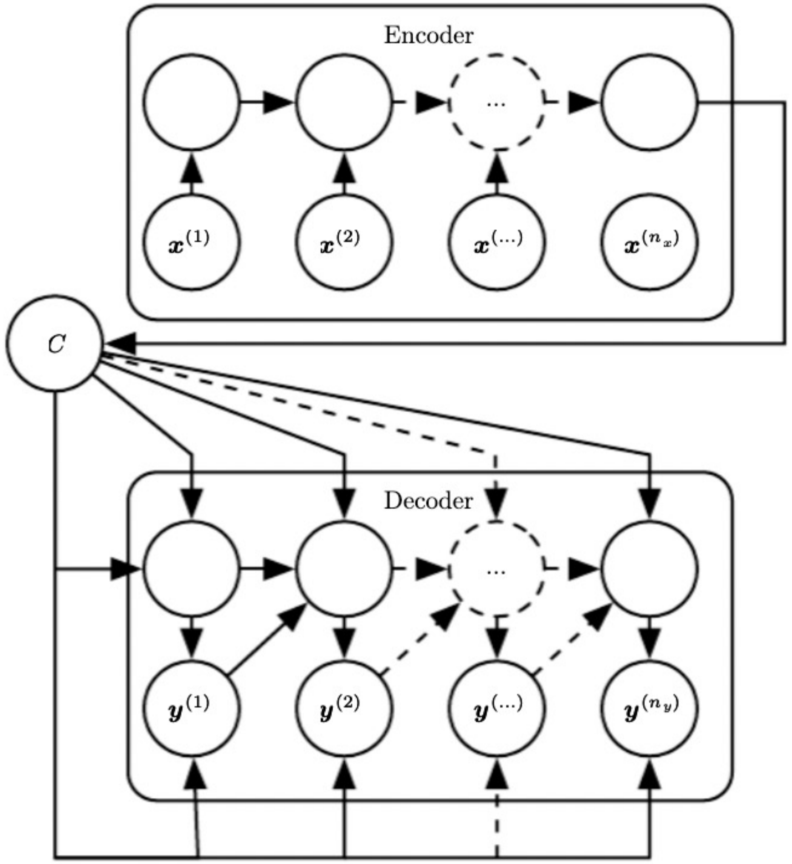
Transformer

Neural Networks Design And Application

Encoder-decoder for seq2seq



Attention mechanism

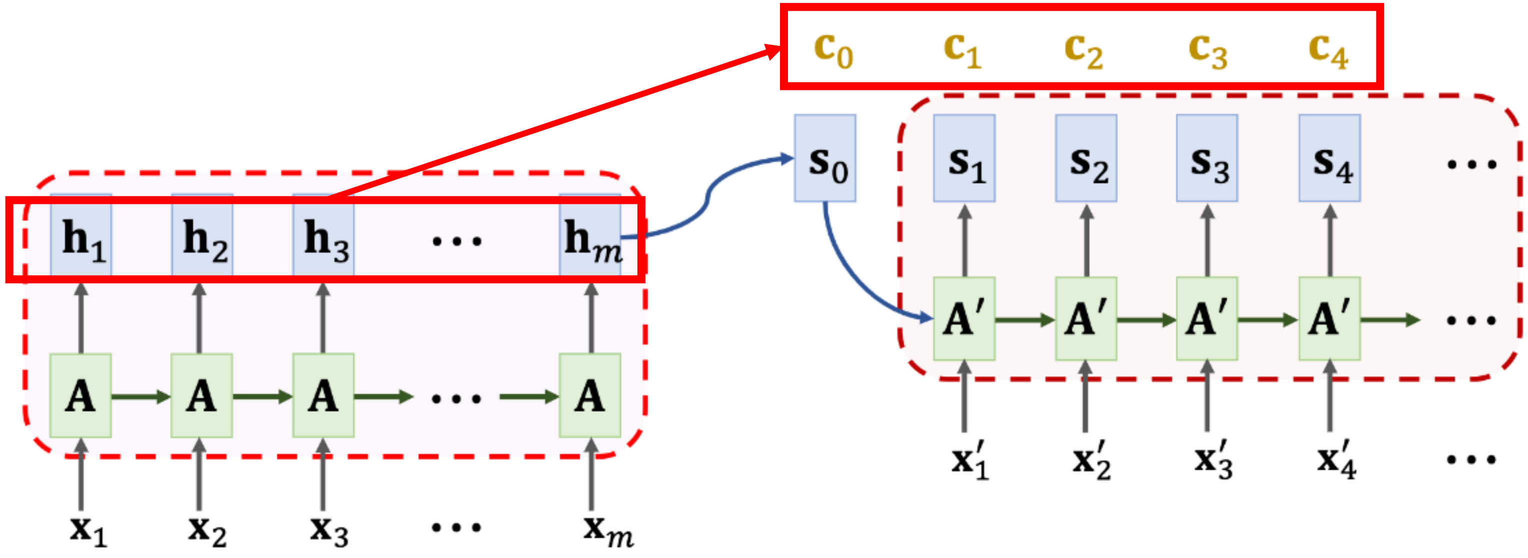


Image from https://github.com/wangshusen/DeepLearning/blob/master/Slides/9_RNN_8.pdf

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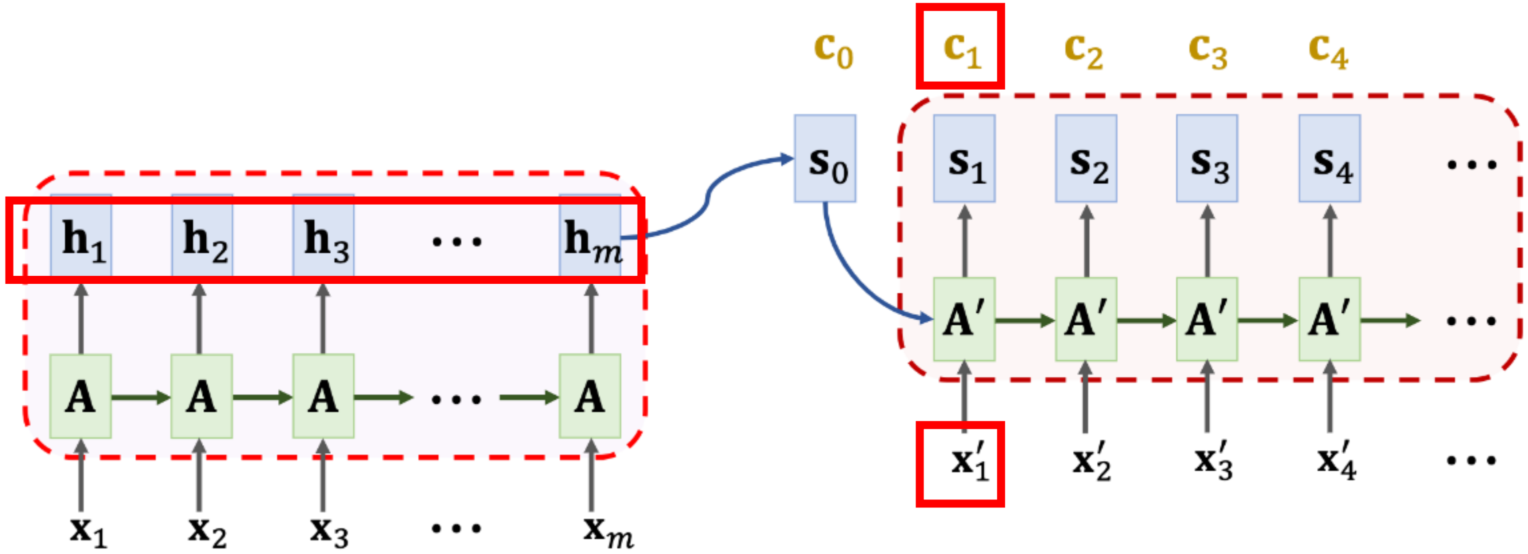

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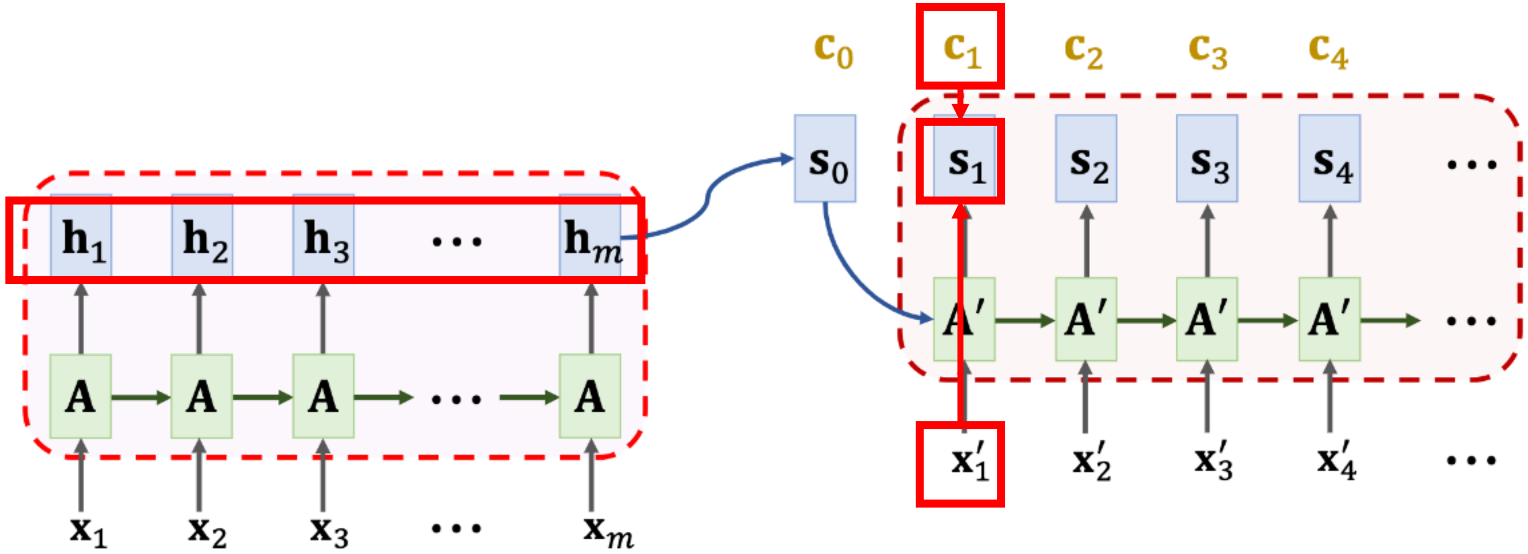

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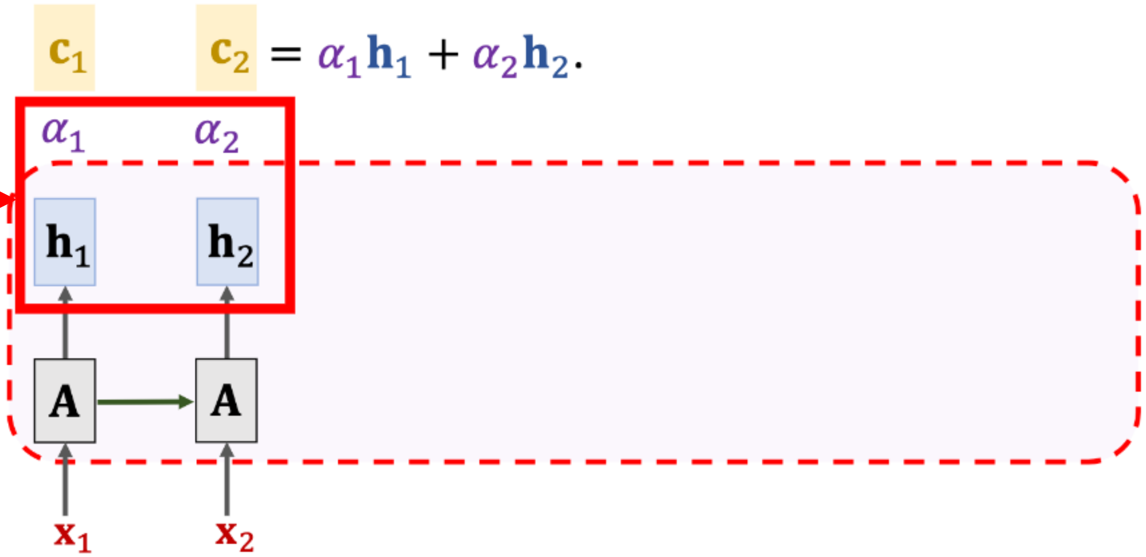
Self-attention (intra-attention)

Weighted average



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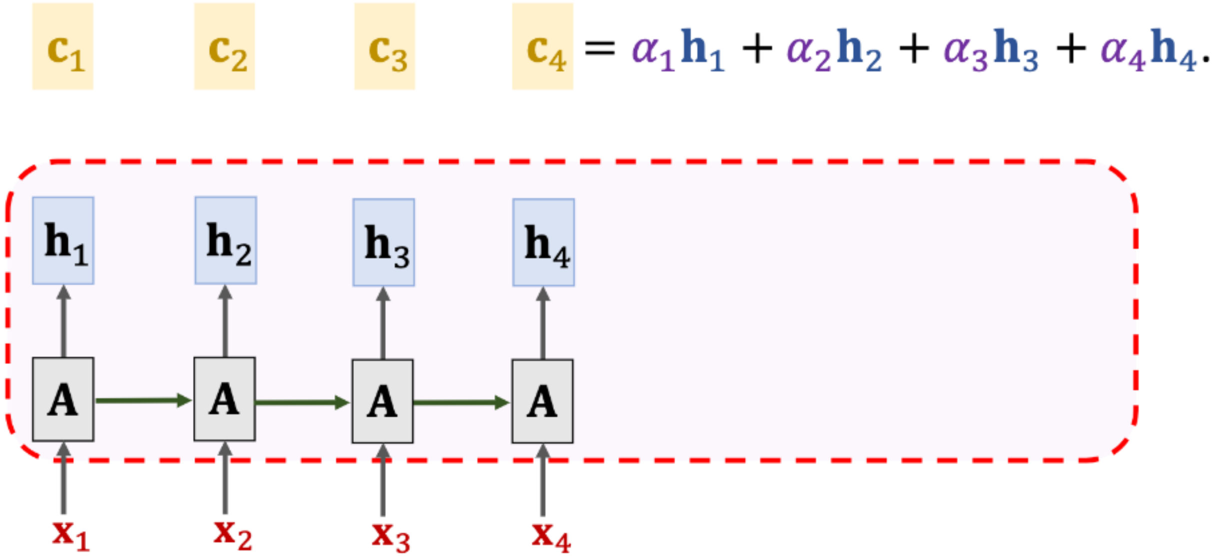

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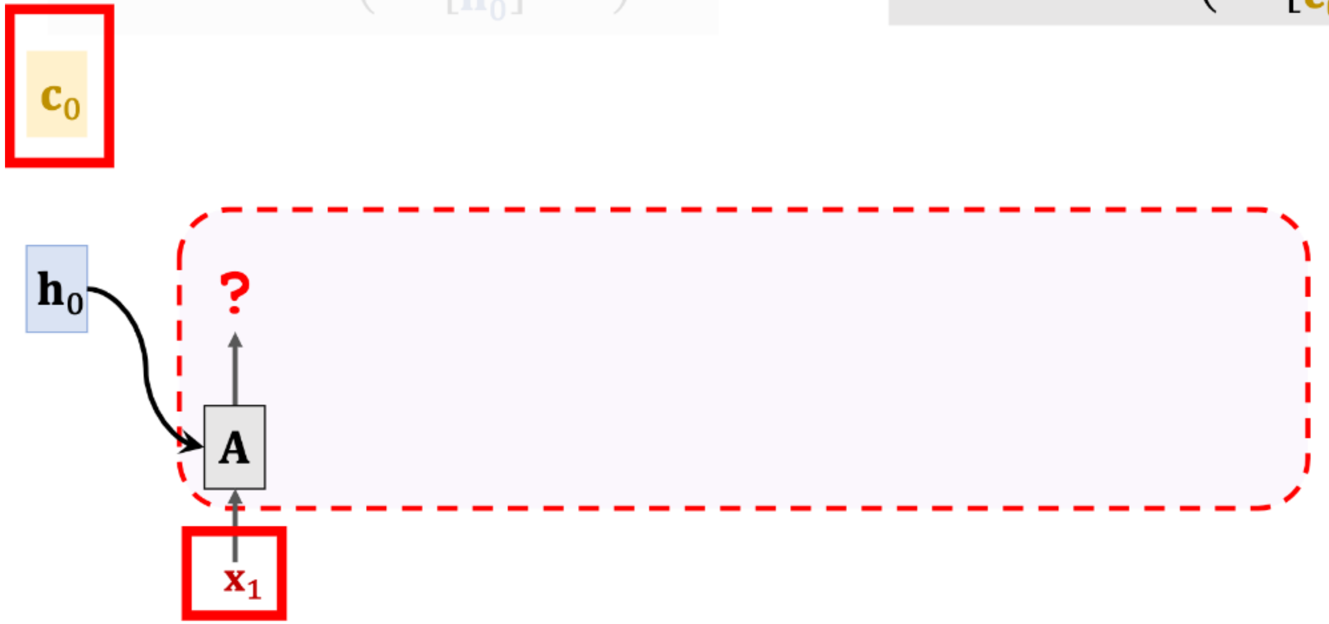
Self-attention (intra-attention)

SimpleRNN:

$$\mathbf{h}_1 = \tanh\left(\mathbf{A} \cdot \begin{bmatrix} \mathbf{x}_1 \\ \mathbf{h}_0 \end{bmatrix} + \mathbf{b}\right)$$

SimpleRNN + Self-Attention:

$$\mathbf{h}_1 = \tanh\left(\mathbf{A} \cdot \begin{bmatrix} \mathbf{x}_1 \\ \mathbf{c}_0 \end{bmatrix} + \mathbf{b}\right)$$



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not h_{i-1}

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Self-attention builds connection over sequence elements

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Self-attention builds connection over sequence elements

Q: can we use self-attention without RNN?

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Transformer networks

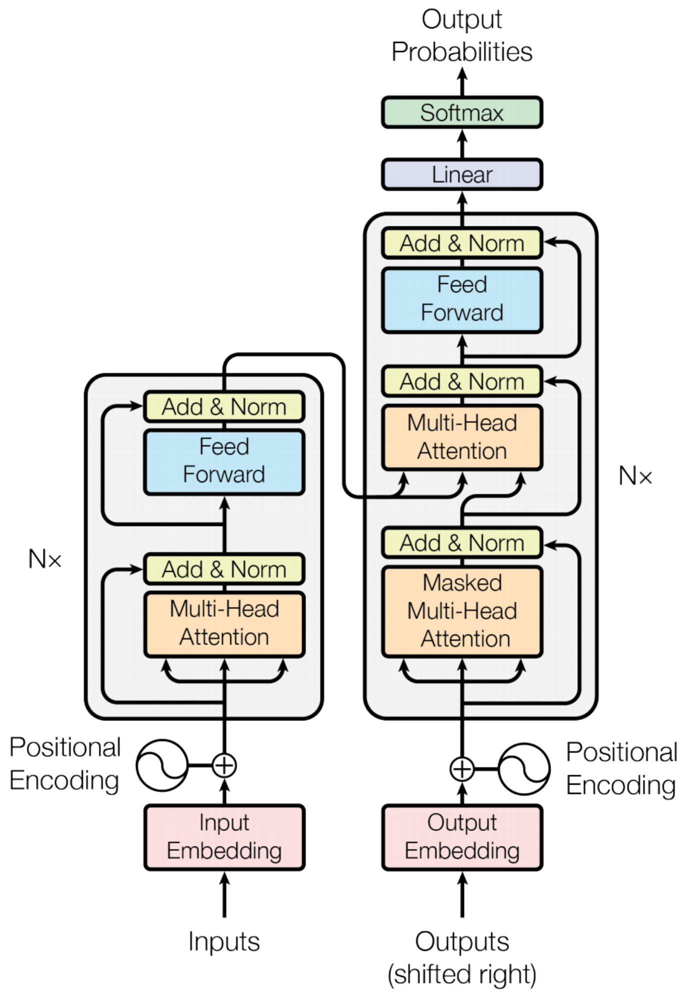

Figure 1: The Transformer - model architecture.

Vaswani, Ashish, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N. Gomez, Lukasz Kaiser, and Illia Polosukhin. "Attention is all you need." *arXiv preprint arXiv:1706.03762* (2017).

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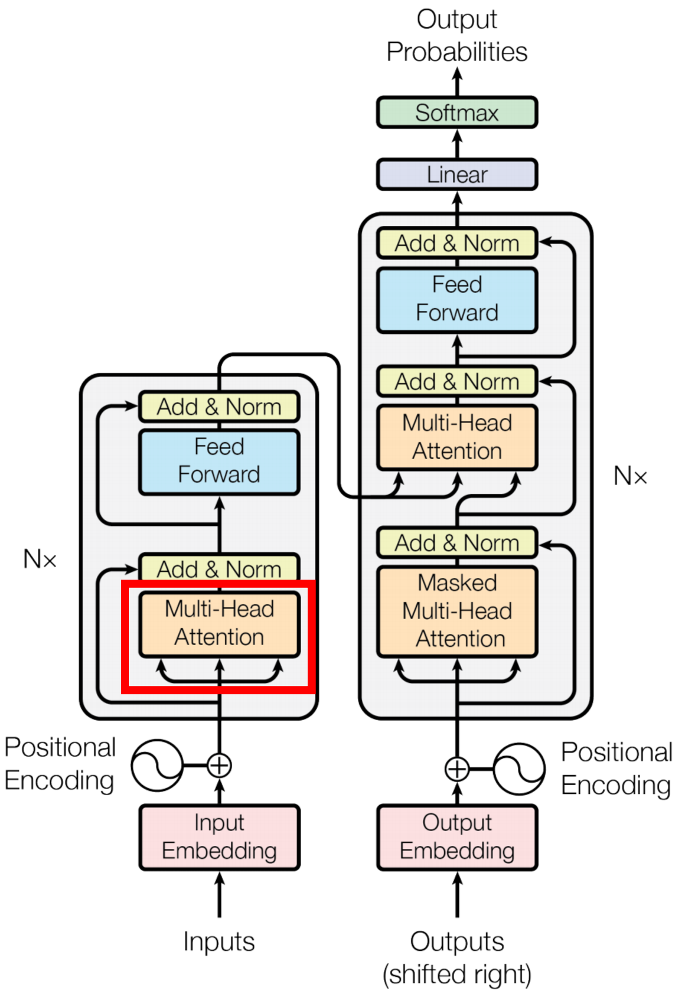

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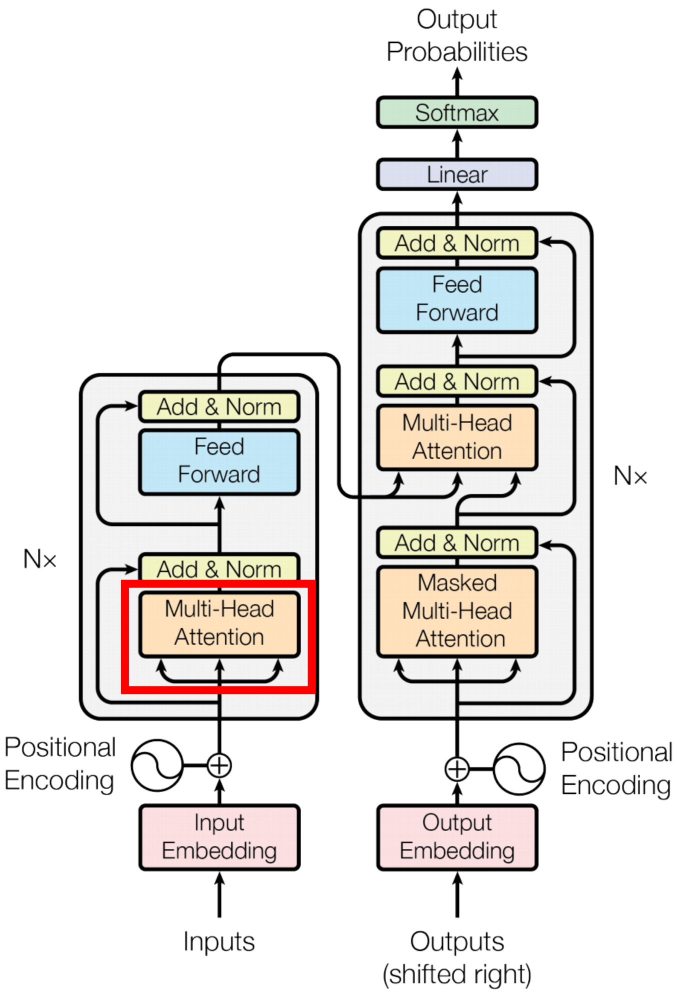
Transformer networks

3 inputs
1 output



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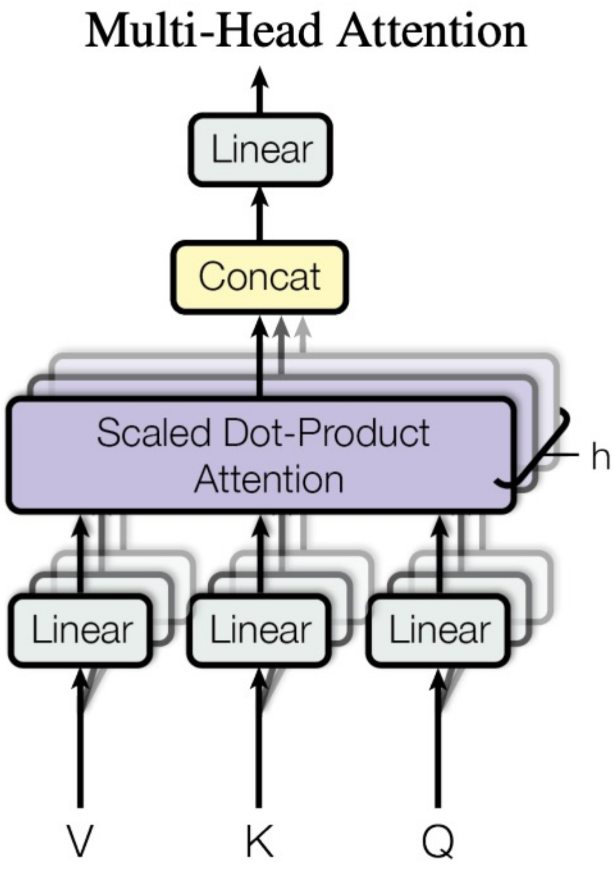

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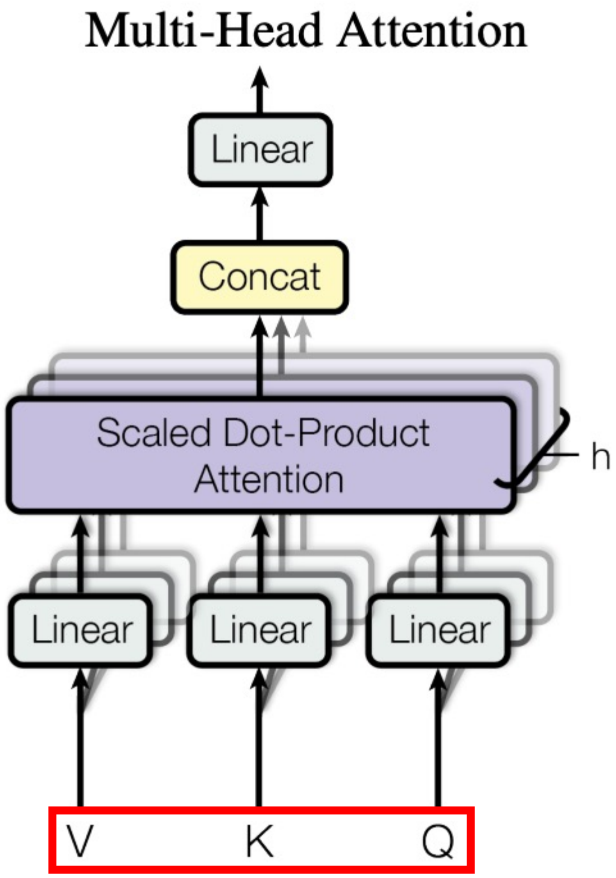

V: value
K: key
Q: query

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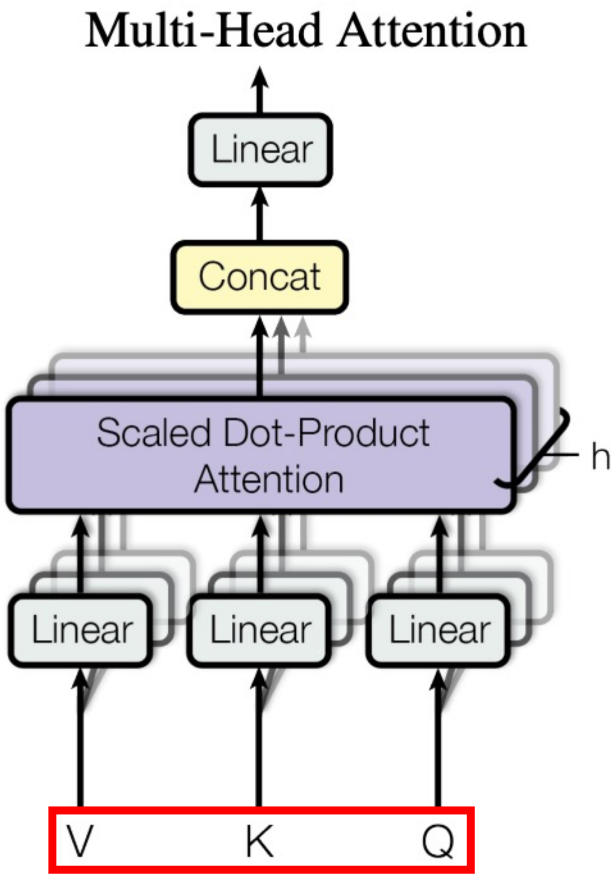

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Interpreted from information retrieval systems: https://stats.stackexchange.com/questions/421935/what-exactly-are-keys-queries-and-values-in-attention-mechanisms

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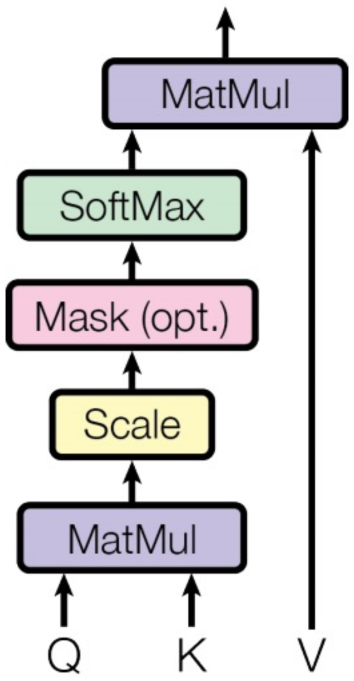
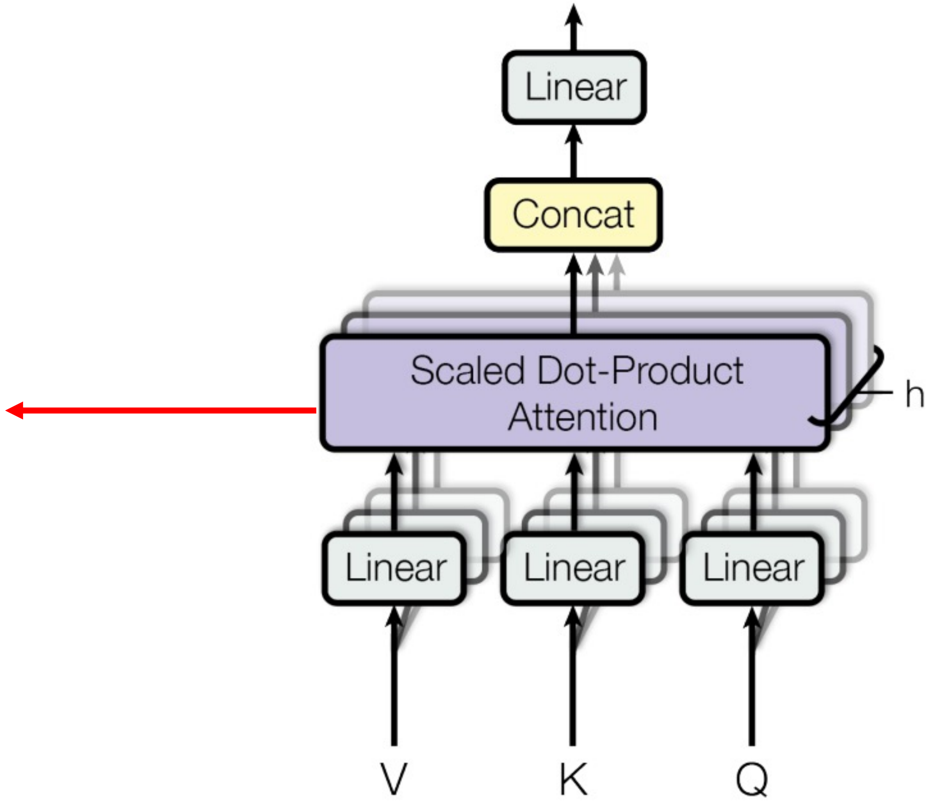
Transformer networks

Scaled Dot-Product Attention



Multi-Head Attention



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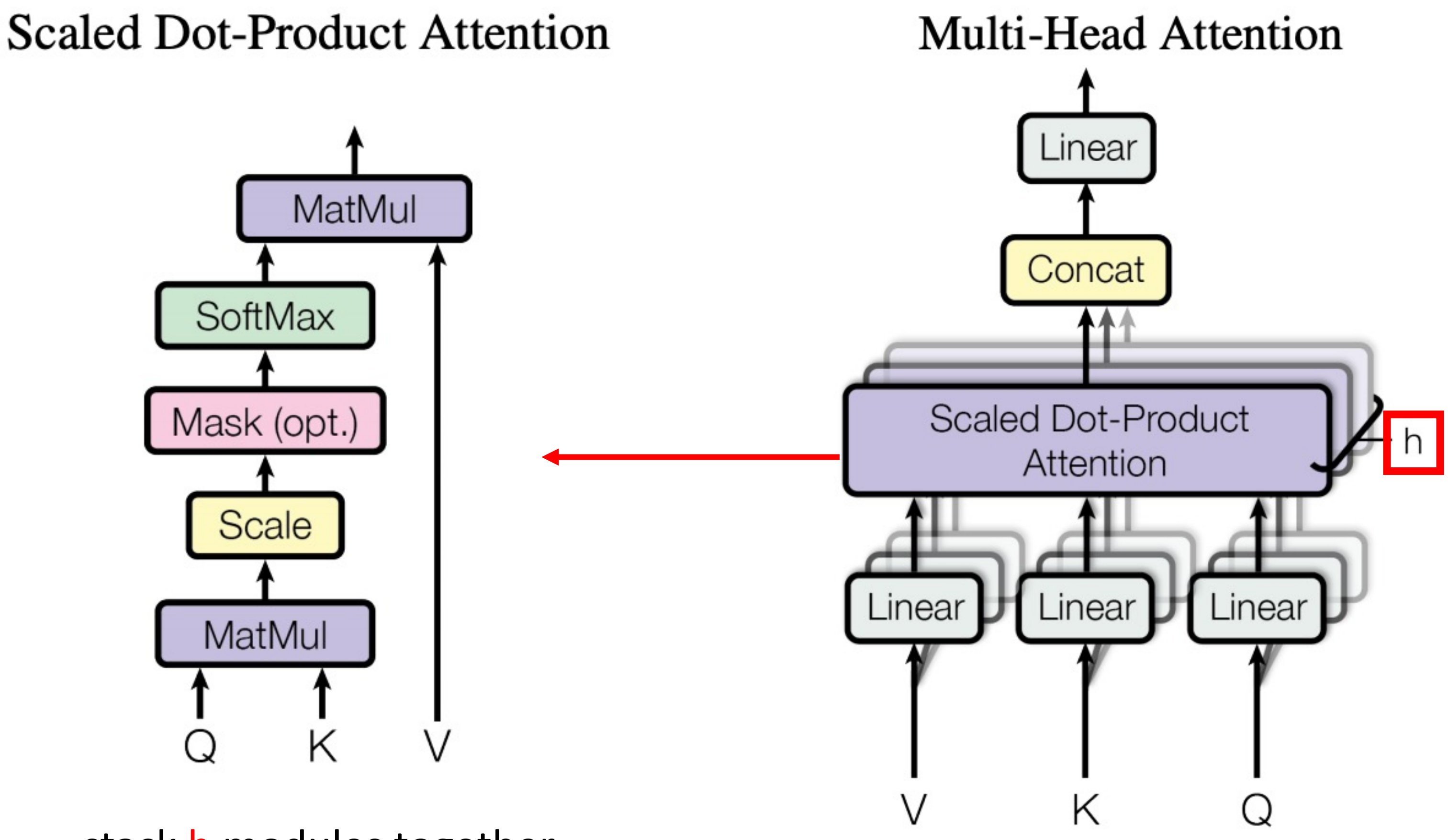

stack h modules together

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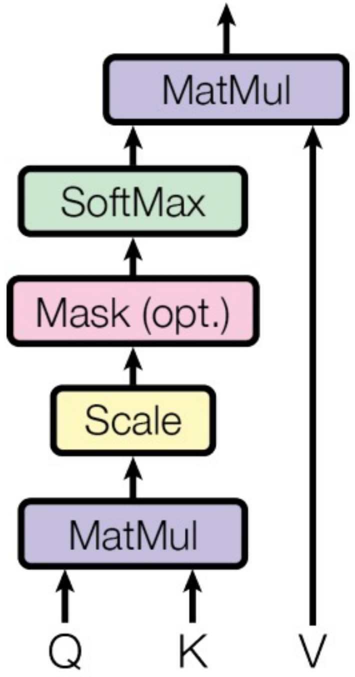

$$\text{Attention}(Q, K, V) = \text{softmax}(\frac{QK^T}{\sqrt{d_k}})V$$

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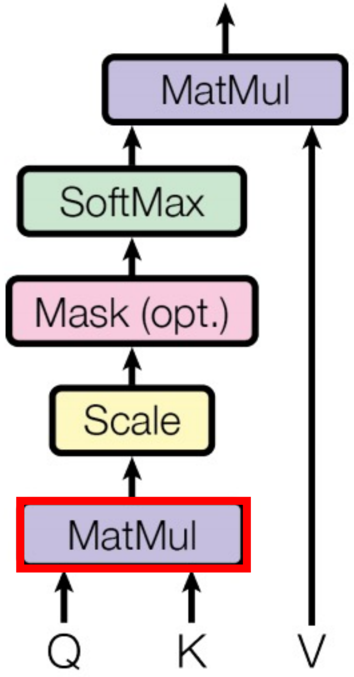

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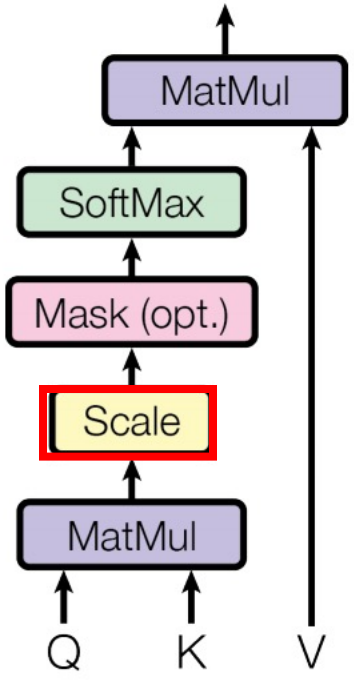

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Dimension of keys

Vaswani, Ashish, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N. Gomez, Lukasz Kaiser, and Illia Polosukhin. "Attention is all you need." *arXiv preprint arXiv:1706.03762* (2017).

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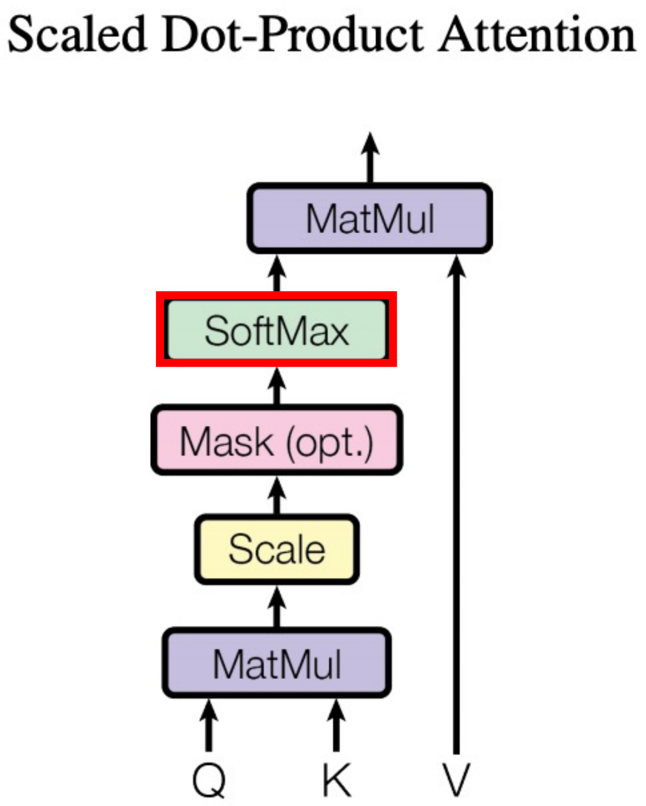

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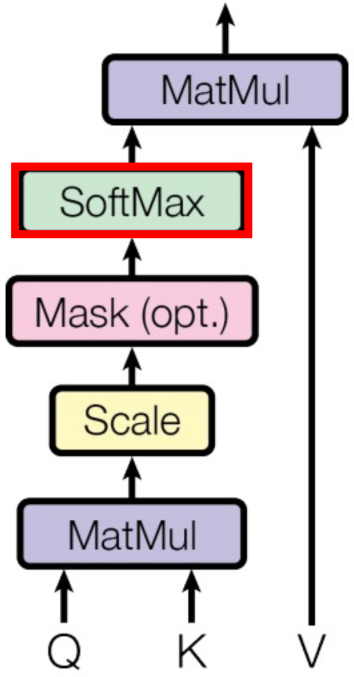

weights for selection (keys in a retrieval system)

$$\mathrm{Attention}(Q,K,V) = \boxed{\mathrm{softmax}(\frac{QK^T}{\sqrt{d_k}})}V$$

An example: one-hot format

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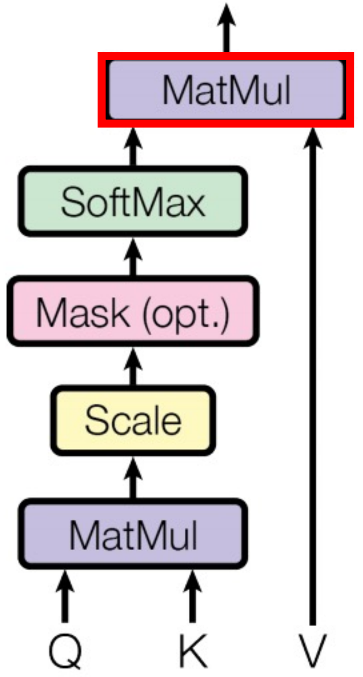
Transformer networks

Scaled Dot-Product Attention



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Transformer networks

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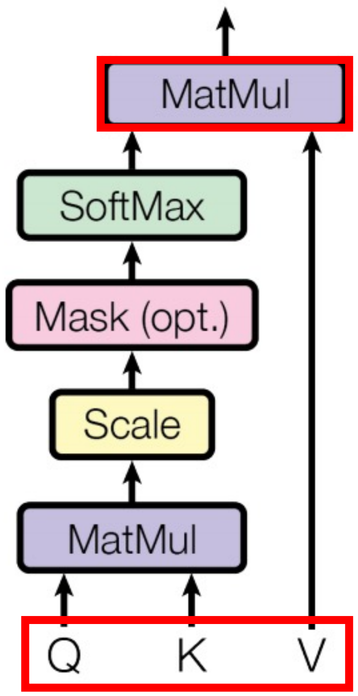

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How to generate

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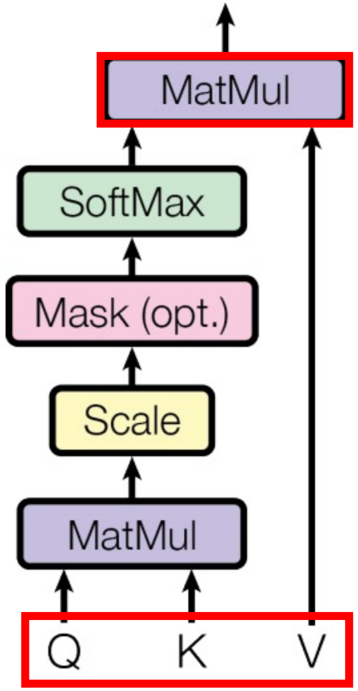

In addition to attention sub-layers, each of the layers in our encoder and decoder contains a fully connected feed-forward network, which is applied to each position separately and identically. This consists of two linear transformations with a ReLU activation in between.

$$\mathrm{FFN}(x) = \max(0, xW_1 + b_1)W_2 + b_2 \tag{2}$$

While the linear transformations are the same across different positions, they use different parameters from layer to layer. Another way of describing this is as two convolutions with kernel size 1. The dimensionality of input and output is $d_{\text{model}} = 512$, and the inner-layer has dimensionality $d_{ff} = 2048$.

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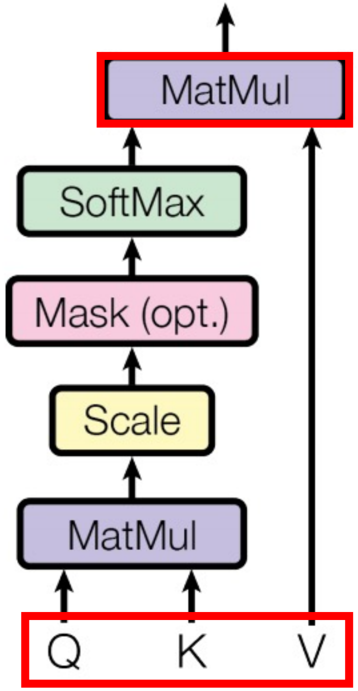

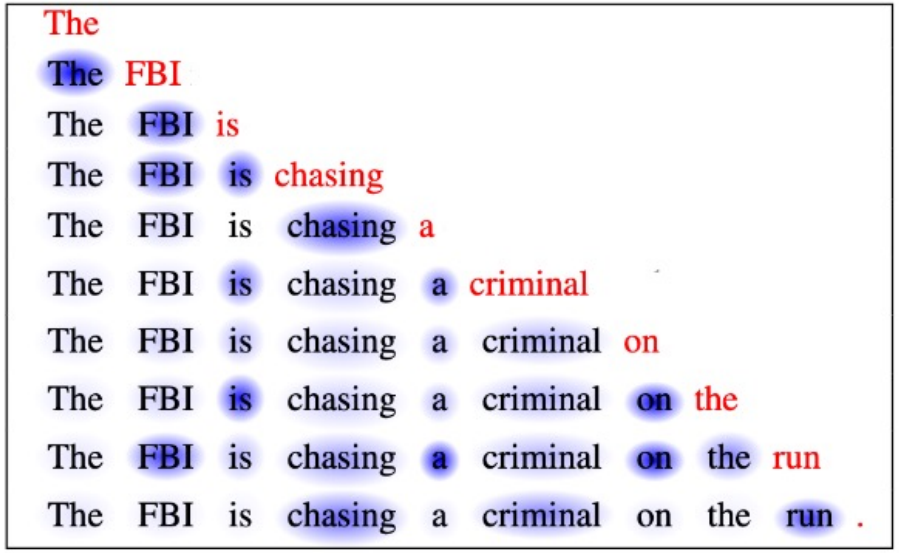

Figure is from the paper " Long Short-Term Memory-Networks for Machine Reading."

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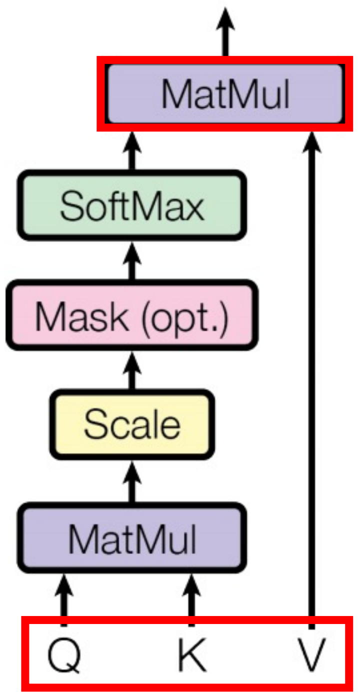
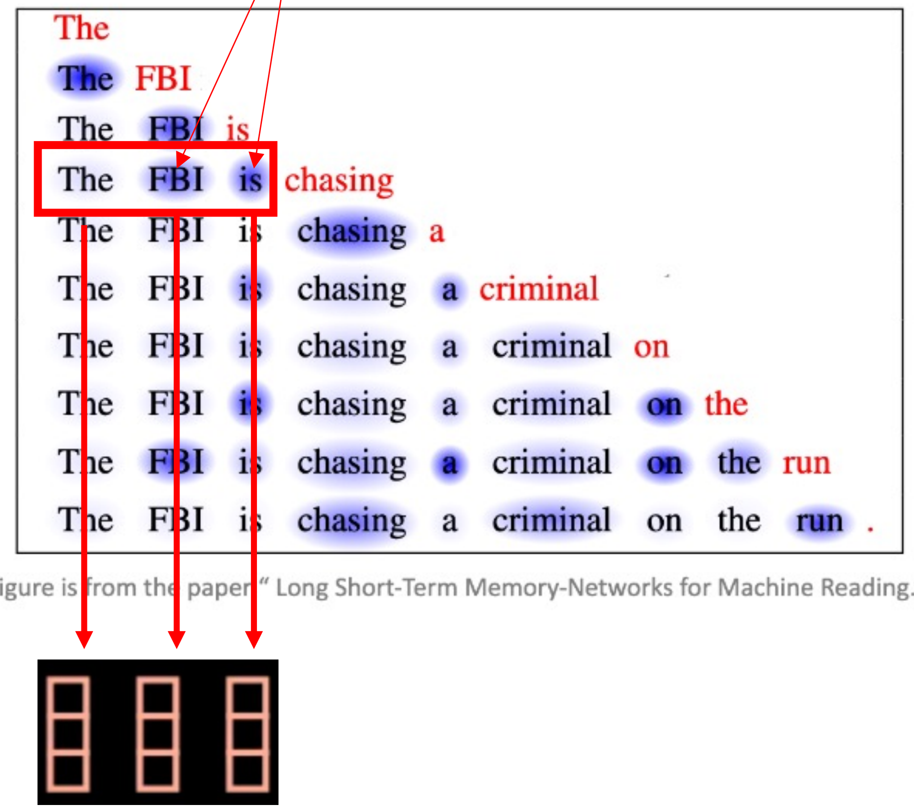


Greater weights (larger Softmax output)



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Embedding feature vectors (a matrix)

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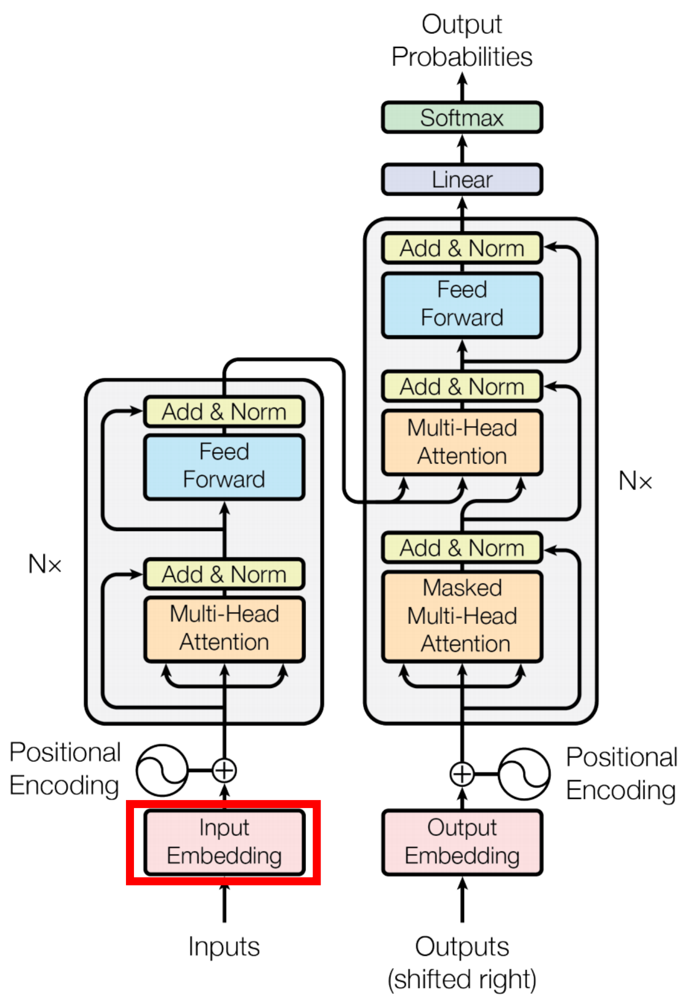
Transformer networks



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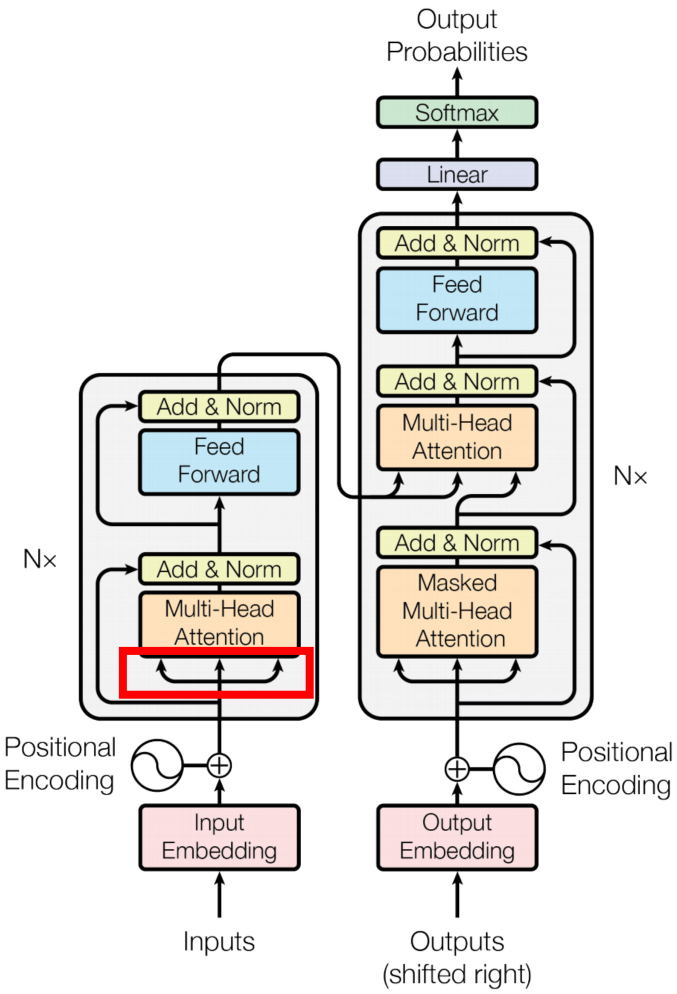

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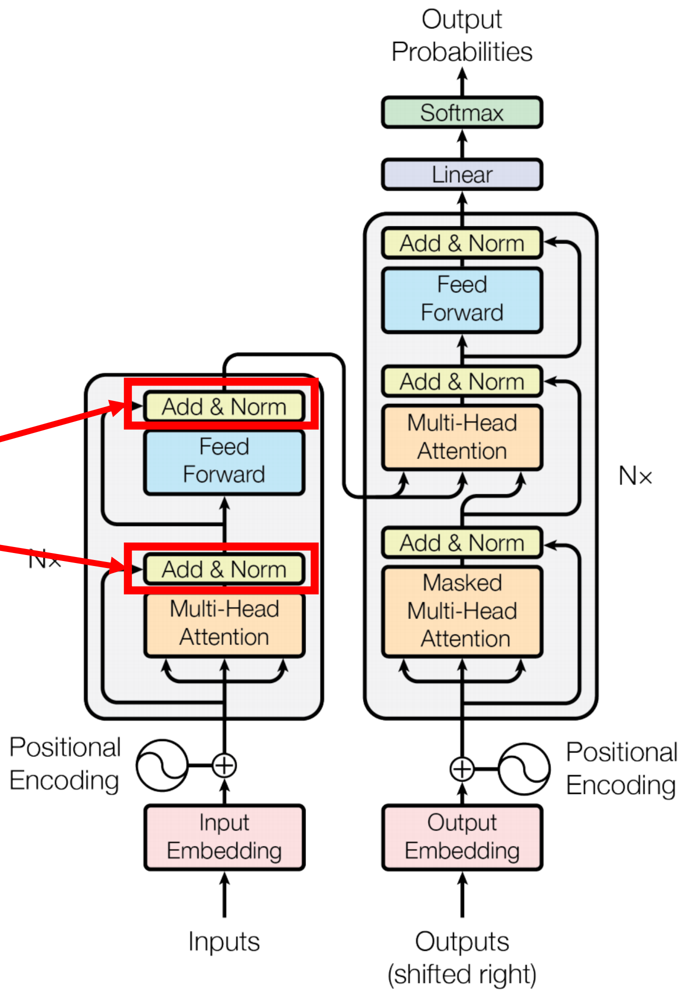
Transformer networks

Shortcut connection



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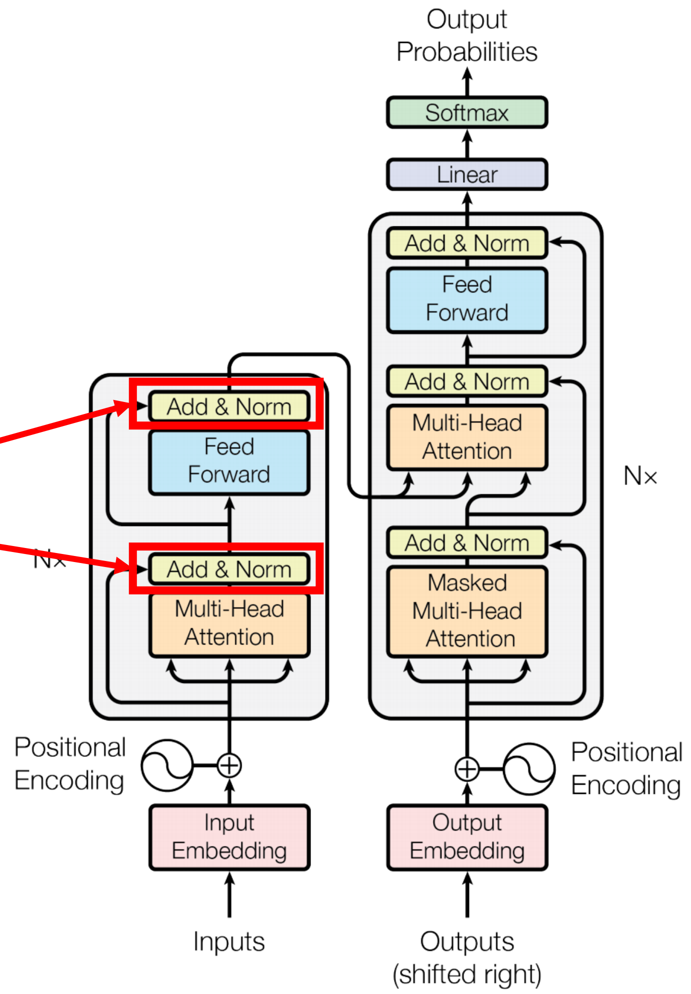
Transformer networks

Shortcut connection
(residual connection)



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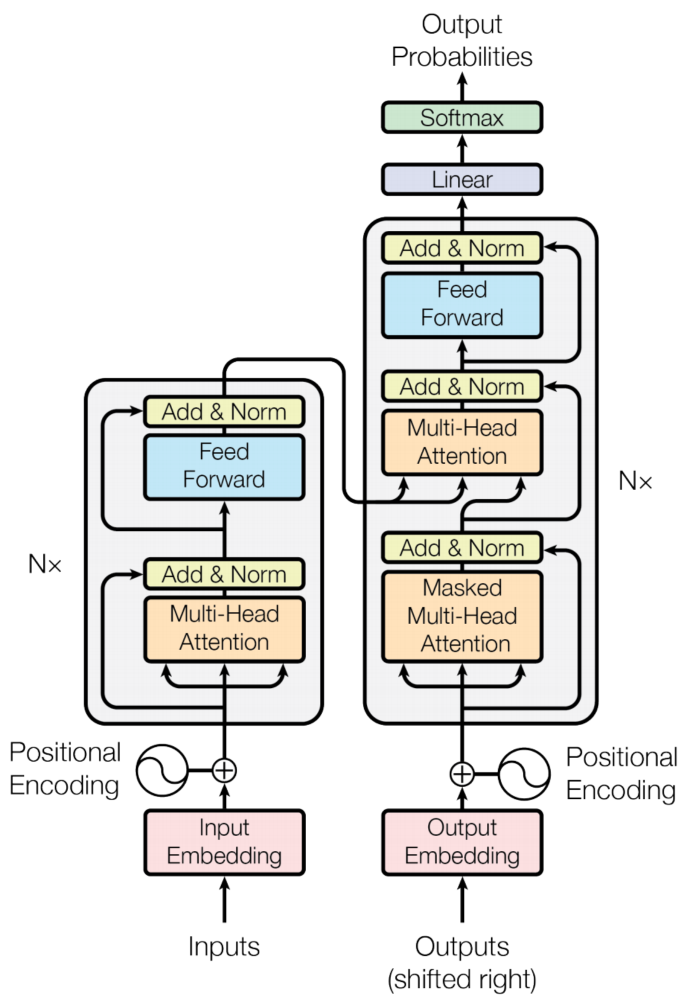
Transformer networks

No recurrent structure → not RNN



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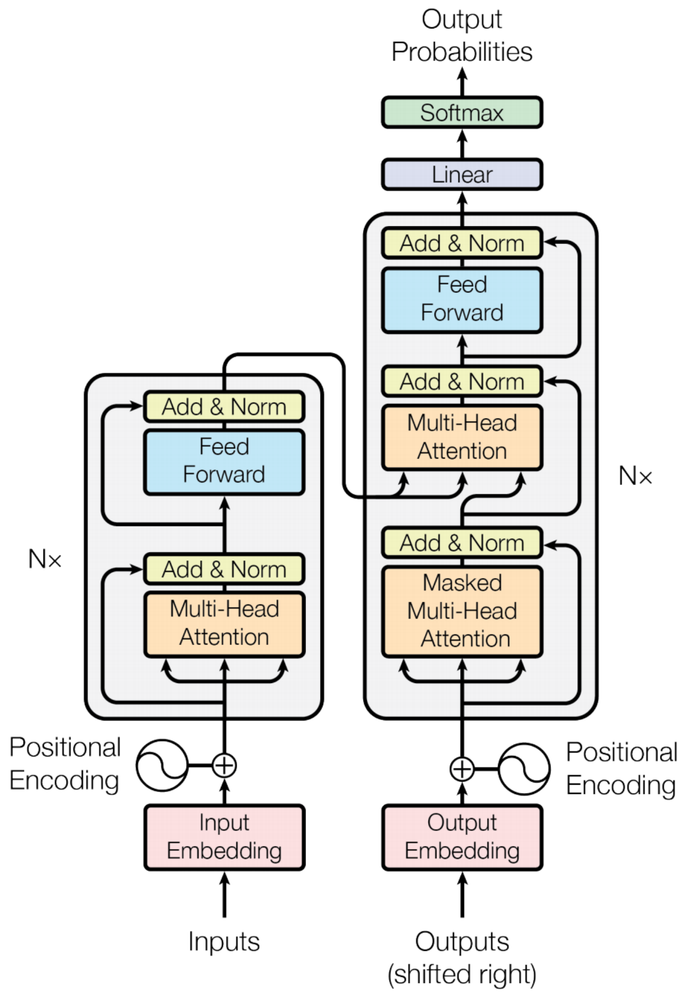
Q: any benefit?



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Transformer networks

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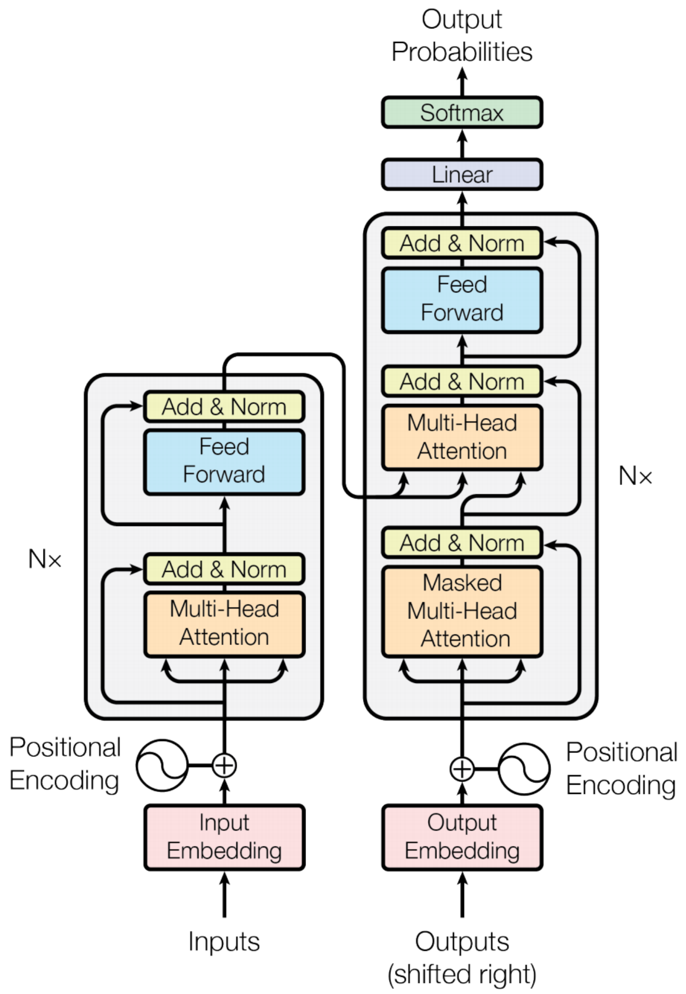
Q: any benefit?

1. No sequential dependence



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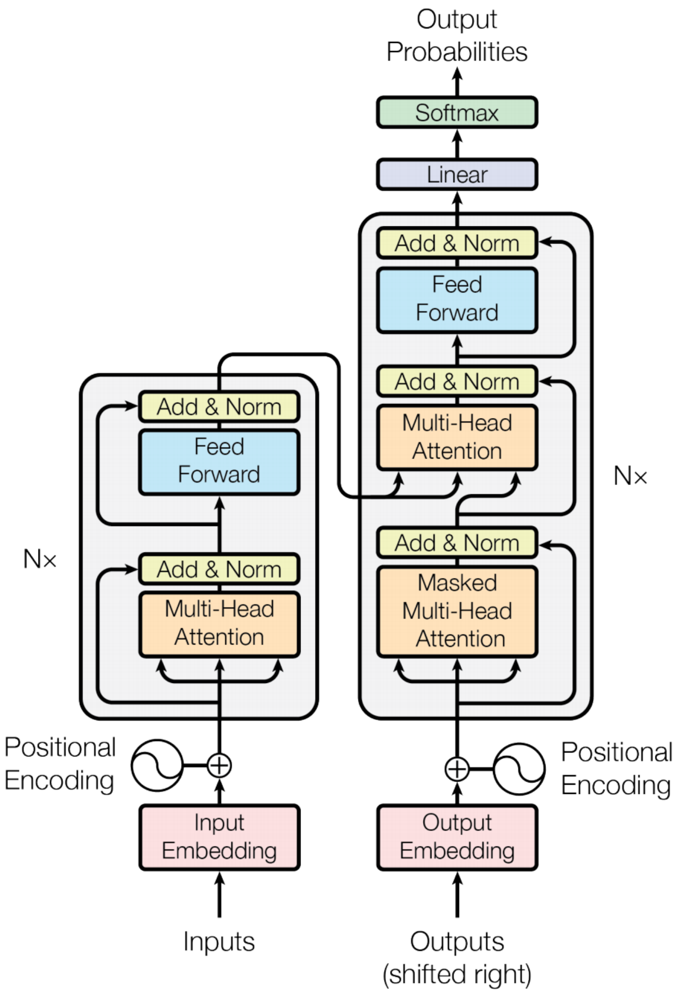
Transformer networks

No recurrent structure → not RNN

Q: any benefit?

1. No sequential dependence
2. Parallel processing



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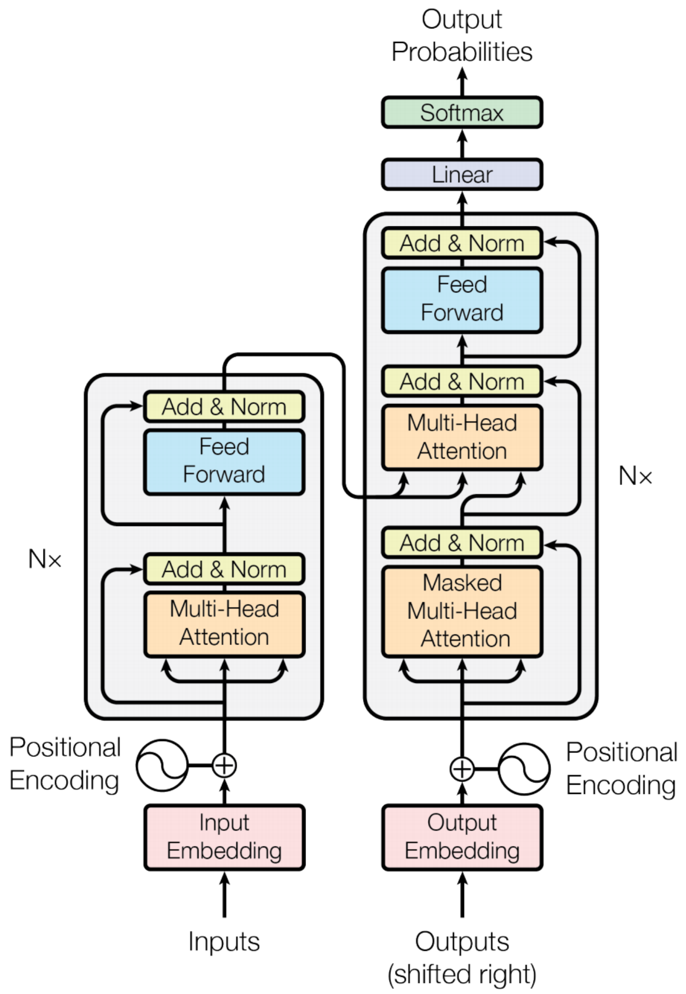
Transformer networks

No recurrent structure → not RNN

Q: any benefit?

1. No sequential dependence
2. Parallel processing
3. …



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