Dual Memory Neural Computer for Asynchronous Two-view Sequential Learning

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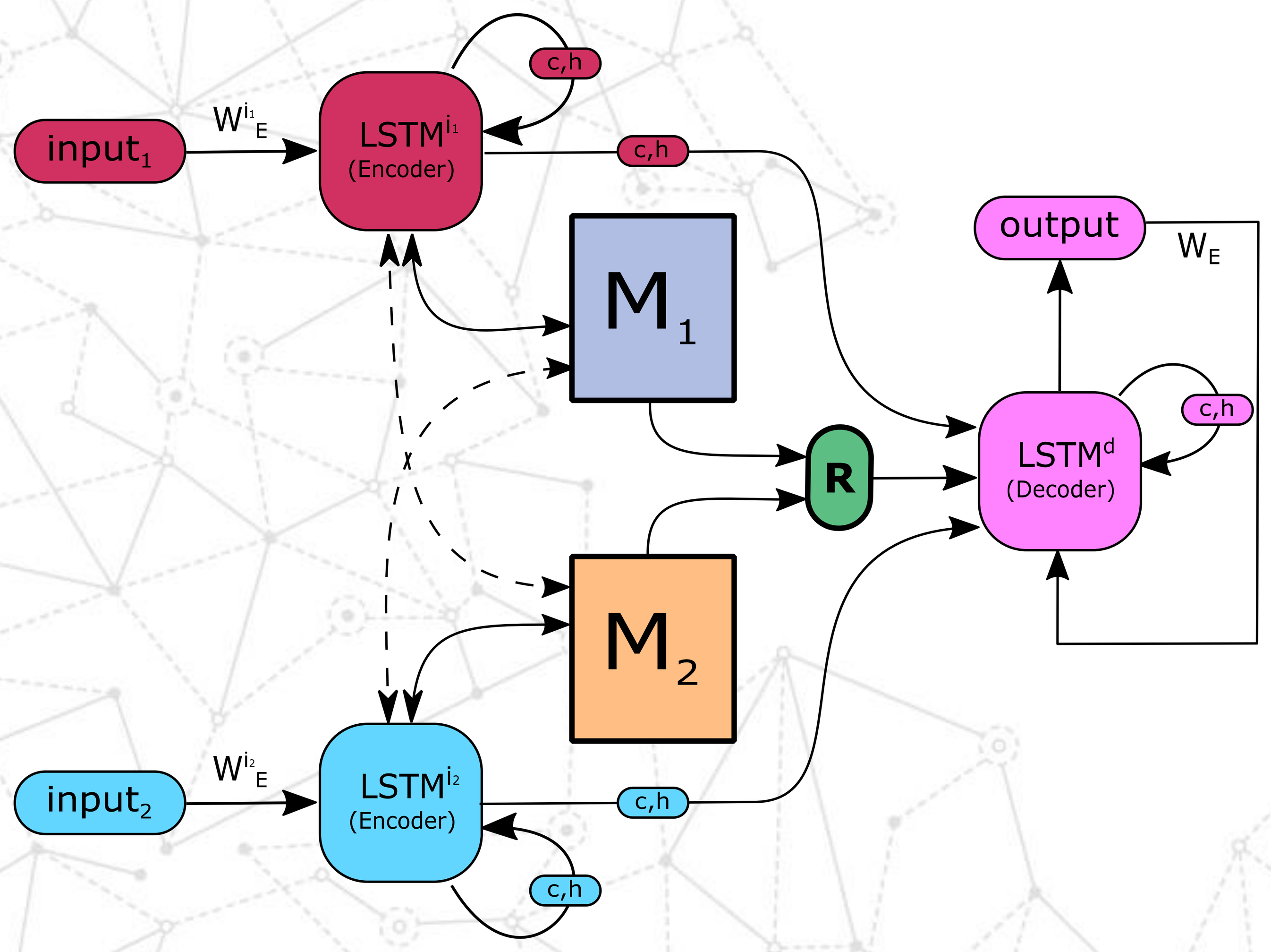
Introduction

One of the core tasks in multi-view learning is to capture relations among views. For sequential data, the relations not only span across views, but also extend throughout the view length to form long-term intra-view and inter-view interactions. In this paper, we present a new memory augmented neural network that aims to model these complex interactions between two asynchronous sequential views.

Methods

We leverage memory read/write operations from DNC [1] to capture long-term dependencies in multiple sequential views. To model interactions among views, our model supports **early-fusion** and **late-fusion** addressing schemes.



Dual Memory Neural Computer (DMNC). There are two encoders and one decoder implemented as LSTMs. The dash arrows represent cross-memory accessing in early-fusion mode

Memory reading:

- Controller output: $o_{t_i}^i = LSTM^i\left(x_{t_i}^i, h_{t_i-1}^i\right); i = \overline{1,2}$
- Late-fusion: $r_{t_i}^i = m_{read}^i\left(o_{t_i}^i, M_i\right); i = \overline{1,2}$
- Early-fusion: $r_{t_i}^i = m_{read}\left(o_{t_i}^i, [M_1, M_2]\right); i = \overline{1,2}$

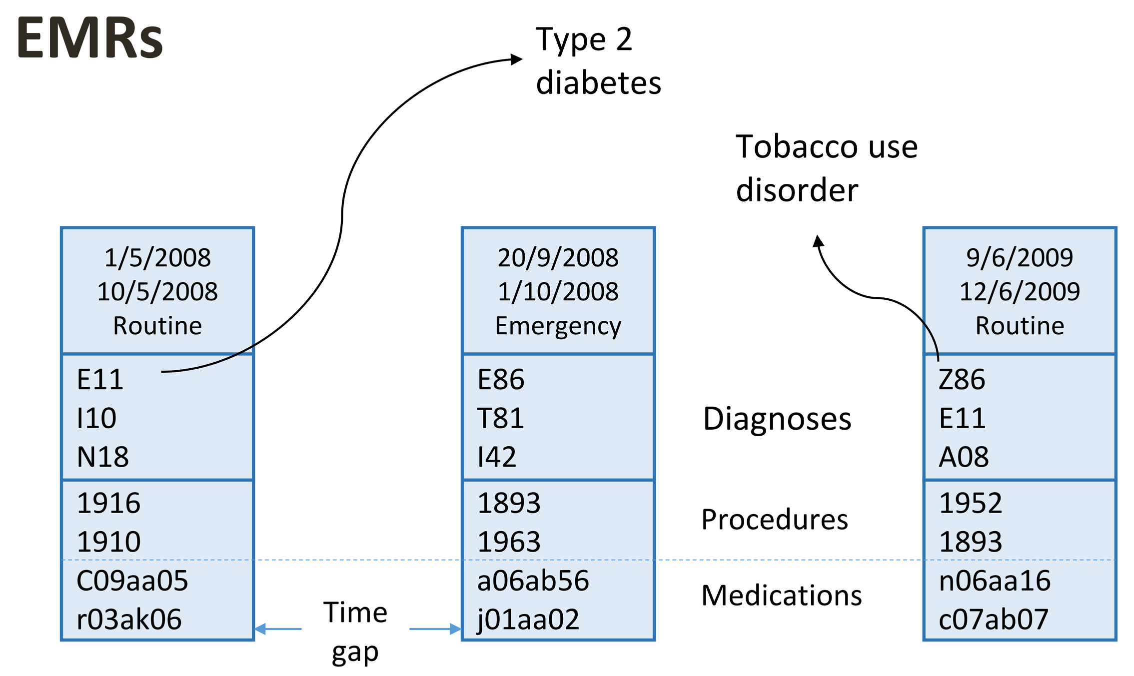
Memory writing:

- Gated cache: $c_t = g_t^c \circ c_{t-1} + (1 - g_t^c)v_t; c_0 = \vec{0}$
- Update: $M_t = M_{t-1} \circ (1 - g_t^w w_t^w e_t) + g_t^w w_t^w c_t$

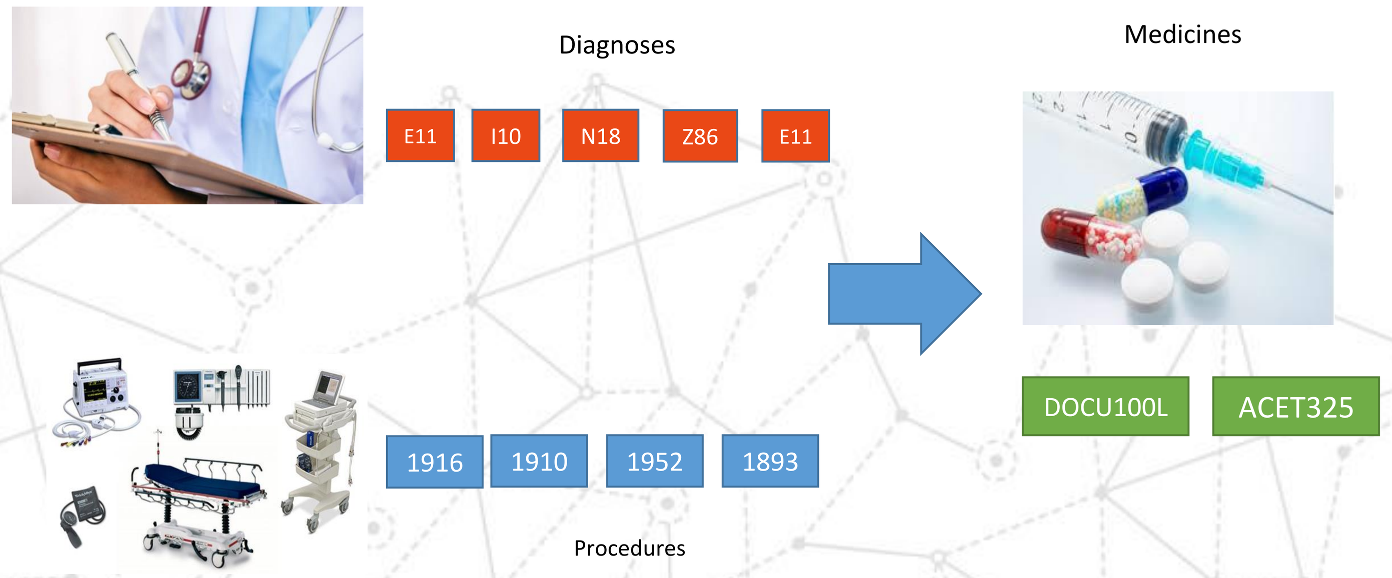
Persistent memory for healthcare data (EMRs):

- Keep memory updating during admission encoding
- Flush memory when processing a new patient record

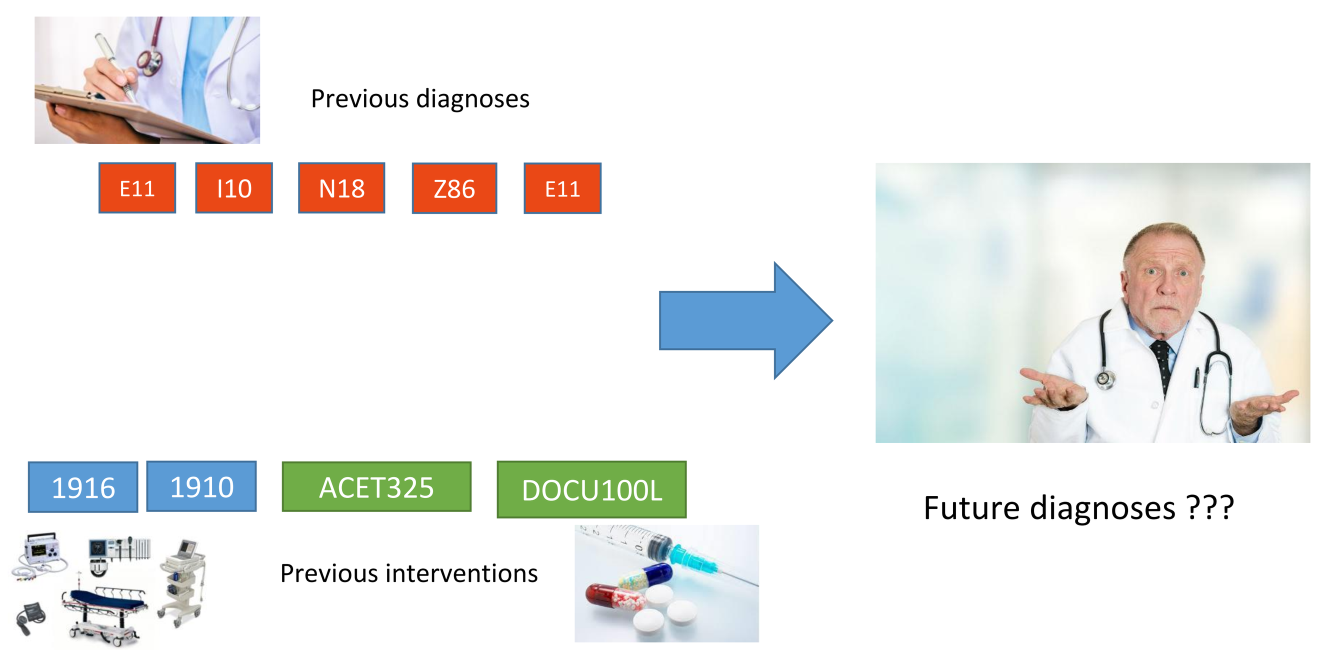
Applications in healthcare



Medicine prescription

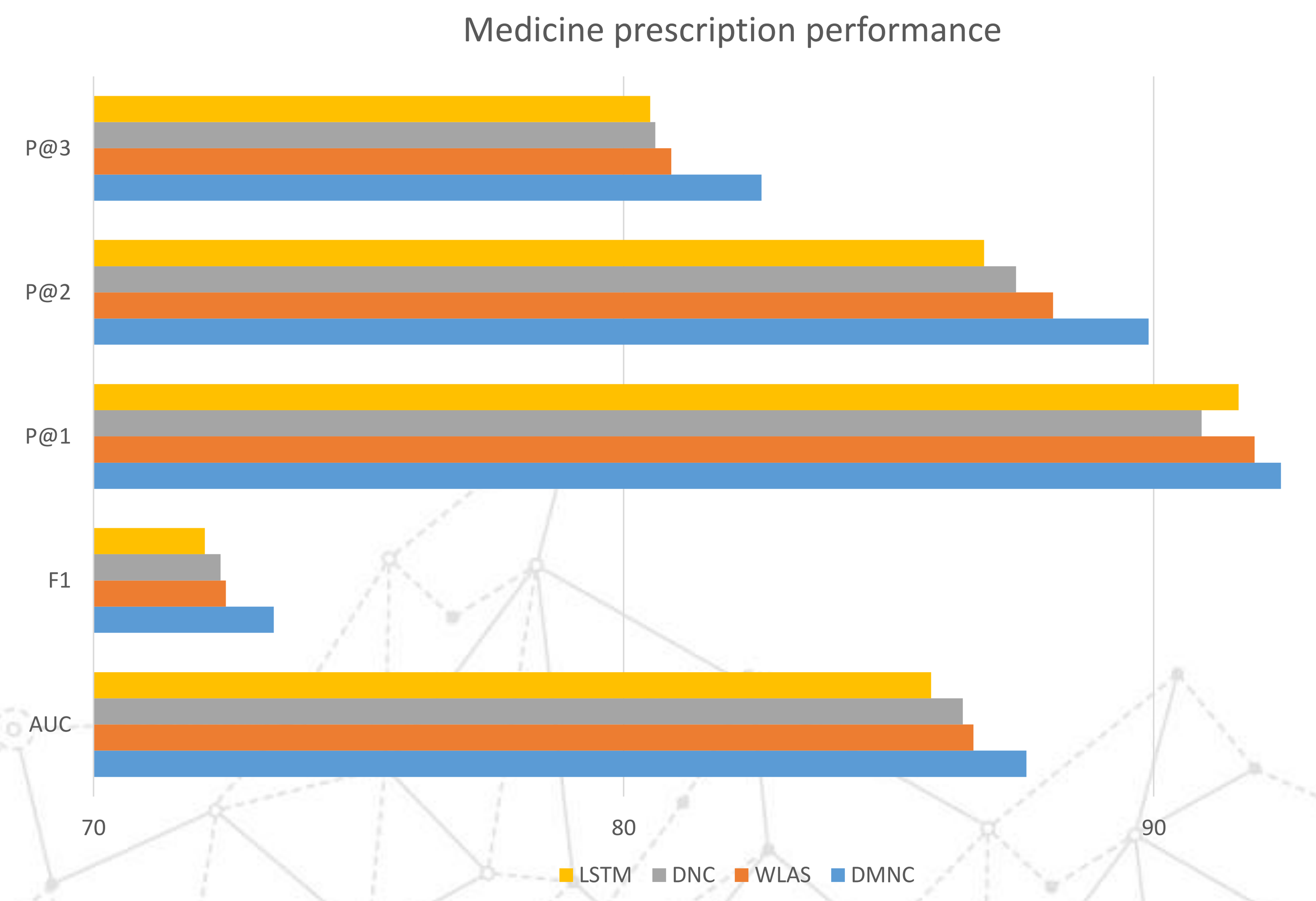


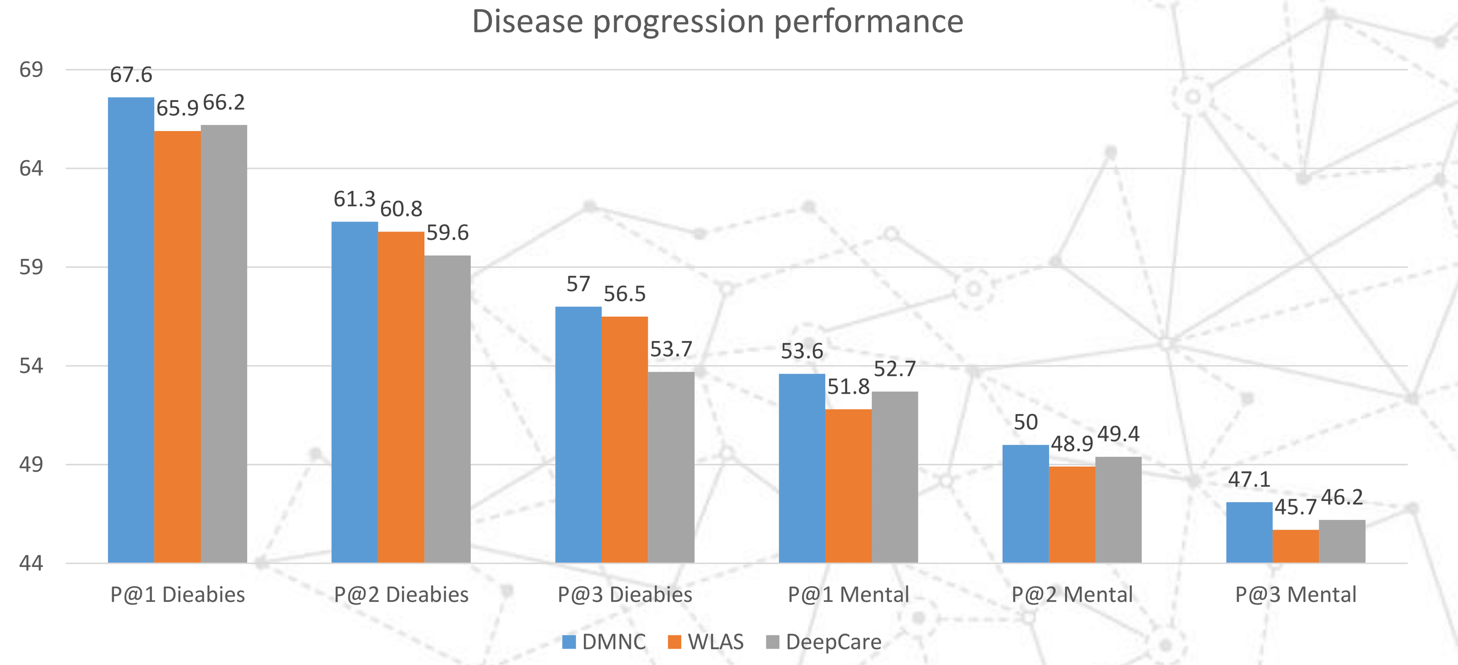
Disease progression



Results

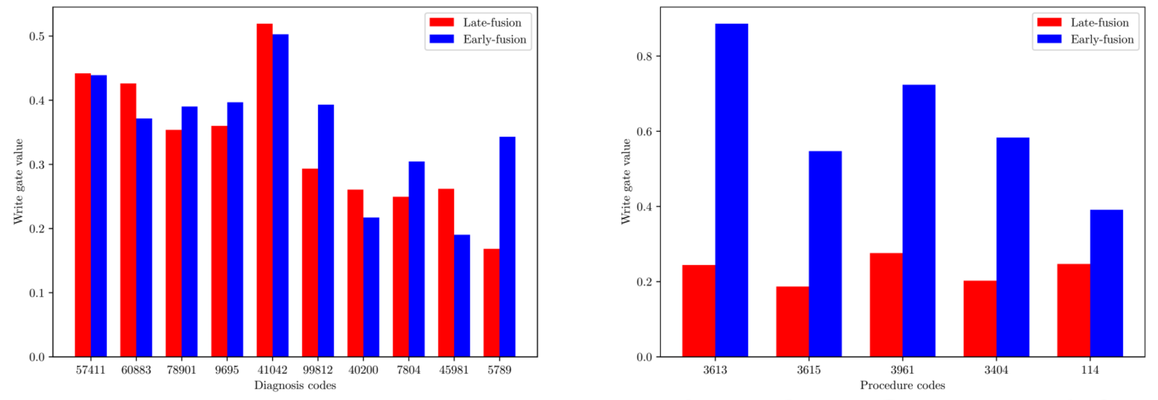
On synthetic sum of two sequence task, DMNC outperforms other baselines by a huge margin of >55% (prediction accuracy). On healthcare application tasks, DMNC consistently demonstrates better results over other baselines such as LSTM, DNC [1], WLAS [2], DeepCare [3].





Case study

Top-5 drugs prescribed for a patient given his current diagnoses and procedures: *Docusate Sodium (DOCU100L), Acetaminophen (ACET325), Potassium Chloride (KCLBASE2)*, Dextrose (DEX50SY), *Acetylsalicylic Acid (ASA81)*



Write gate scores that DMNC assigns to each timestep in two input sequences.

References

[1] Graves et al., Hybrid computing using a neural network with dynamic external memory. Nature, 2016

[2] Chung et al., Lip reading sentences in the wild. IEEE Conference on Computer Vision and Pattern Recognition, 2017

[3] Pham et al., Predicting healthcare trajectories from medical records: A deep learning approach. Journal of Biomedical Informatics, 2017