MEMORY NETWORKS

(Published as a conference paper at ICLR 2015)

박민혜

Introduction

- Question answering을 잘하기 위한 모델
- RNN/LSTM은 메모리 용량(hidden state)이 작음
- Long term memory 더 잘 기억하기 위해서는 external memory 필요
- QA를 잘하기 위해서는 연관된 사실을 chaining하는 것이 중요함

Sample dataset

```
1 Fred is either in the school or the park.
2 Mary went back to the office.
3 Is Mary in the office?	yes	2
4 Bill is either in the kitchen or the park.
5 Fred moved to the cinema.
6 Is Fred in the park?	no	5
7 Fred is in the office.
8 Bill moved to the cinema.
9 Is Bill in the cinema?	yes	8
10 Bill is in the park.
11 Bill is either in the office or the kitchen.
12 Is Bill in the office?	maybe	11
13 Bill is either in the cinema or the park.
14 Mary moved to the park.
15 Is Bill in the park?	maybe	13
1 Mary travelled to the kitchen.
2 Fred is in the school.
3 Is Mary in the school?	no	1
4 Fred went back to the office.
5 Julie is either in the park or the office.
6 Is Mary in the cinema?	no	1
```

```
The file format for each task is as follows:
ID text
ID text
ID text
ID question[tab]answer[tab]supporting fact IDS.
...

The IDs for a given "story" start at 1 and increase.
When the IDs in a file reset back to 1 you can consider the following sentences as a new "story".
Supporting fact IDs only ever reference the sentences within a "story".
```

https://github.com/aykutaaykut/Memory-Networks

Chaining

1	Mary moved to the bathroom.
2	Sandra journeyed to the bedroom.
3	John went to the kitchen.
4	Mary got the football there.
5	Mary went back to the kitchen.
6	Mary went back to the garden.

- Inputs : 1~6 sentences, "Where is the football?" (k = 2)
- Output1: "Mary got the football there"
- Output2 : "Mary went back to the garden"
- Response : "Garden"

Memory networks

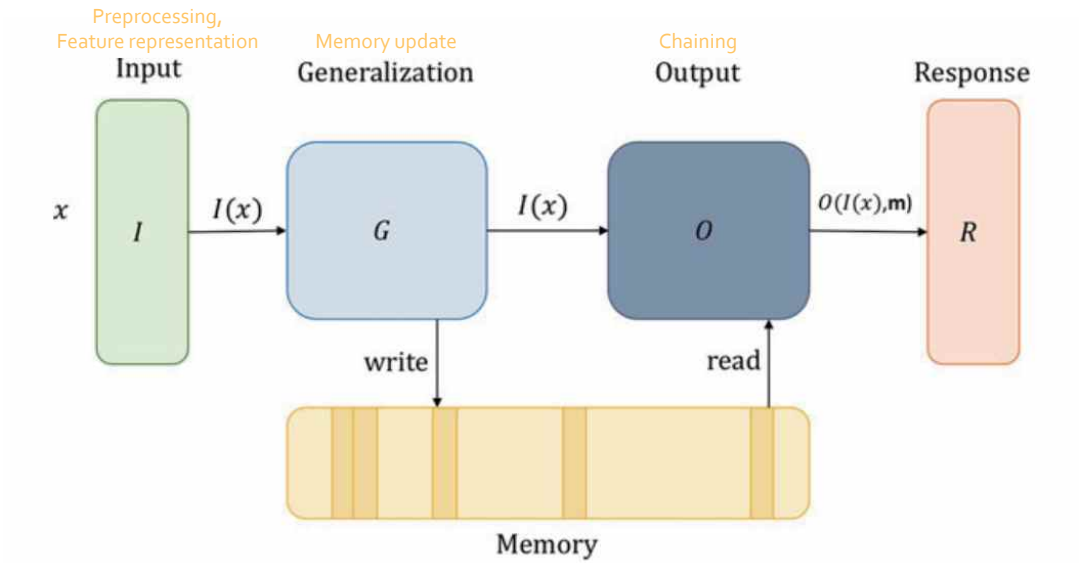

Fig. 9.7: Memory networks

- Input : "Where is the football?"
- Output1 : "Mary got the football there"
- Output2 : "Mary went back to the garden"
- Response : "Garden"

memory slot ($\mathbf{m}_i$)	sentence
1	Mary moved to the bathroom.
2	Sandra journeyed to the bedroom.
3	John went to the kitchen.
4	Mary got the football there.
5	Mary went back to the kitchen.
6	Mary went back to the garden.

Memory networks – example

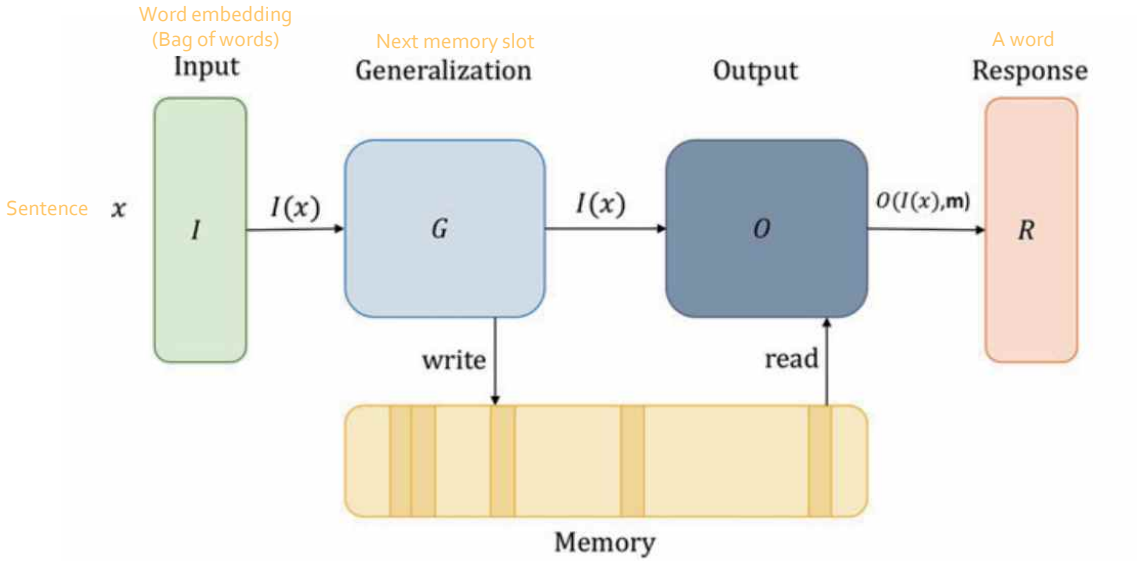

Fig. 9.7: Memory networks

- Input : "Where is the football?"
- Output1 : "Mary got the football there"
- Output2 : "Mary went back to the garden"
- Response : "Garden"

memory slot ($\mathbf{m}_i$)	sentence
1	Mary moved to the bathroom.
2	Sandra journeyed to the bedroom.
3	John went to the kitchen.
4	Mary got the football there.
5	Mary went back to the kitchen.
6	Mary went back to the garden.

Memory networks

- I, G, O, R can potentially use any existing ideas from the machine learning literature
- Memory neural networks : the components are neural networks.
- Two kinds of scoring functions (S_O, S_R)
- Supervised(output 1, output 2, … output n, response, k = n)

Sample dataset – memory flush

```
1 Fred is either in the school or the park.
2 Mary went back to the office.
3 Is Mary in the office?	yes	2
4 Bill is either in the kitchen or the park.
5 Fred moved to the cinema.
6 Is Fred in the park?	no	5
7 Fred is in the office.
8 Bill moved to the cinema.
9 Is Bill in the cinema?	yes	8
10 Bill is in the park.
11 Bill is either in the office or the kitchen.
12 Is Bill in the office?	maybe	11
13 Bill is either in the cinema or the park.
14 Mary moved to the park.
15 Is Bill in the park?	maybe	13
1 Mary travelled to the kitchen.
2 Fred is in the school.
3 Is Mary in the school?	no	1
4 Fred went back to the office.
5 Julie is either in the park or the office.
6 Is Mary in the cinema?	no	1
```

```
The file format for each task is as follows:
ID text
ID text
ID text
ID question[tab]answer[tab]supporting fact IDS.
...

The IDs for a given "story" start at 1 and increase.
When the IDs in a file reset back to 1 you can consider the following sentences as a new "story".
Supporting fact IDs only ever reference the sentences within a "story".
```

https://github.com/aykutaaykut/Memory-Networks

Sample dataset – training

```
1  1 Fred is either in the school or the park.
2  2 Mary went back to the office.
3  3 Is Mary in the office?        yes     2
4  4 Bill is either in the kitchen or the park.
5  5 Fred moved to the cinema.
6  6 Is Fred in the park?  no      5
7  7 Fred is in the office.
8  8 Bill moved to the cinema.
9  9 Is Bill in the cinema?        yes     8
10 10 Bill is in the park.
11 11 Bill is either in the office or the kitchen.
12 12 Is Bill in the office?       maybe   11
13 13 Bill is either in the cinema or the park.
14 14 Mary moved to the park.
15 15 Is Bill in the park?         maybe   13
16 1 Mary travelled to the kitchen.
17 2 Fred is in the school.
18 3 Is Mary in the school?        no      1
19 4 Fred went back to the office.
20 5 Julie is either in the park or the office.
21 6 Is Mary in the cinema?        no      1
```

```
The file format for each task is as follows:
ID text
ID text
ID text
ID question[tab]answer[tab]supporting fact IDS.
...

The IDs for a given "story" start at 1 and increase.
When the IDs in a file reset back to 1 you can consider the following sentences as a new "story".
Supporting fact IDs only ever reference the sentences within a "story".
```

https://github.com/aykutaaykut/Memory-Networks

Efficient memory vis hashing

- Via word hash
- Via cluster hash (word embedding)

Experiments

Figure 3: An example story with questions correctly answered by a MemNN. The MemNN was trained on the simulation described in Section 5.2 and had never seen many of these words before, e.g., Bilbo, Frodo and Gollum.

Bilbo travelled to the cave. Gollum dropped the ring there. Bilbo took the ring.
Bilbo went back to the Shire. Bilbo left the ring there. Frodo got the ring.
Frodo journeyed to Mount-Doom. Frodo dropped the ring there. Sauron died.
Frodo went back to the Shire. Bilbo travelled to the Grey-havens. The End.
Where is the ring? A: Mount-Doom
Where is Bilbo now? A: Grey-havens
Where is Frodo now? A: Shire

Figure 4: An example dialogue with a MemNN system trained on both the simulation data and the large-scale QA data. The system is able to (attempt to) answer questions about general world knowledge and about specific story-based statements in the dialogue.

Fred went to the kitchen. Fred picked up the milk. Fred travelled to the office.
Where is the milk ? A: office
Where does milk come from ? A: milk come from cow
What is a cow a type of ? A: cow be female of cattle
Where are cattle found ? A: cattle farm become widespread in brazil
What does milk taste like ? A: milk taste like milk
What does milk go well with ? A: milk go with coffee
Where was Fred before the office ? A: kitchen

Experiments

- Large-scale QA : (subject, relation, object) triples
  - ex. (milne, authored, winnie-the-pooh), (sheep, be-afraid-of, wolf)

Table 1: Results on the large-scale QA task of (Fader et al., 2013).

Method	F1
(Fader et al., 2013)	0.54
(Bordes et al., 2014b)	0.73
MemNN (embedding only)	0.72
MemNN (with BoW features)	0.82

Table 2: Memory hashing results on the large-scale QA task of (Fader et al., 2013).

Method	Embedding F1	Embedding + BoW F1	Candidates (speedup)
MemNN (no hashing)	0.72	0.82	14M (0x)
MemNN (word hash)	0.63	0.68	13k (1000x)
MemNN (cluster hash)	0.71	0.80	177k (80x)

Experiments

- Simulation QA : a simple simulation of 4 characters, 3 objects, 5 rooms
  - actor w/o before "where is the football?"
  - actor "where was Bill before the kitchen?"

Actions The underlying actions in the simulation consist of the following:

go <location>, *get <object>*, *get <object1> from <object2>*,
put <object1> in/on <object2>, *give <object> to <actor>*,
drop <object>, *look*, *inventory*, *examine <object>*.

Table 3: Test accuracy on the simulation QA task.

	Difficulty 1			Difficulty 5	
Method	actor w/o before	actor	actor+object	actor	actor+object
RNN	100%	60.9%	27.9%	23.8%	17.8%
LSTM	100%	64.8%	49.1%	35.2%	29.0%
MemNN $k = 1$	97.8%	31.0%	24.0%	21.9%	18.5%
MemNN $k = 1$ (+time)	99.9%	60.2%	42.5%	60.8%	44.4%
MemNN $k = 2$ (+time)	100%	100%	100%	100%	99.9%