Learning to Reason and Memorize with Self-Questioning

Jack Lanchantin, Shubham Toshniwal, Jason Weston, Arthur Szlam, Sainbayar Sukhbaatar

Meta AI

Multi-step reasoning problems

2-step problem

Alice has the key. Alice is at the lake.
Q: Where is the key? The key is at the lake.

Multi-step reasoning problems

2-step problem

Alice has the key. Alice is at the lake.
Q: Where is the key? The key is at the lake.

3-step problem

The key is in the bag. Alice has the bag. Alice is at the lake.
Q: Where is the key? The key is at the lake.

Multi-step reasoning problems

2-step problem

Alice has the key. Alice is at the lake.
Q: Where is the key? The key is at the lake.

3-step problem

The key is in the bag. Alice has the bag. Alice is at the lake.
Q: Where is the key? The key is at the lake.

3-step problem with self-questioning

The key is in the bag. Alice has the bag.

Multi-step reasoning problems

2-step problem

Alice has the key. Alice is at the lake.
Q: Where is the key? The key is at the lake.

3-step problem

The key is in the bag. Alice has the bag. Alice is at the lake.
Q: Where is the key? The key is at the lake.

3-step problem with self-questioning

The key is in the bag. Alice has the bag. SQ: Who has the key? Alice has the key. Alice is at the lake.
Q: Where is the key? The key is at the lake.

Self-questioning in state-tracking problems

State tracking

```
e = 3 ;
e ++ ;
i = 4 ;
e -- ;
if i > e : e -- ;
g = 3 ;
print e
```

e = 2 ;

Self-questioning in state-tracking problems

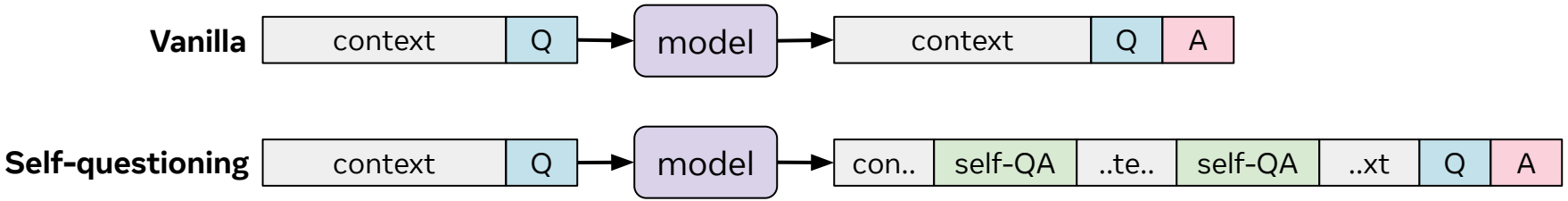
State tracking

```
e = 3 ;
e ++ ;
i = 4 ;
e -- ;
if i > e : e -- ;
g = 3 ;
print e
e = 2 ;
```

State tracking with self-questioning

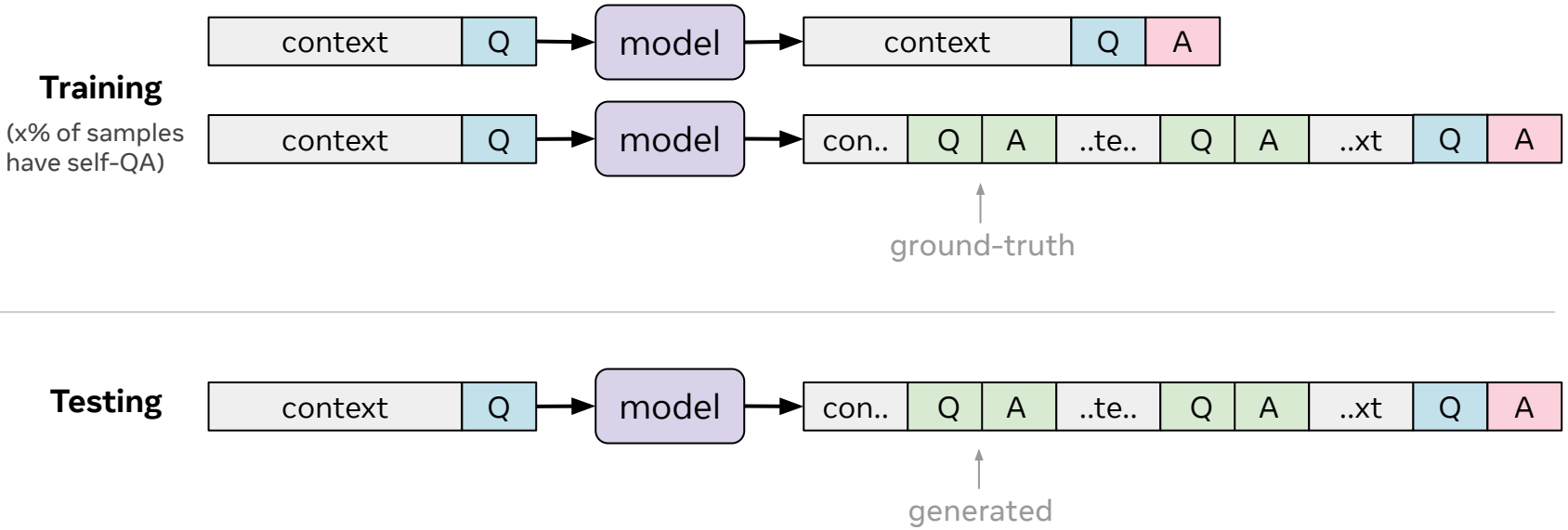
```
e = 3 ;
print e  e = 3 ;
e ++ ;
print e  e = 4 ;
i = 4 ;
print i  i = 4 ;
e -- ;
print e  e = 3 ;
if i > e : e -- ;
print e  e = 2 ;
g = 3 ;
print g  g = 3 ;
print e
e = 2 ;
```

Self-questioning Model



a general method that allows language models to take internal notes in the form of self-QAs

Training/Testing



Data

Toy-story Task

Original context:
The banana is inside the box.
Jessie has the bag.
The ball is inside the box.
The key is inside the suitcase.
Sid has the box.
Buzz has the suitcase.
Woody is at the station.

Question: who has the key?

Answer: Buzz has the key.

Context with self-QA:
The banana is inside the box.
Jessie has the bag.
The ball is inside the box.
The key is inside the suitcase.
Sid has the box.
SQ: Who has the banana?
Sid has the banana.
SQ: Who has the ball?
Sid has the ball.
Buzz has the suitcase
Woody is at the station.

Question: who has the key?

Answer: Buzz has the key.

Algorithmic Task

Original context:
e = 3 ;
e ++ ;
i = 4 ;
e -- ;
if i > e : e -- ;
g = 3 ;

Question: print e

Answer: e = 2 ;

Context with self-QA:
e = 3 ;
print e e = 3 ;
e ++ ;
print e e = 4 ;
i = 4 ;
print i i = 4 ;
e -- ;
print e e = 3 ;
if i > e : e -- ;
print e e = 2 ;
g = 3 ;
print g g = 3 ;

Question: print e

Answer: e = 2 ;

Results

Method	Train self-QA	Test self-QA	Algorithmic ≤50	Algorithmic ≤100	Algorithmic ≤200*	Toy-Story 3-hop*	Toy-Story 4-hop*
GPT-2 fine-tuned	none	none	69.5	53.2	40.0	59.8	39.4
Scratchpad	100%	generated	**100.0**	61.0	30.0	98.6	95.4
Self-Questioning	100%	generated	**100.0**	**100.0**	**98.8**	**99.7**	**98.6**
	75%		99.5	99.6	98.3	98.9	98.5
	50%		98.8	98.2	95.0	98.9	96.8
	25%		95.8	93.5	85.7	97.1	95.1