Memory Networks

by Jason Weston, Sumit Chopra & Antoine Bordes
https://arxiv.org/pdf/1410.3916.pdf

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What is the problem?

- Question Answering
- Reading and understanding a story, and then answering questions about that particular story.
- Answering questions requires understanding the story, inference from sentences, chaining relevant sentences, induction, deduction..

Introduction

- MemNN uses an external memory in order to remember the past.
- The long-term memory can be read and written, and used for predicting an answer for a given question.
- Output is textual response.

Example Story and Question

1 Mary moved to the bathroom.

2 Sandra journeyed to the bedroom.

3 Mary got the football there.

4 John went to the kitchen.

5 Mary went back to the kitchen.

6 Mary went back to the garden.

7 Where is the football? *garden* *3 6*

Model

MemNN has 4 components:

- **I component:** Pre-processing of the input.
- **G component:** Updating the external memory.
- **O component:** Finding relevant and necessary memory states given a question.
- **R component:** Predicting the final answer of the question using the output of the O component.

I Component

- Bag of Words (BoW) approach

```
garden => 16
football => 10
there => 11
is => 18
back => 15
where => 17
got => 9
bathroom => 5
went => 13
bedroom => 8
the => 4
Mary => 1
moved => 2
journeyed => 7
John => 12
to => 3
kitchen => 14
Sandra => 6
INFO: 18 unique words.
[1.0; 1.0; 1.0; 1.0; 1.0; 0.0; 0.0; 0.0; 0.0; 0.0; 0.0; 0.0; 0.0; 0.0; 0.0; 0.0; 0.0; 0.0]
```

BoW representation of “Mary moved to the bathroom.”

G Component

- Sentence internal feature representation is added in the memory.

1 Mary moved to the bathroom.

2 Sandra journeyed to the bedroom.

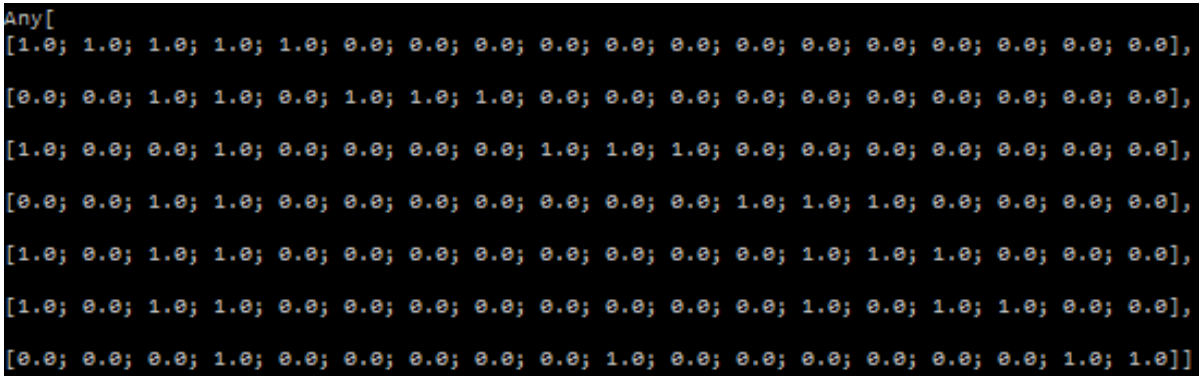
3 Mary got the football there.

4 John went to the kitchen.

5 Mary went back to the kitchen.

6 Mary went back to the garden.

7 Where is the football? *garden 3 6*



Memory after insertion of the story

O Component

- Scores the match between each sentence in the memory and the question.

$$O(x, m) = \underset{i=1,\ldots,N}{\operatorname{argmax}} \; s_o(x,\, m_i)$$

- Calculates the probability of being related for memory states and returns the state with the highest probability.

$$s(x, y) = \phi_x(\mathbf{x})^T \, U^T \, U \, \phi_y(\mathbf{y})$$

R Component

- Returns the final prediction of the model using the same method with O component.

$$r = \arg\max_w \; s_r([x, m_{o1}, m_{o2}], w)$$

Training

- Fully supervised learning
- Softloss
- Knet.Adam as the parameter optimizer
- Reading text line by line, no mini batching
- 100 epoch

Experiments and Results

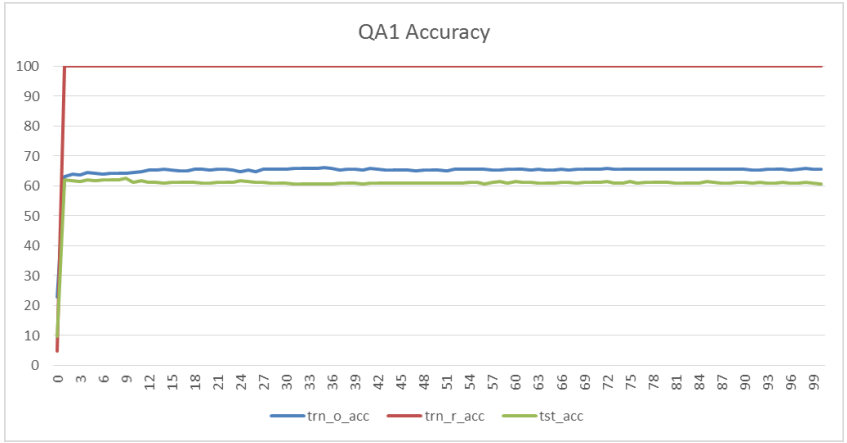
- Toy Task dataset of “Towards AI-Complete Question Answering: A Set of Prerequisite Toy Tasks” is used.
- 20 different tasks

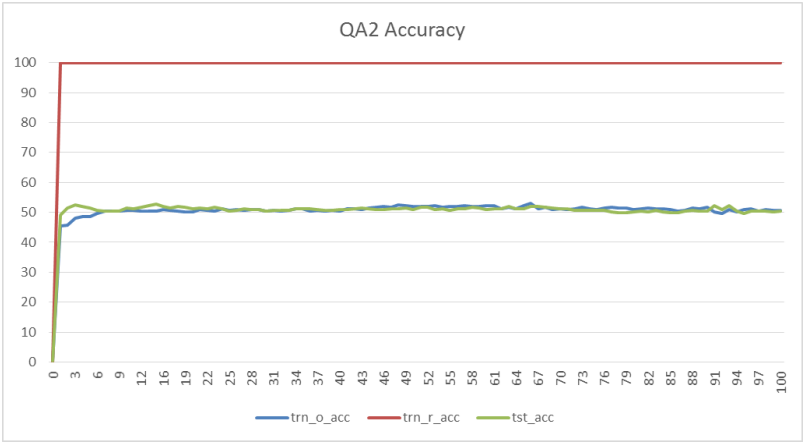
Task 1: Single Supporting Fact

Mary went to the bathroom.
John moved to the hallway.
Mary travelled to the office.
Where is Mary? A:office

Task 2: Two Supporting Facts

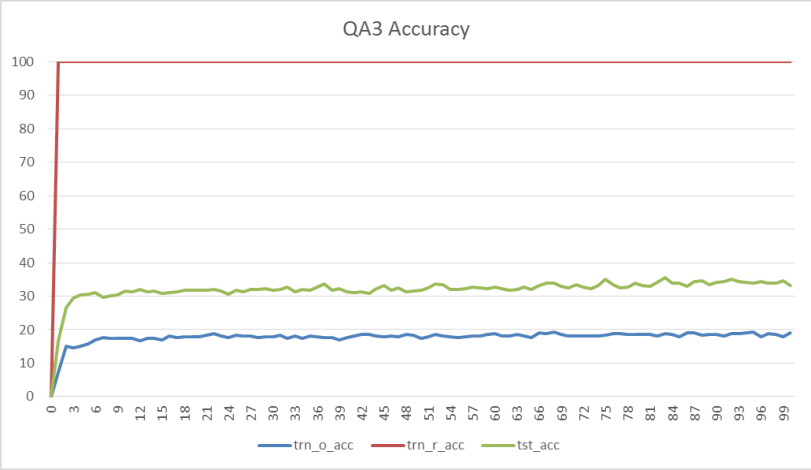
John is in the playground.
John picked up the football.
Bob went to the kitchen.
Where is the football? A:playground





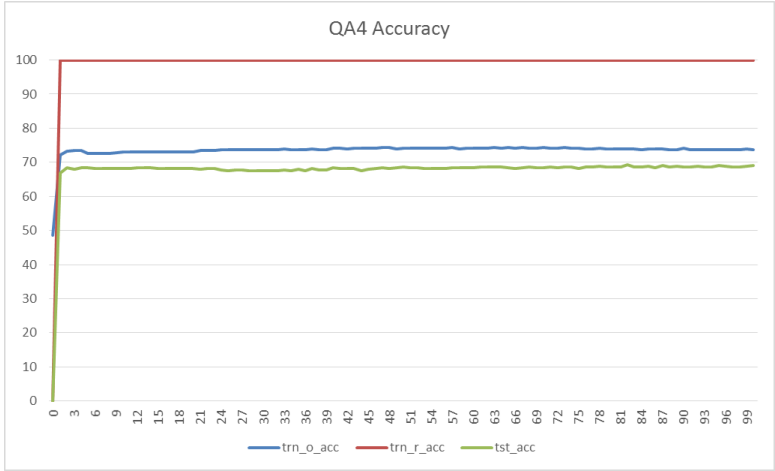
Task 3: Three Supporting Facts

John picked up the apple.
John went to the office.
John went to the kitchen.
John dropped the apple.
Where was the apple before the kitchen? A:office



Task 4: Two Argument Relations

The office is north of the bedroom.
The bedroom is north of the bathroom.
The kitchen is west of the garden.
What is north of the bedroom? A: office
What is the bedroom north of? A: bathroom

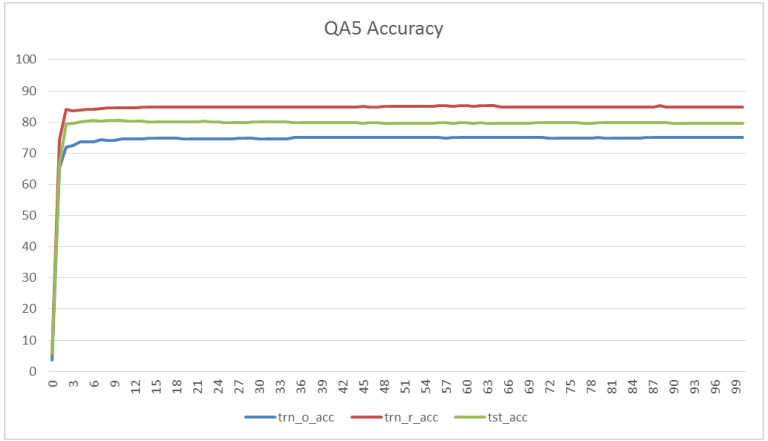


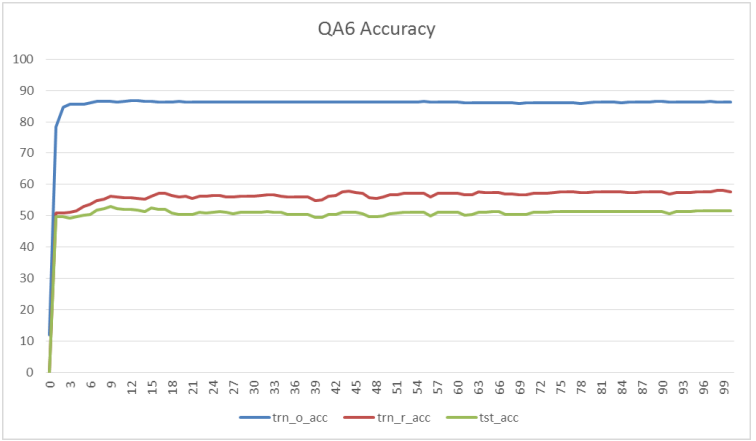
Task 5: Three Argument Relations

Mary gave the cake to Fred.
Fred gave the cake to Bill.
Jeff was given the milk by Bill.
Who gave the cake to Fred? A: Mary
Who did Fred give the cake to? A: Bill

Task 6: Yes/No Questions

John moved to the playground.
Daniel went to the bathroom.
John went back to the hallway.
Is John in the playground? A:no
Is Daniel in the bathroom? A:yes



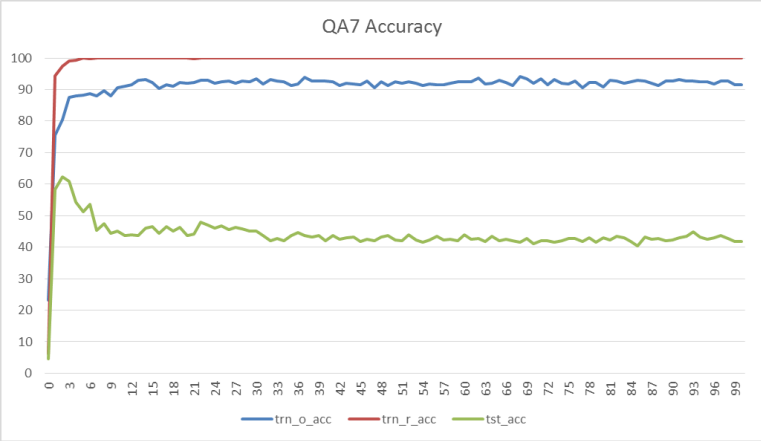


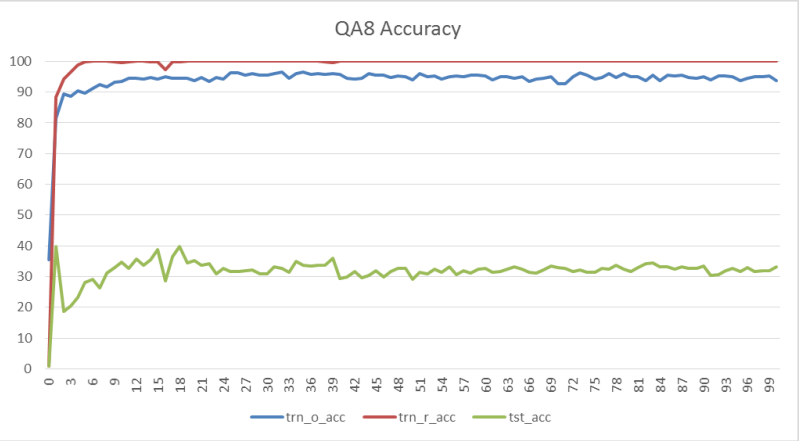
Task 7: Counting

Daniel picked up the football.
Daniel dropped the football.
Daniel got the milk.
Daniel took the apple.
How many objects is Daniel holding? A: two

Task 8: Lists/Sets

Daniel picks up the football.
Daniel drops the newspaper.
Daniel picks up the milk.
John took the apple.
What is Daniel holding? milk, football



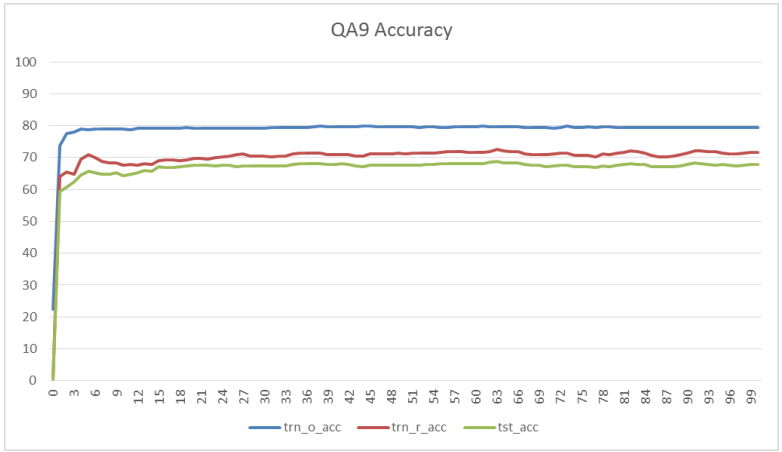


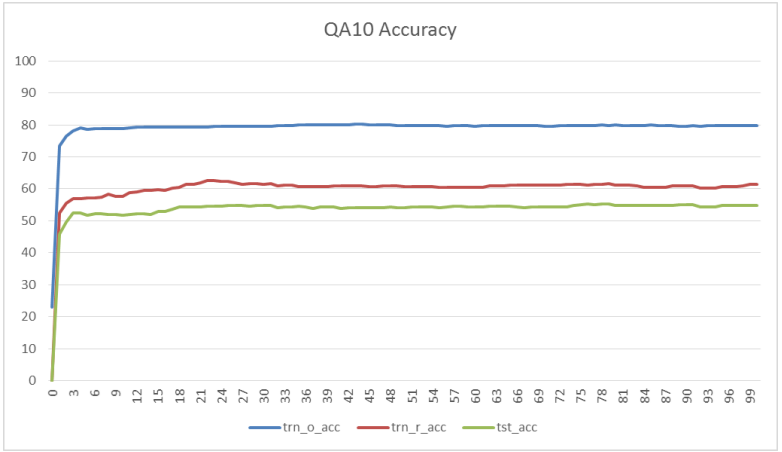
Task 9: Simple Negation

Sandra travelled to the office.
Fred is no longer in the office.
Is Fred in the office? A:no
Is Sandra in the office? A:yes

Task 10: Indefinite Knowledge

John is either in the classroom or the playground.
Sandra is in the garden.
Is John in the classroom? A:maybe
Is John in the office? A:no



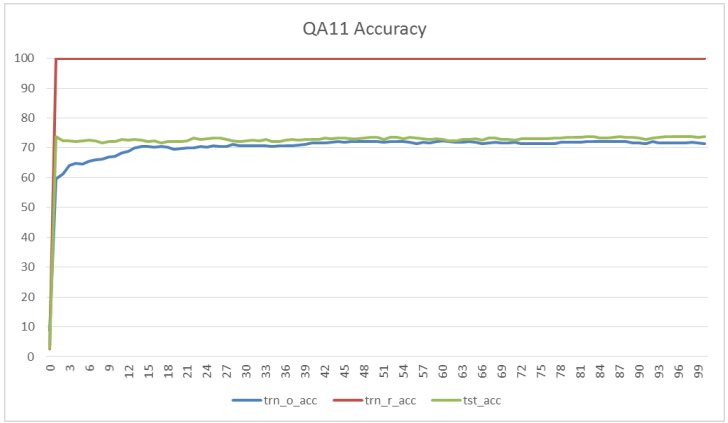


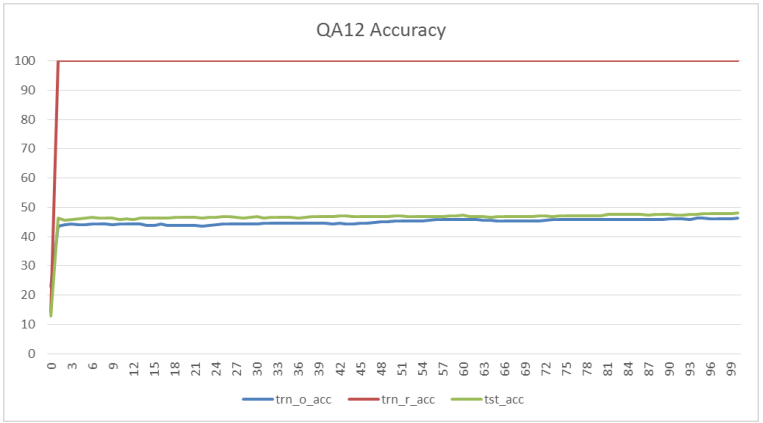
Task 11: Basic Coreference

Daniel was in the kitchen.
Then he went to the studio.
Sandra was in the office.
Where is Daniel? A:studio

Task 12: Conjunction

Mary and Jeff went to the kitchen.
Then Jeff went to the park.
Where is Mary? A: kitchen
Where is Jeff? A: park



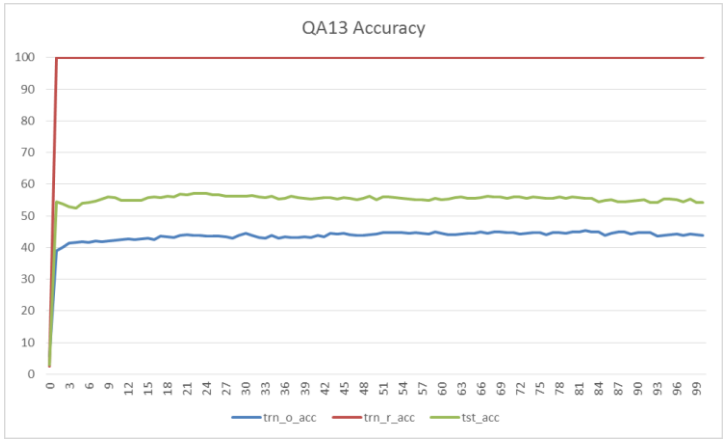


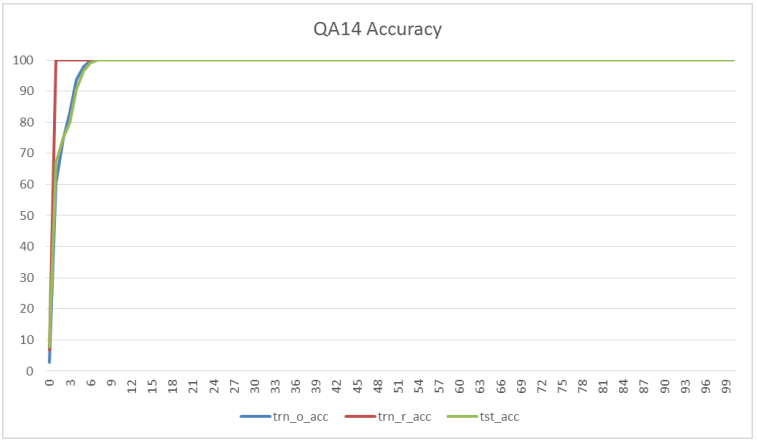
Task 13: Compound Coreference

Daniel and Sandra journeyed to the office.
Then they went to the garden.
Sandra and John travelled to the kitchen.
After that they moved to the hallway.
Where is Daniel? A: garden

Task 14: Time Reasoning

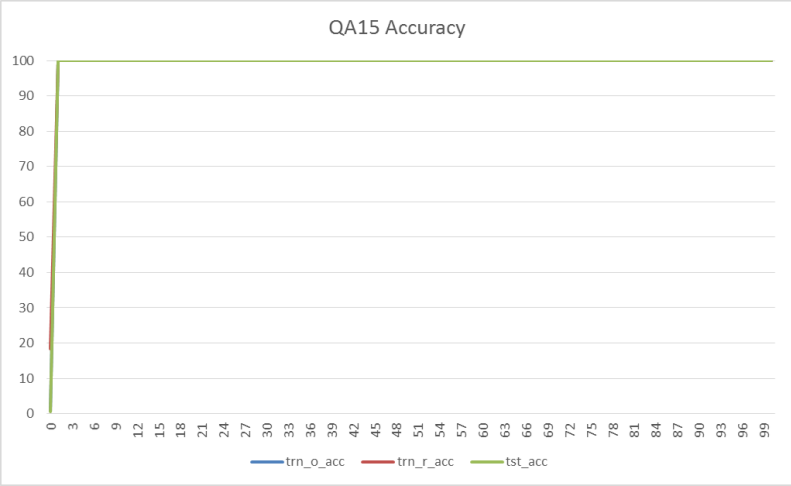
In the afternoon Julie went to the park.
Yesterday Julie was at school.
Julie went to the cinema this evening.
Where did Julie go after the park? A:cinema
Where was Julie before the park? A:school





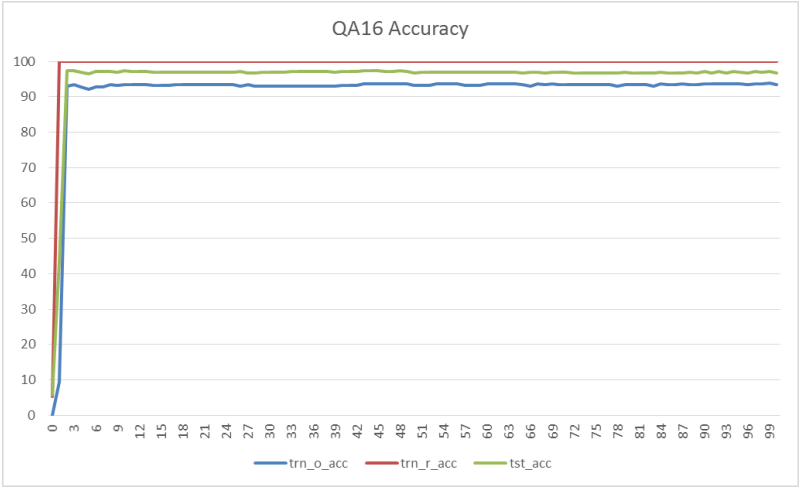
Task 15: Basic Deduction

Sheep are afraid of wolves.
Cats are afraid of dogs.
Mice are afraid of cats.
Gertrude is a sheep.
What is Gertrude afraid of? A:wolves



Task 16: Basic Induction

Lily is a swan.
Lily is white.
Bernhard is green.
Greg is a swan.
What color is Greg? A:white

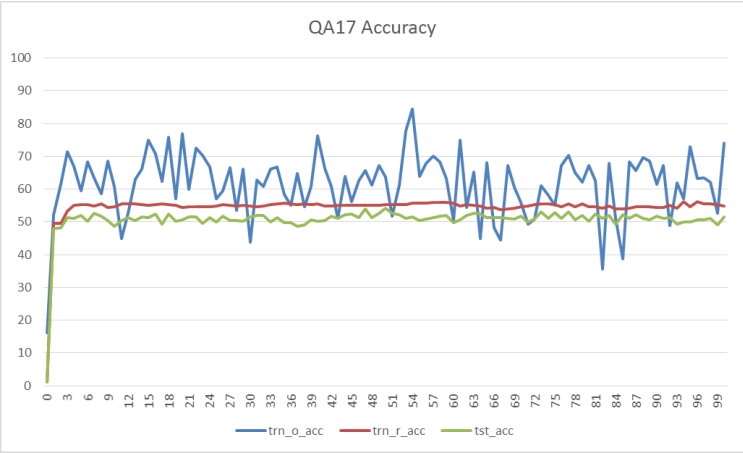


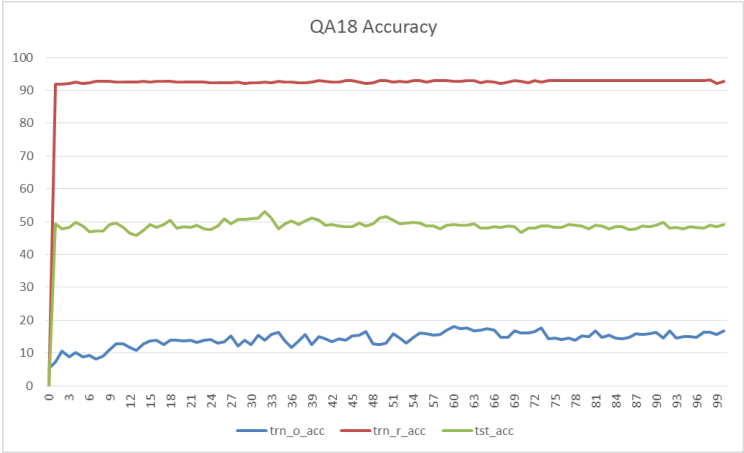
Task 17: Positional Reasoning

The triangle is to the right of the blue square.
The red square is on top of the blue square.
The red sphere is to the right of the blue square.
Is the red sphere to the right of the blue square? A:yes
Is the red square to the left of the triangle? A:yes

Task 18: Size Reasoning

The football fits in the suitcase.
The suitcase fits in the cupboard.
The box is smaller than the football.
Will the box fit in the suitcase? A:yes
Will the cupboard fit in the box? A:no



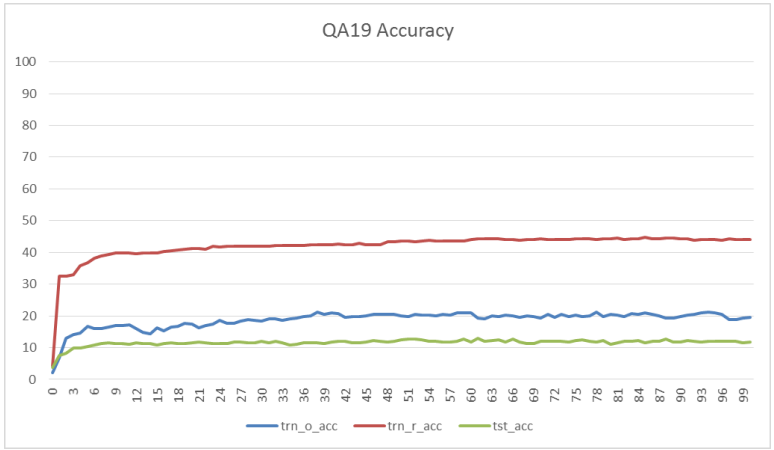


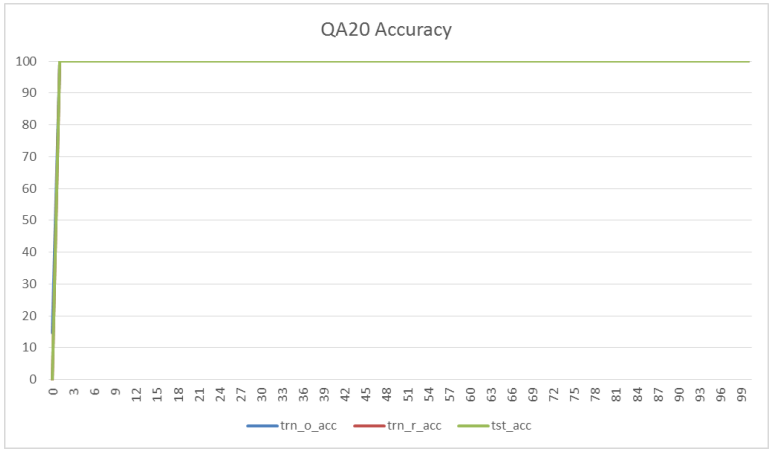
Task 19: Path Finding

The kitchen is north of the hallway.
The bathroom is west of the bedroom.
The den is east of the hallway.
The office is south of the bedroom.
How do you go from den to kitchen? A: west, north
How do you go from office to bathroom? A: north, west

Task 20: Agent's Motivations

John is hungry.
John goes to the kitchen.
John grabbed the apple there.
Daniel is hungry.
Where does Daniel go? A:kitchen
Why did John go to the kitchen? A:hungry





Comparison

Tasks	Results in the paper	Results of my implementation
1 – Single Supporting Fact	100	62.5
2 – Two Supporting Facts	100	52.8
3 – Three Supporting Facts	20	35.5
4 – Two Argument Relations	71	69.2
5 – Three Argument Relations	83	80.4
6 – Yes/No Questions	47	53
7 – Counting	68	62.2
8 – Lists/Sets	77	39.9
9 – Simple Negation	65	68.7
10 – Indefinite Knowledge	59	55.3
11 – Basic Coreference	100	73.8
12 – Conjunction	100	48
13 – Compound Coreference	100	57
14 – Time Reasoning	99	100
15 – Basic Deduction	74	100
16 – Basic Induction	27	97.4
17 – Positional Reasoning	54	54.2
18 – Size Reasoning	57	53.1
19 – Path Finding	0	12.9
20 – Agent's Motivation	100	100
Mean	**70.05**	**63.8**

Conclusion

- In 14 tasks, similar or better accuracy is achieved.
- In 6 tasks, poorer accuracy is achieved. Possible reasons:
  - Absolute time instead of relative time
  - Softloss instead of hinge loss
  - Inner feature representation
  - Variable number of supporting facts
- Overall my implementation achieved nearly same accuracy in terms of mean performance and fulfilled the task of reimplementation of MemNN.

Thank you for listening..

Questions?