Computation of Self-Attention

Intuition behind Self Attention

"The kids were scared of the lions, so they left right away."

Intuition behind Self Attention

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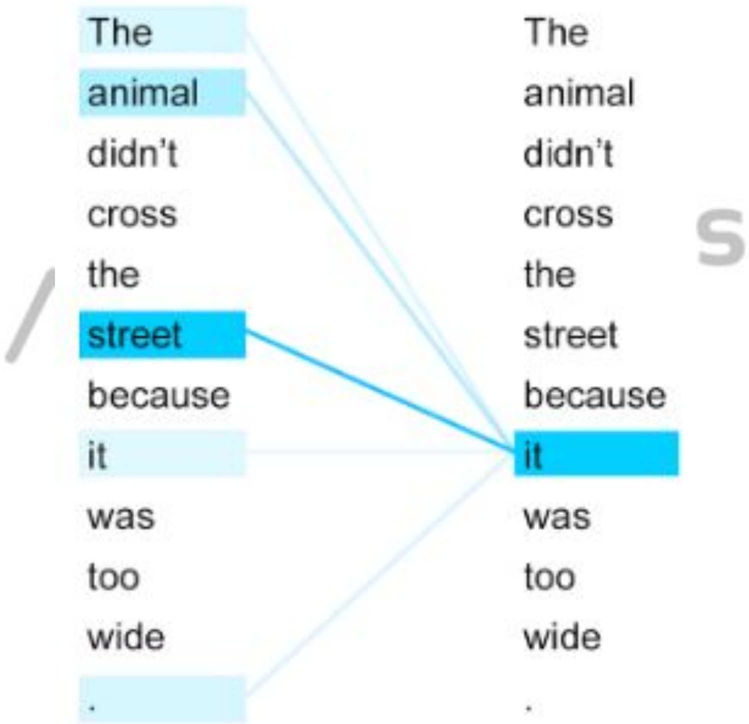
Intuition behind Self Attention

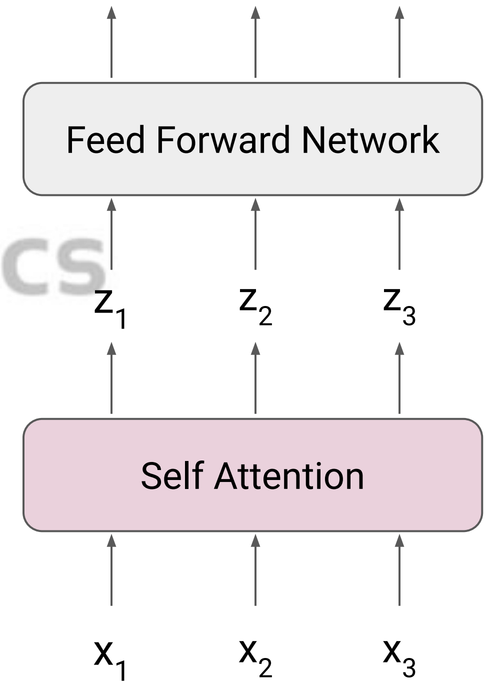
"The kids were scared of the lions, so they left right away."

Self-Attention



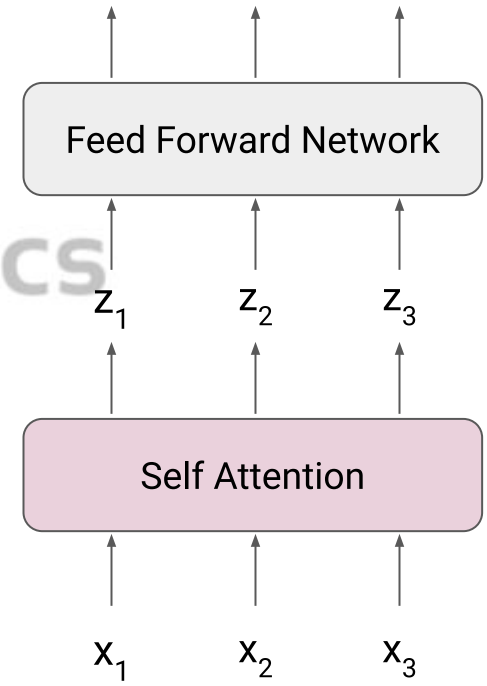
Self-Attention

- Each encoder or decoder has a self attention layer and a feed forward network



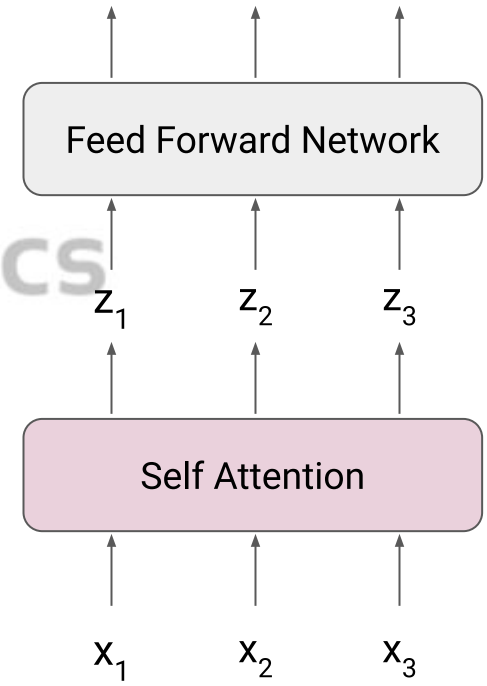
Self-Attention

- Each encoder or decoder has a self attention layer and a feed forward network
- Self attention layer encodes a token by incorporating information from other tokens



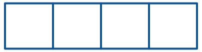
Self-Attention

- Each encoder or decoder has a self attention layer and a feed forward network
- Self attention layer encodes a token by incorporating information from other tokens
- x_i are the input embeddings and z_i are the outputs of self attention layer



Self-Attention

Embeddings

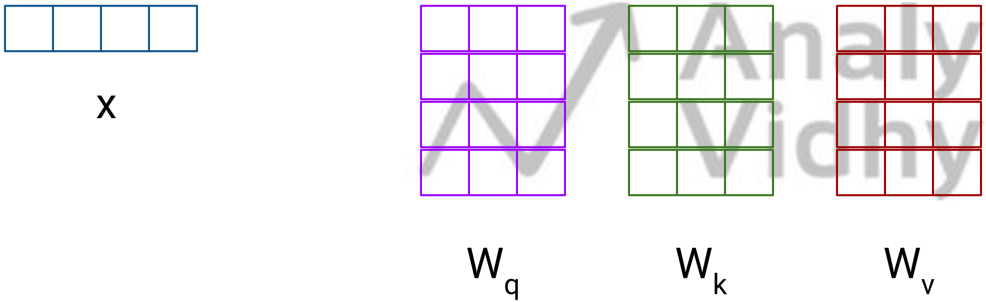


x

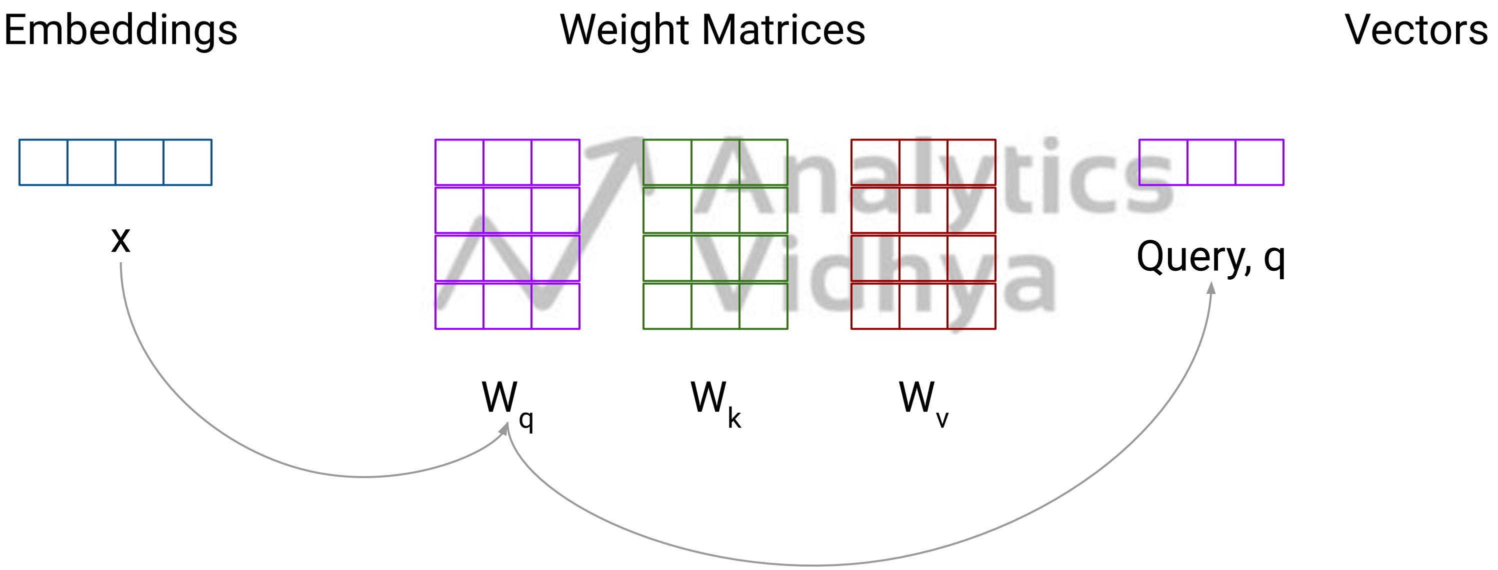
Self-Attention

Embeddings

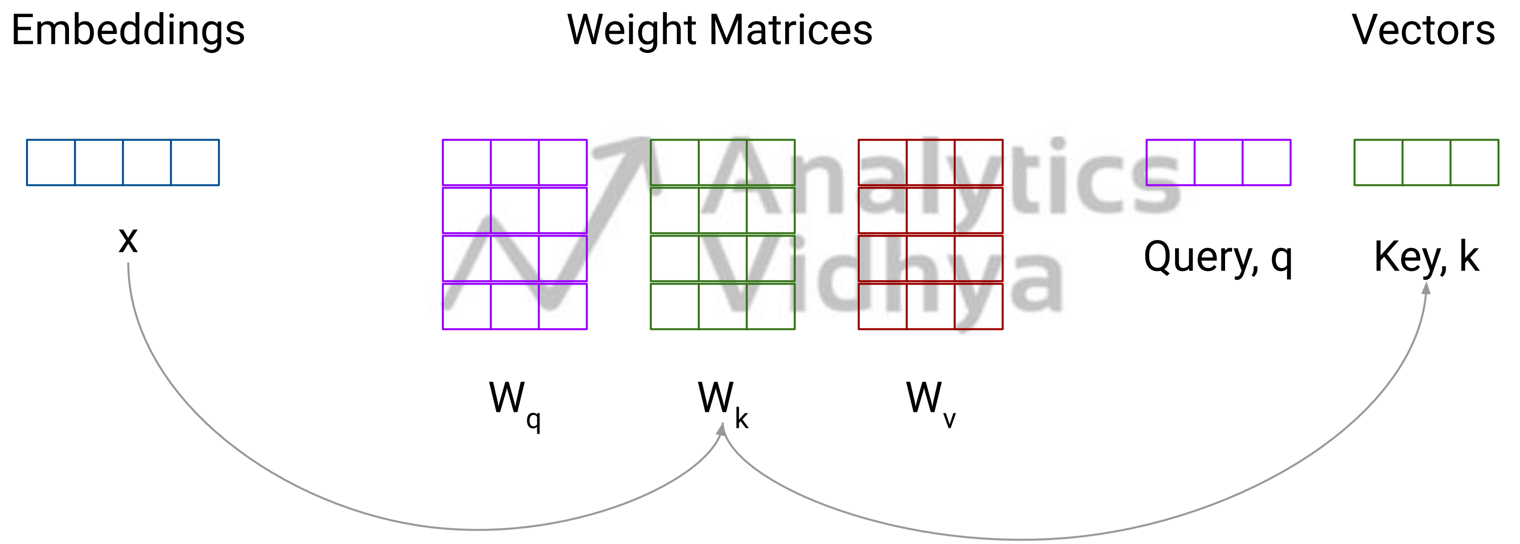
Weight Matrices



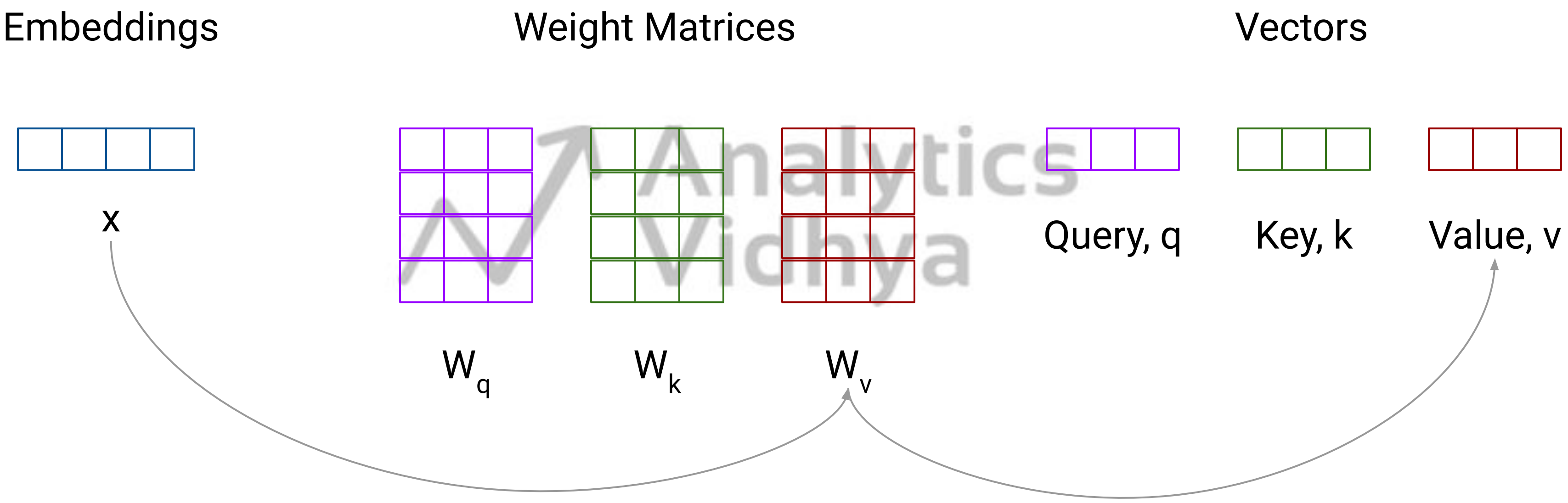
Self Attention Layer



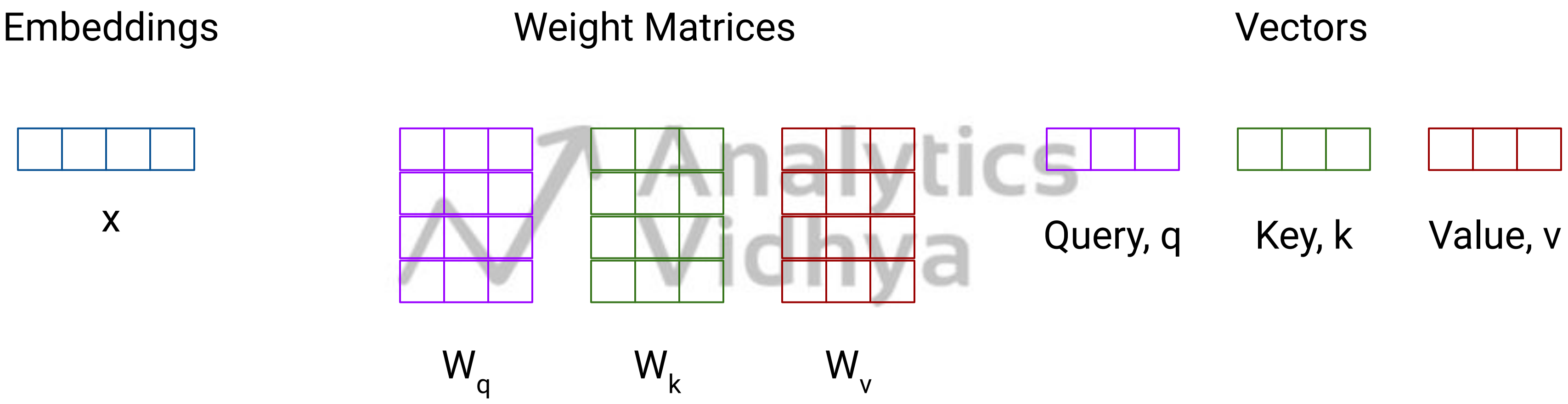
Self Attention Layer



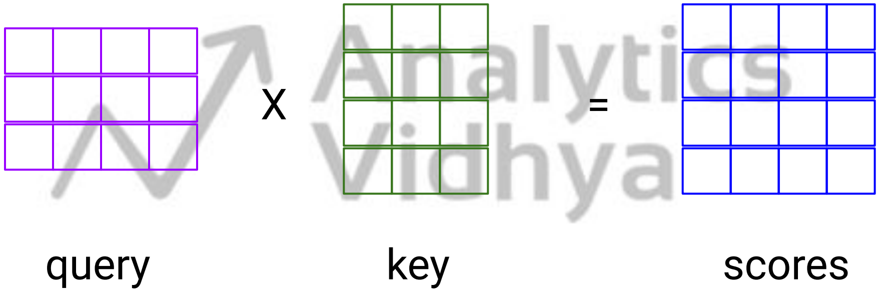
Self Attention Layer



Self Attention Layer



Concepts of Query, Key, and Value



Concepts of Query, Key, and Value

	have	a	nice	day
have	96	23	27	11
a	23	98	35	28
nice	27	35	91	56
day	11	28	56	93

scores

Self Attention Layer: Computations

Word	q vector	k vector	v vector	score
Action	q_1	k_1	v_1	$q_1 . k_1$
gets		k_2	v_2	$q_1 . k_2$
results		k_3	v_3	$q_1 . k_3$

Self Attention Layer: Computations

Word	q vector	k vector	v vector	score
Action		k_1	v_1	$q_2 \cdot k_1$
gets	q_2	k_2	v_2	$q_2 \cdot k_2$
results		k_3	v_3	$q_2 \cdot k_3$

Self Attention Layer: Computations

Word	q vector	k vector	v vector	score
Action		k_1	v_1	$q_3 . k_1$
gets		k_2	v_2	$q_3 . k_2$
results	q_3	k_3	v_3	$q_3 . k_3$

Self Attention Layer: Computations

Word	q vector	k vector	v vector	score	score / 8
Action	q_1	k_1	v_1	$q_1 . k_1$	$q_1 . k_1 / 8$
gets		k_2	v_2	$q_1 . k_2$	$q_1 . k_2 / 8$
results		k_3	v_3	$q_1 . k_3$	$q_1 . k_3 / 8$

Self Attention Layer: Computations

Word	q vector	k vector	v vector	score	score / 8	Softmax
Action	q_1	k_1	v_1	$q_1 . k_1$	$q_1 . k_1 / 8$	x_{11}
gets		k_2	v_2	$q_1 . k_2$	$q_1 . k_2 / 8$	x_{12}
results		k_3	v_3	$q_1 . k_3$	$q_1 . k_3 / 8$	x_{13}

Self Attention Layer: Computations

Word	q vector	k vector	v vector	score	score / 8	Softmax	Softmax * v	Sum
Action	q_1	k_1	v_1	$q_1 . k_1$	$q_1 . k_1 / 8$	x_{11}	$x_{11} * v_1$	z_1
gets		k_2	v_2	$q_1 . k_2$	$q_1 . k_2 / 8$	x_{12}	$x_{12} * v_2$	
results		k_3	v_3	$q_1 . k_3$	$q_1 . k_3 / 8$	x_{13}	$x_{13} * v_3$	

Self Attention Layer: Computations

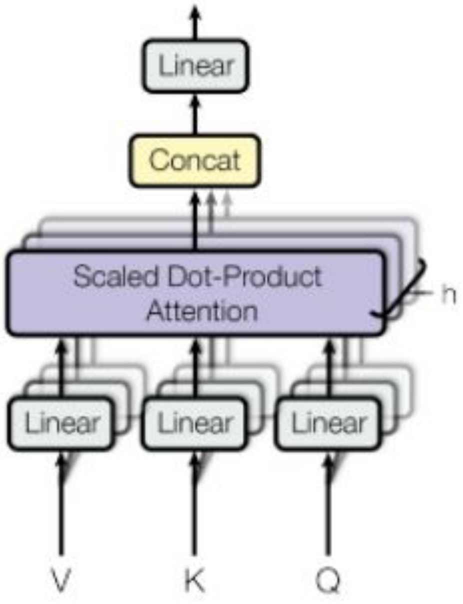
Word	q vector	k vector	v vector	score	score / 8	Softmax	Softmax * v	Sum#
Action		k_1	v_1	$q_2 . k_1$	$q_2 . k_1 / 8$	x_{21}	$x_{21} * v_1$	
gets	q_2	k_2	v_2	$q_2 . k_2$	$q_2 . k_2 / 8$	x_{22}	$x_{22} * v_2$	z_2
results		k_3	v_3	$q_2 . k_3$	$q_2 . k_3 / 8$	x_{23}	$x_{23} * v_3$	

Self Attention Layer: Computations

Word	q vector	k vector	v vector	score	score / 8	Softmax	Softmax * v	Sum#
Action		k_1	v_1	$q_3 . k_1$	$q_3 . k_1 / 8$	x_{31}	$x_{31} * v_1$	
gets		k_2	v_2	$q_3 . k_2$	$q_3 . k_2 / 8$	x_{32}	$x_{32} * v_2$	
results	q_3	k_3	v_3	$q_3 . k_3$	$q_3 . k_3 / 8$	x_{33}	$x_{33} * v_3$	z_3

Multi-headed Self-Attention

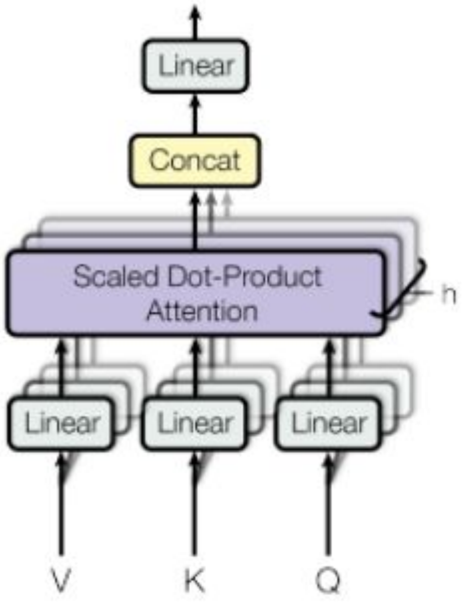
- Multiple sets of W_q , W_k , W_v and query, key and value vectors..



Multi-Head Attention

Multi-headed Self-Attention

- Multiple sets of W_q , W_k , W_v and query, key and value vectors.
- Transformer uses 8 self-attention heads.



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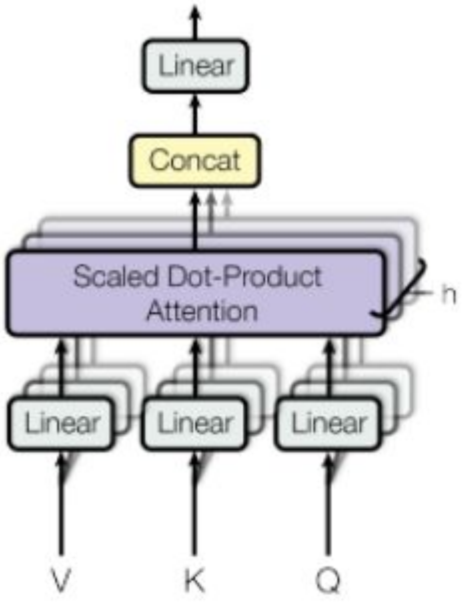

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Multi-headed Self-Attention

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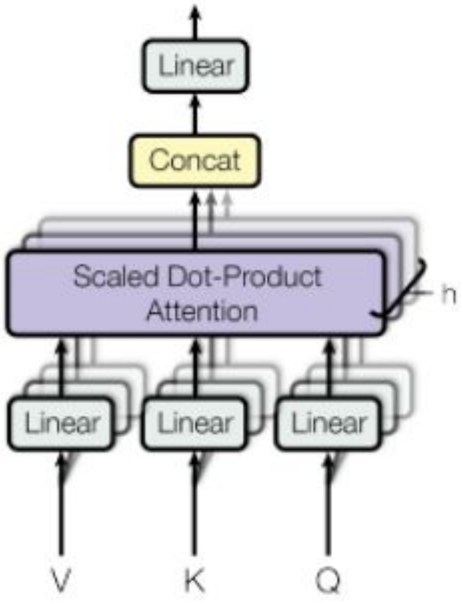
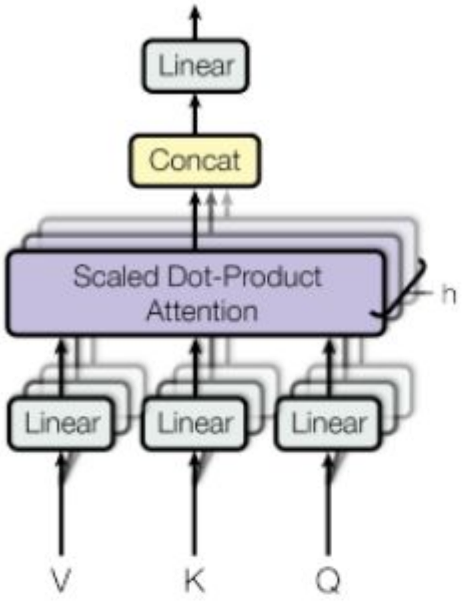
- Transformer uses 8 self-attention heads.
- Each head represents the input embeddings into a different representation space.
- $(q_0, k_0, v_0), (q_1, k_1, v_1), (q_2, k_2, v_2), \ldots, (q_7, k_7, v_7)$



Multi-Head Attention

Multi-headed Self-Attention

- Each head produces a Z-score matrix (Z_0, Z_1, Z_2,..., Z_7)
- These Z matrices are concatenated and multiplied with another weight matrix W to arrive at the final Z_f matrix.



Multi-Head Attention

Thank You