Modeling User Fatigue for Sequential Recommendation

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Code: https://github.com/tsinghua-ffb-lab/SIGIR24-FRec

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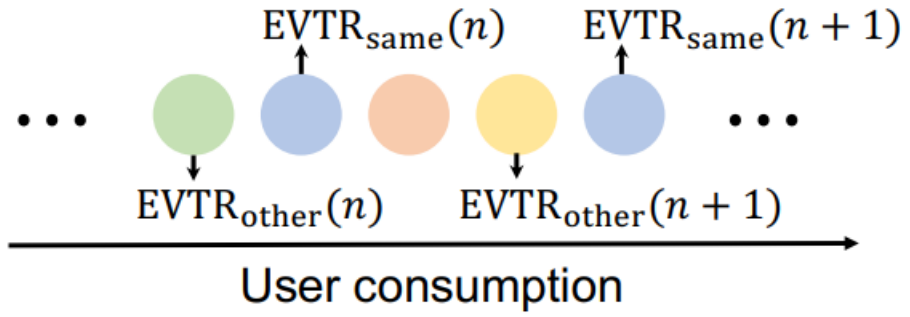
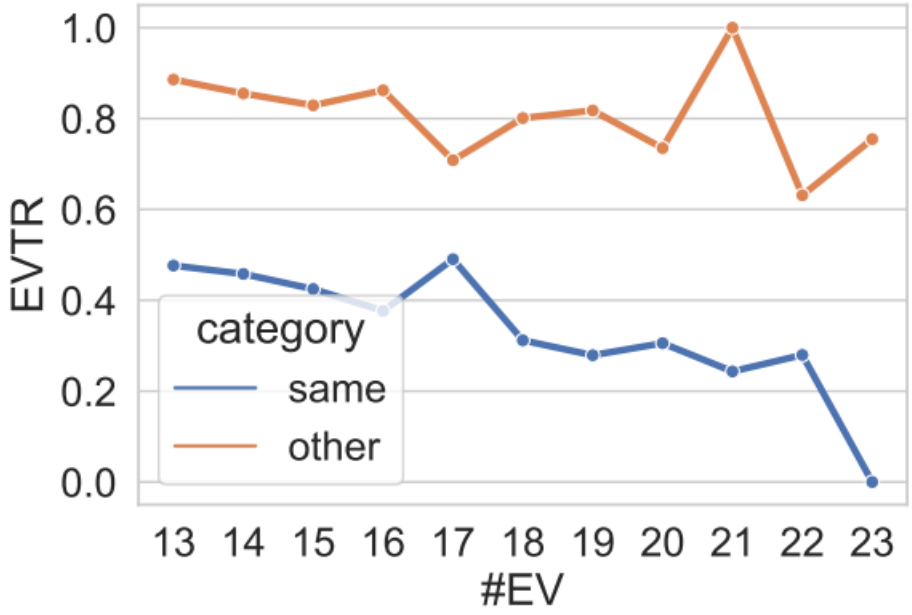
Introduction



(a) Illustration demo



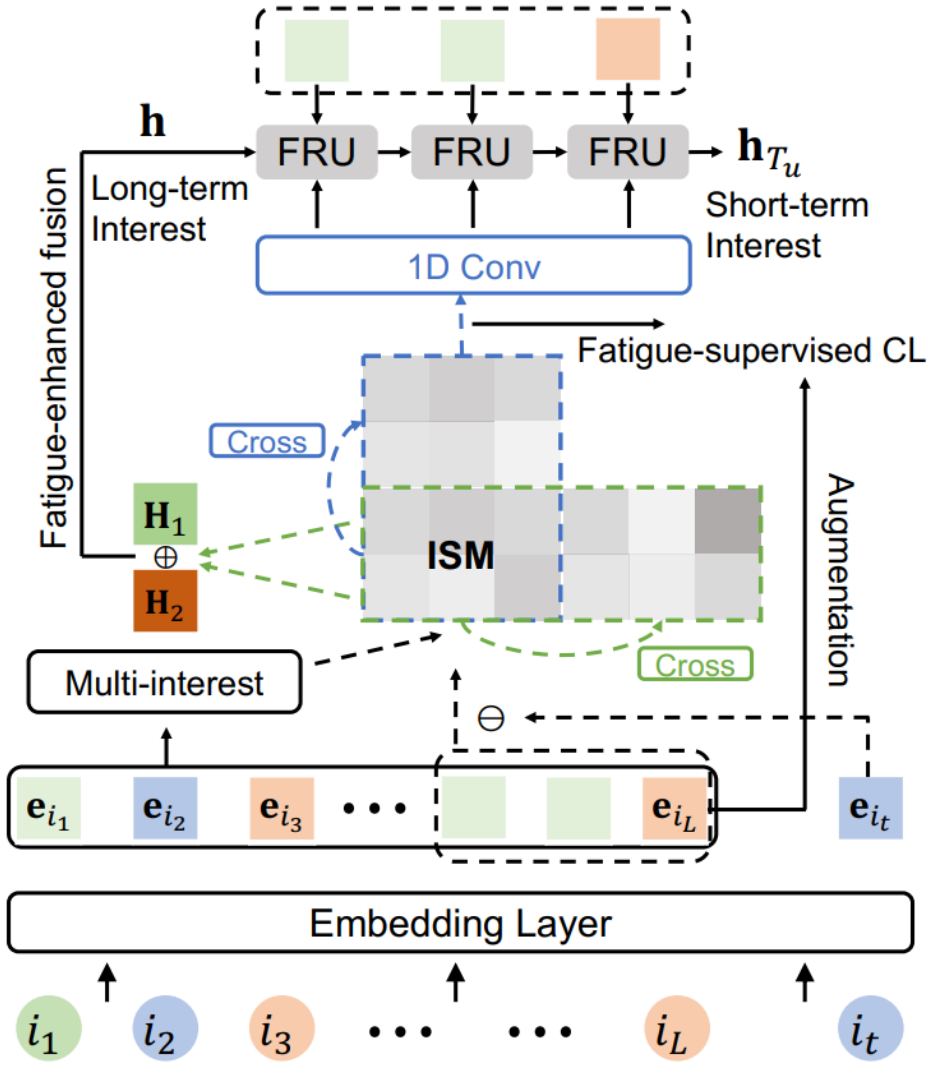
(b) EVTR trend

Fine-grained features are hard to obtain to support fatigue modeling

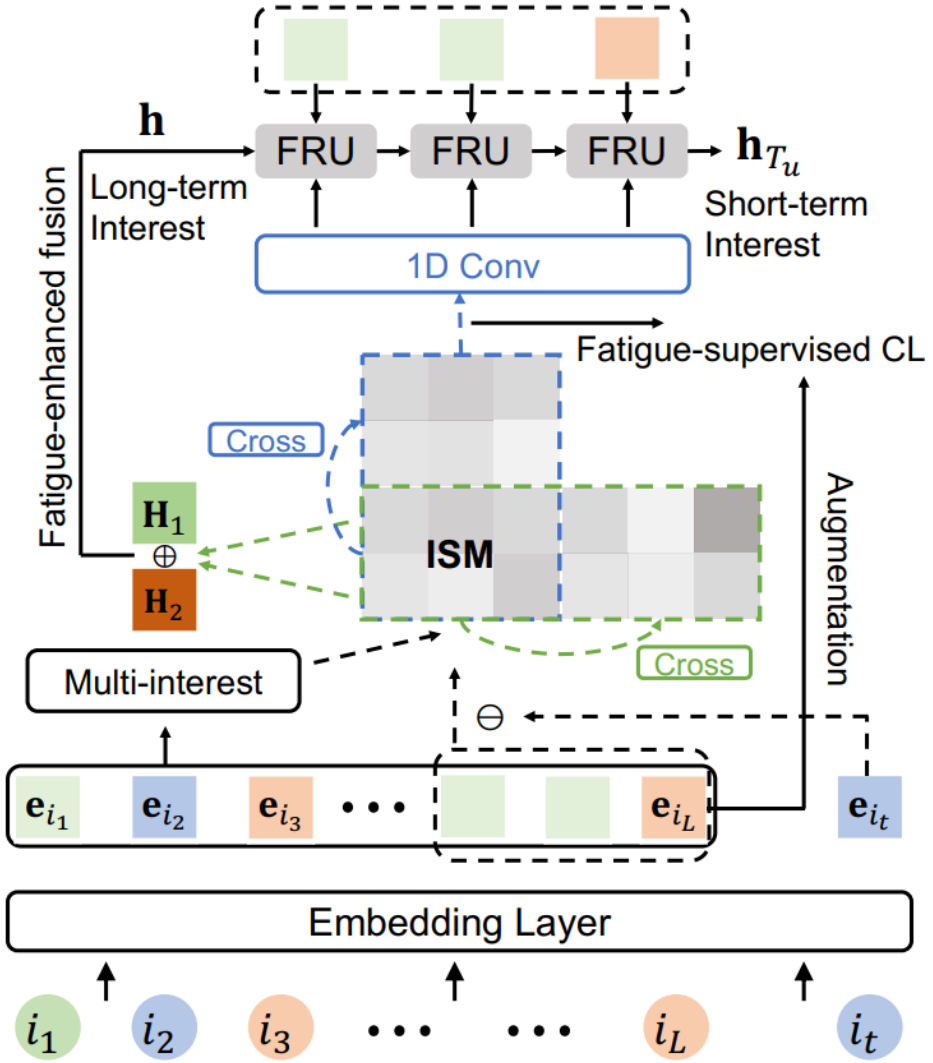
The inffuence of user fatigue on interests is complex.

There are no explicit signals of user fatigue contained in historical consumption.

Overview


h
FRU
FRU
FRU
$\mathbf{h}_{T_u}$
Long-term Interest
Short-term Interest
1D Conv
Fatigue-enhanced fusion
Fatigue-supervised CL
Cross
$\mathbf{H}_1$
$\mathbf{H}_2$
ISM
Augmentation
Multi-interest
Cross
$\mathbf{e}_{i_1}$ $\mathbf{e}_{i_2}$ $\mathbf{e}_{i_3}$ ... $\mathbf{e}_{i_L}$ $\mathbf{e}_{i_t}$
Embedding Layer
i_1 i_2 i_3 ... ... i_L i_t

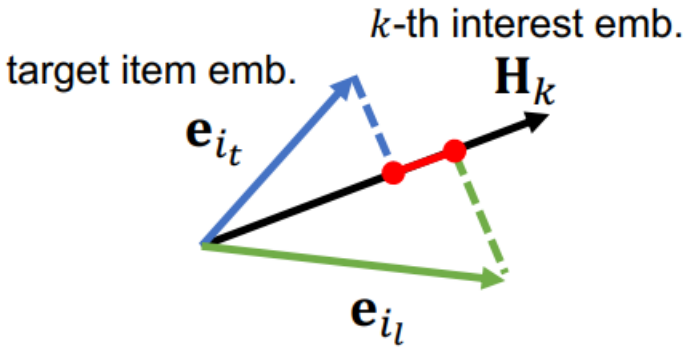
Method



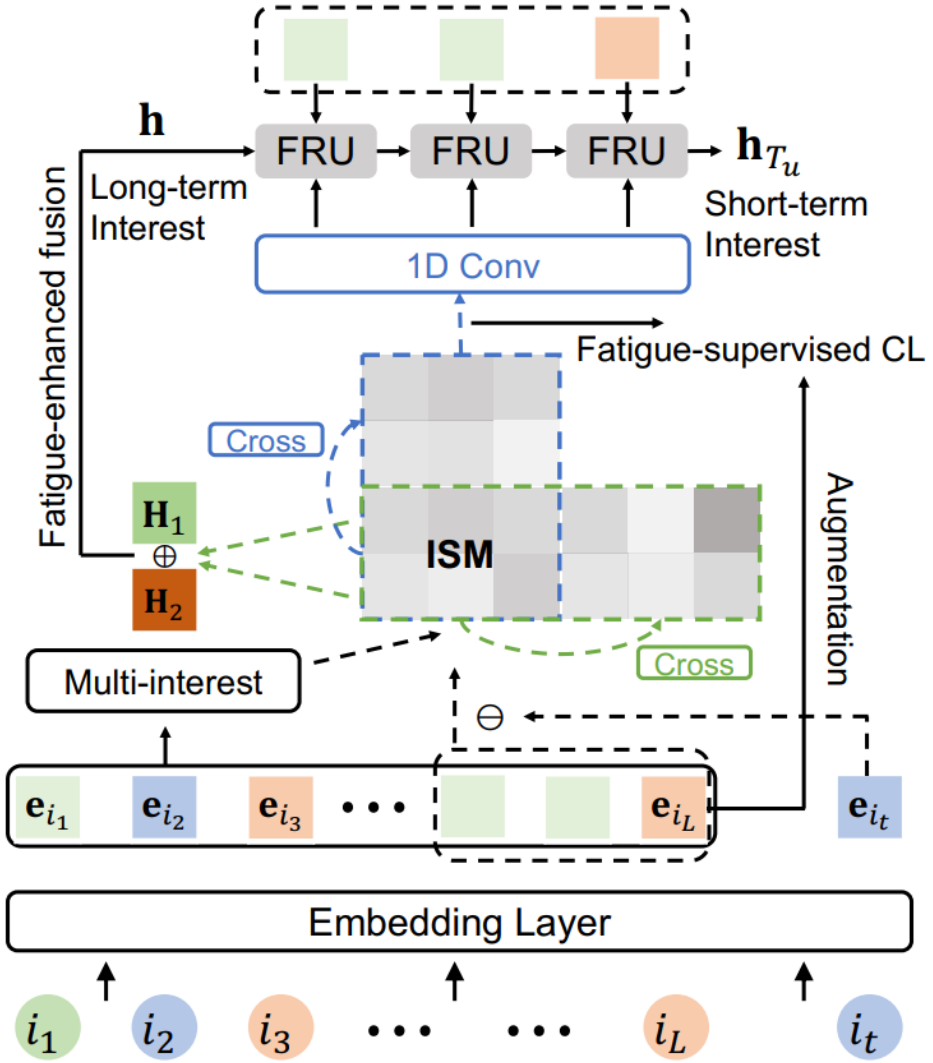
$$\mathbf{H} = \mathbf{S}_u \mathbf{A}, \quad \mathbf{A} = softmax(\mathbf{MLP}_1(\mathbf{S}_u^\top)), \tag{1}$$

$$\mathbf{F}_{l,k} = \frac{1}{1 + \left| \frac{\mathbf{e}_{i_t}^\top \mathbf{H}_k}{\|\mathbf{H}_k\|} - \frac{\mathbf{e}_{i_l}^\top \mathbf{H}_k}{\|\mathbf{H}_k\|} \right|}, \tag{2}$$

$$\mathbf{F} \in \mathbb{R}^{T \times K}$$



Method

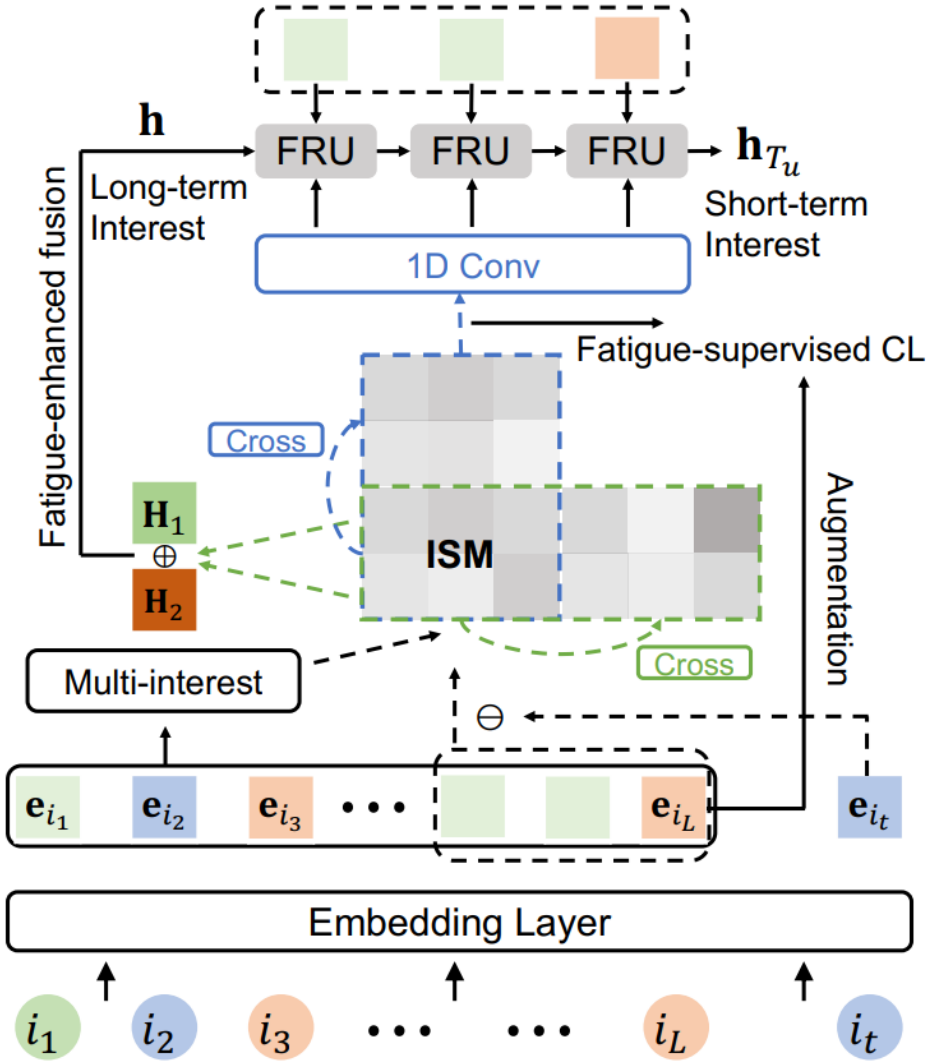


$$\mathbf{h} = \mathbf{H}\mathbf{w},$$
$$\mathbf{w} = softmax(\mathbf{MLP}_2(\mathbf{F}^\top)), \tag{3}$$

$$\mathbf{P}_{c+1} = \mathbf{P}_0 \odot (\mathbf{W}_c\mathbf{P}_c) + \mathbf{P}_c, \tag{4}$$

$$\mathbf{h} = \mathbf{H}\mathbf{w},$$
$$\mathbf{w} = softmax\left(\mathbf{MLP}_2\left([\mathbf{P}_C^\top, \mathbf{P}_0^\top]\right)\right). \tag{5}$$

Method

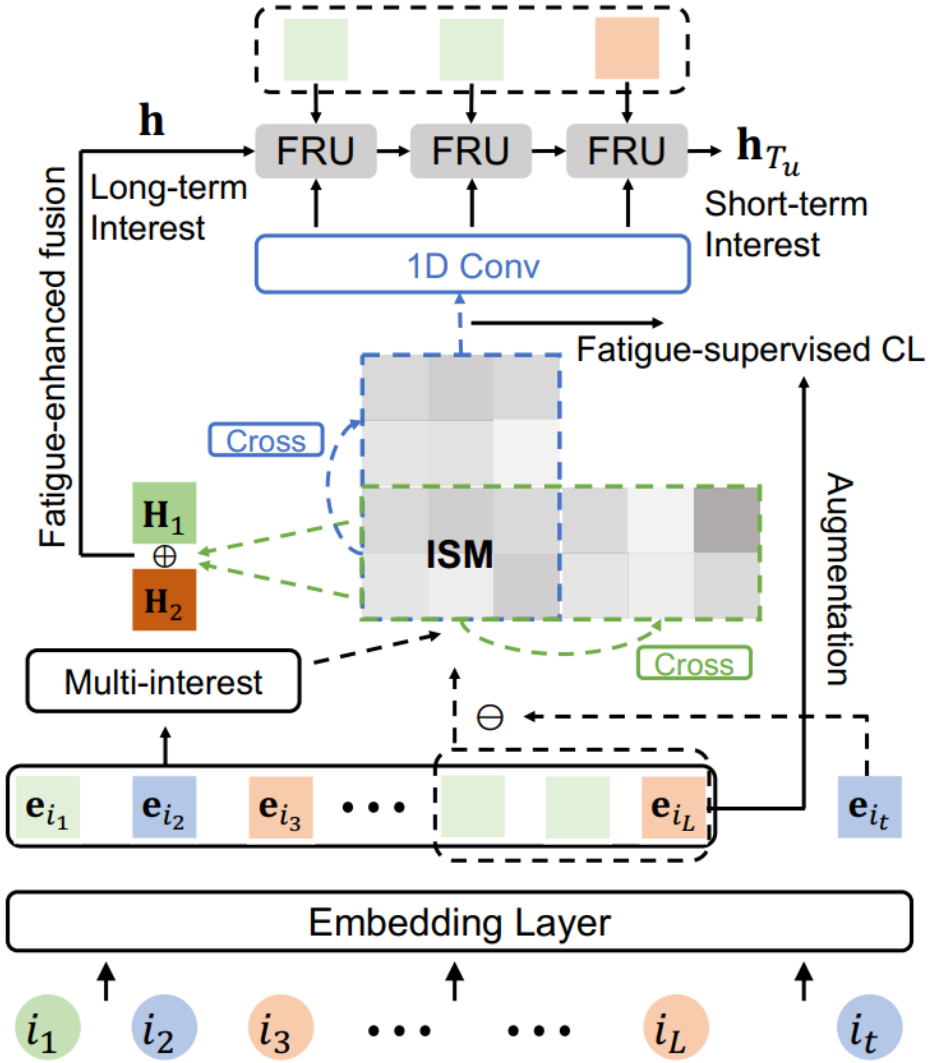


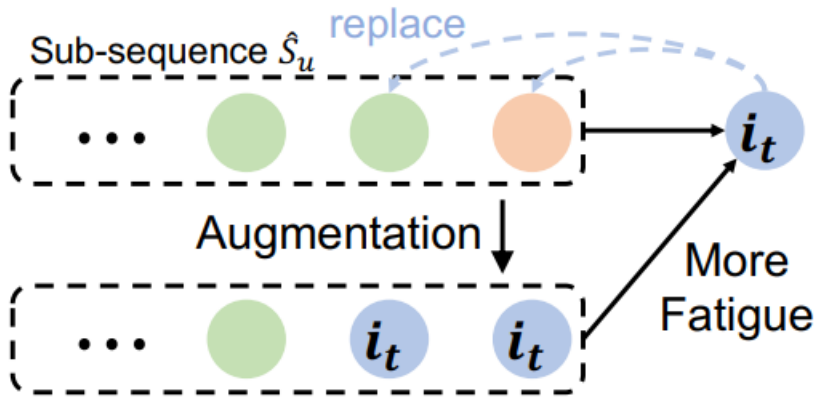
$$\mathbf{Q}_{c+1} = \mathbf{Q}_0 \odot (\mathbf{Q}_c \mathbf{W}'_c) + \mathbf{Q}_c, \tag{6}$$

$$\begin{aligned} \hat{\mathbf{Q}}_l^\top &= [q_l^1, q_l^2, \cdots, q_l^{d_{\text{out}}}]^\top, \\ q_l^n &= LeakyRelu\left(\text{SUM}\left(\hat{\mathbf{Q}}_{l-s+1:l}^\top \odot \mathbf{W}_{\text{conv}}^n\right)\right), \end{aligned} \tag{7}$$

$$\begin{aligned} \mathbf{z}_l &= sigmoid(\mathbf{W}_z \mathbf{x}_l + \mathbf{U}_z \mathbf{h}_{l-1} + \underline{\mathbf{V}_z \hat{\mathbf{Q}}_l} + \mathbf{b}_z), \\ \mathbf{r}_l &= sigmoid(\mathbf{W}_r \mathbf{x}_l + \mathbf{U}_r \mathbf{h}_{l-1} + \underline{\mathbf{V}_r \hat{\mathbf{Q}}_l} + \mathbf{b}_r), \\ \hat{\mathbf{h}}_l &= tanh\left(\mathbf{W}_h \mathbf{x}_l + \mathbf{U}_h(\mathbf{r}_l \odot \mathbf{h}_{l-1}) + \mathbf{b}_h\right), \\ \mathbf{h}_l &= (1 - \mathbf{z}_l) \odot \mathbf{h}_{l-1} + \mathbf{z}_l \odot \hat{\mathbf{h}}_l, \end{aligned} \tag{8}$$

Method

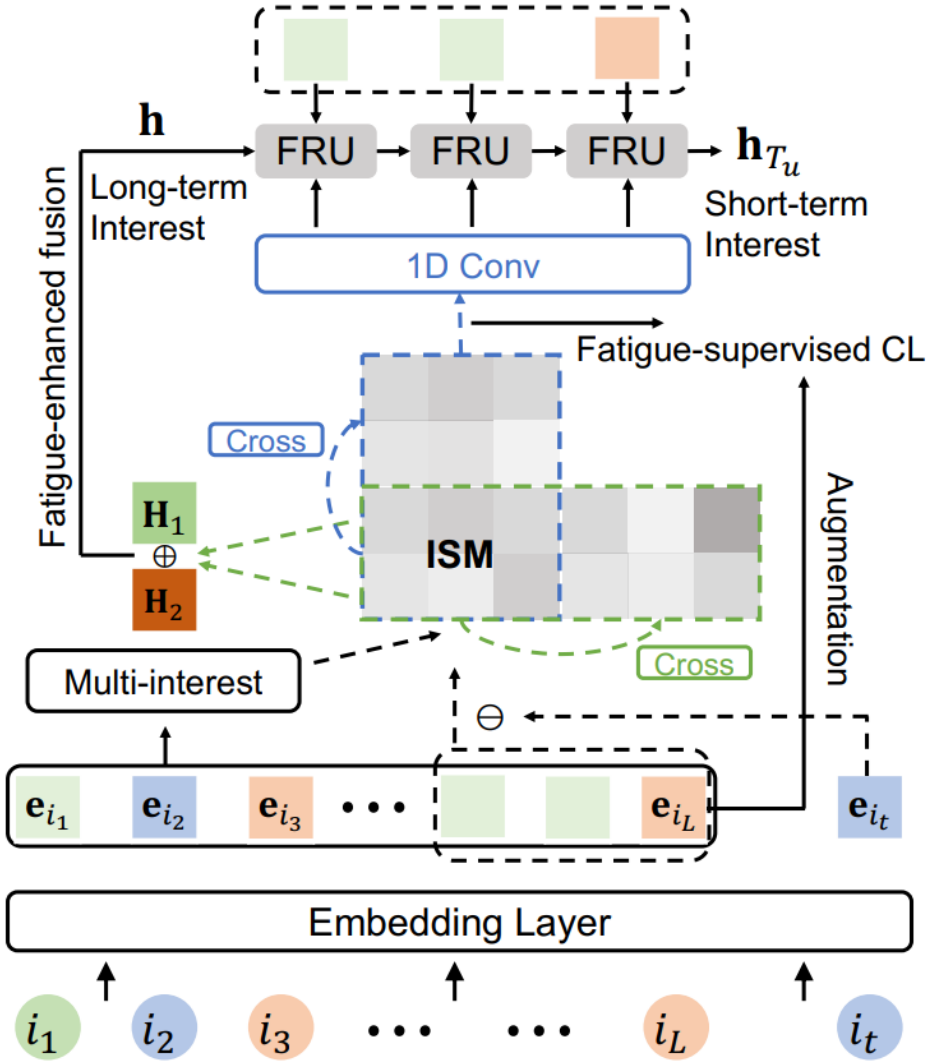




$$f = \mathrm{MEAN}\left(\mathbf{MLP}_3\left([\mathbf{Q}_C, \mathbf{Q}_0]\right)\right),$$
$$f' = \mathrm{MEAN}\left(\mathbf{MLP}_3\left([\mathbf{Q}'_C, \mathbf{Q}'_0]\right)\right). \tag{9}$$

$$\mathcal{L}_{\mathrm{con}} = \sum -\log \frac{\exp(-f)}{\exp(-f) + \sum_{j=1}^{4} \exp(-f'_j)}, \tag{10}$$

Method



$$y_{u,i_t} = \mathbf{MLP}_4([\mathbf{h}^\top, \mathbf{h}_{T_u}^\top, \mathbf{e}_{i_t}^\top]) - tanh(f). \tag{11}$$

$$\mathcal{L}_{\text{rec}} = \sum_{(u,i_t,i_1' \sim i_4') \in O} -\log \frac{\exp(y_{u,i_t})}{\exp(y_{u,i_t}) + \sum_{j=1}^{4} \exp(y_{u,i_j'})}, \tag{12}$$

$$\mathcal{L} = \mathcal{L}_{\text{rec}} + \alpha \mathcal{L}_{\text{con}}, \tag{13}$$

Experiments

Dataset	#Users	#Items	#Instances	Avg. Length
Kuaishou	37,502	131,063	6,427,764	171.4
Taobao	41,101	90,524	2,256,967	54.9
Industrial	38,467,817	19,863,454	804,934,827	20.9

Experiments

	Model	DIN	DIEN	GRU4Rec	SASRec	AdaMCT	Caser	SLi-Rec	CLSR	SUM	ComiRec -DR	ComiRec -SA	MGNM	DFN	FRec
Kuaishou	AUC	0.6054	0.7520	0.8306	0.8298	0.8067	0.8228	0.8258	0.8263	0.8235	0.8239	0.8441	OOM[7]	0.6613	**0.8533**
	GAUC	0.8204	0.8198	0.8401	0.8270	0.8033	0.8417	0.8388	0.8473	0.8414	0.8259	0.8464	OOM	0.8159	**0.8564**
	HR@2	0.6179	0.6249	0.6570	0.6226	0.5776	0.6552	0.6651	0.6703	0.6570	0.6301	0.6658	OOM	0.6284	**0.6878**
	HR@4	0.8269	0.8356	0.8642	0.8466	0.8172	0.8683	0.8585	0.8747	0.8670	0.8429	0.8705	OOM	0.8424	**0.8860**
	NDCG@2	0.5417	0.5484	0.5784	0.5428	0.4982	0.5749	0.5897	0.5901	0.5779	0.5523	0.5869	OOM	0.5509	**0.6077**
	NDCG@4	0.6403	0.6479	0.6765	0.6486	0.6112	0.6758	0.6812	0.6869	0.6772	0.6527	0.6837	OOM	0.6519	**0.7016**
	MRR	0.6045	0.6111	0.6355	0.6073	0.5719	0.6327	0.6442	0.6444	0.6353	0.6143	0.6422	OOM	0.6136	**0.6583**
Taobao	AUC	0.6800	0.7592	0.8257	0.8455	0.8412	0.8264	0.8333	0.8527	0.8247	0.7820	0.8359	0.7291	0.7630	**0.8795**
	GAUC	0.8469	0.8263	0.8327	0.8430	0.8336	0.8376	0.8381	0.8601	0.8281	0.7779	0.8333	0.7279	0.8459	**0.8792**
	HR@2	0.7072	0.6737	0.6922	0.6964	0.6842	0.6878	0.6857	0.7305	0.6818	0.5675	0.6667	0.4897	0.7144	**0.7660**
	HR@4	0.8585	0.8393	0.8331	0.8460	0.8325	0.8417	0.8464	0.8667	0.8312	0.7702	0.8374	0.7055	0.8485	**0.8873**
	NDCG@2	0.6444	0.6101	0.6397	0.6373	0.6268	0.6311	0.6224	0.6754	0.6248	0.5010	0.6039	0.4258	0.6631	**0.7143**
	NDCG@4	0.7159	0.6883	0.7061	0.7079	0.6967	0.7036	0.6983	0.7397	0.6953	0.5964	0.6845	0.5271	0.7263	**0.7716**
	MRR	0.6897	0.6623	0.6888	0.6851	0.6765	0.6818	0.6723	0.7177	0.6752	0.5736	0.6585	0.5121	0.7082	**0.7501**

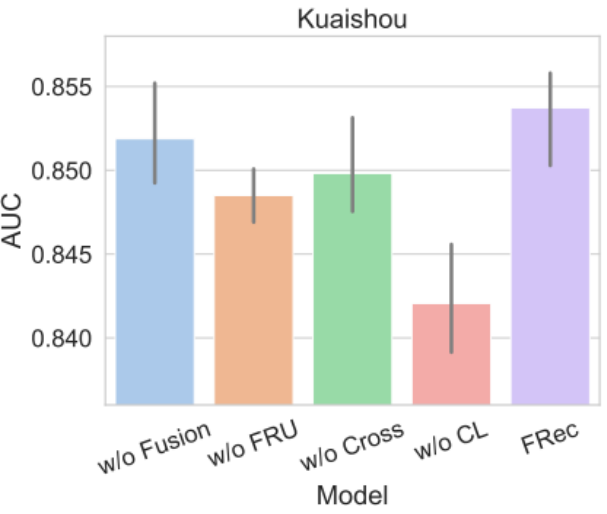
Experiments

Metric	GRU4Rec	SLi-Rec	CLSR	ComiRec-SA	FRec
AUC	0.7252	0.7302	0.7267	0.7247	**0.7408**
GAUC	0.6525	0.6604	0.6584	0.6433	**0.6709**

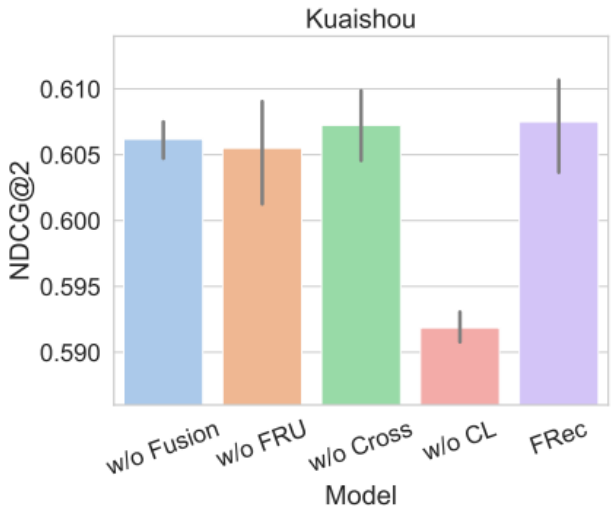
Experiments

Model	DIN	DIEN	GRU4Rec	SASRec	AdaMCT	Caser	SLi-Rec	CLSR	SUM	ComiRec -DR	ComiRec -SA	MGNM	DFN	FRec
Kuaishou	17.0	17.2	18.8	59.3	17.8	16.8	24.1	21.7	83.2	16.6	17.0	OOM	19.5	23.2
Taobao	7.8	8.5	9.8	14.0	9.0	13.4	11.1	11.3	35.3	7.9	7.9	30.0	10.0	12.7

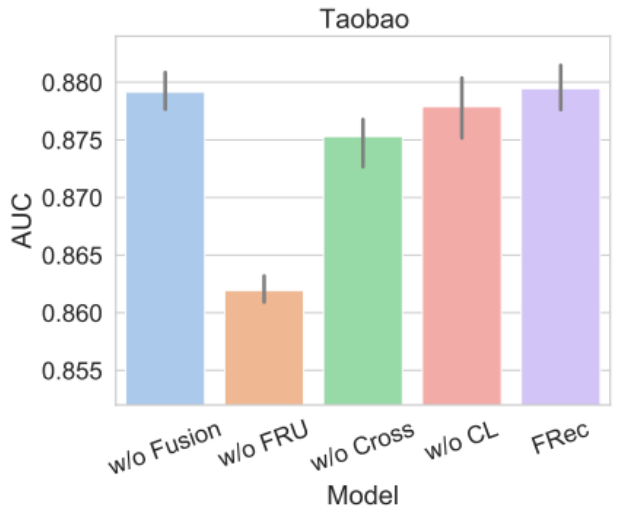
Experiments



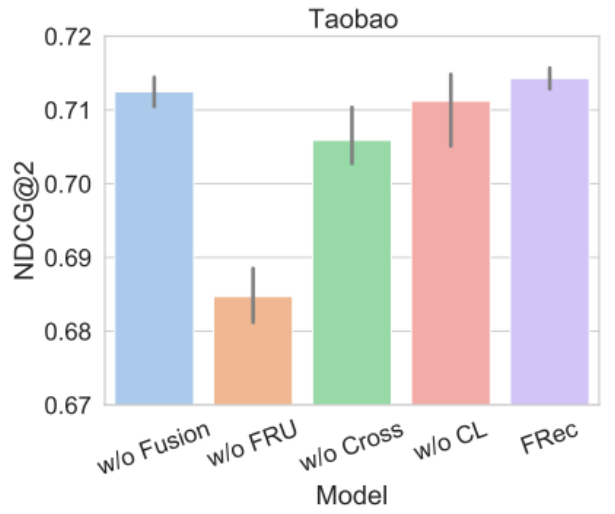
(a) AUC on Kuaishou



(b) NDCG@2 on Kuaishou



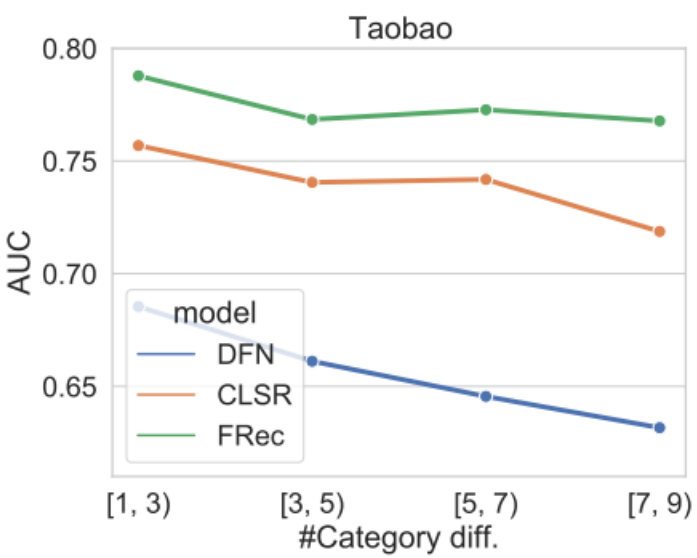
(c) AUC on Taobao



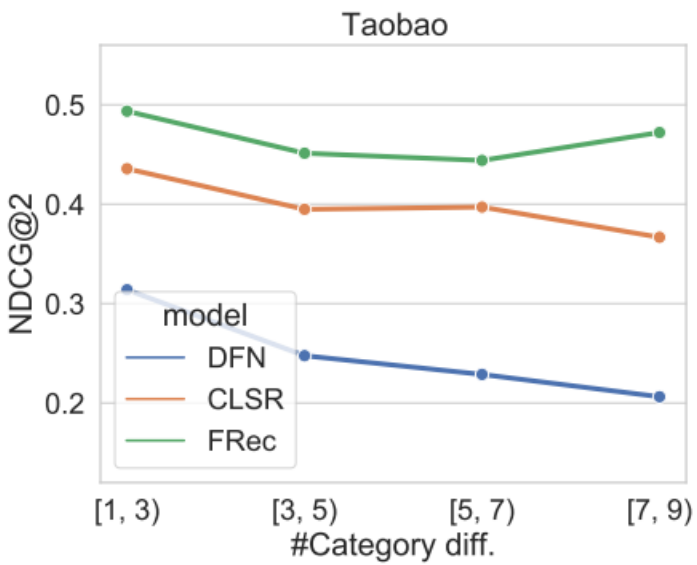
(d) NDCG@2 on Taobao

Experiments

$$m = \sum_{i_n} (m_{i_n} - m_{i_p}), \tag{14}$$



(a) AUC on Taobao



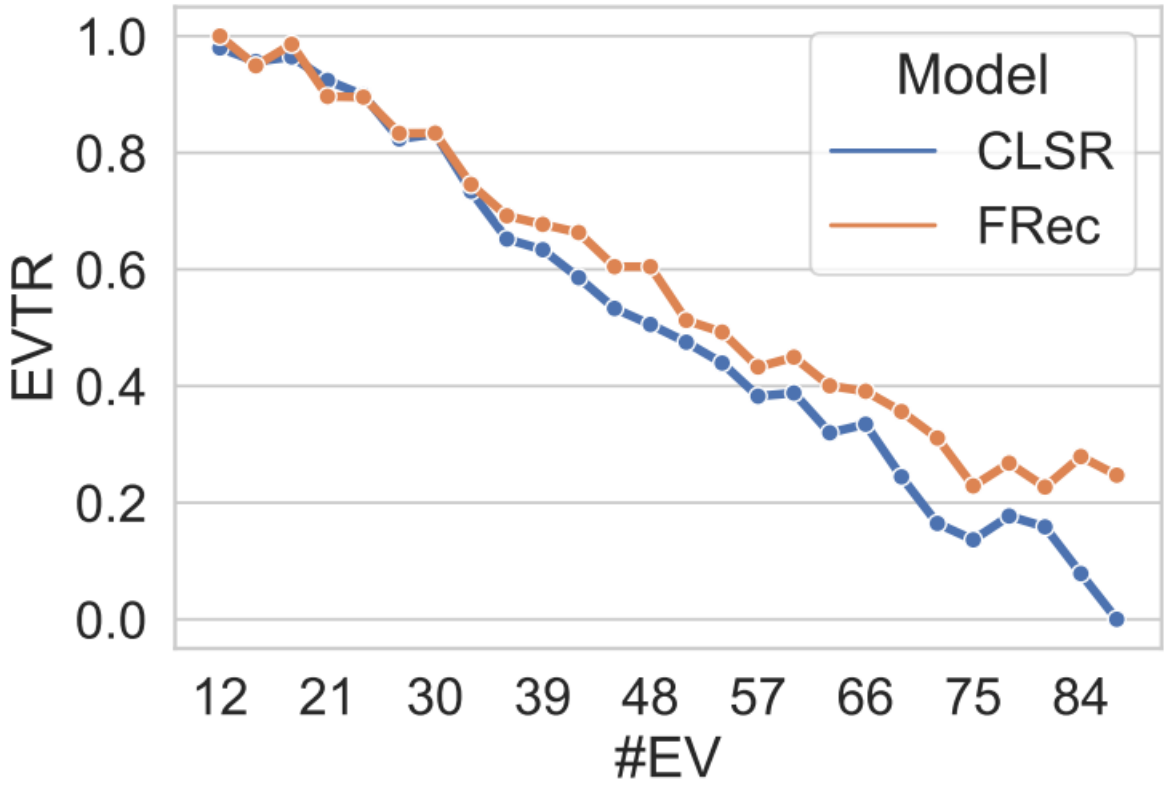
(b) NDCG@2 on Taobao

Experiments

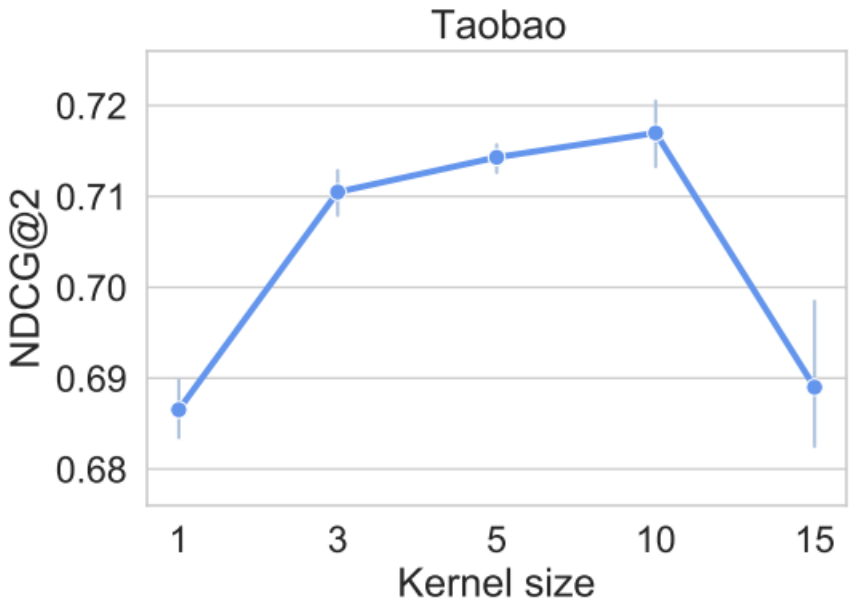
Table 6: The improvement of key online metrics. ↑ (↓) means higher (lower) is better.

Metric	App usage ↑	#Play ↑	#Category ↑	Concentration ↓
Impr. (%)	+0.300	+0.466	+0.408	-0.136

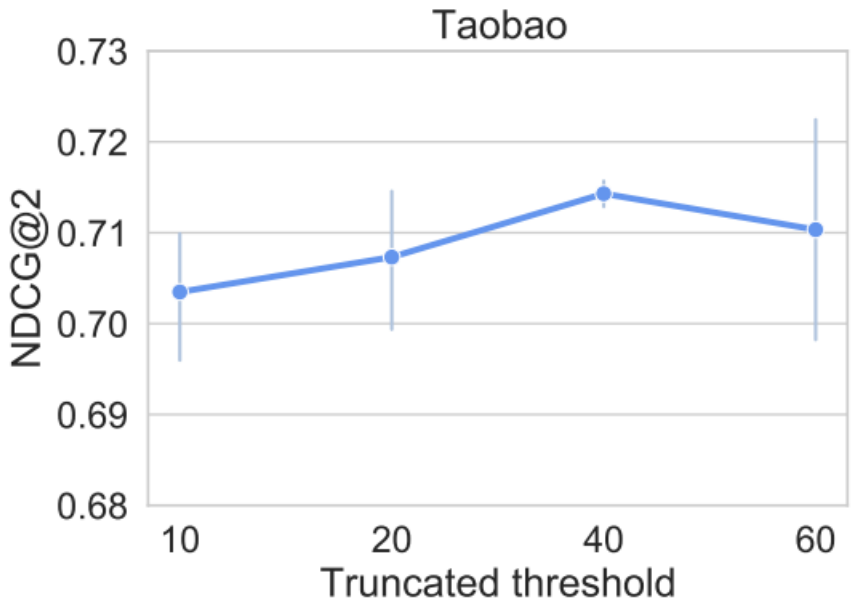
Experiments



Experiments



(a) Kernel size



(b) Truncated threshold

Thanks!