Methods		Phase gate	Event filter	Event gate
death prediction	AUC(1st epoch)	0.9301	0.9105	**0.9370**
	AUC	0.9471	**0.9518**	0.9516
	AP(1st epoch)	0.6856	0.6048	**0.7094**
	AP	0.7467	0.7679	**0.7687**
	Entropy(1st epoch)	0.1561	0.1835	**0.1479**
	Entropy	0.1369	0.1301	**0.1297**
abnormal lab test prediction	AUC(1st epoch)	0.7050	0.6747	**0.7275**
	AUC	0.7945	0.7559	**0.7987**
	AP(1st epoch)	0.2752	0.2403	**0.2965**
	AP	0.3875	0.3410	**0.3914**
	Entropy(1st epoch)	0.3373	0.3448	**0.3298**
	Entropy	0.3019	0.3178	**0.3003**

Table 4: Performance with different settings of the event gate

dency of heterogeneous events. Both the event gate and the event filter achieve good performance in all metrics and both datasets when the training is finished. For example, the event gate and the event filter improve the AUC of death prediction by 0.5% and 0.5% compared to the phase gate, while the improvements of AP are 2.8% and 2.9% and the improvements of entropy are 4.9% and 5.2%.

The phase gate helps to achieve a fast convergence in the early stage of training by fitting the multi-scaled sampling rates of different events. HE-LSTM and the model with only phase gate get much higher performance in all metrics and both datasets in the first epoch of training. Take results in lab test task for example, the phase gate and the event gate improve the AUC in first epoch by 4.6% and 7.9% compared to the event filter, while the improvements of AP are 14.5% and 23.3% and the improvements of entropy are 2.2% and 4.3%.

From these comparisons, we draw the conclusion that the event filter and the phase gate collaborates jointly in modeling the dependency in heterogeneous temporal events with the multi-scale sampling rates, which leads to the accurate and efficient performance on the clinical endpoint prediction task.

Experiment on varying length of multiple sequential data To evaluate the ability to model the temporal dependency of heterogeneous temporal events of our proposed architect and the other baselines, we feed the trained models multiple events in test set with various length, in the range of 20 to 1000, as input. From figure 3, we can draw the following conclusions:

Firstly, temporal information is effective for endpoint prediction tasks. The performances of most models improve with the increase of the input sequence length. Especially, the performance increases sharply when the length of input sequence is less than 200.

Secondly, HE-LSTM is better at handling the dependency of heterogeneous temporal events than other models. When the input sequence is short, the performances of different models are similar. The reason lies in the fact that, for short sequence input, the combination of independent representations of a single event makes less difference from the joint representation of heterogeneous events in HE-LSTM. But when the input sequence get longer and longer, the performance of our model steadily increase from 0.7551 to 0.7687 in term of AP and from 0.9482 to 0.9516 in term of AUC. The performance of other models remained almost unchanged at almost 0.9465 of AUC and 0.7434 of AP.

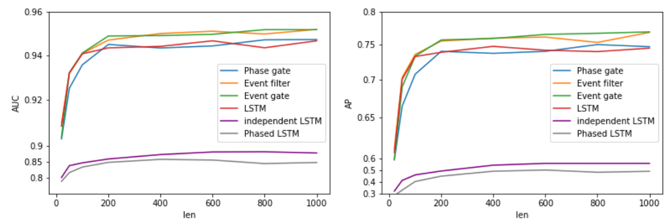

Figure 3: the performance on death prediction task with varying input length of the heterogeneous event sequence data

Different initial period To explore the effect of the event filter in the event gate when modeling heterogeneous sequential EHR data, we compare the performance of the proposed HE-LSTM with the reduced HE-LSTM, of which the event filter factor in the event gate is removed. We use different initial periods of τ during training for death prediction task. The period was drawn uniformly in the exponential domain, comparing four sampling intervals $\exp(U(1,2))$, $\exp(U(2,3))$, $\exp(U(3,4))$, and $\exp(U(4,5))$ for each model. The results in Figure.4 show that the initialization of τ affects the performance of both models. But HE-LSTM is more robust to the initialization. For example, the improvements of HE-LSTM compared to the one without event filter are 4.1%, 4.1%, 2.8%and 6.6% on average. We can draw the conclusion that, with the help of event filter, the event gate can be more adaptive to multi-scale sampling rates of the events in the heterogeneous temporal sequence.

Conclusion

In this paper, we propose a novel HE-LSTM model to learn joint representations of heterogeneous temporal events for clinical endpoint prediction. Our model can adaptively fit the multi-scaled sampling rates of events in the heterogeneous event sequence. By tracing the temporal information of different kinds of events in the long sequence, the temporal dependency of different types of events can be cap-

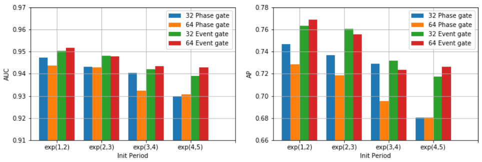

Figure 4: Different initial period

tured in our learned representations. Experimental results with real-world clinical data on the tasks of predicting death and abnormal lab tests prove the effectiveness of our proposed approach over competitive baselines.

Acknowledgement

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