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Siamese Networks

Question Duplicates

How old are you? = What is your age?

Where are you from? \neq Where are you going?

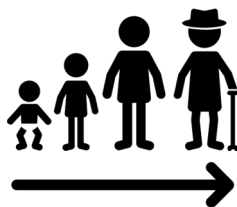
What do Siamese Networks learn?

I am happy because I am
learning



Classification: categorize things

Siamese Networks: Identify similarity between things

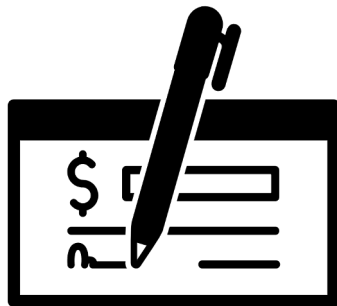


What is your age?
How old are you?



Difference or
Similarity

Siamese Networks in NLP



Handwritten checks



What is your age?
How old are you?

Question duplicates



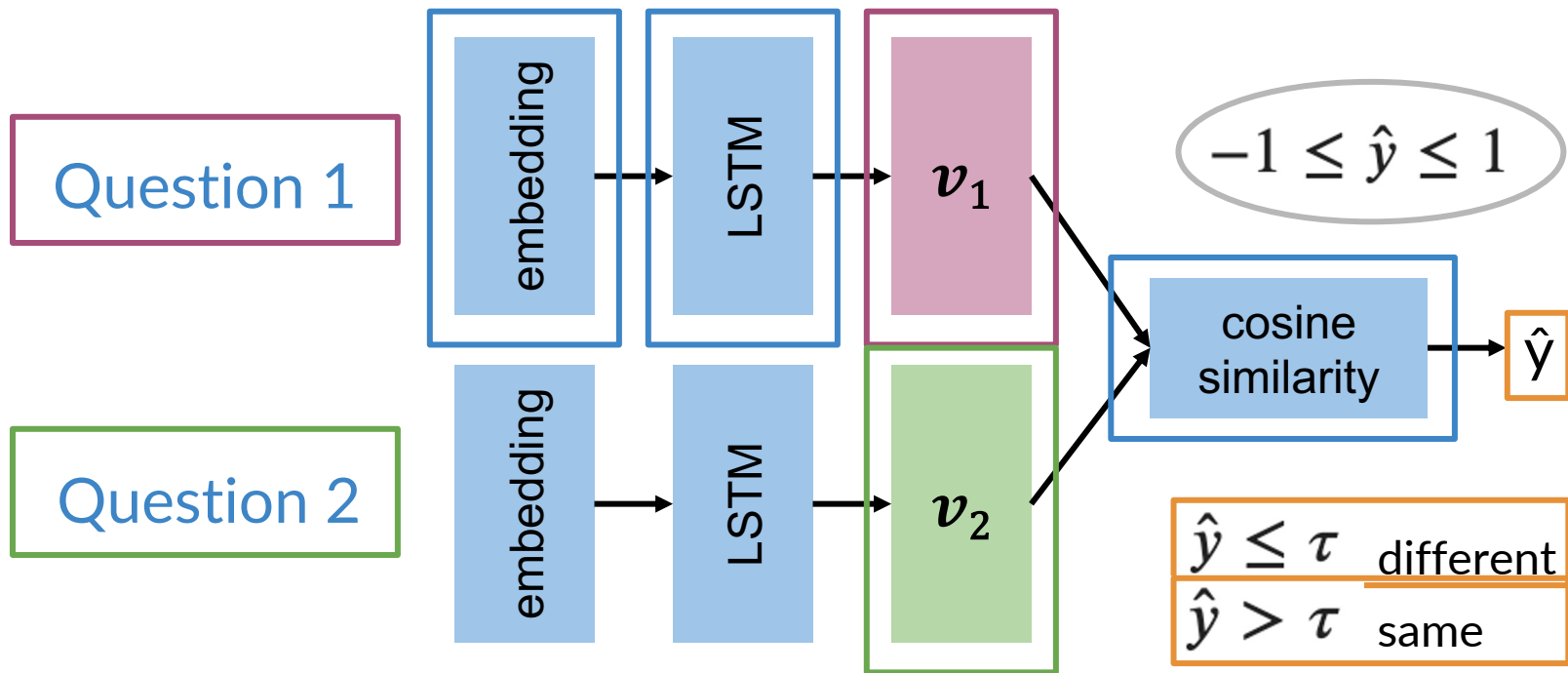
Queries



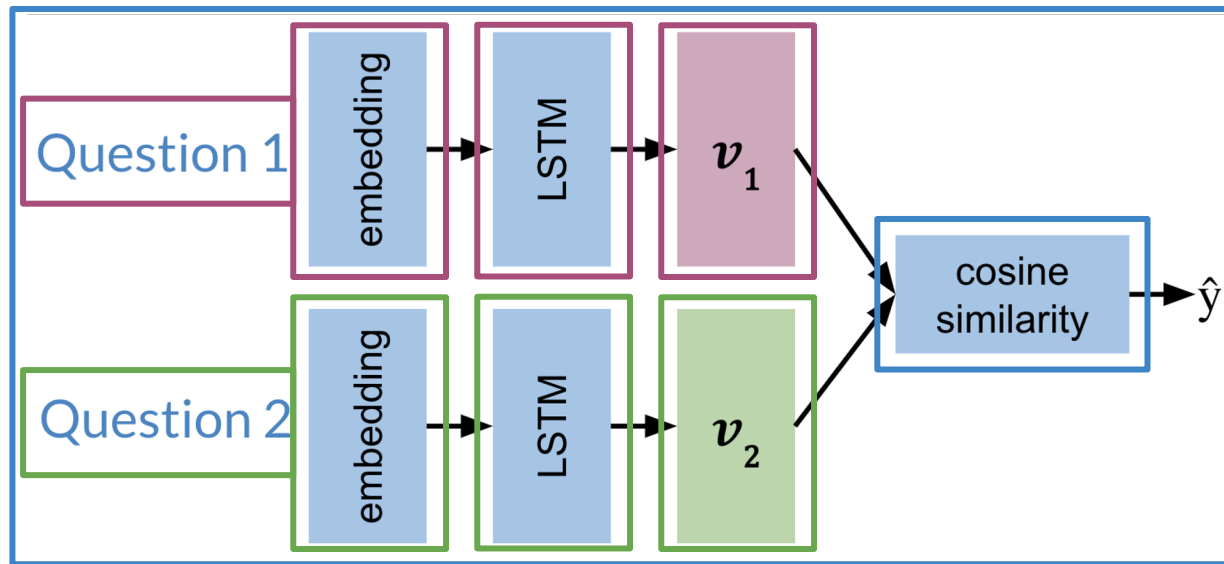
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Architecture

Model Architecture



Model Architecture



1) Inputs

2)

3) Embedding
LSTM

4) Vectors

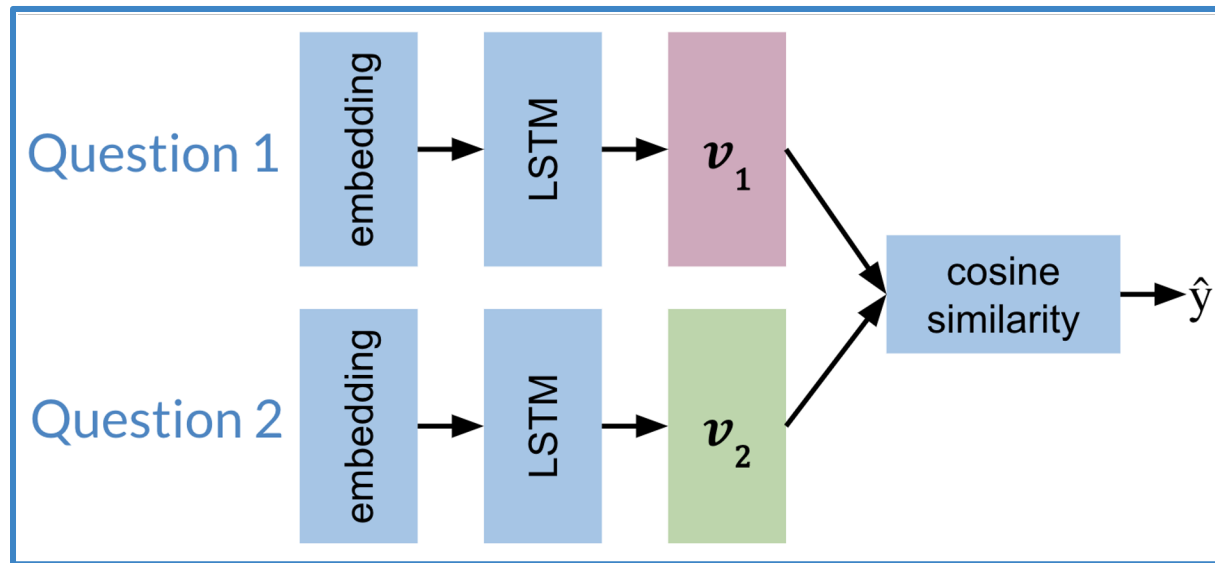
5) Cosine
Similarity



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Loss Function

Loss Function



$$\hat{y} = s(v_1, v_2)$$

Loss Function

How old are you?

Anchor

$$\cos(v_1, v_2) = \frac{v_1 \cdot v_2}{||v_1|| ||v_2||}$$
$$s(v_1, v_2)$$

What is your age?

Positive

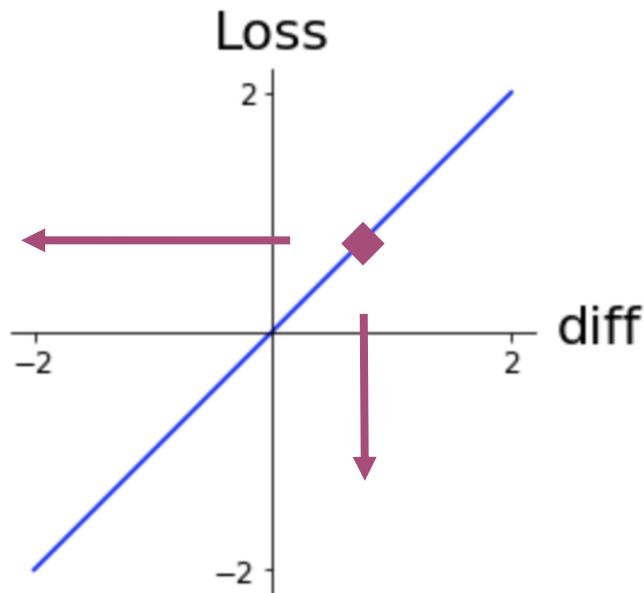
$s(A, P)$

Where are you from? Negative

$s(A, N) \approx -1$

$s(A, N) - s(A, P)$

Loss Function



$$\text{diff} = s(A, N) - s(A, P)$$



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Triplets

Triplets

How old are you?

What is your age?

Where are you from?

Anchor

Positive

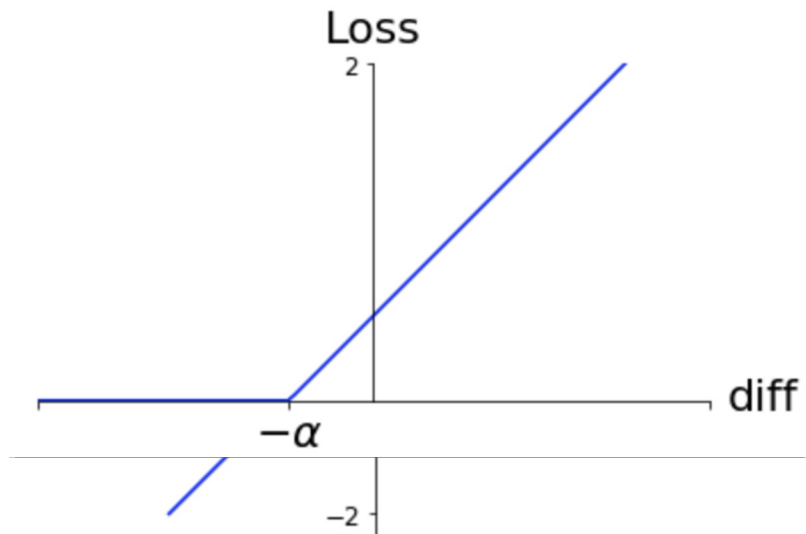
Negative

Triplets



Whether or not a question has the same meaning as the anchor

Triplet Loss



Simple loss:

$$\text{diff} = s(A, N) - s(A, P)$$

Anchor With non-linearity

$$\mathcal{L} = \begin{cases} 0; & \text{if } \text{diff} \leq 0 \\ \text{diff}; & \text{if } \text{diff} > 0 \end{cases}$$

Negative

With alpha margin

$$\mathcal{L} = \begin{cases} 0; & \text{if } \text{diff} + \alpha \leq 0 \\ \text{diff} + \alpha; & \text{if } \text{diff} + \alpha > 0 \end{cases}$$

Triplet Loss

$$\mathcal{L} = \begin{cases} 0; & \text{if } diff + \alpha \leq 0 \\ diff + \alpha; & \text{if } diff + \alpha > 0 \end{cases}$$



Simplified


$$\mathcal{L}(\underline{A, P, N}) = \max(diff + \alpha, 0)$$



From the neural
network

You can use any similarity
function or distance metric

Triplet Selection

Triplet A, P,  duplicate set: A, P
non-duplicate set: A, N

N

$$\mathcal{L} = \max(\text{diff} + \alpha, 0)$$

$$\text{diff} = s(A, N) - s(A, P)$$

Random

Easy to satisfy. Little to learn

$$s(A, N) \approx s(A, P)$$

Hard

Harder to train. More to learn



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Computing The Cost I

Computing The Cost

Prepare the batches as follows:



What is your age?	How old are you?
Can you see me?	Are you
seeing me?	
Where are thou?	Where are
you?	

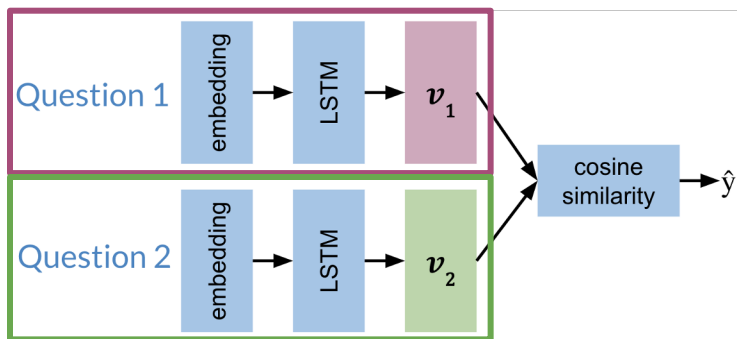


$b = 4$

When is the game?

What time is the

Computing The Cost



Batch 1

What is your age?
Can you see me?
Where are thou?
When is the game?

Batch 2

How old are you?
Are you seeing me?
Where are you?
What time is the game?

$v_1 = (1, \boxed{d_model})$

v_{1_1}				
v_{1_2}				
v_{1_3}				
v_{1_4}				

v_2

v_{2_1}				
v_{2_2}				
v_{2_3}				
v_{2_4}				

Computing The Cost

$$s(v_1, v_2)$$

v_1

_1 _2 _3 _4

_1	0.9	-0.8	0.3	-0.5
_2	-0.8	0.5	0.1	-0.2
_3	0.3	0.1	0.7	-0.8
_4	-0.5	-0.2	-0.8	1.0

v_2

Computing The Cost

$$s(v_1, v_2)$$

v_1

_1 _2 _3 _4

v_2	_1	0.9	-0.8	0.3	-0.5
	_2	-0.8	0.5	0.1	-0.2
	_3	0.3	0.1	0.7	-0.8
	_4	-0.5	-0.2	-0.8	1.0

Computing The Cost

$$s(v_1, v_2)$$

v_1

_1 _2 _3 _4

v_2	_1	0.9	-0.8	0.3	-0.5
	_2	-0.8	0.5	0.1	-0.2
	_3	0.3	0.1	0.7	-0.8
	_4	-0.5	-0.2	-0.8	1.0

Computing The Cost

		$s(v_1, v_2)$			
		v_1			
		_1	_2	_3	_4
v_2	_1	0.9	-0.8	0.3	-0.5
	_2	-0.8	0.5	0.1	-0.2
	_3	0.3	0.1	0.7	-0.8
	_4	-0.5	-0.2	-0.8	1.0

$$\mathcal{L}(A, P, N) = \max(\text{diff} + \alpha, 0)$$

$$\text{diff} = s(A, N) - s(A, P)$$

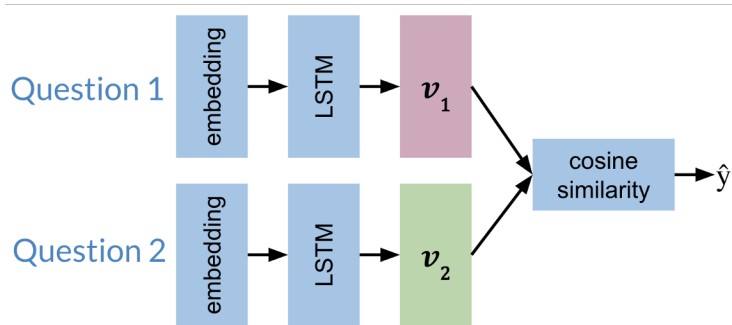
$$\mathcal{J} = \sum_{i=1}^m \mathcal{L}(A^{(i)}, P^{(i)}, N^{(i)})$$



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Computing The Cost II

Computing The Cost



Batch 1

What is your age?
Can you see me?
Where are thou?
When is the game?

Batch 2

How old are you?
Are you seeing me?
Where are you?
What time is the game?

$v_1 = (1, d_{\text{model}})$

v_{1_1}				
v_{1_2}				
v_{1_3}				
v_{1_4}				

v_2

v_{2_1}				
v_{2_2}				
v_{2_3}				
v_{2_4}				

Hard Negative Mining

		$s(v_1, v_2)$			
		v_1			
		_1	_2	_3	_4
v_2	_1	0.9	-0.8	0.3	-0.5
	_2	-0.8	0.5	0.1	-0.2
	_3	0.3	0.1	0.7	-0.8
	_4	-0.5	-0.2	-0.8	1.0

mean negative:

mean of off-diagonal values in each

row

closest negative:

off-diagonal value closest to (but less than) the value on diagonal in each row

Hard Negative Mining

mean negative: mean of off-diagonal values

closest negative: closest off-diagonal value

$$\mathcal{L}_{\text{Original}} = \max \left(\underbrace{s(A, N) - s(A, P)}_{\text{diff}} + \alpha, 0 \right)$$

Hard Negative Mining

$$\mathcal{L}_{\text{Full}}(A, P, N) = \mathcal{L}_1 + \mathcal{L}_2$$

$$\mathcal{J} = \sum_{i=1}^m \mathcal{L}_{\text{Full}}(A^{(i)}, P^{(i)}, N^{(i)})$$

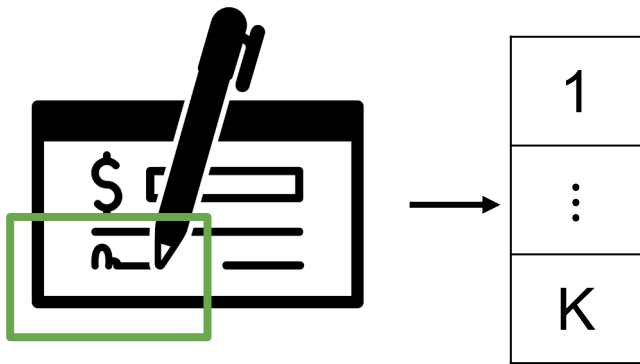


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One Shot Learning

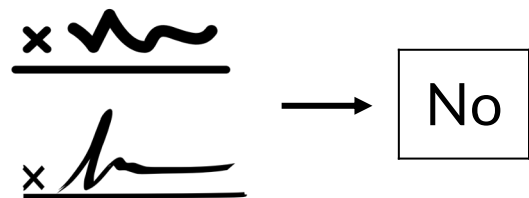
Classification vs One Shot Learning

Classification



Classify as 1 of K classes

One Shot Learning



Measure similarity between 2 classes

One Shot Learning

No need for retraining !



Learn a similarity score!

$$s(sig1, sig2) > \tau$$





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Training / Testing

Dataset

Question 1	Question 2	is_duplicate
What is your age?	How old are you?	true
Where are you from?	Where are you going?	false
:	:	:

Prepare Batches

Question 1:
batch size b

Batch 1

What is your age?
Can you see me?
Where are thou?
When is the game?

$v_1 = (1, d_{\text{model}})$

$v_{1,1}^1$ $q_{1,a}^1$				
$v_{1,2}^1$ $q_{1,b}^1$				
$v_{1,3}$				
$v_{1,4}$				

Question 2:
batch size b

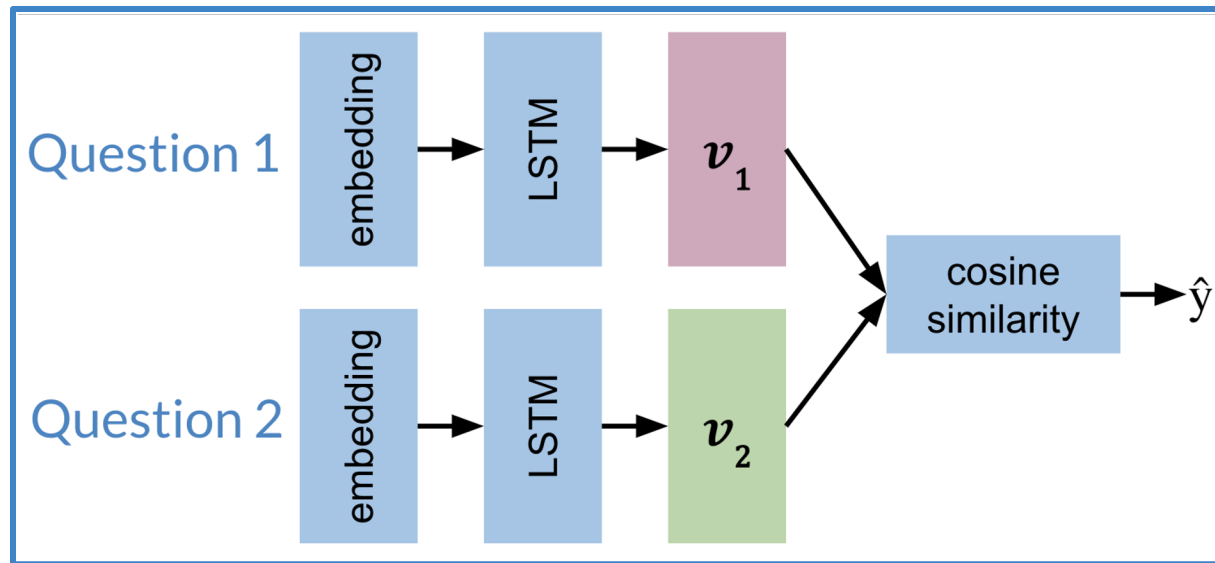
Batch 2

How old are you?
Are you seeing me?
Where are you?
What time is the game?

v_2

$v_{2,1}^2$ $q_{2,a}^2$				
$v_{2,2}^2$ $q_{2,b}^2$				
$v_{2,3}$				
$v_{2,4}$				

Siamese Model



Create a subnetwork:

- 1) Embedding
- 2) LSTM
- 3) Vectors
- 4) Cosine Similarity

Testing

1. Convert each input into an array of numbers
2. Feed arrays into your model
3. Compare v_1, v_2 using cosine similarity
4. Test against a threshold τ