good choice. Do you watch Game of Thrones?
[PERSON 1:] No, I do not have much time for TV.
[PERSON 2:] I usually spend my time painting: but, I love the show.

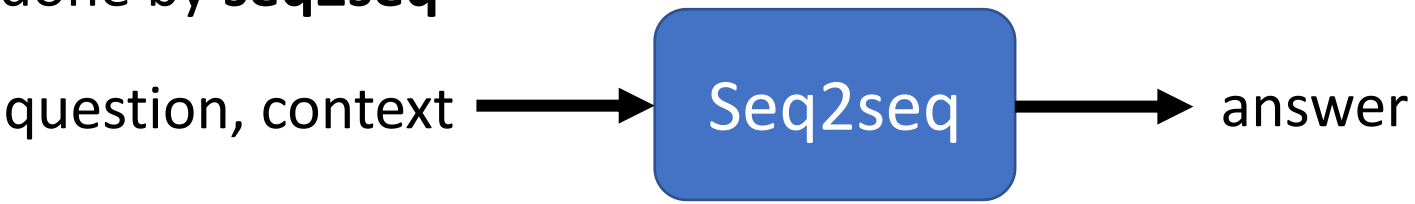
Most Natural Language Processing applications …

Question Answering (QA)

Question	Context	Answer
What is a major importance of Southern California in relation to California and the US?	...Southern California is a major economic center for the state of California and the US....	major economic center
What is the translation from English to German?	Most of the planet is ocean water.	Der Großteil der Erde ist Meerwasser
What is the summary?	Harry Potter star Daniel Radcliffe gains access to a reported £320 million fortune...	Harry Potter star Daniel Radcliffe gets £320M fortune...
Hypothesis: Product and geography are what make cream skimming work. Entailment, neutral, or contradiction?	Premise: Conceptually cream skimming has two basic dimensions – product and geography.	Entailment
Is this sentence positive or negative? (sentiment analysis)	A stirring, funny and finally transporting re-imagining of Beauty and the Beast and 1930s horror film.	positive

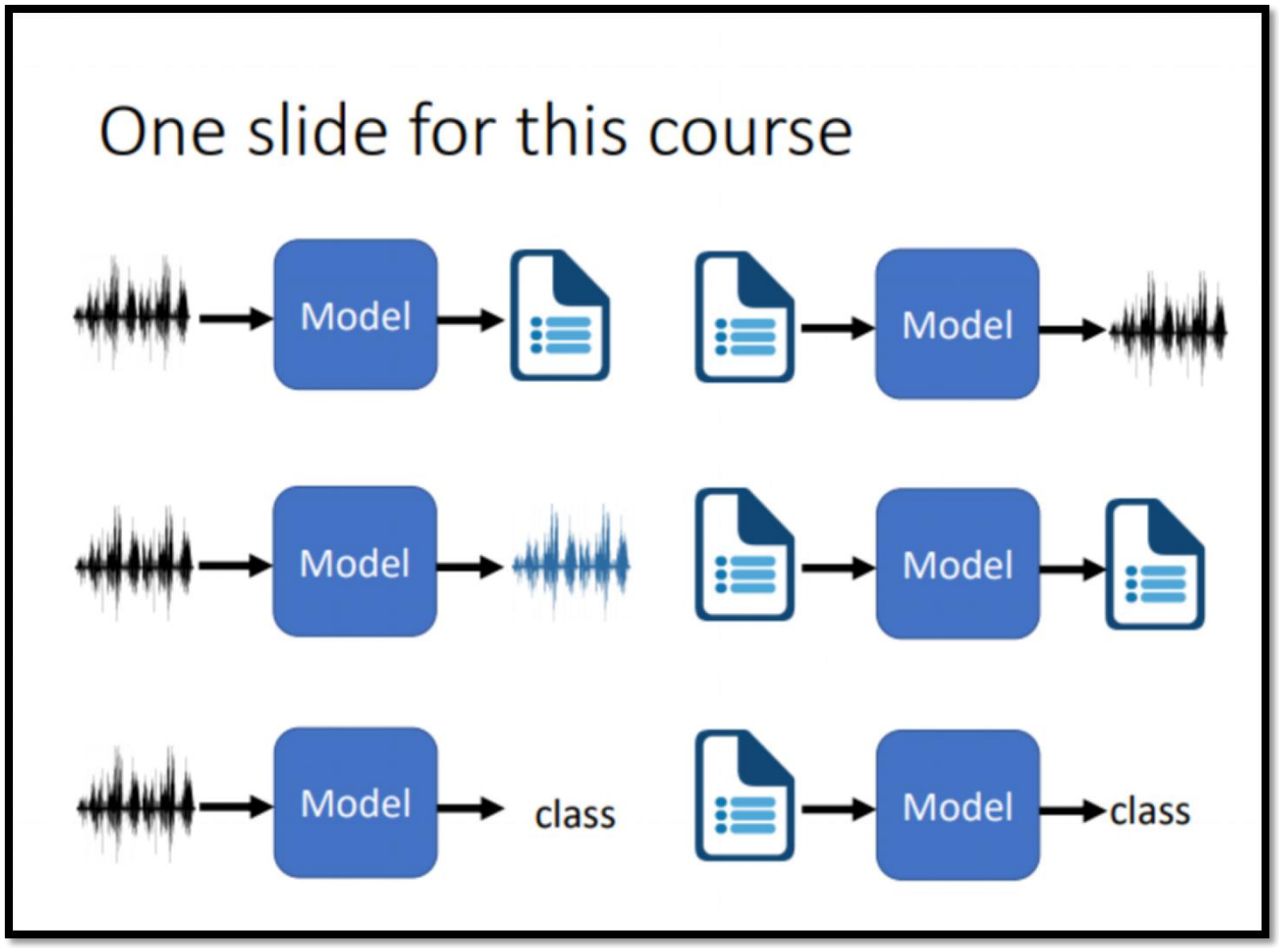
decaNLP

QA can be done by **seq2seq**



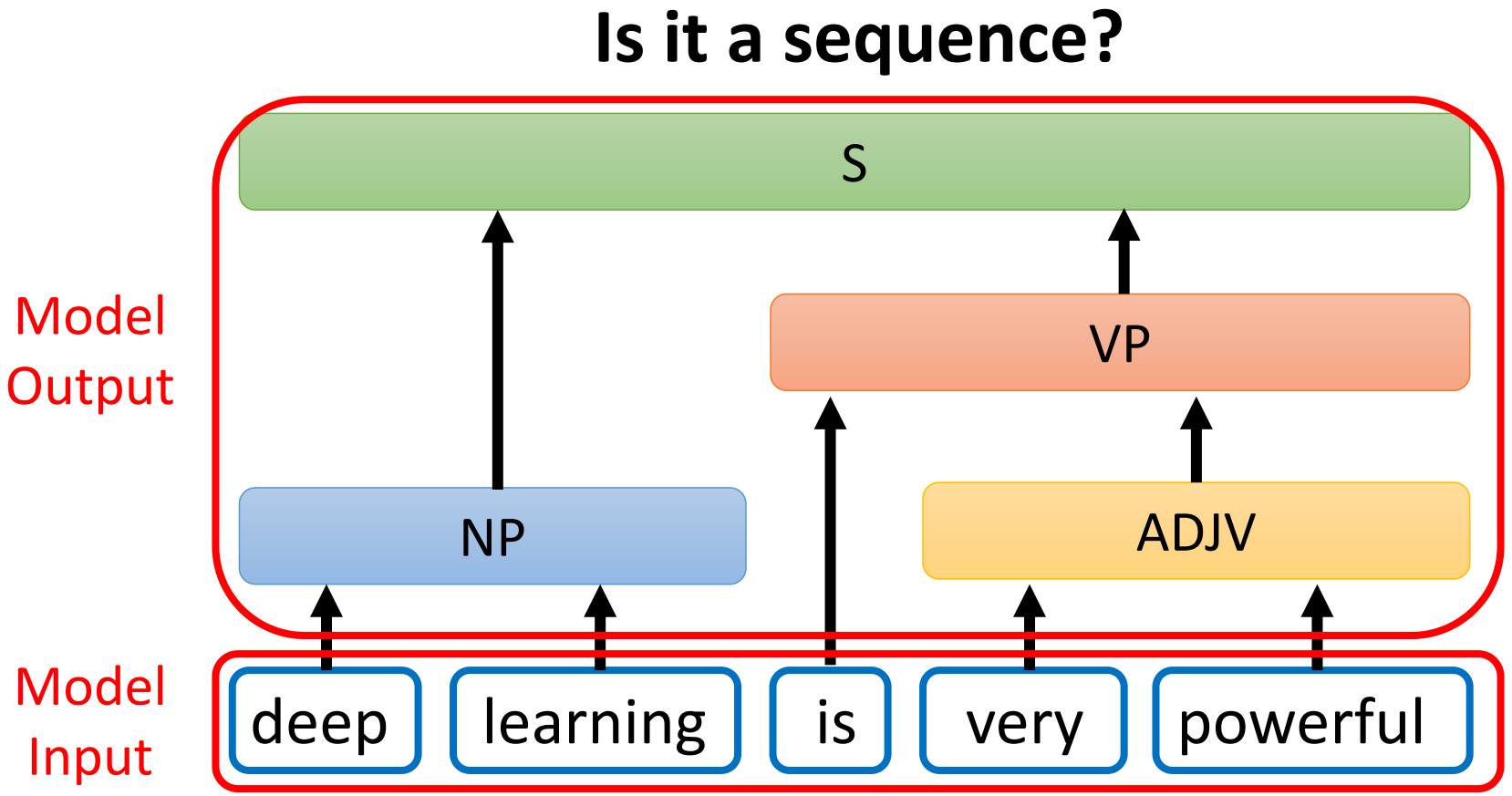
https://arxiv.org/abs/1806.08730
https://arxiv.org/abs/1909.03329

Deep Learning for Human Language Processing

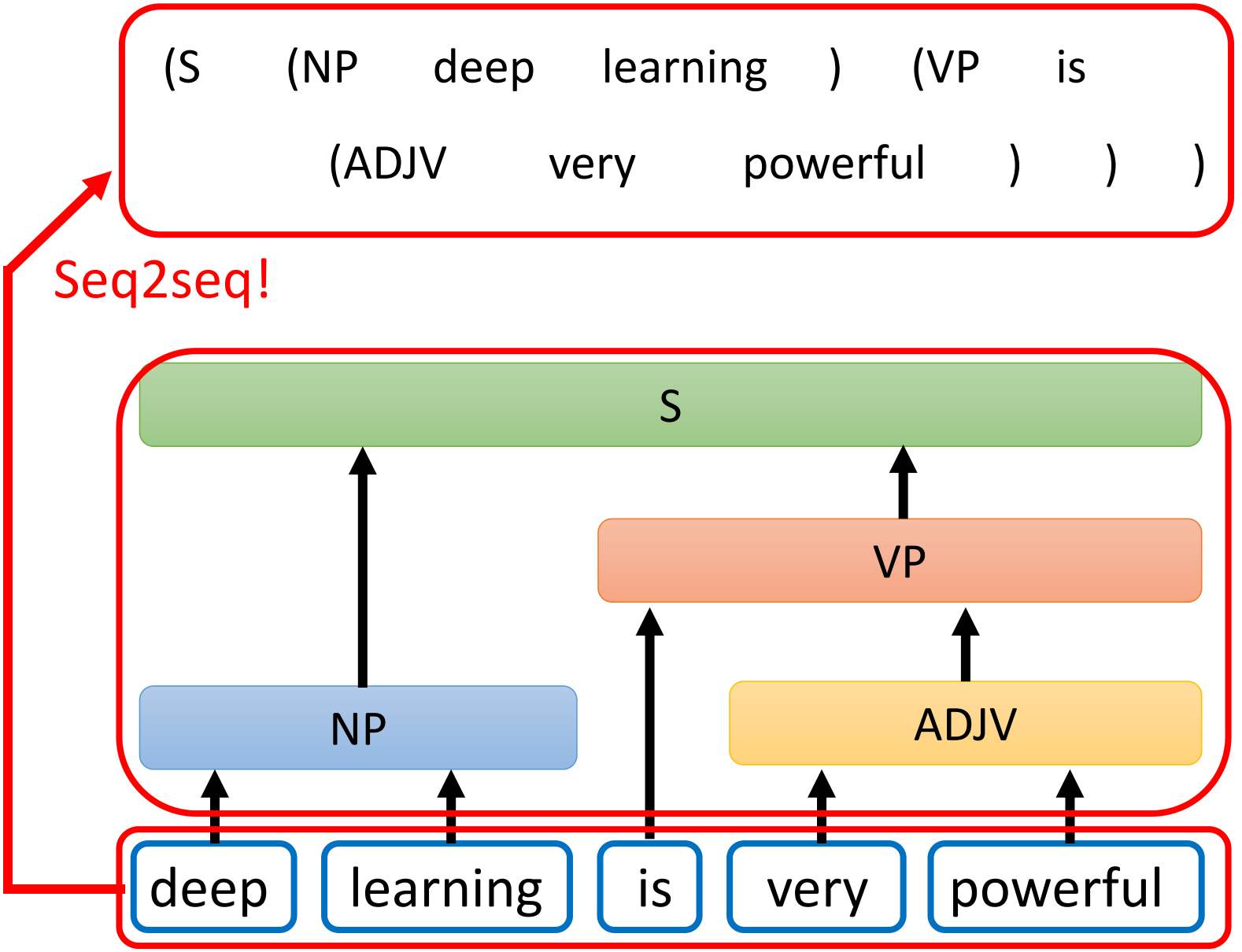


Source webpage: https://speech.ee.ntu.edu.tw/~hylee/dlhlp/2020-spring.html

Seq2seq for Syntactic Parsing



Seq2seq for Syntactic Parsing



Seq2seq for Syntactic Parsing

(S (NP deep learning) (VP is (ADJV very powerful)))

Grammar as a Foreign Language

Oriol Vinyals*
Google
vinyals@google.com

Lukasz Kaiser*
Google
lukaszkaiser@google.com

Terry Koo
Google
terrykoo@google.com

Slav Petrov
Google
slav@google.com

Ilya Sutskever
Google
ilyasu@google.com

Geoffrey Hinton
Google
geoffhinton@google.com

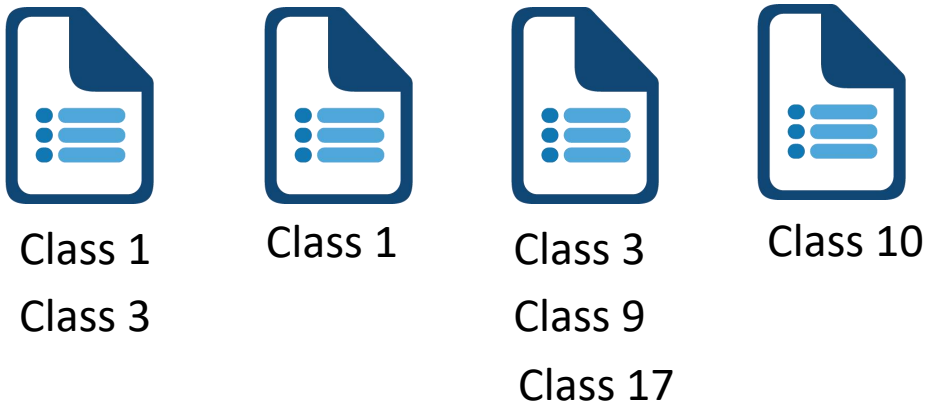
https://arxiv.org/abs/1412.7449

deep learning is very powerful

Seq2seq for Multi-label Classification

c.f. Multi-class Classification

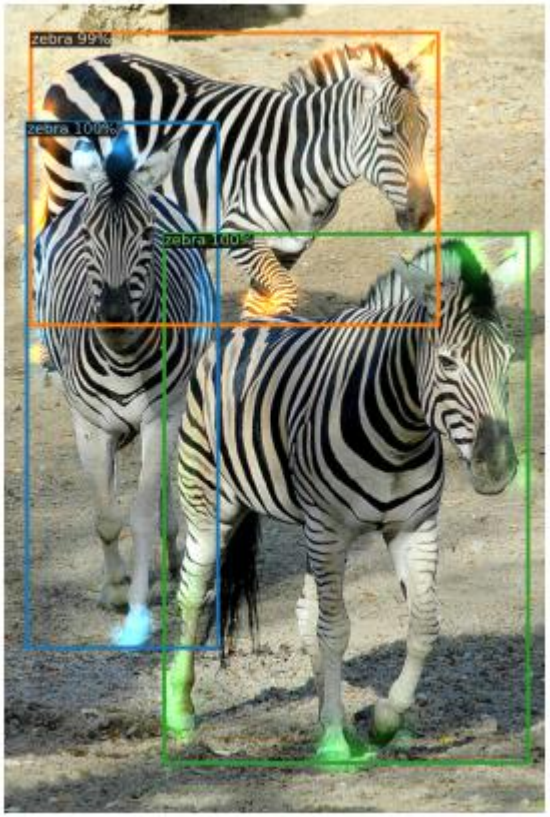
An object can belong to multiple classes.

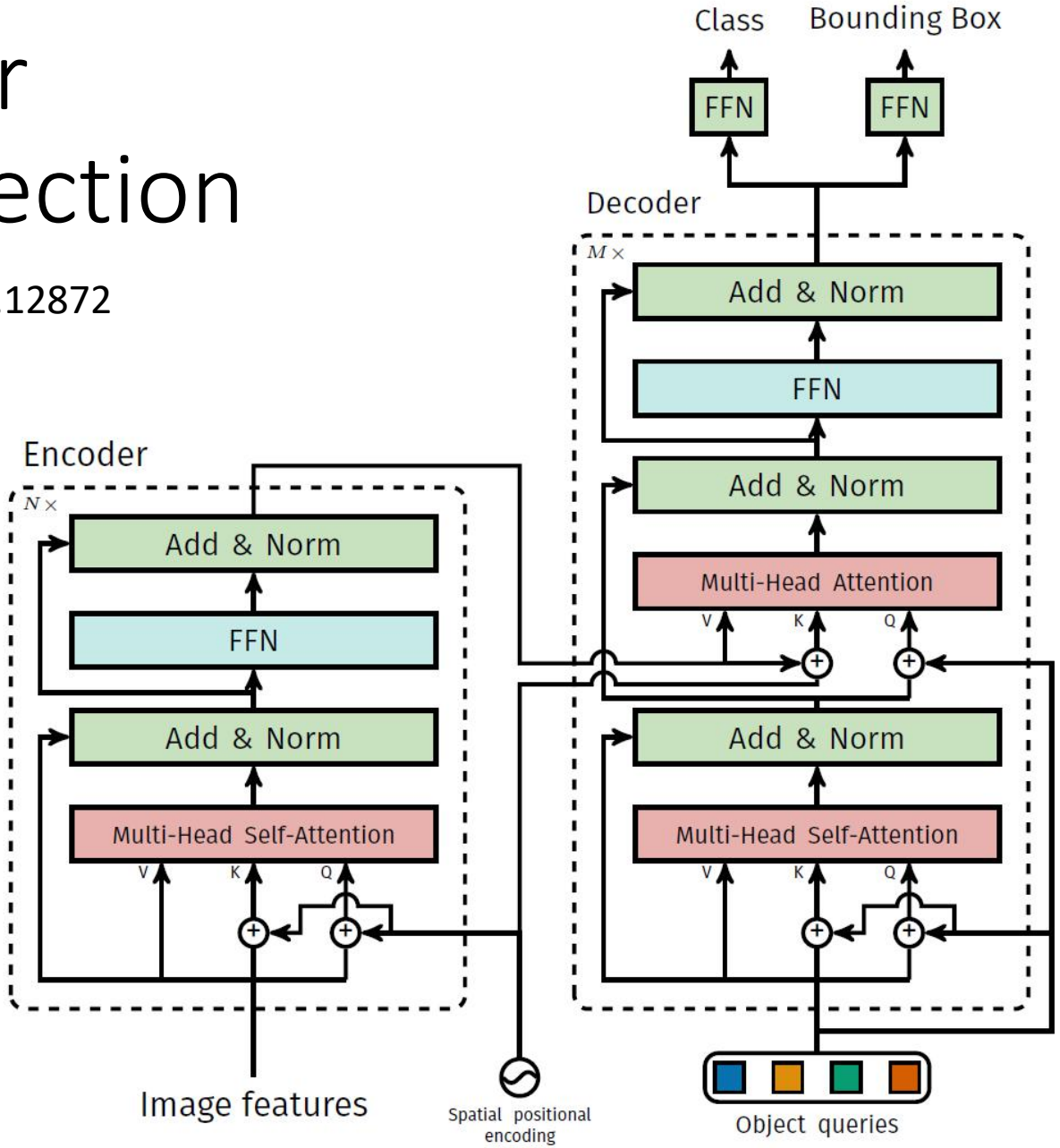


https://arxiv.org/abs/1909.03434
https://arxiv.org/abs/1707.05495

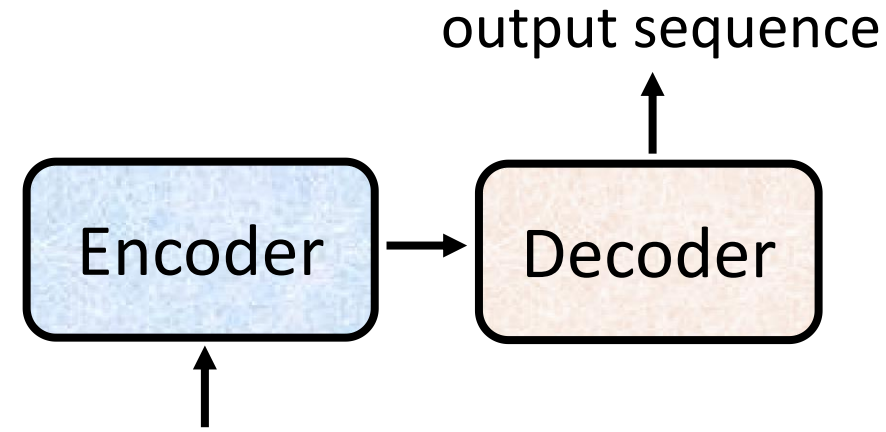
Seq2seq for Object Detection

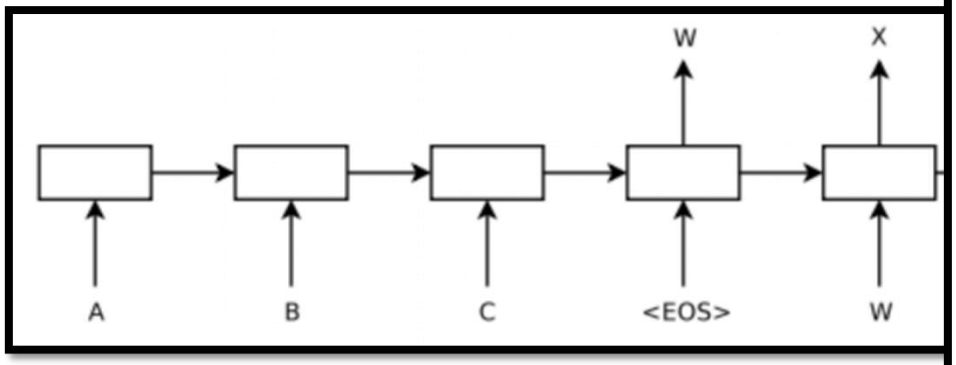
https://arxiv.org/abs/2005.12872





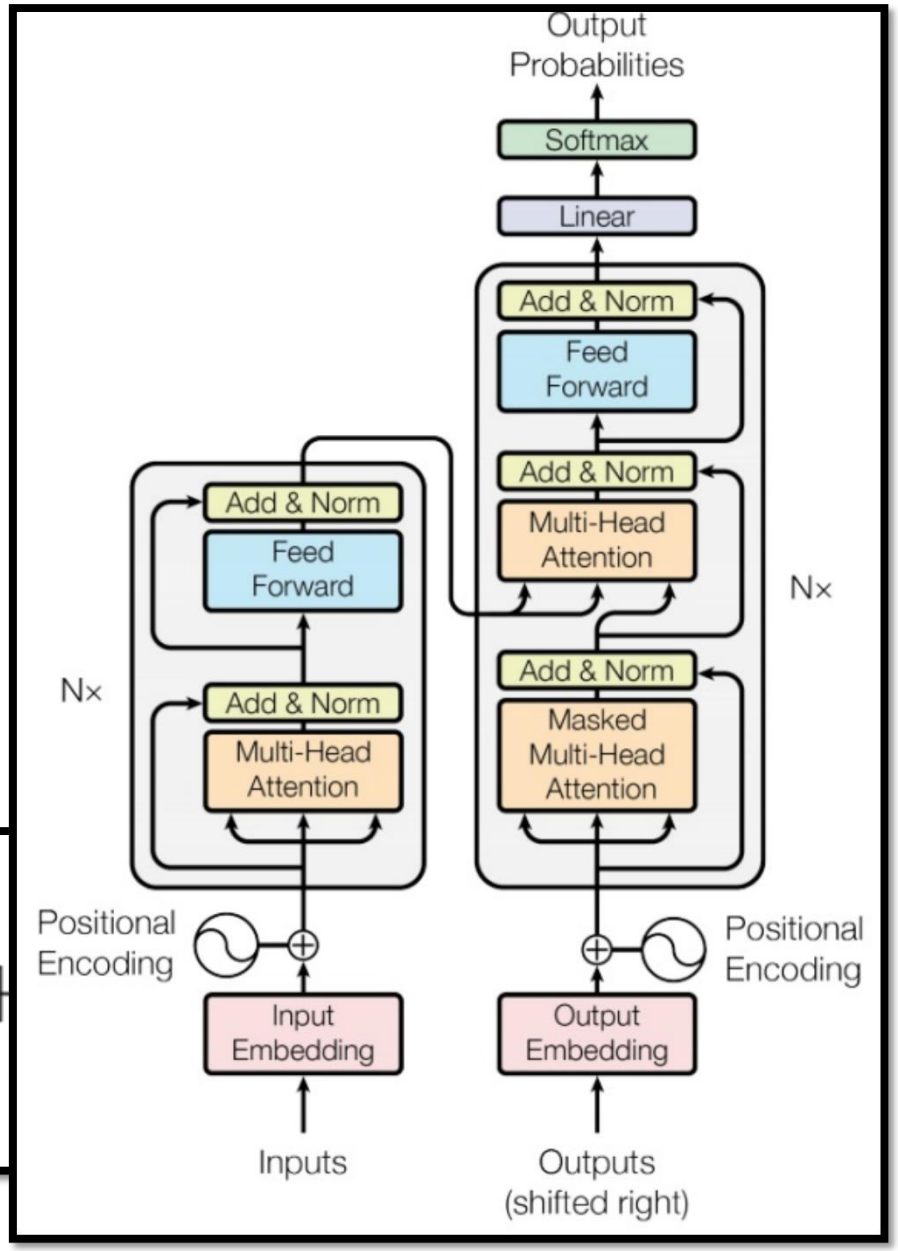
Seq2seq





Sequence to Sequence Learning with Neural Networks

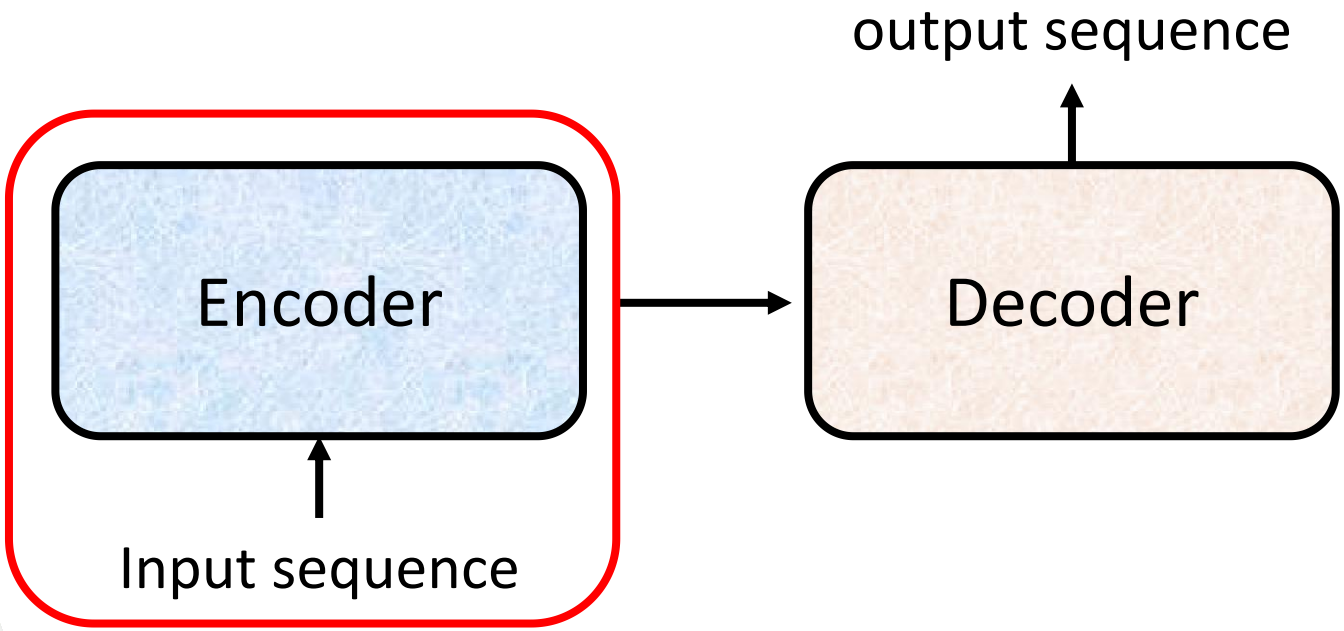
https://arxiv.org/abs/1409.3215



Transformer

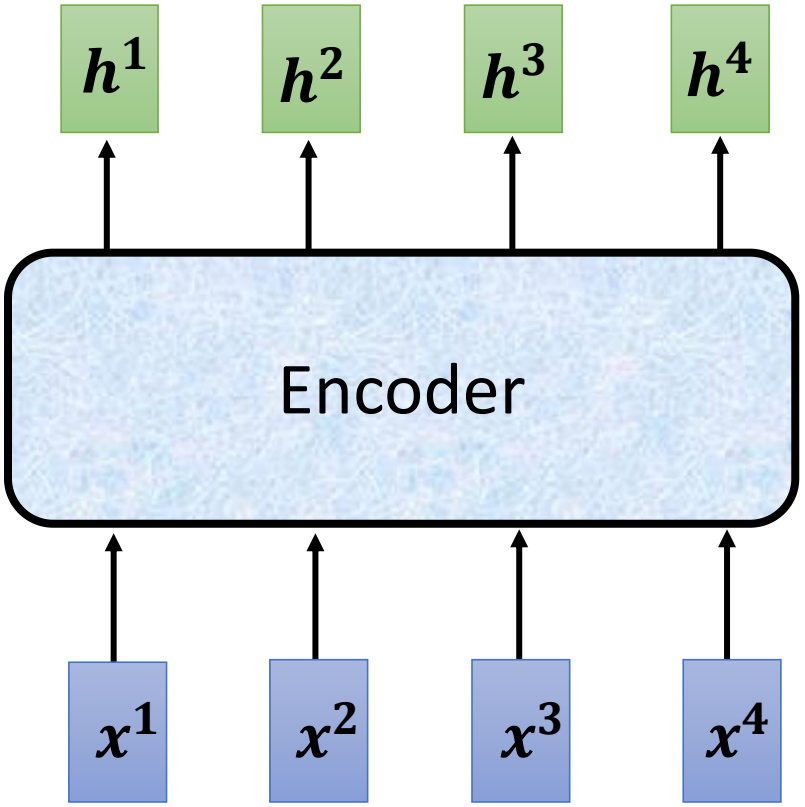
https://arxiv.org/abs/1706.03762

Encoder

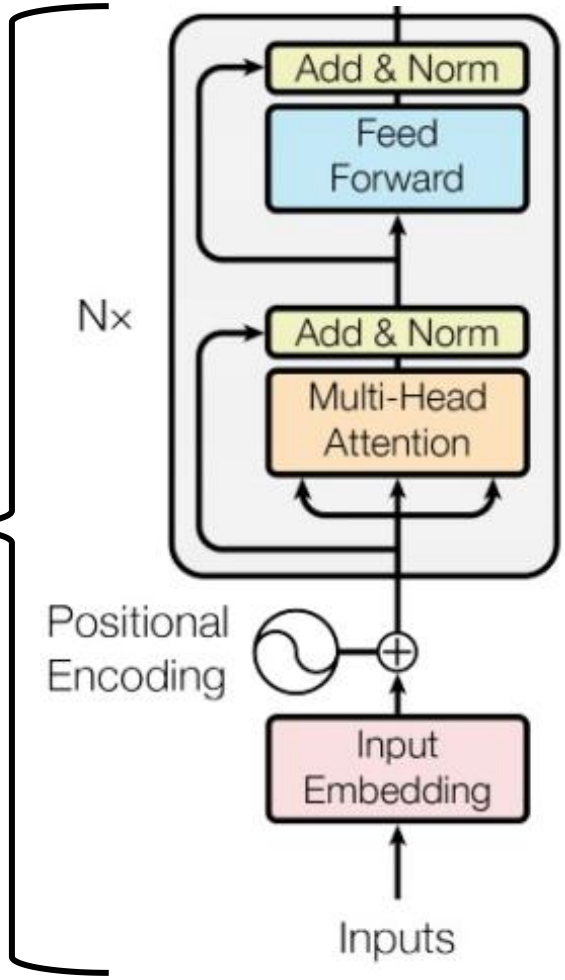


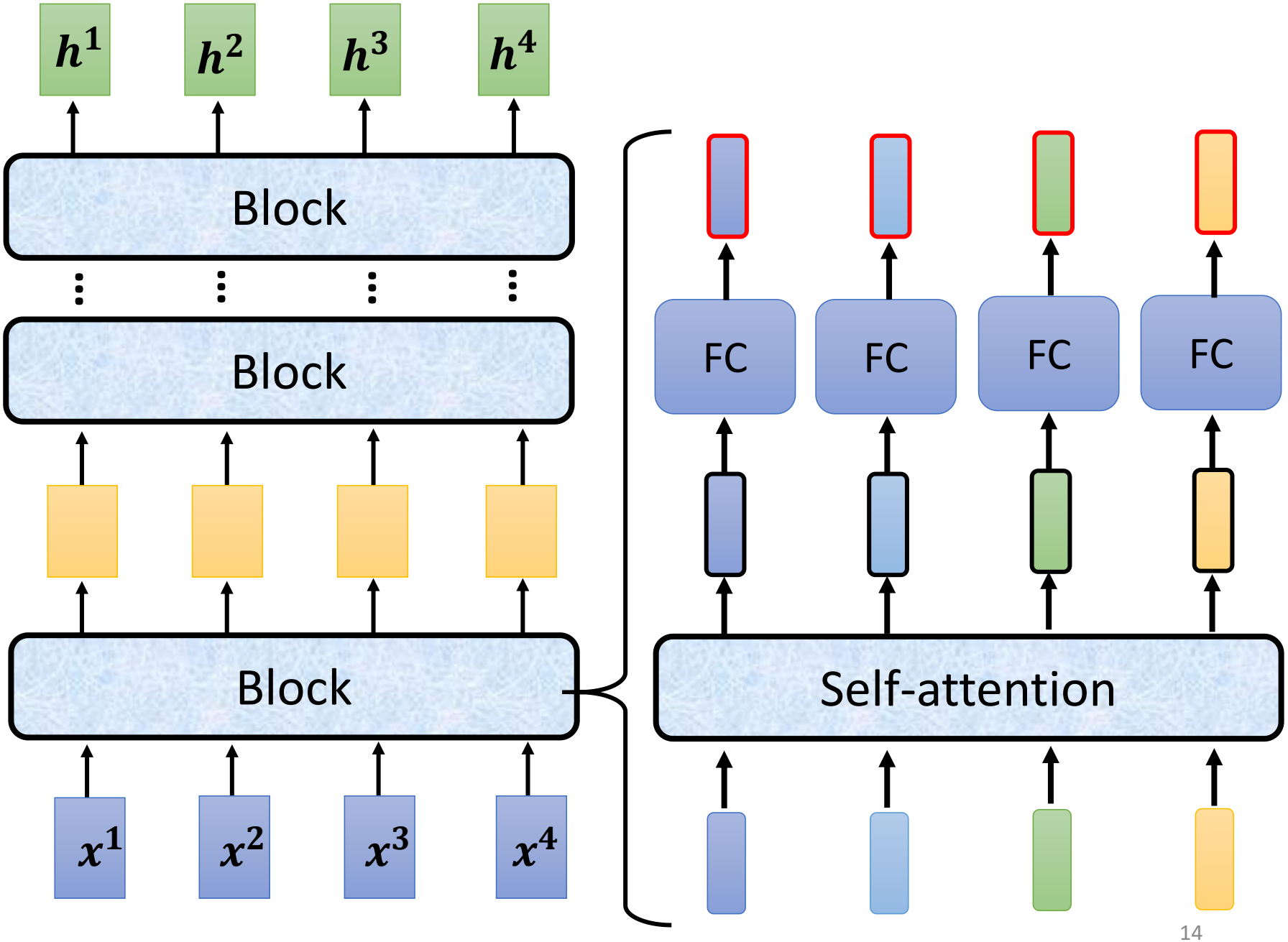
Encoder

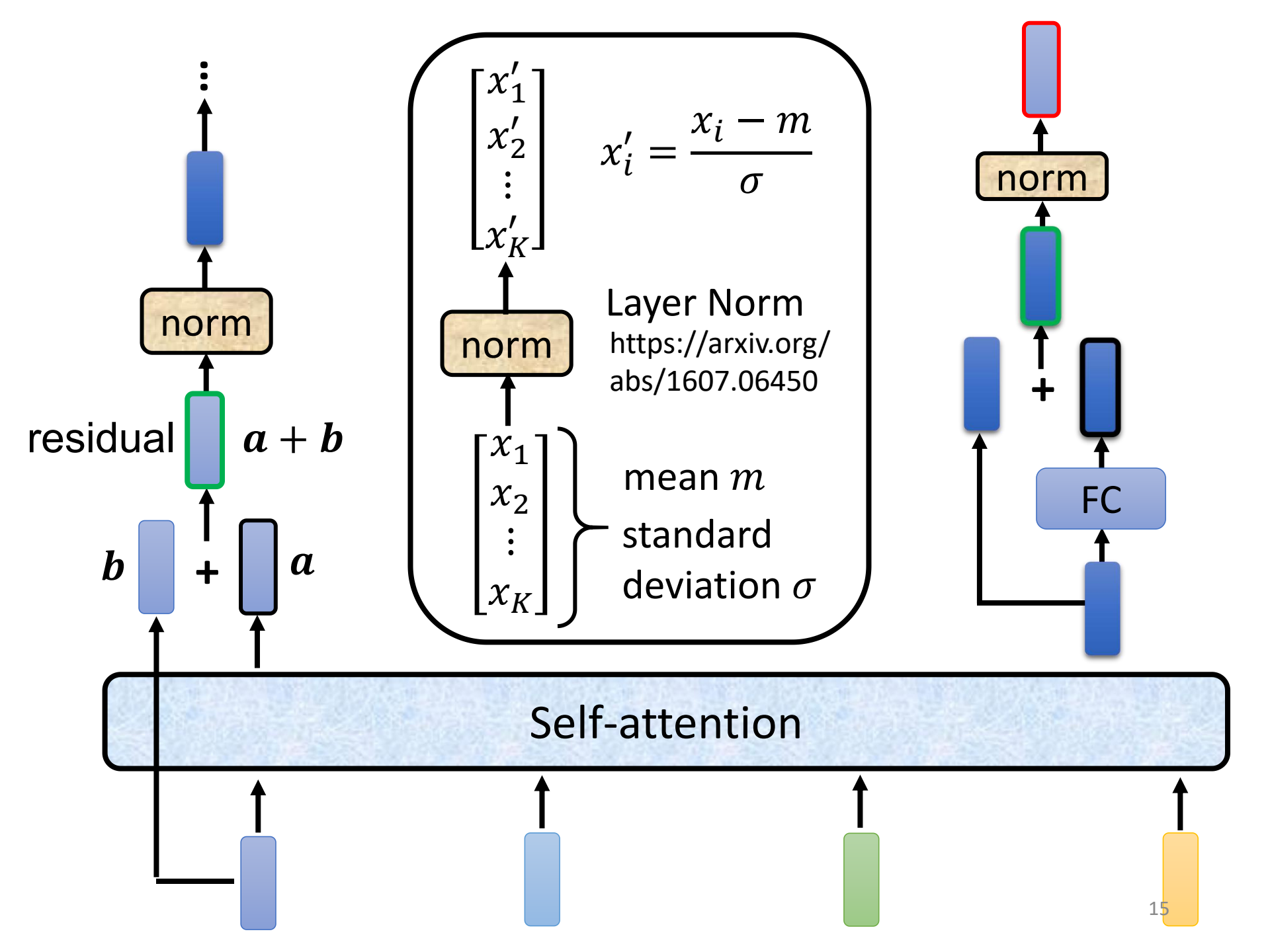
You can use **RNN** or **CNN**.



Transformer's Encoder

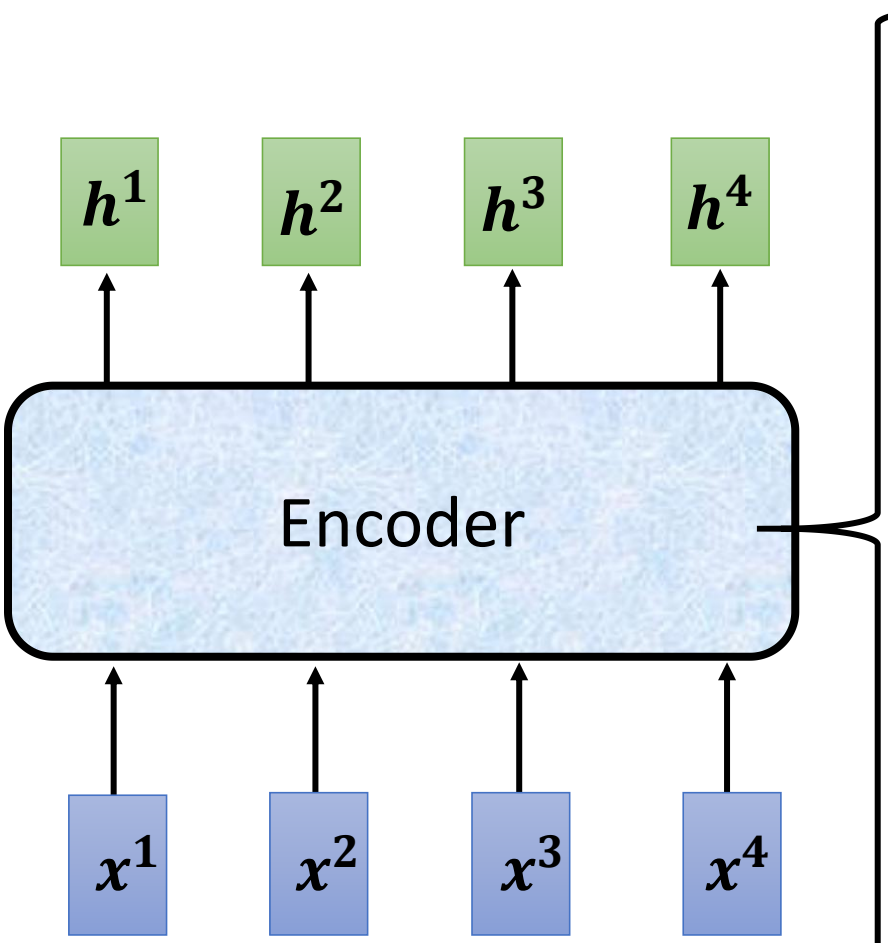


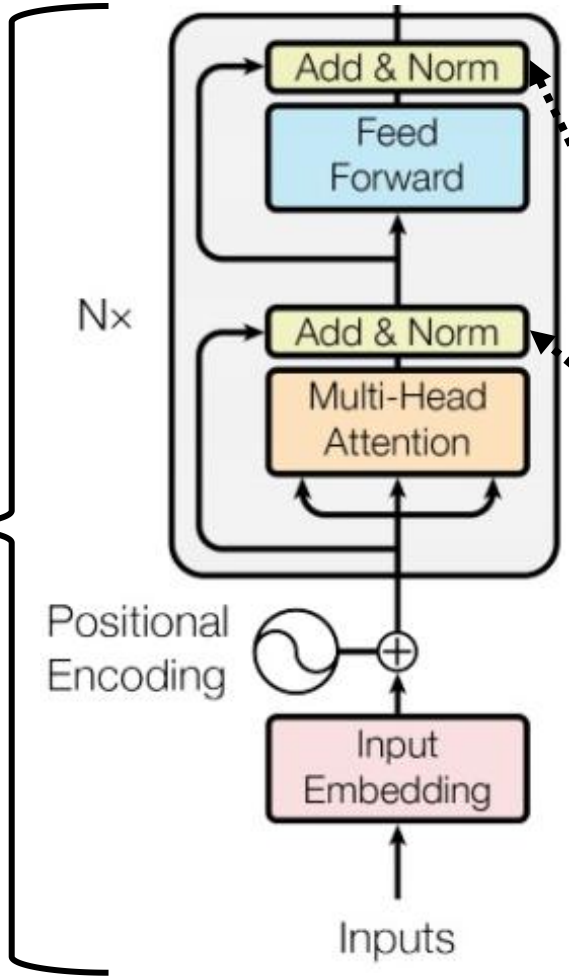

h^1
h^2
h^3
h^4
Block
Block
Block
x^1
x^2
x^3
x^4
FC
FC
FC
FC
Self-attention


norm
residual
$a + b$
b
+
a
$\begin{bmatrix} x'_1 \\ x'_2 \\ \vdots \\ x'_K \end{bmatrix}$
$x'_i = \frac{x_i - m}{\sigma}$
norm
Layer Norm
https://arxiv.org/abs/1607.06450
$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_K \end{bmatrix}$
mean m
standard deviation σ
norm
+
FC
Self-attention

BERT

I use the **same** network architecture as **transformer encoder**.



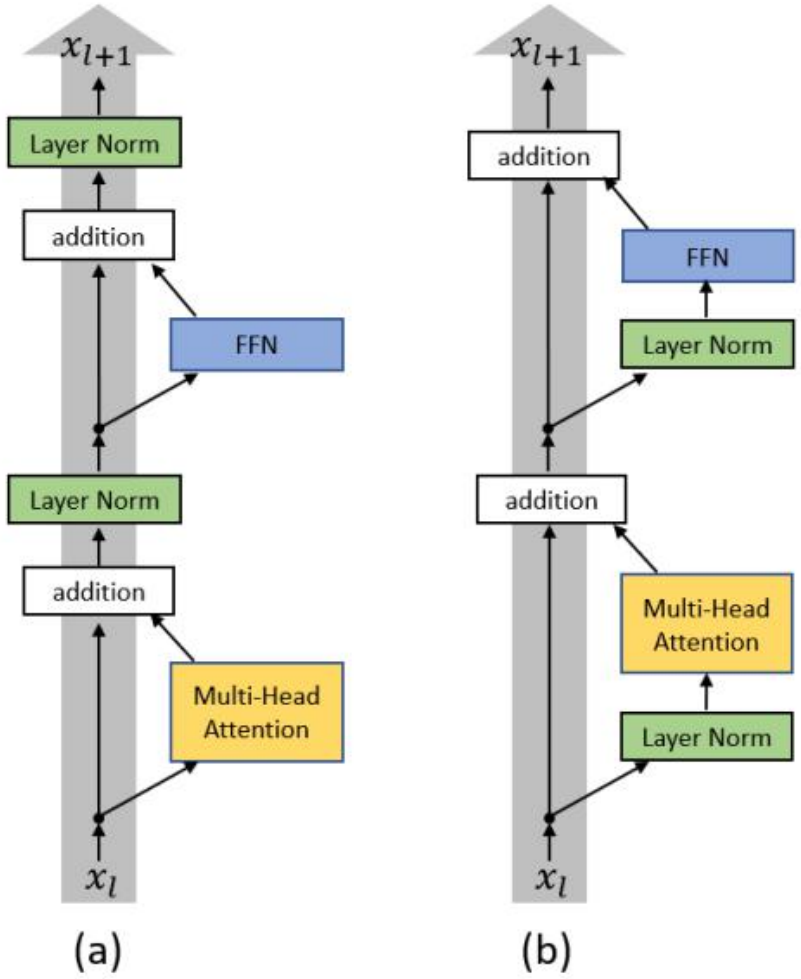


Residual + Layer norm

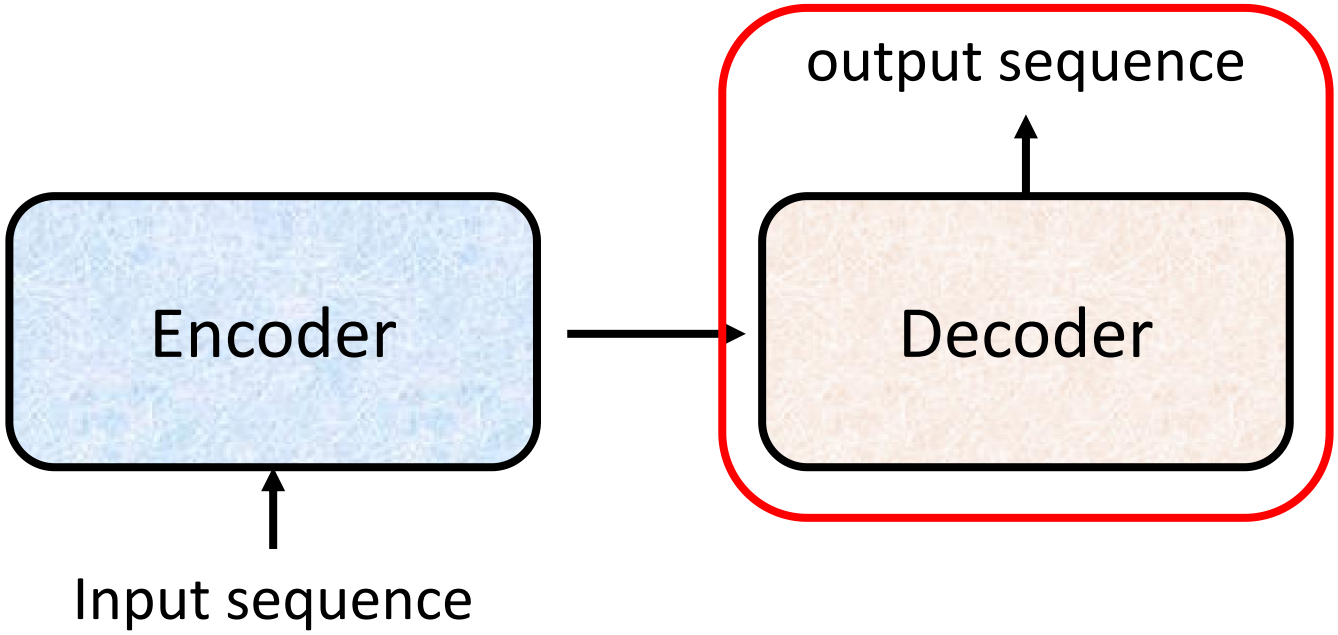
To learn more ……

- On Layer Normalization in the Transformer Architecture
- https://arxiv.org/abs/2002.04745

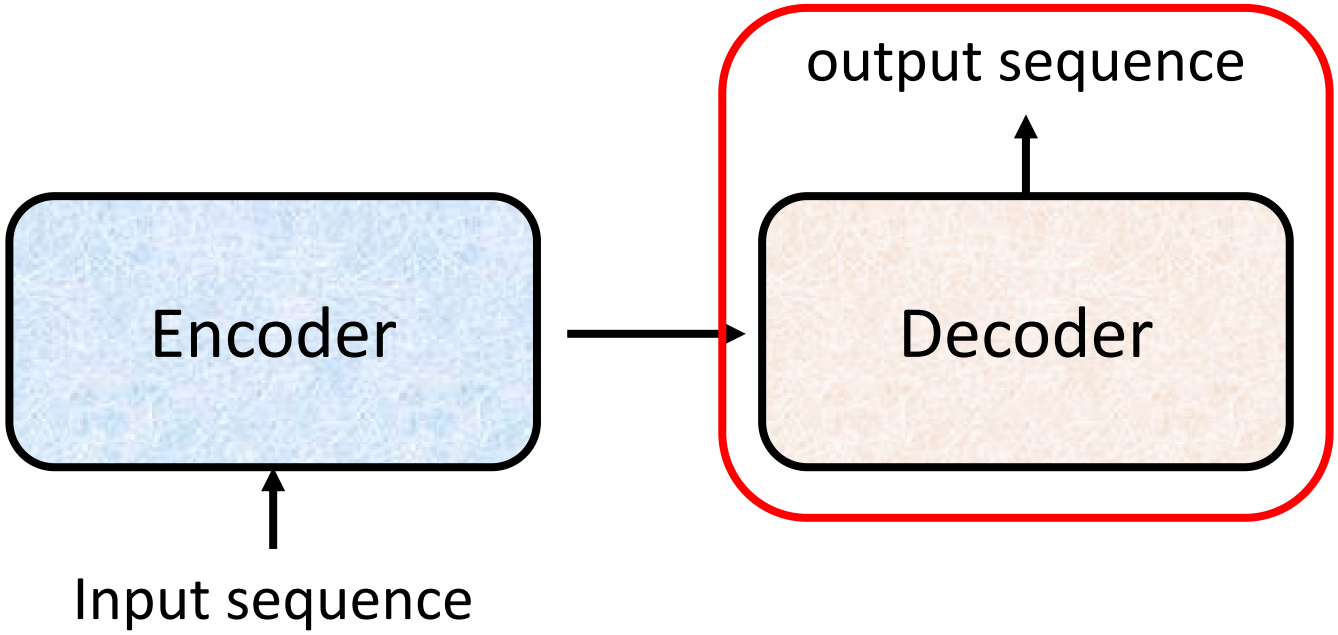
- *PowerNorm: Rethinking Batch Normalization in Transformers*
- https://arxiv.org/abs/2003.07845



Decoder

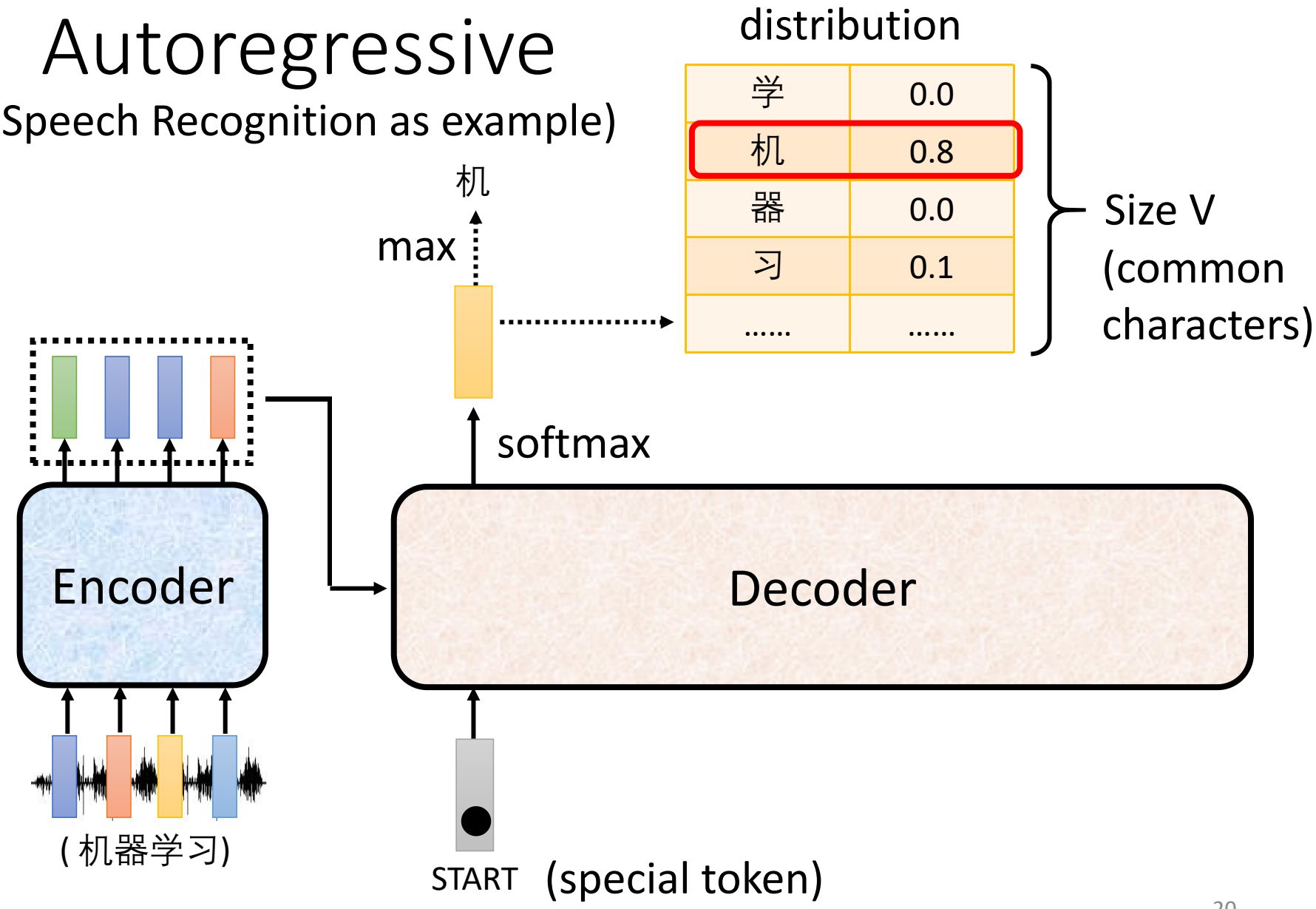


Decoder – Autoregressive (AT)

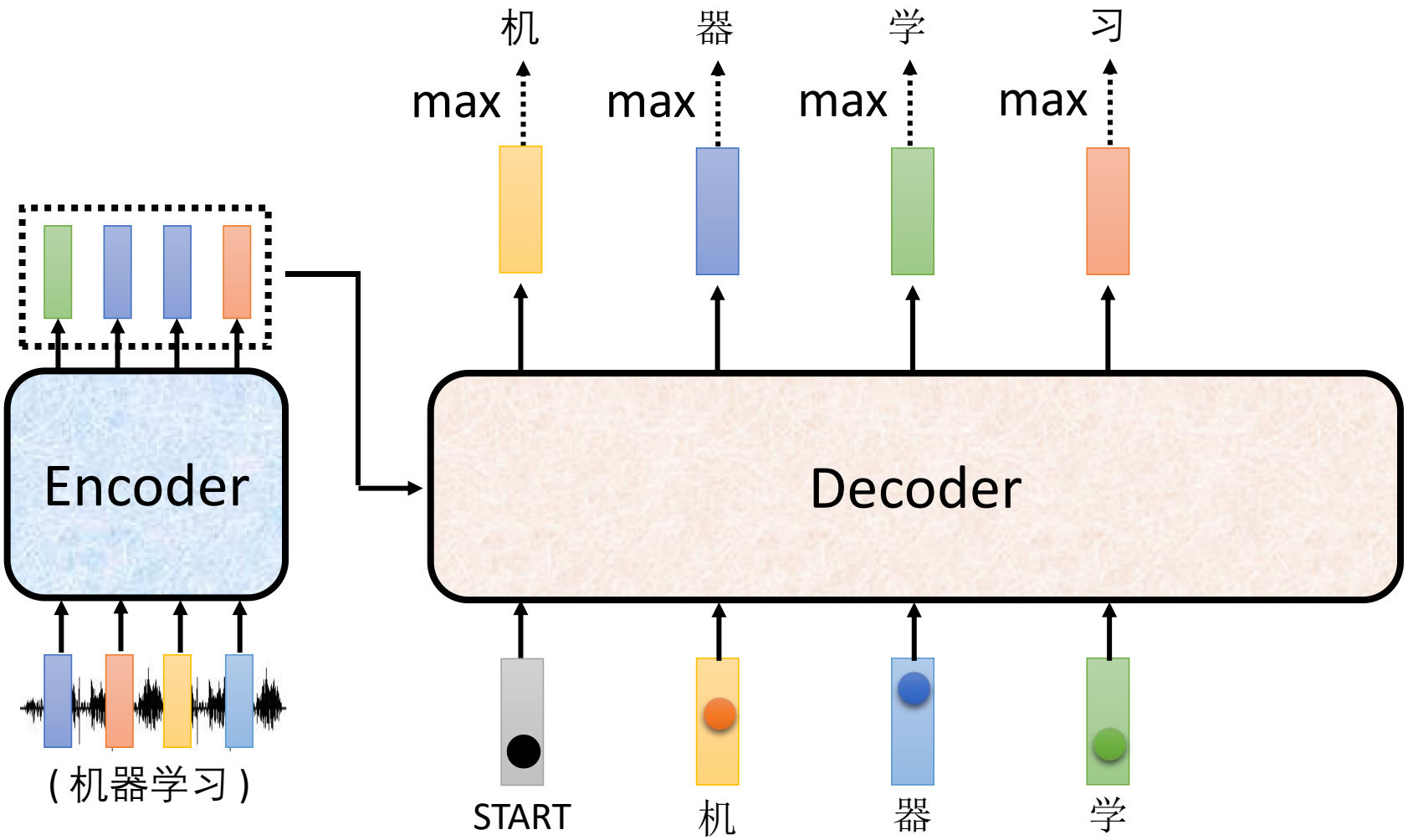


Autoregressive

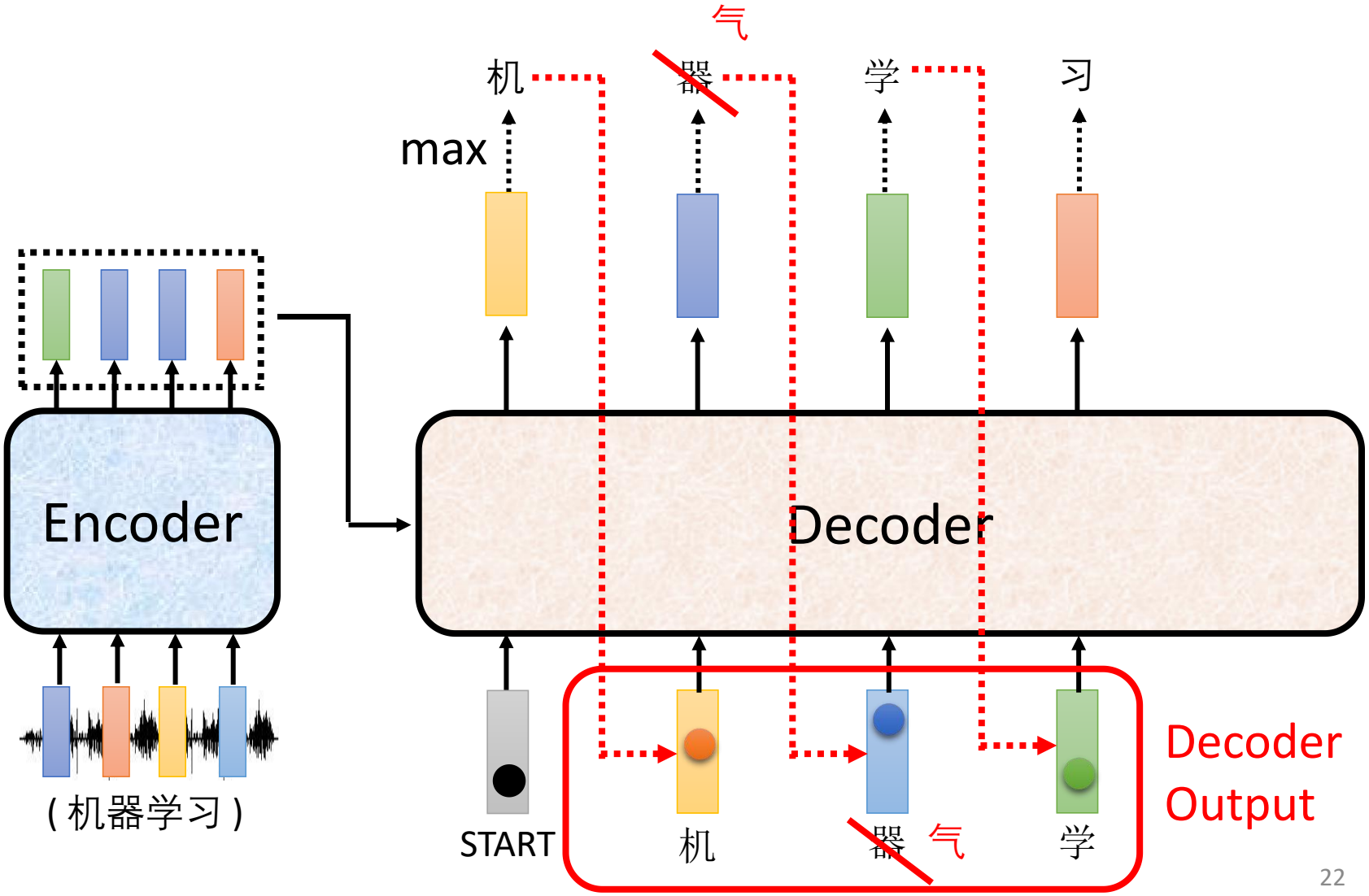
(Speech Recognition as example)



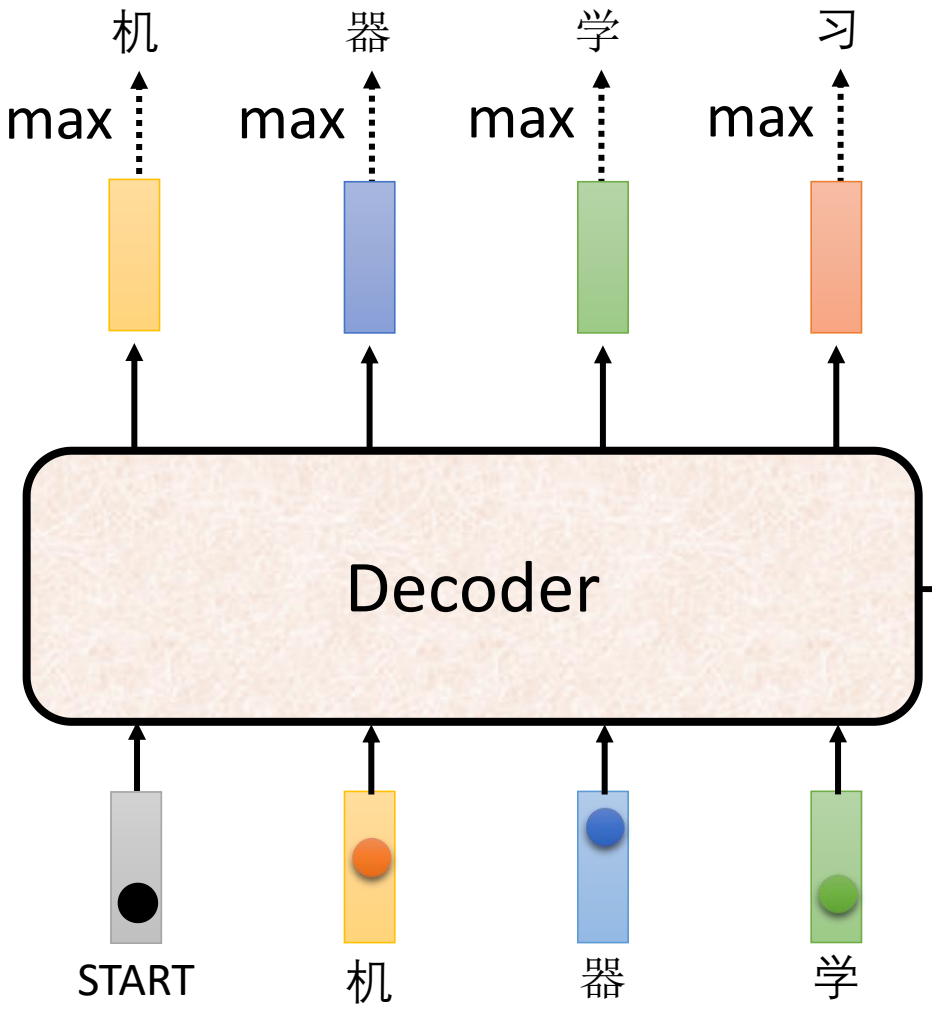
Autoregressive

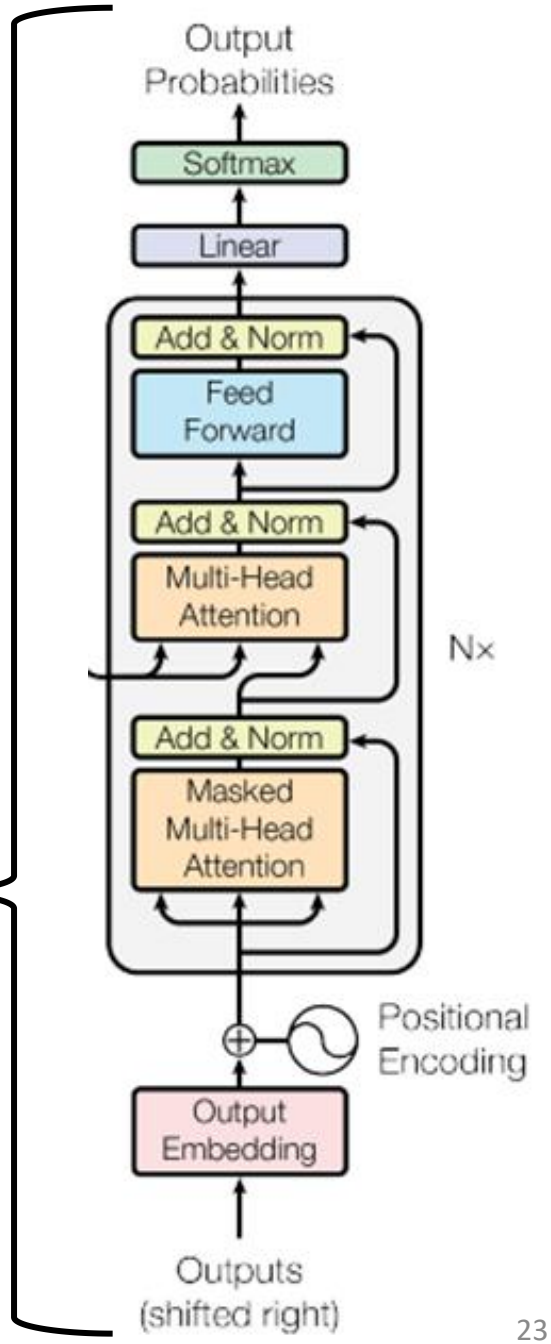


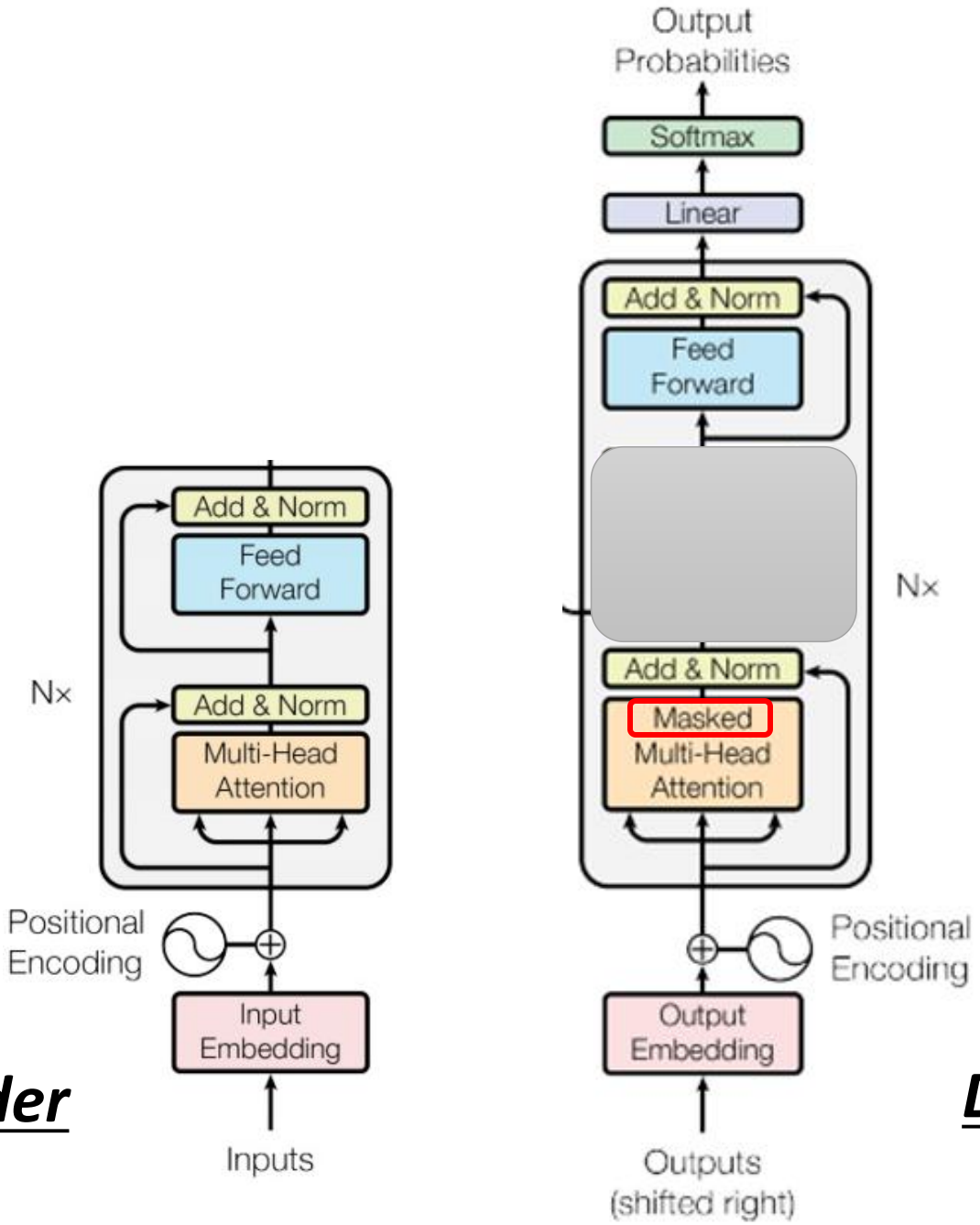
Autoregressive



ignore the input from the encoder here ☺



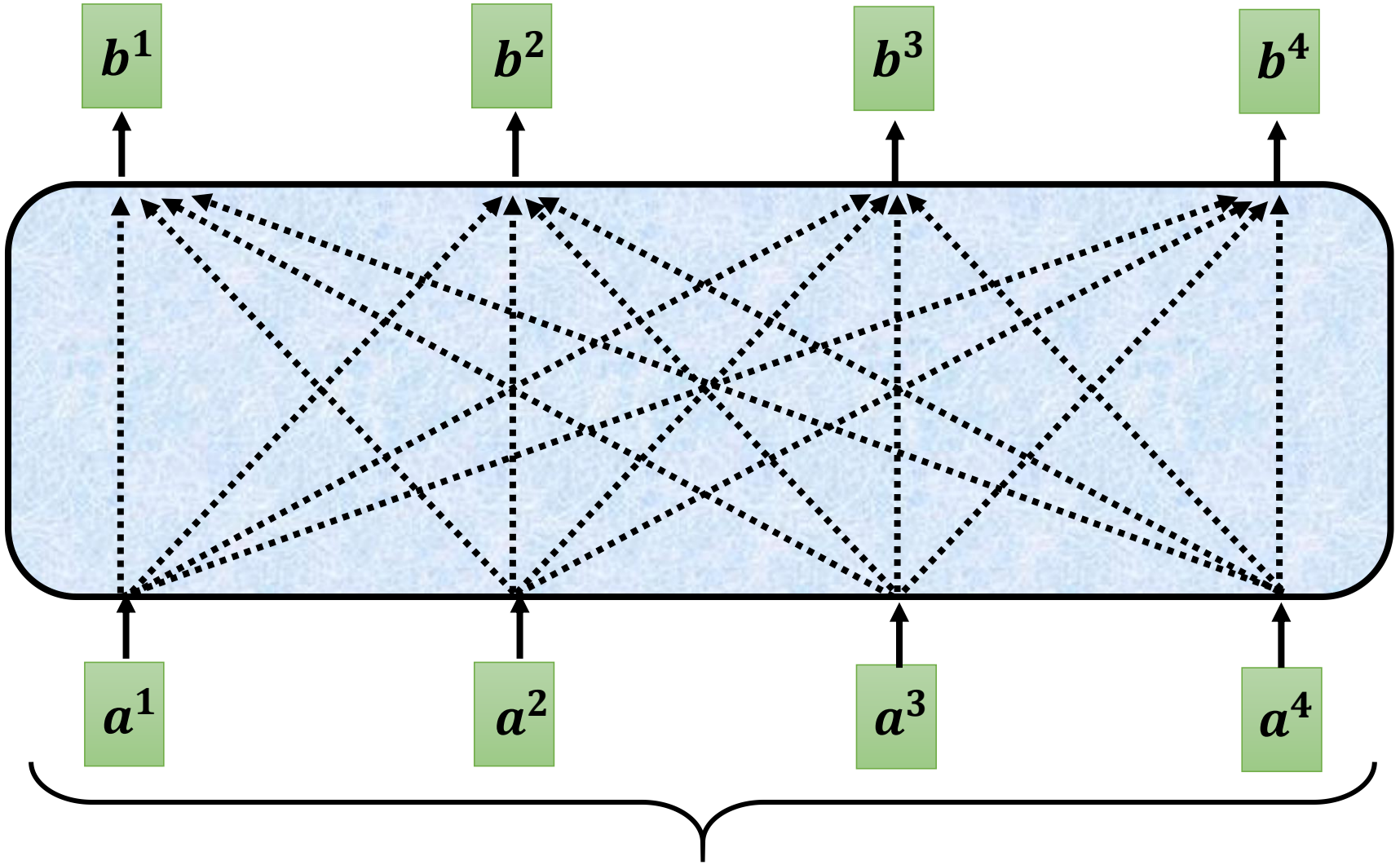




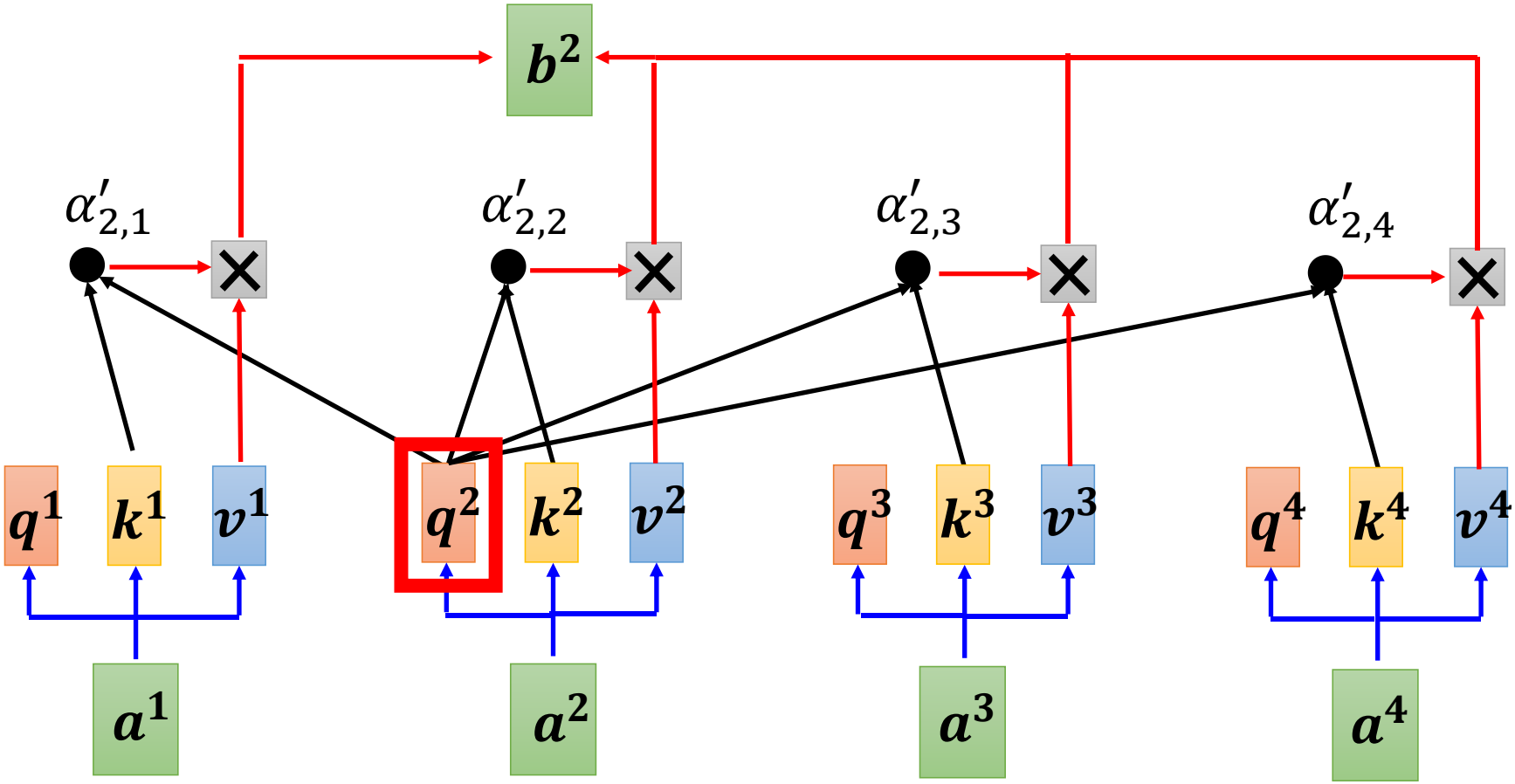
Encoder

Decoder

Self-attention → ***Masked Self-attention***



Self-attention → ***Masked Self-attention***

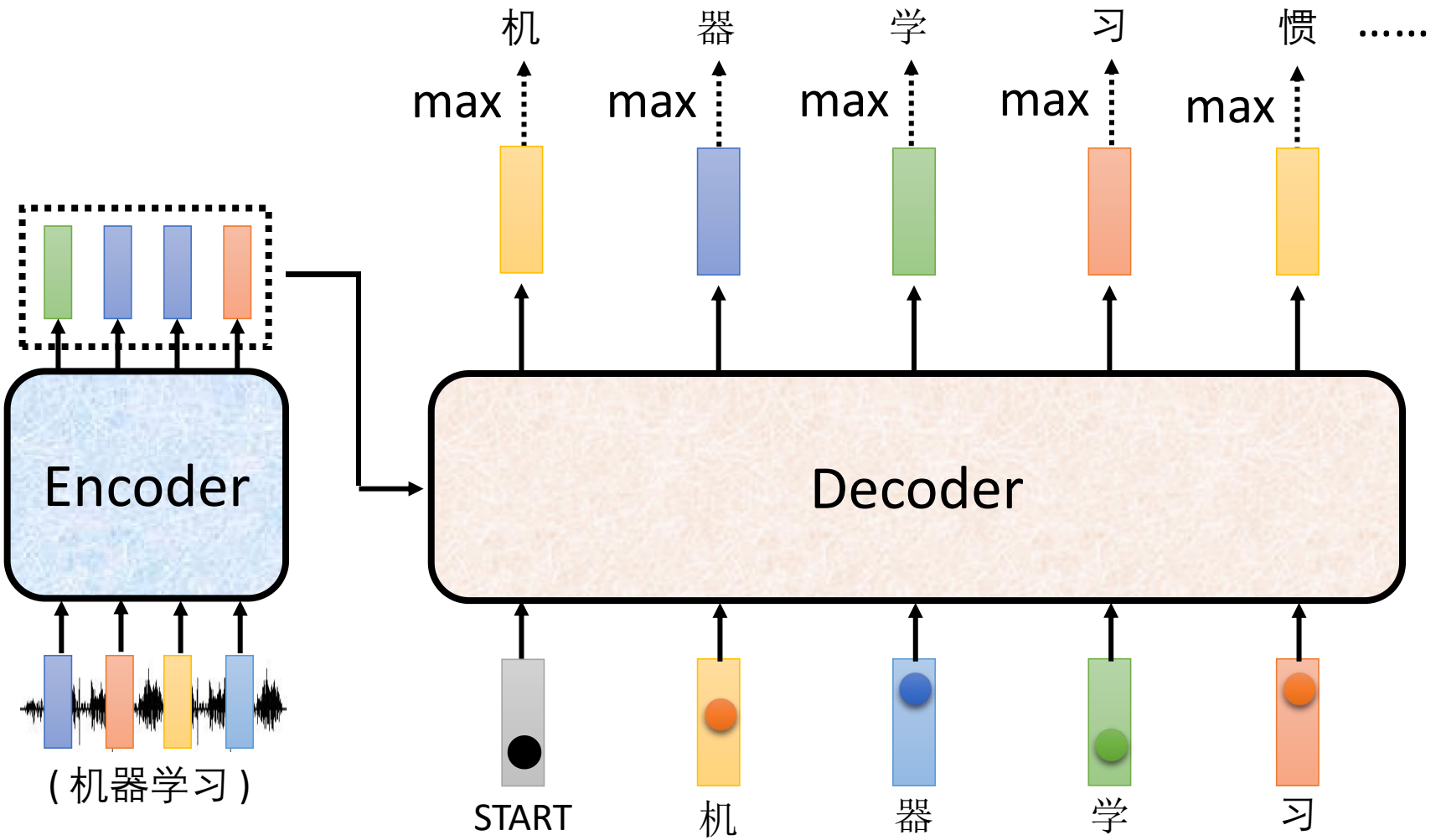


Why masked? Consider how does decoder work

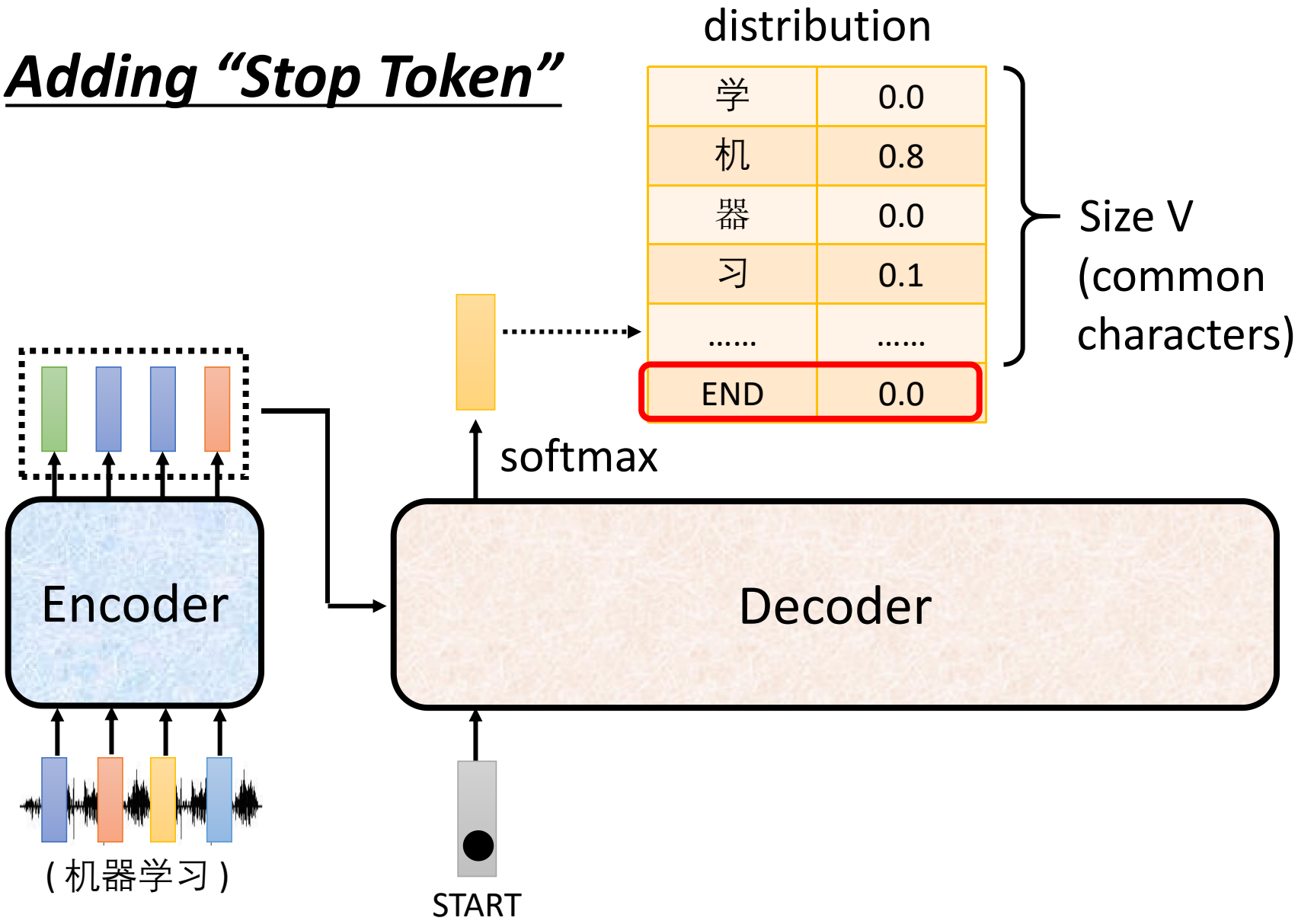
Autoregressive

We do not know the correct output length.

Never stop!

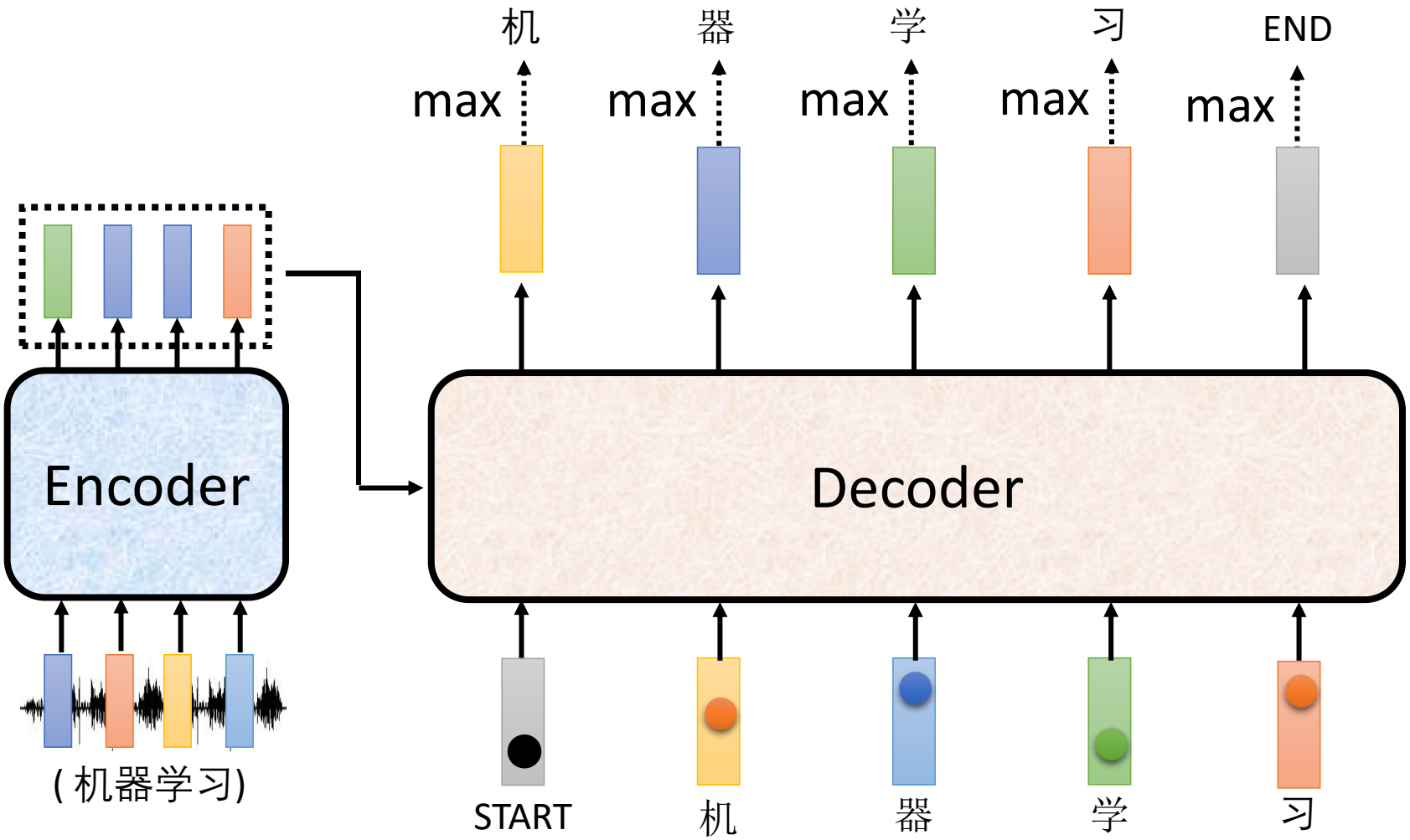


Adding "Stop Token"

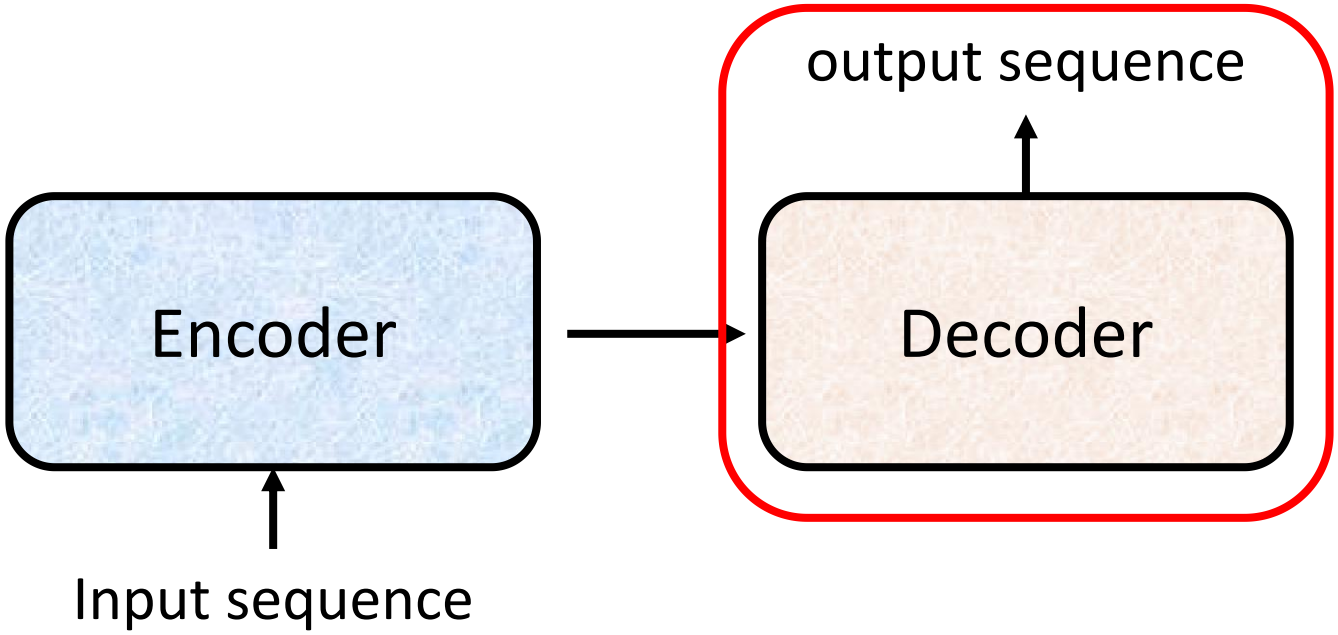


Autoregressive

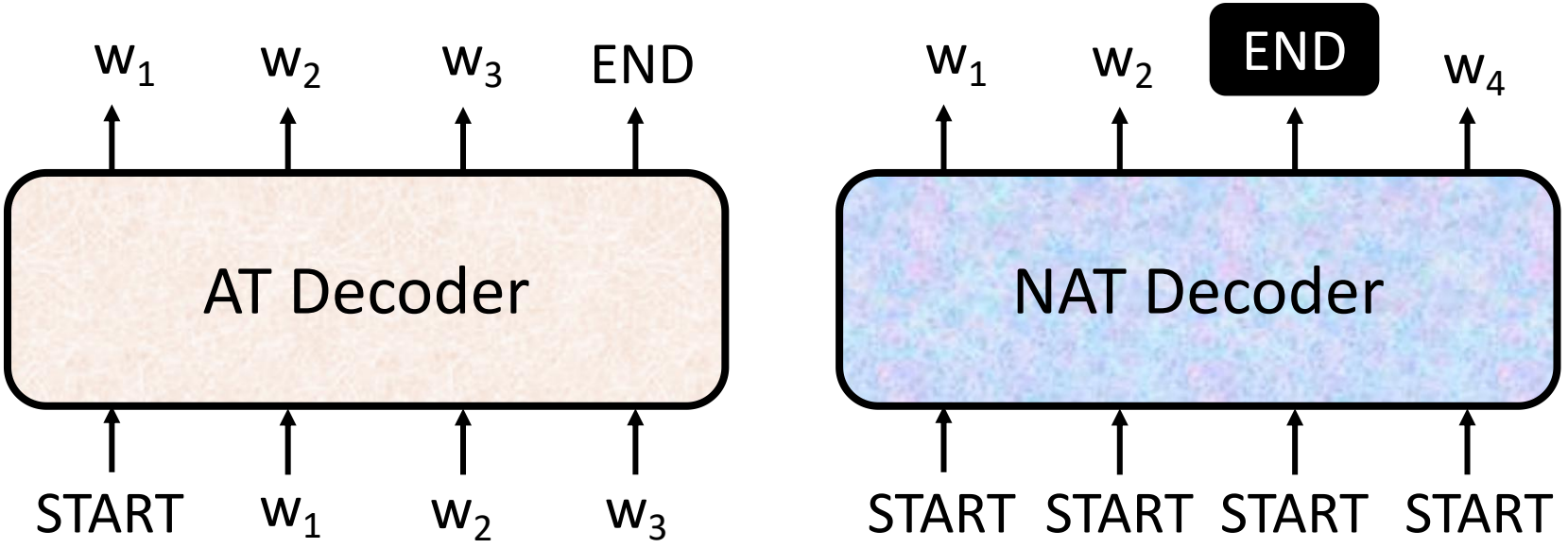
Stop at here!



Decoder
– Non-autoregressive (NAT)

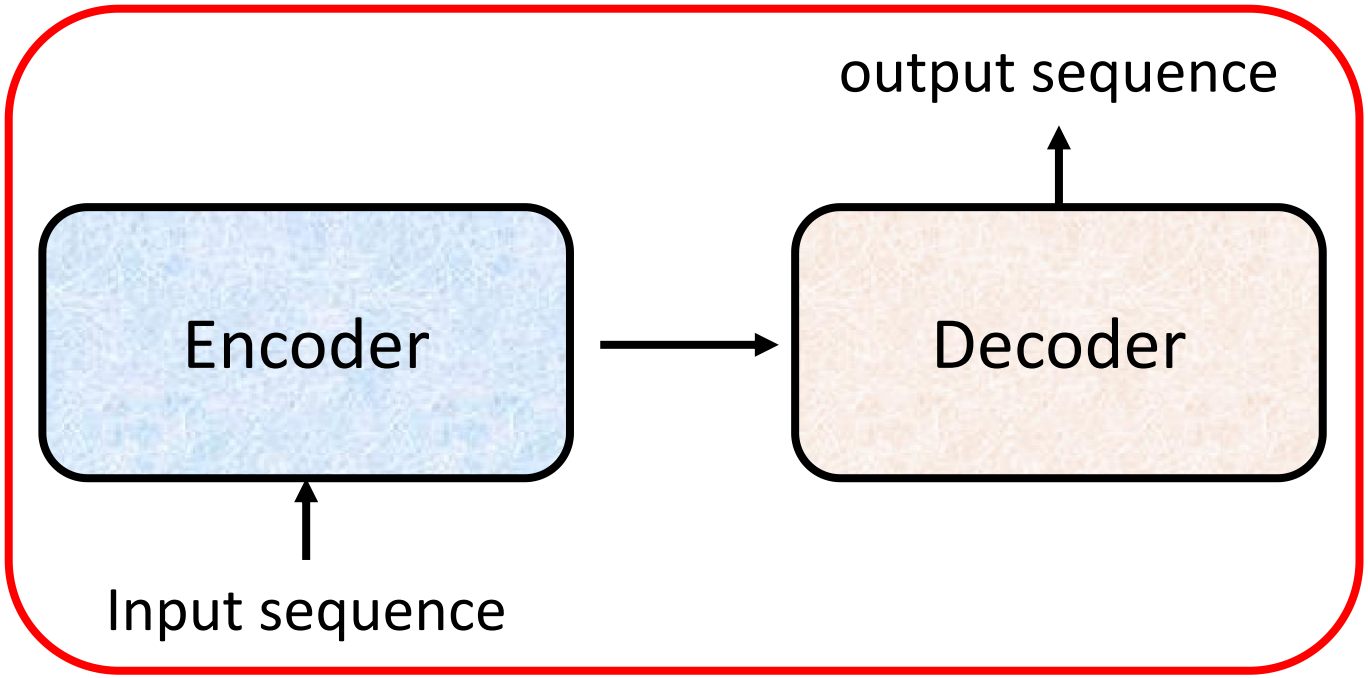


AT v.s. NAT

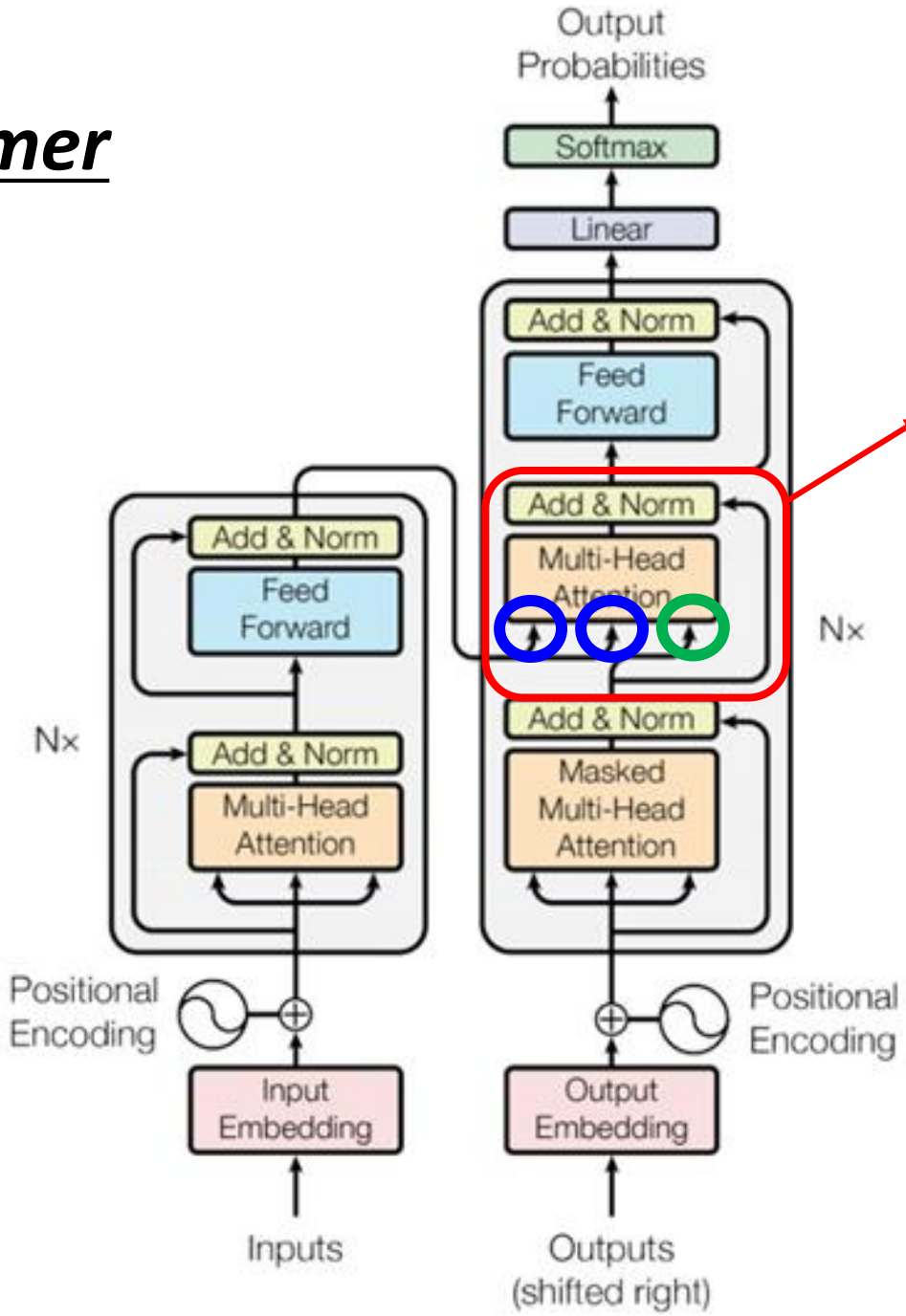


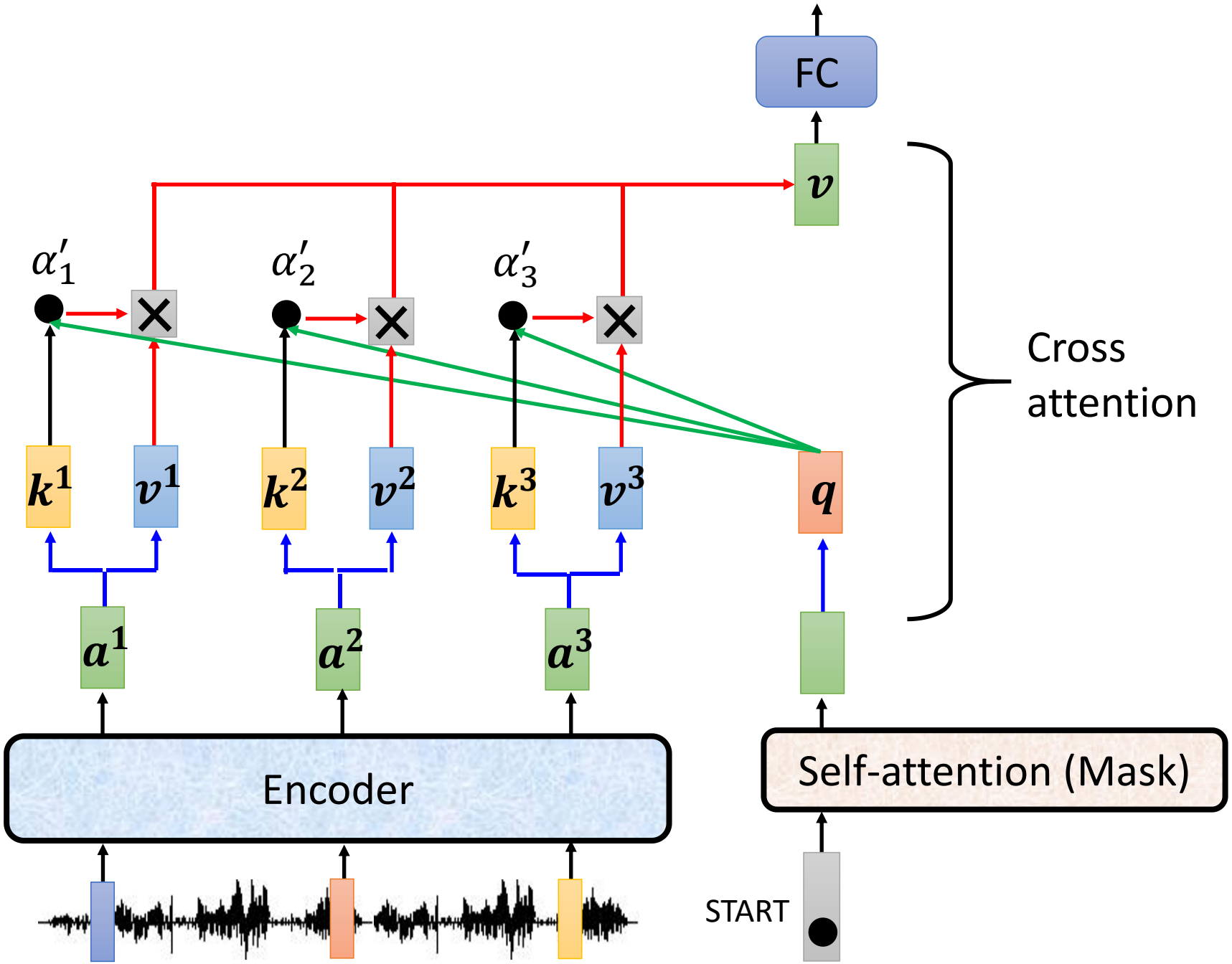
- How to decide the output length for NAT decoder?
  - Another predictor for output length
  - Output a very long sequence, ignore tokens after END
- Advantage: parallel, more stable generation (e.g., TTS)
- NAT is usually worse than AT

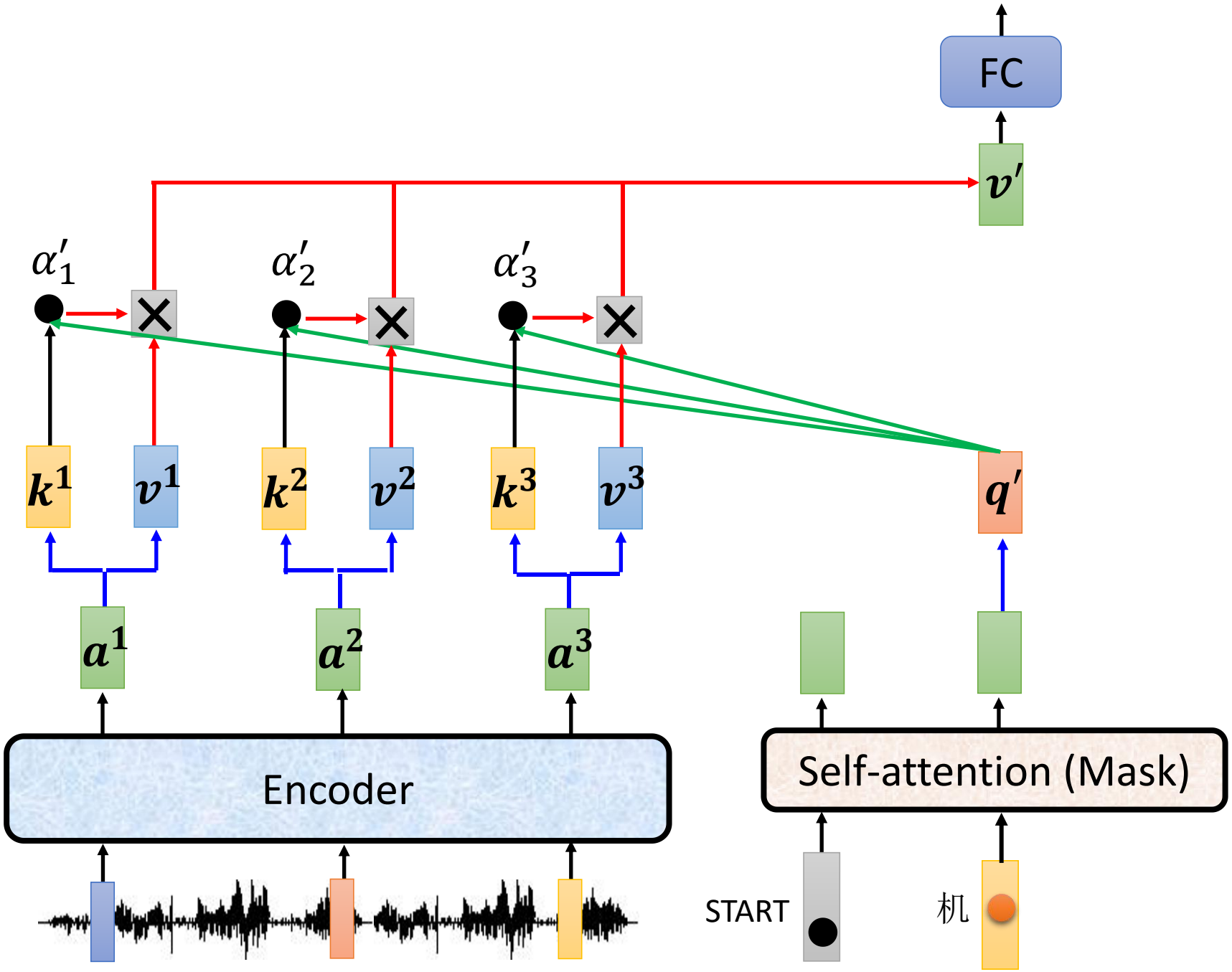
Encoder-Decoder



Transformer



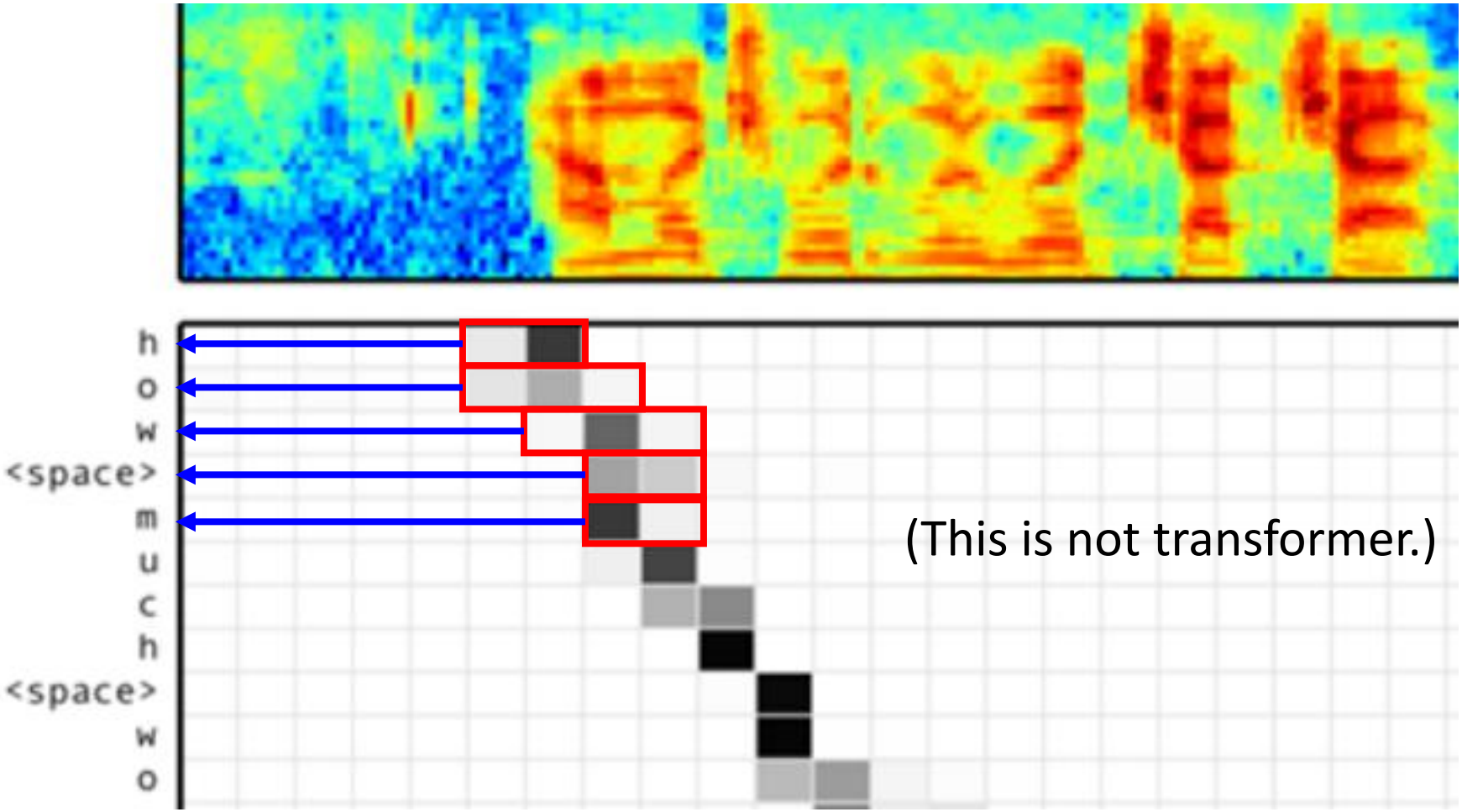

FC
v
α'_1
α'_2
α'_3
Cross attention
k^1
v^1
k^2
v^2
k^3
v^3
q
a^1
a^2
a^3
Encoder
Self-attention (Mask)
START


FC
v'
α'_1
α'_2
α'_3
k^1
v^1
k^2
v^2
k^3
v^3
q'
a^1
a^2
a^3
Encoder
Self-attention (Mask)
START
机

Cross Attention

Listen, attend and spell: A neural network for large vocabulary conversational speech recognition

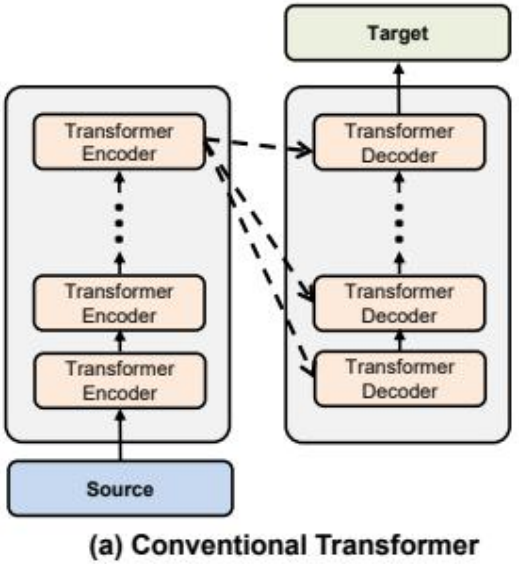
https://ieeexplore.ieee.org/document/7472621



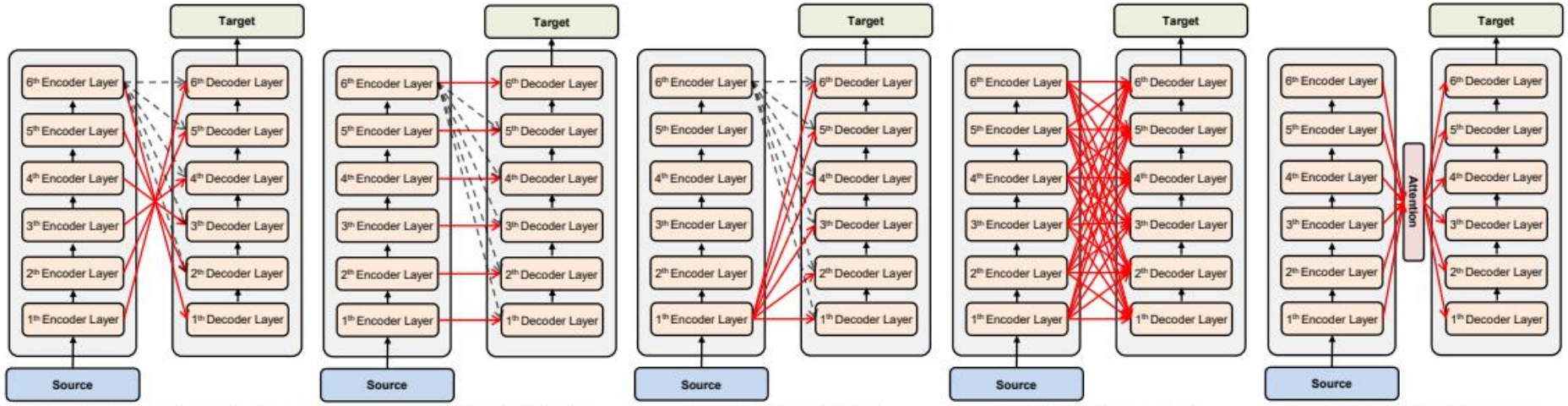
(This is not transformer.)

Cross Attention

Source of image:
https://arxiv.org/abs/2005.08081

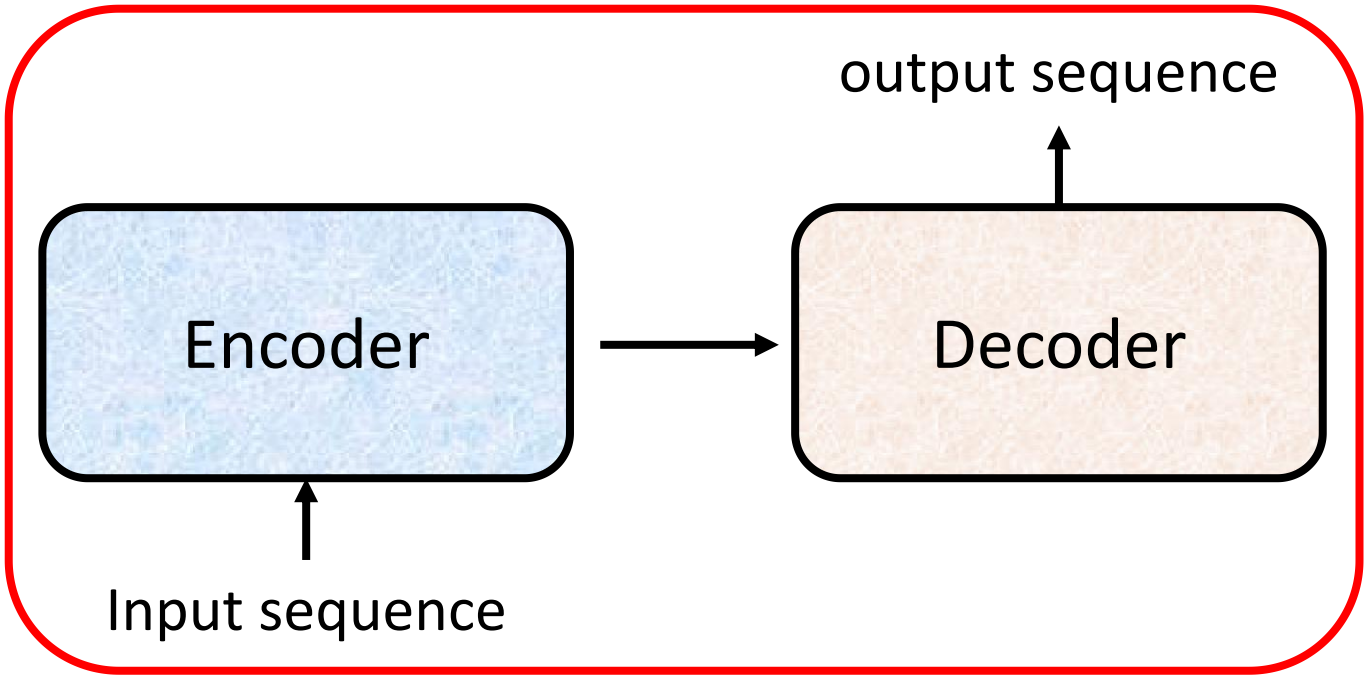


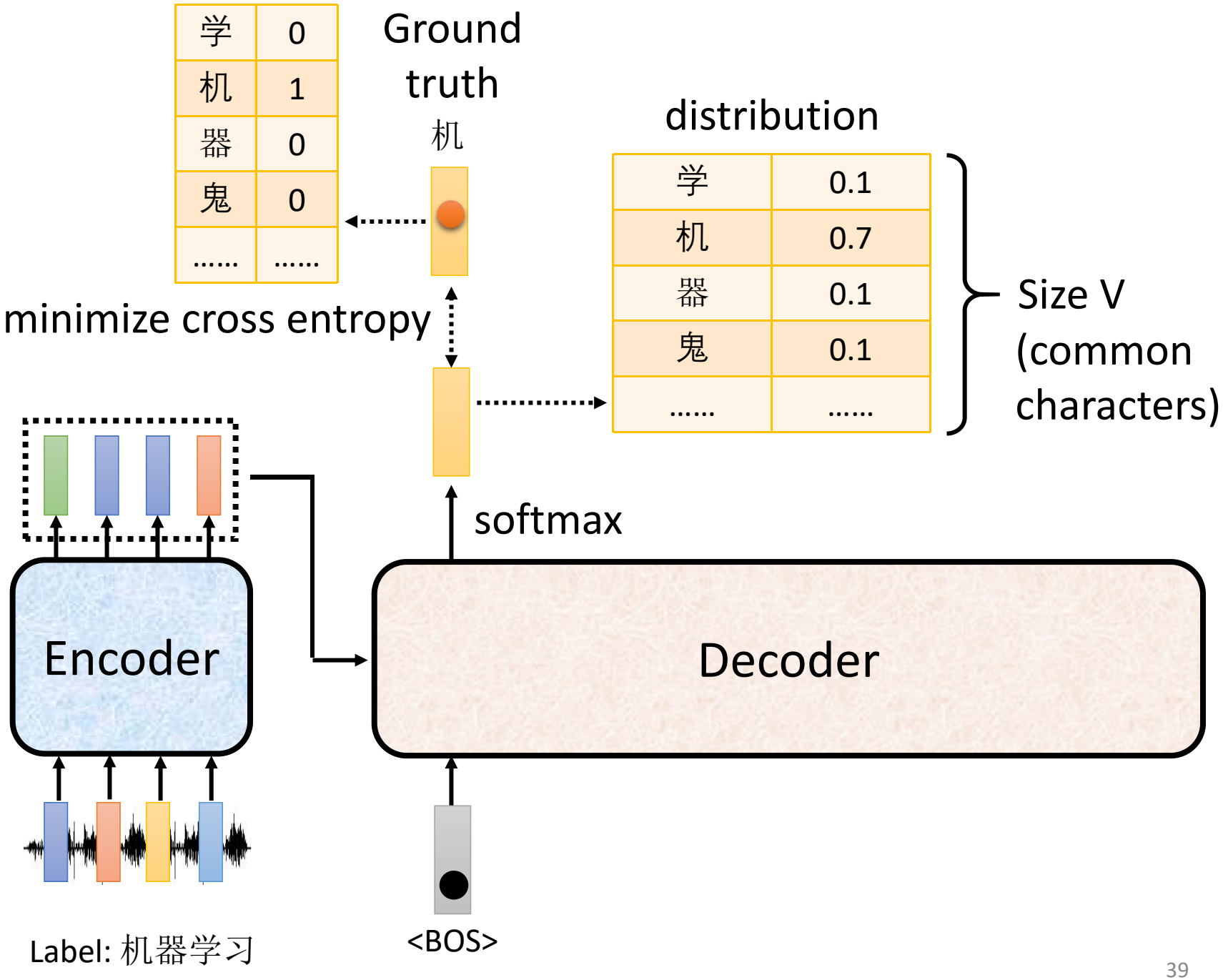
(a) Conventional Transformer



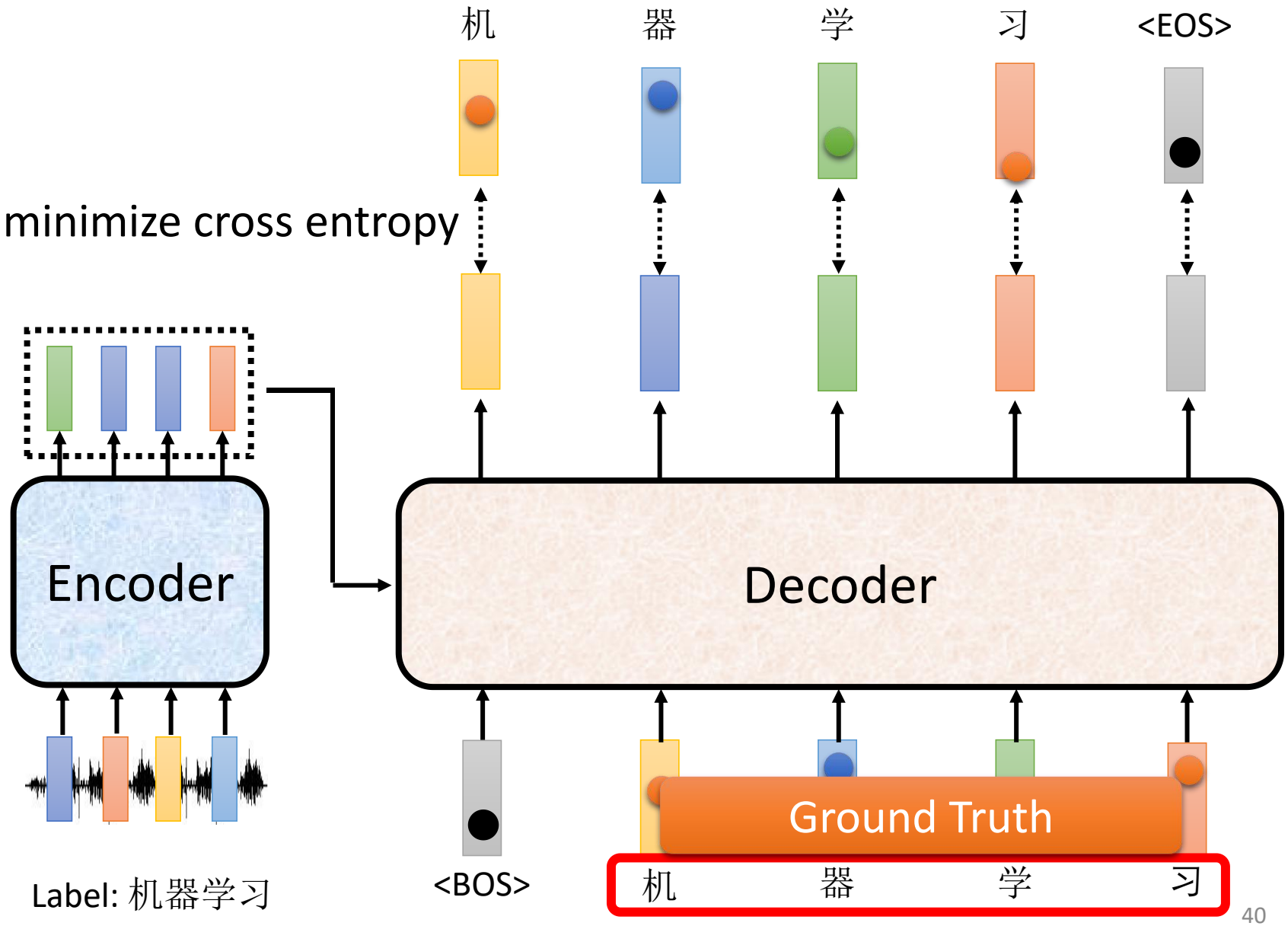
(a) Granularity Consistent Attention (b) Granularity Parallel Attention (c) Fine-Grained Attention (d) Full Matching Attention (e) Adaptive Matching Attention

Training

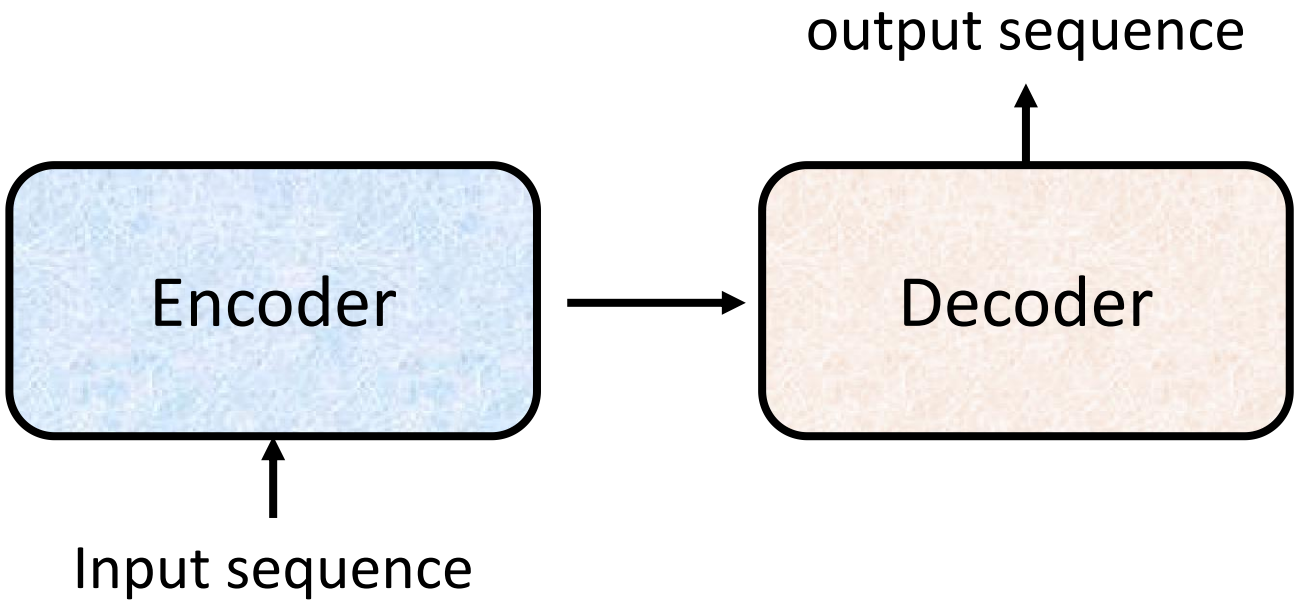



学 0
机 1
器 0
鬼 0
....
Ground truth
机
distribution
学 0.1
机 0.7
器 0.1
鬼 0.1
....
Size V (common characters)
minimize cross entropy
softmax
Encoder
Decoder
<BOS>
Label: 机器学习

Teacher Forcing: using the ground truth as input.

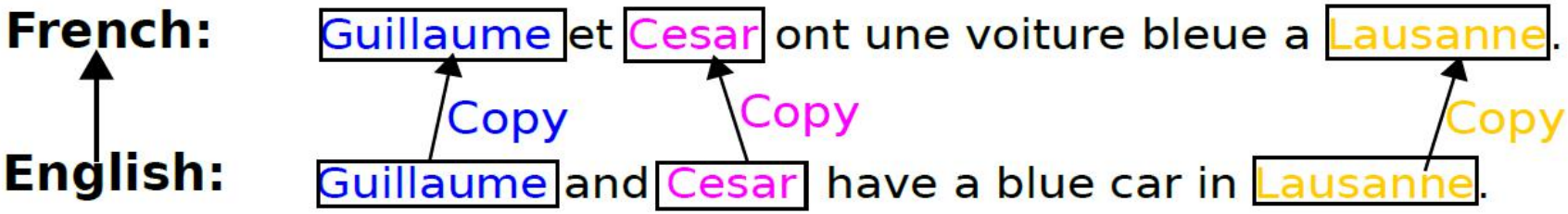


Tips



Copy Mechanism

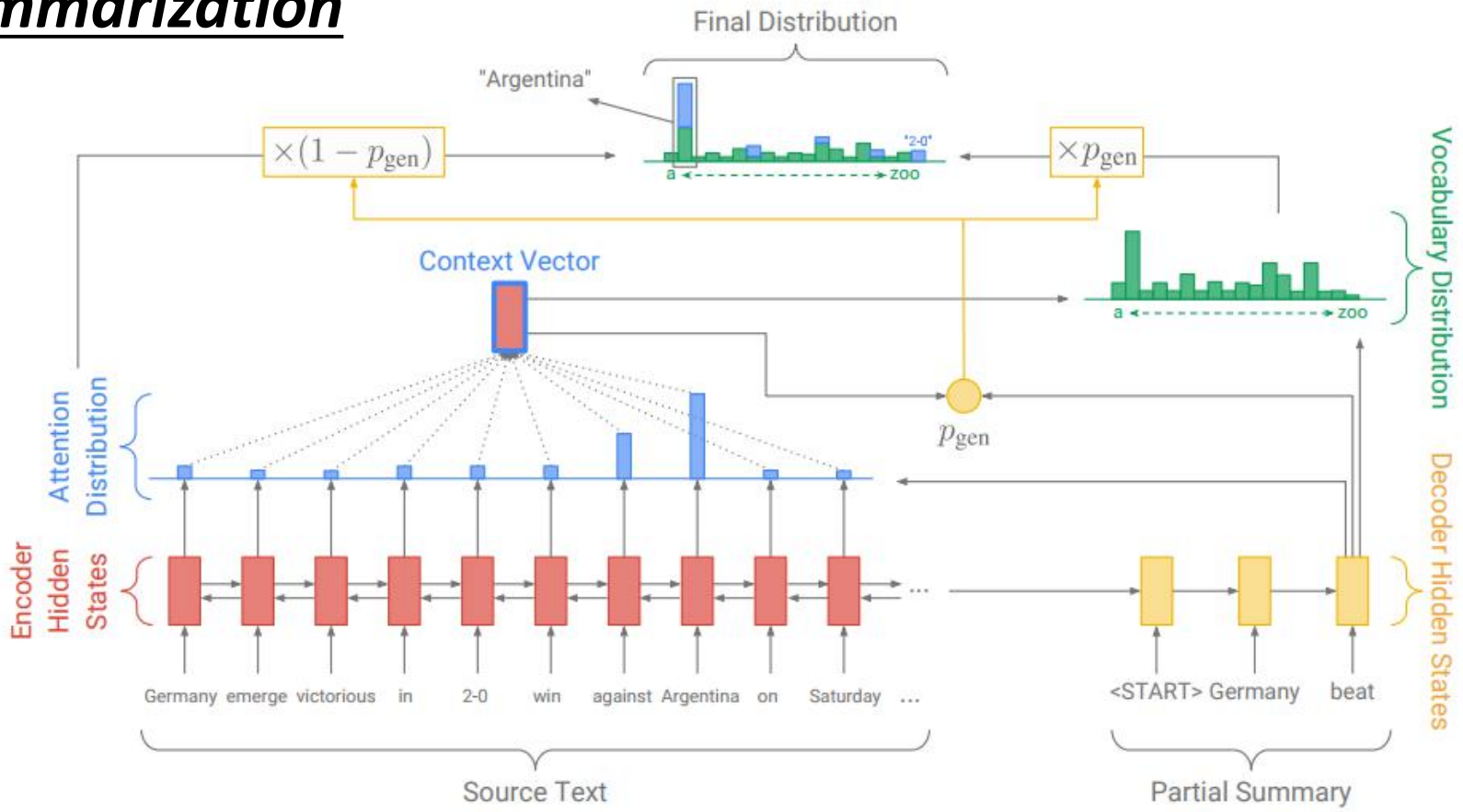
Machine Translation



Copy Mechanism

https://arxiv.org/abs/1704.04368

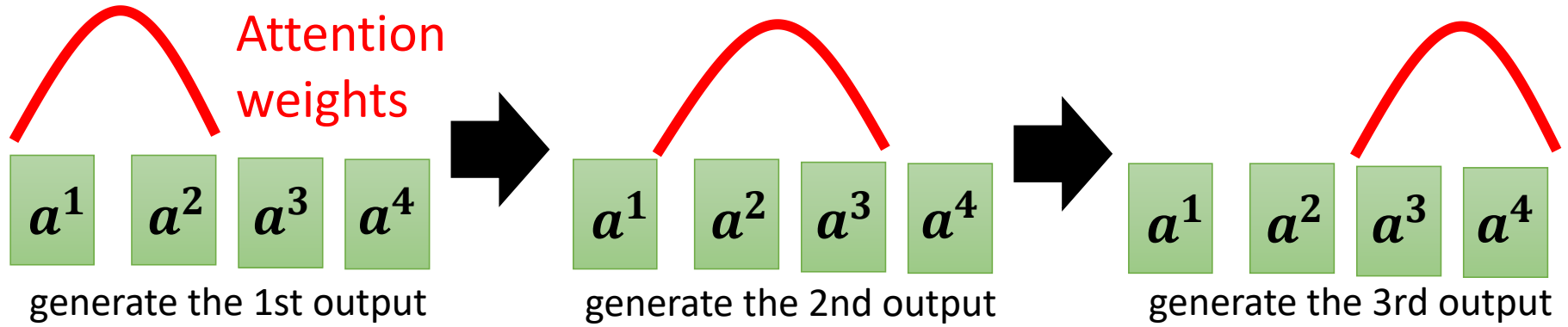
Summarization

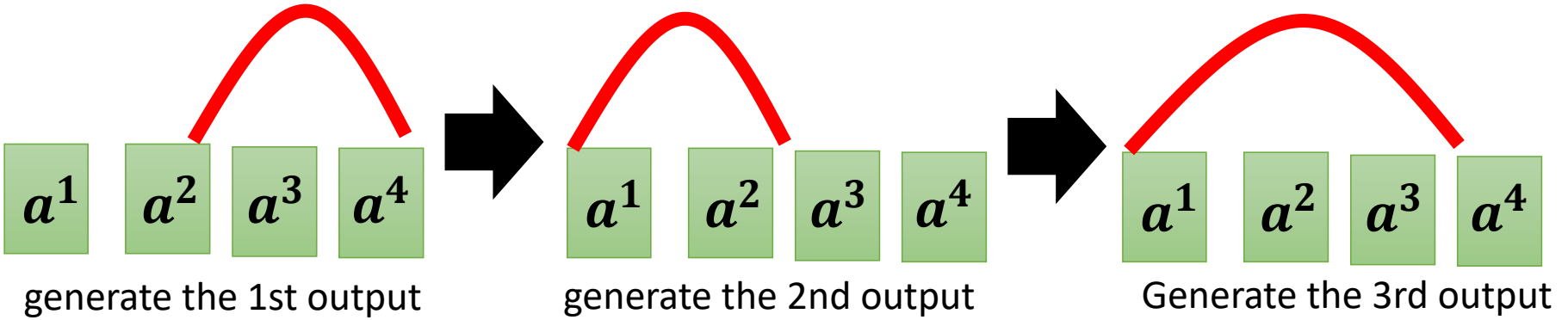


Guided Attention

Monotonic Attention
Location-aware attention

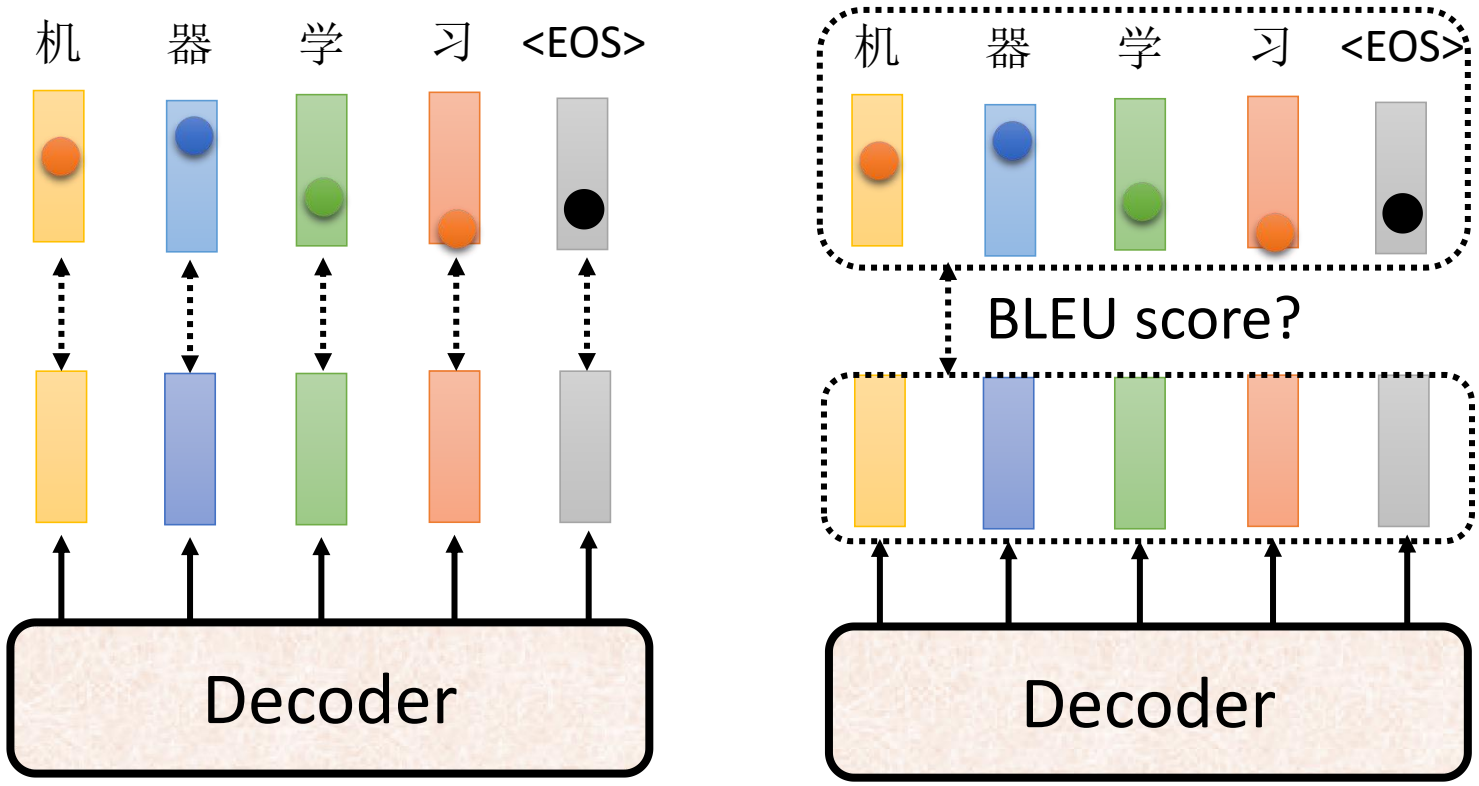
In some tasks, input and output are monotonically aligned.
For example, speech recognition, TTS, etc.





Something wrong!

Optimizing Evaluation Metrics?

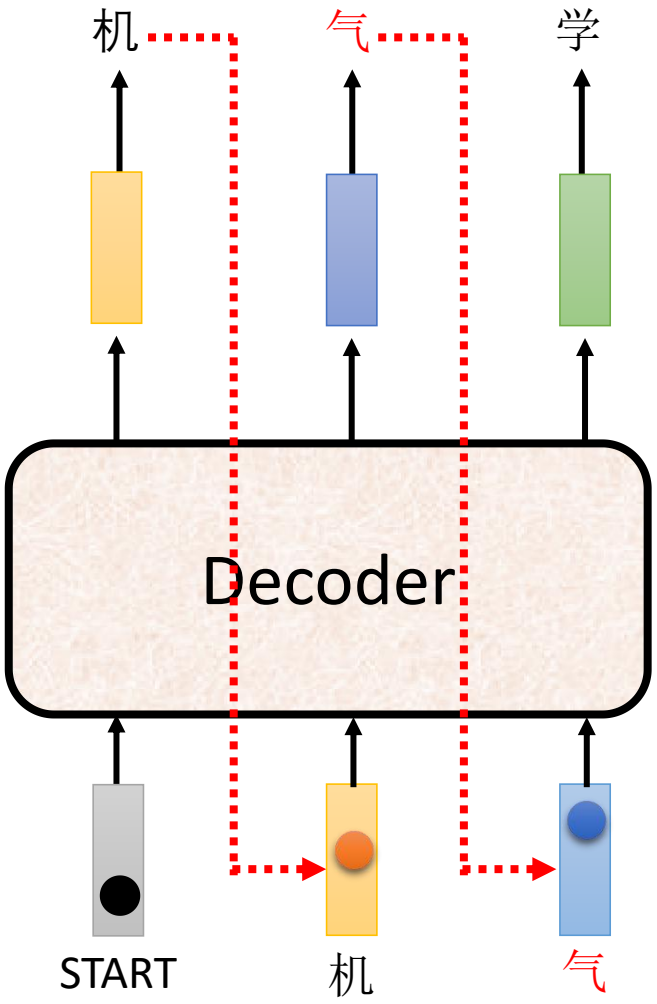


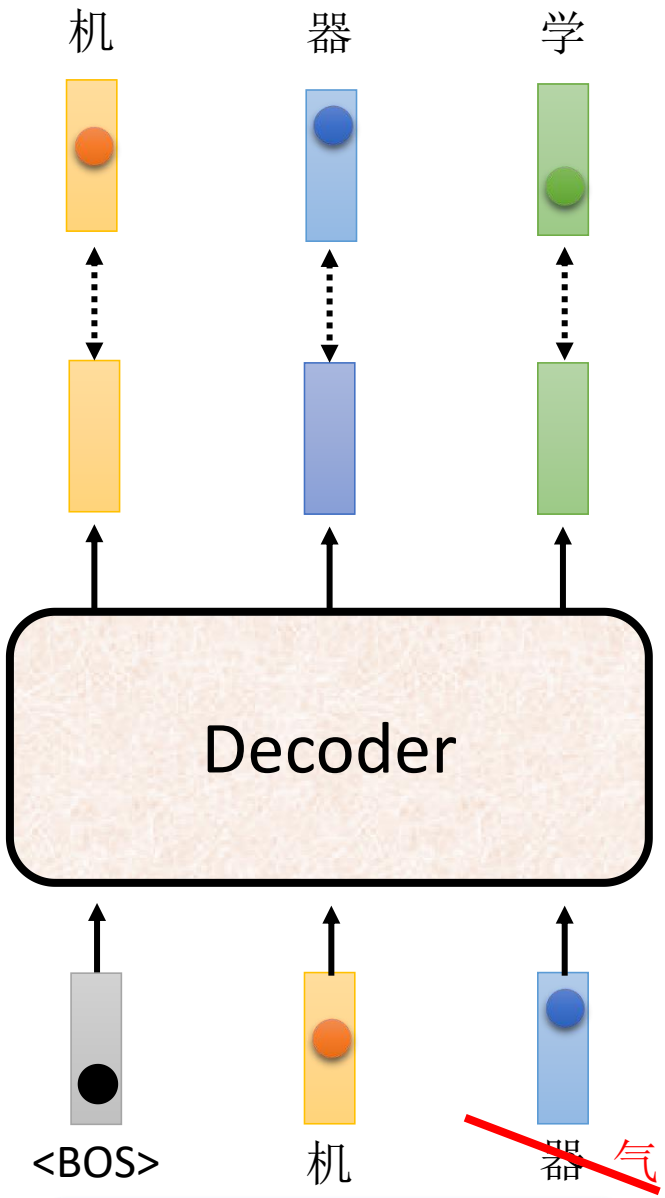
How to do the optimization?

When you don't know how to optimize, just use reinforcement learning (RL)! https://arxiv.org/abs/1511.06732

There is a mismatch! ☹

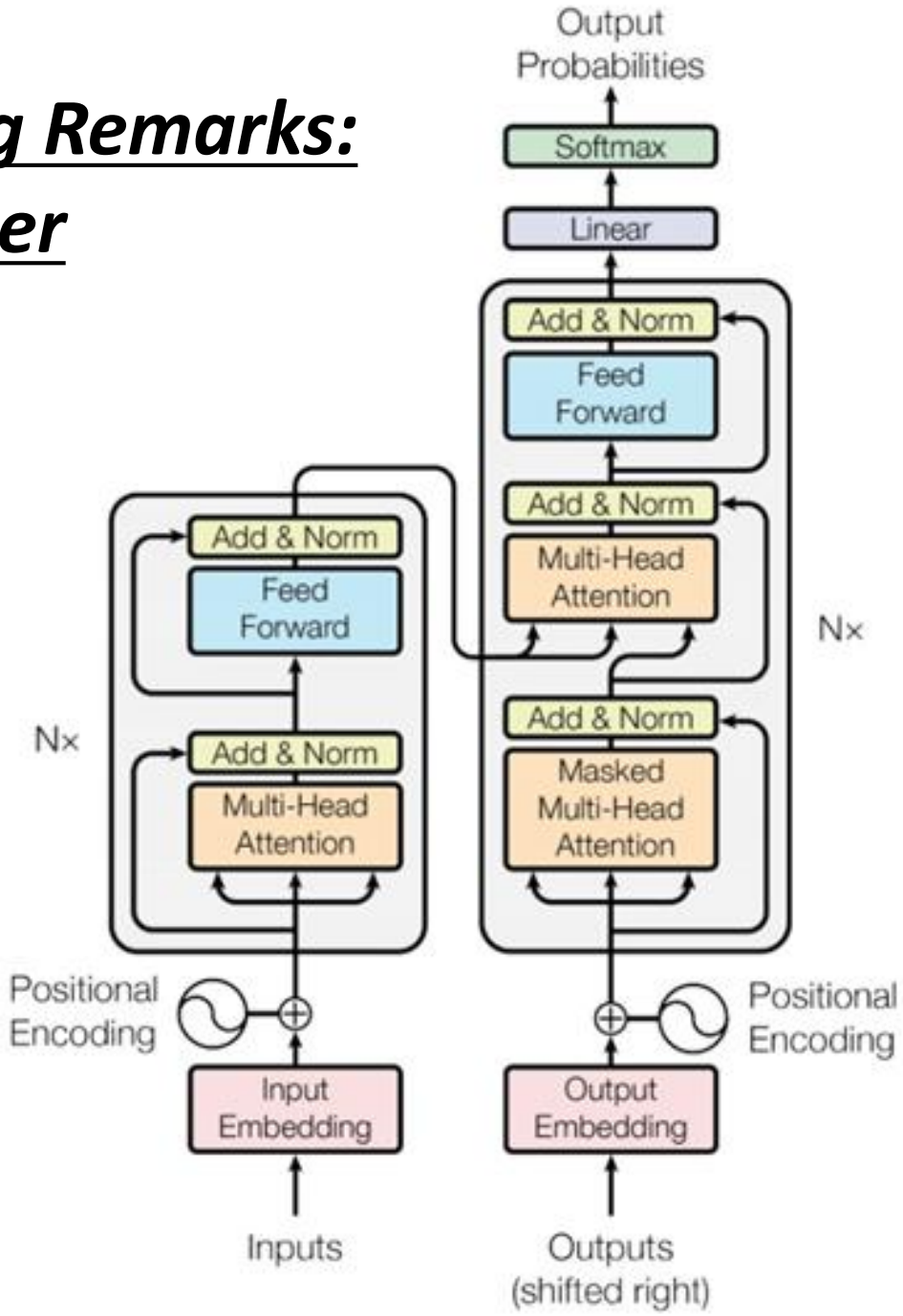
exposure bias





Ground Truth

Concluding Remarks: Transformer




Q&A