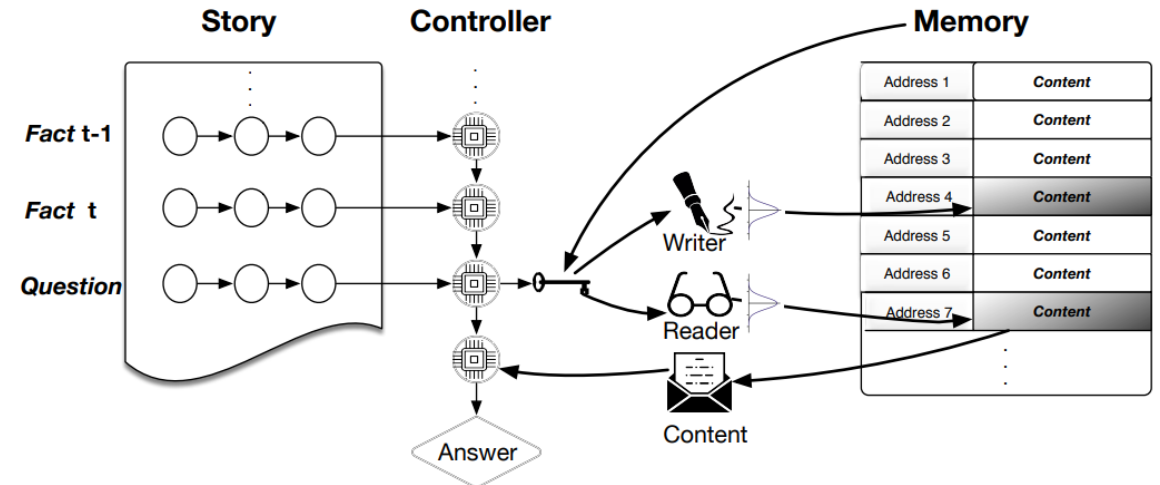# A Memory Model for Question Answering from Streaming Data Supported by Rehearsal and Anticipation of Coreference Information

Vladimir Araujo, Álvaro Soto, Marie-Francine Moens

Memory Networks for NLP

- Memory networks mimic the human process of incremental comprehension and compression of information in a memory (Graves et al., 2014, 2016).

- Memory models can read contiguous text (stories) and, via a controller, write and read information to and from memory to solve a task (e.g., answer a question).

Source: (Gulcehre et al., 2017)

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Memory Networks for NLP

Problem:

- Memory networks rely on a single task to maintain memory.

Human memory:

- Humans are endowed with mechanisms for memorization.
    - Anticipation (Hawkins and Blakeslee, 2004).
    - Memory rehearsal (Waugh and Norman, 1965)
- Complementary mechanisms (Ferreira, 2018).

Proposed Solution:

- Support a memory model with anticipation and rehearsal.

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A Memory Model Supported by Rehearsal and Anticipation of Coreference Information

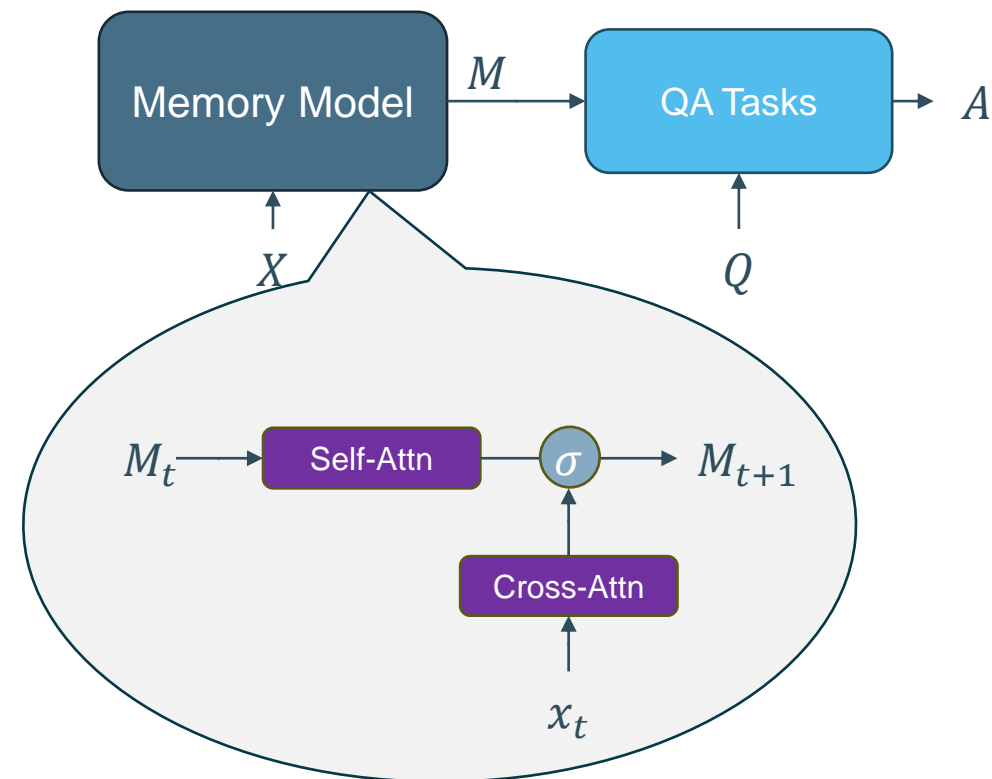RAM: A memory network augmented with rehearsal and anticipation mechanisms.

RAM Method:

- Main task: Question answering (QA) from streaming data:

$$M = F(X), \text{ where } X = [x_1, x_2, x_3, \dots, x_T]$$
$$A = G(M, Q)$$

- Improved Memory Cell:
    - Memory integration based on cross-attention.
    - Gating (σ) for allowing forgetting.

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RAM Method:

- Pretext tasks as masked modeling:
  - Rehearsal as a prediction of previous elements.
  - Anticipation as a prediction of future elements.

- Rehearsal and anticipation are related and might be using the same machinery (Cole et al., 2015)
  - Shared decoder with auxiliary task.

What to rehearse and anticipate?

- Coreference information guides memory retrieval and expectations (Jaffe et al., 2020).
  - coreference-related tokens (nouns, pronouns, verbs)
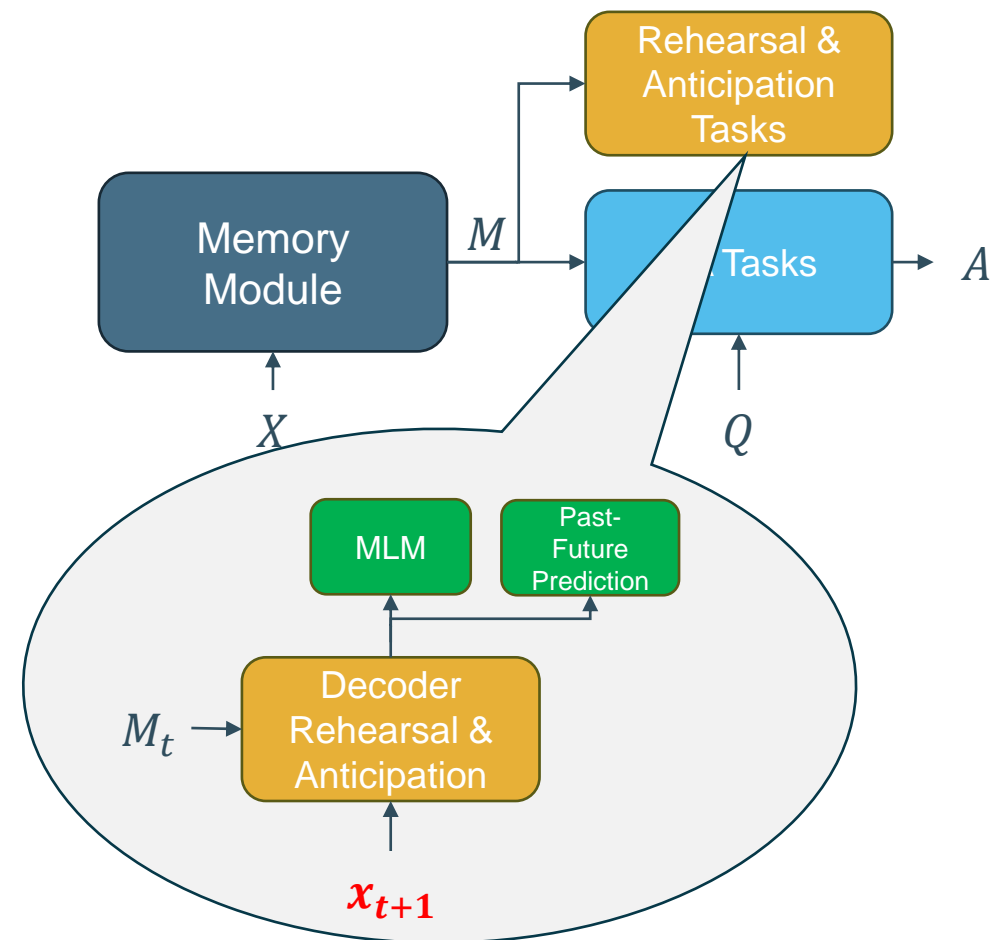
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Findings:

- Improved performance across tasks (also video).

- Coreference information is important.

- Rehearsal and anticipation improve memorization.

- Rehearsal has more impact than anticipation.

Method	bAbI (Mean Error)	NarrativeQA (MRR)	ActivityNet-QA (Acc)
DNC	16.70 ± 7.60	25.2	30.3
NUTM	5.60 ± 1.90	27.2	33.1
HMem	8.93 ± 0.73	25.5	31.9
DAM	1.53 ± 1.33	27.5	32.4
STM	0.39 ± 0.18	26.7	33.7
CT	0.81 ± 0.26	28.3	35.4
RM	0.33 ± 0.15	28.7	36.3
RAM	$\mathbf{0.25 \pm 0.16}$	**30.9**	**37.4**

*Error rate: lower is better

Method	bAbI (Error Rate)	NarrativeQA (MRR)	ActivityNet-QA (Acc)
RAM	0.25 ± 0.16	30.9	37.4
RAM (random masking)	0.28 ± 0.19	30.6	37.4
RAM w/o $\mathcal{L}_{anticipation}$	0.31 ± 0.17	28.9	35.9
RAM w/o $\mathcal{L}_{rehearsal}$	0.34 ± 0.17	29.7	36.4
RAM w/o $\mathcal{L}_{ssm}$	0.37 ± 0.18	28.0	35.0

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What is memory storing?:

- Memory slots capture information related to the entities and activities.

- Also, the relation between entities and objects.

- Memory behaves the same for visual information.

Conclusions

Anticipation and Memory Rehearsal are complementary and improve language modeling (an increase of ~11%).

- Predicting the future and rehearsing past elements improve memorization (an increase of ~16%).

- Coreference information plays an important role (an increase of ~4%).

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Thank you

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