Modeling Temporal Positive and Negative Excitation for Sequential Recommendation

Chengkai Huang*
chengkai.huang1@unsw.edu.au
The University of New South Wales
Sydney, NSW, Australia

Shoujin Wang
shoujin.wang@uts.edu.au
University of Technology Sydney
Sydney, NSW, Australia

Xianzhi Wang
XIANZHI.WANG@uts.edu.au
University of Technology Sydney
Sydney, NSW, Australia

Lina Yao
lina.yao@unsw.edu.au
CSIRO's Data 61 and UNSW
Sydney, NSW, Australia

code:None

WWW 2023

Reported by Minqin Li

Introduction

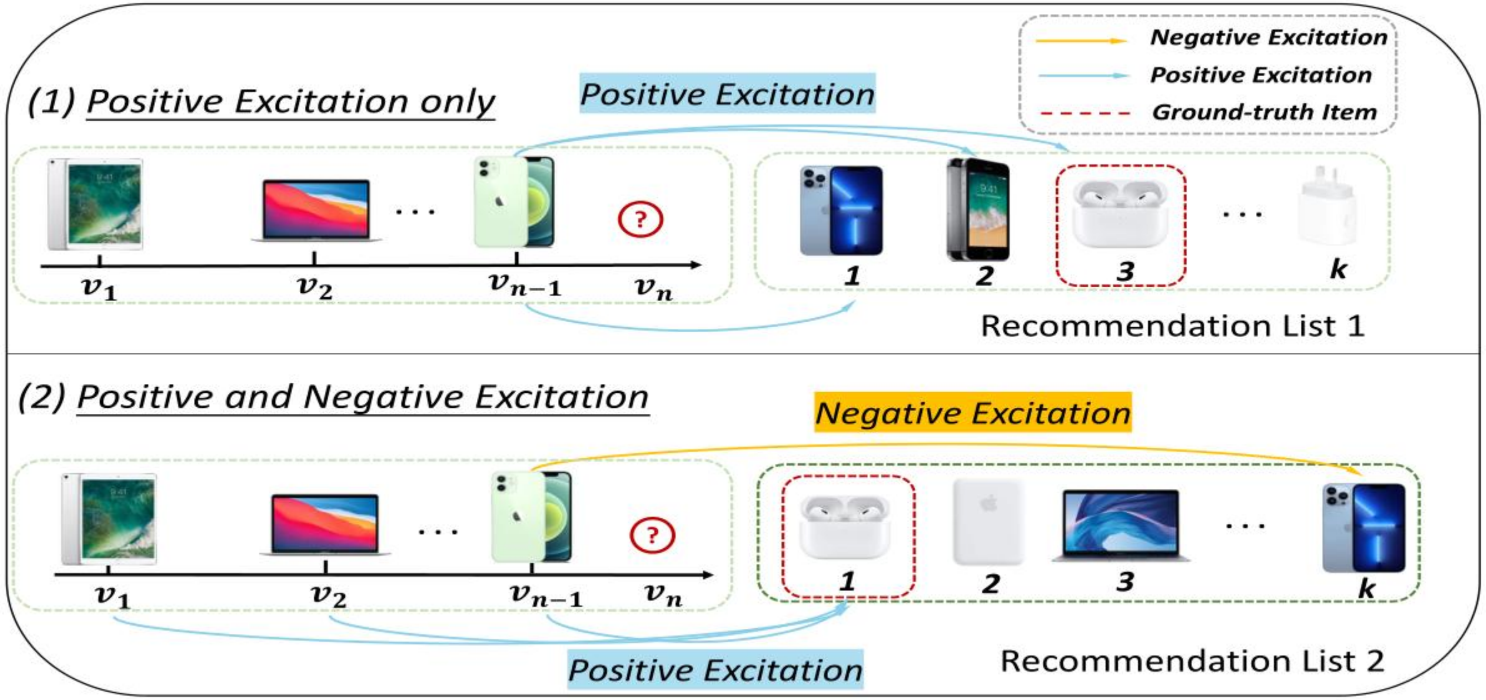


Figure 1: An example of recommendations via modeling positive excitation only (existing methods) and modeling both positive and negative excitation (our proposal). Clearly, the latter achieves better performance via ranking the ground-truth next item AirPods at the Top-1 position in the recommendation list.

Most of the existing SRSs only model users' dynamic interest in items while overlooking users' static interest.

Most of the existing SRSs cannot thoroughly capture users' dynamic interest since they often only model the positive excitation while overlooking negative one.

Method

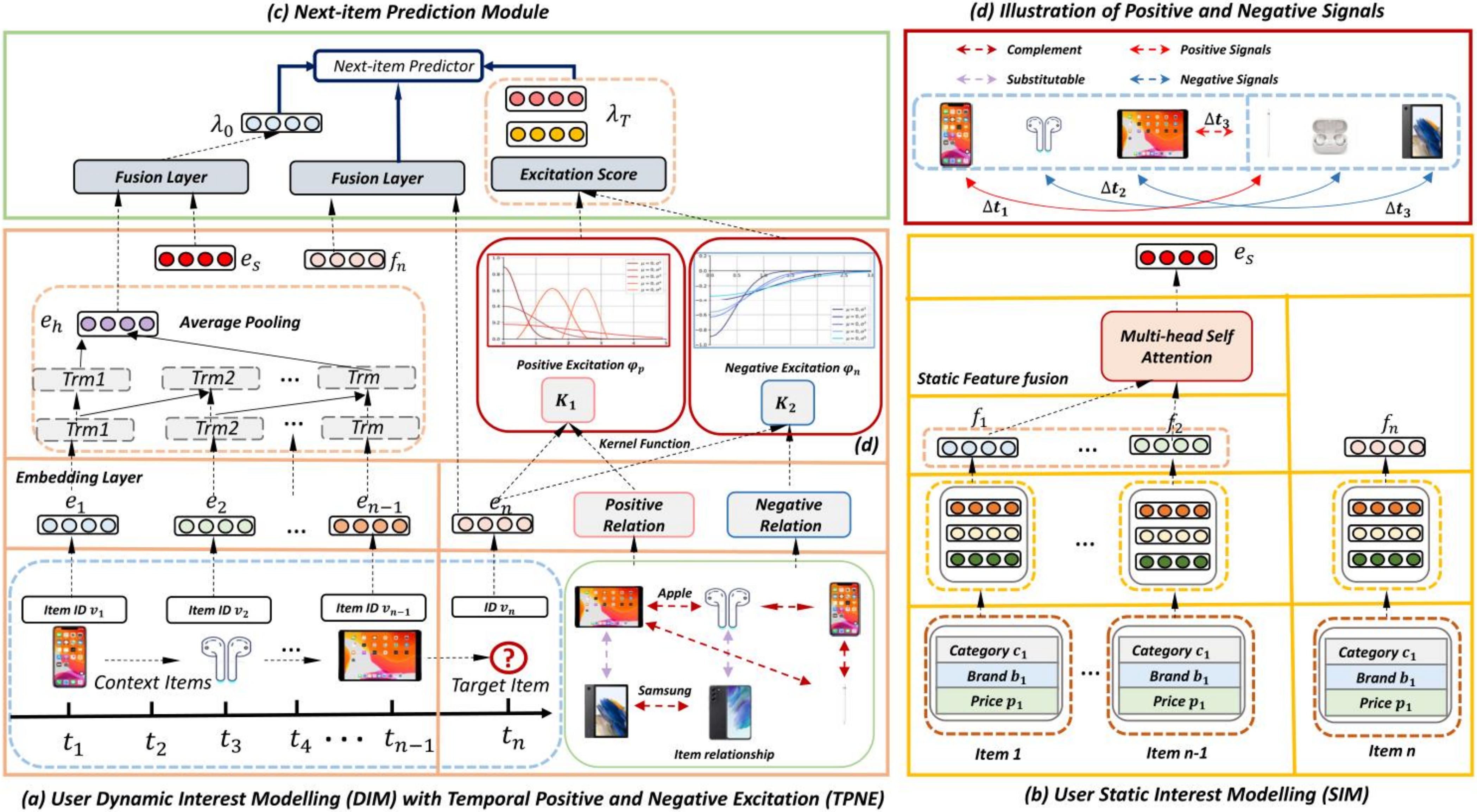
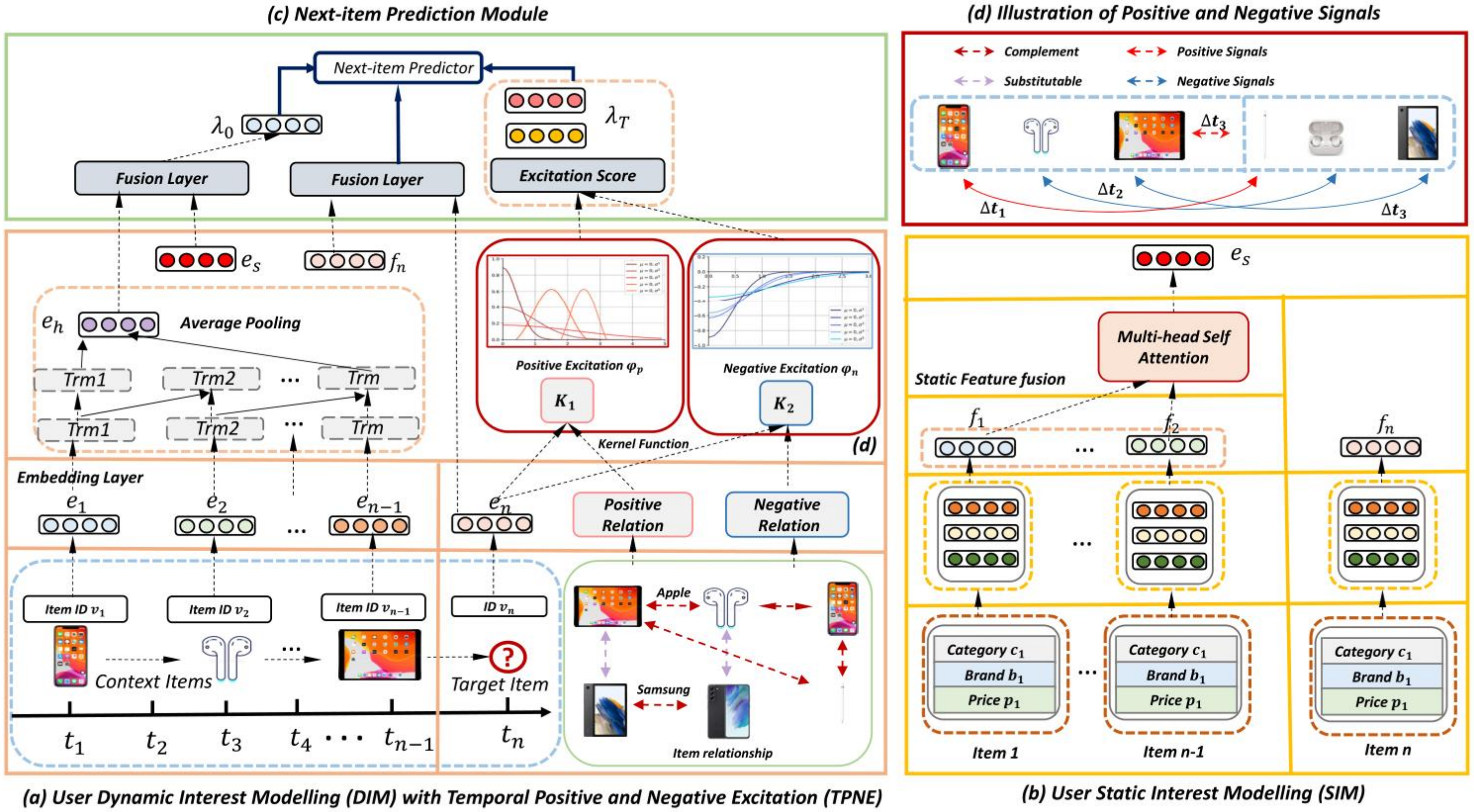


Figure 2: The framework of our proposed SDIL framework.

Four explicit relations:
also_buy (1),
also_view (2),
share_brand (3),
similar_item (4).

Method



$$\lambda(t) = \mu(t) + \sum_{t_i<t} \varphi(t - t_i) \tag{1}$$

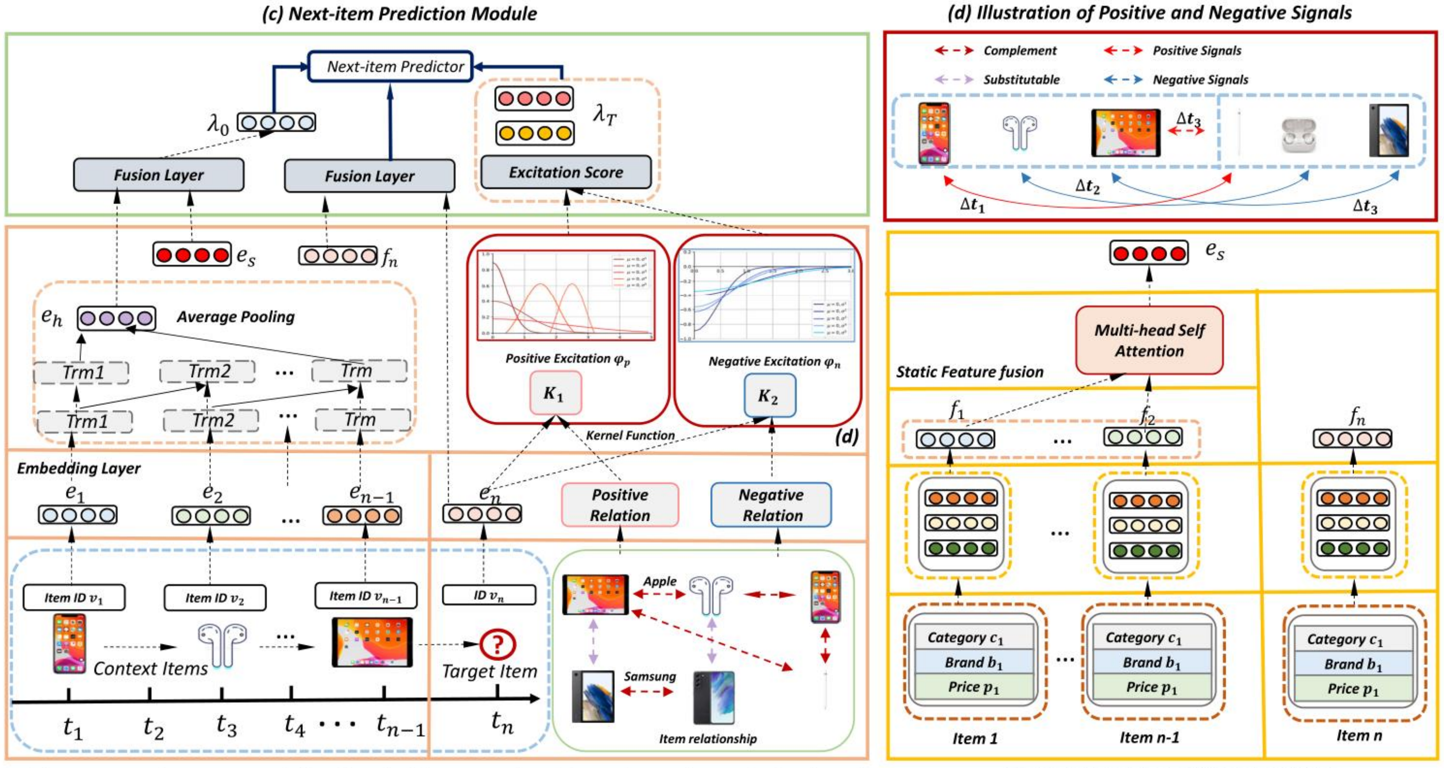
$$\lambda_T(t) = \lambda_0 + \sum_{i:t_i<t_n} \varphi(t_n - t_i) \tag{2}$$

$$\lambda_0 = e_h^T e_{v_n} + u_b + i_b \tag{3}$$

$$A_i = Att((E(H_u)+POS_i)W^Q, (E(H_u)+POS_i)W^K, (E(H_u)+POS_i)W^V) \tag{4}$$

$$Att_i = Attention(Q, K, V) = \text{softmax}\left(\frac{QK^\top}{\sqrt{d}}\right)V \tag{5}$$

Method



(a) User Dynamic Interest Modelling (DIM) with Temporal Positive and Negative Excitation (TPNE)
(b) User Static Interest Modelling (SIM)

$$E(H_u) = LayerNorm(H_u + Dropout(FFN(A_i))) \quad (6)$$

$$e_h = \frac{1}{|N|-1}\sum_{i=1}^{n-1} E(H_u)_i \quad (7)$$

$$\lambda_T(t) = \lambda_0 + \sum_{i:t_i<t_n} \varphi_p(t_n - t_i) - \sum_{j:t_j<t_n} \varphi_n(t_n - t_j) \quad (8)$$

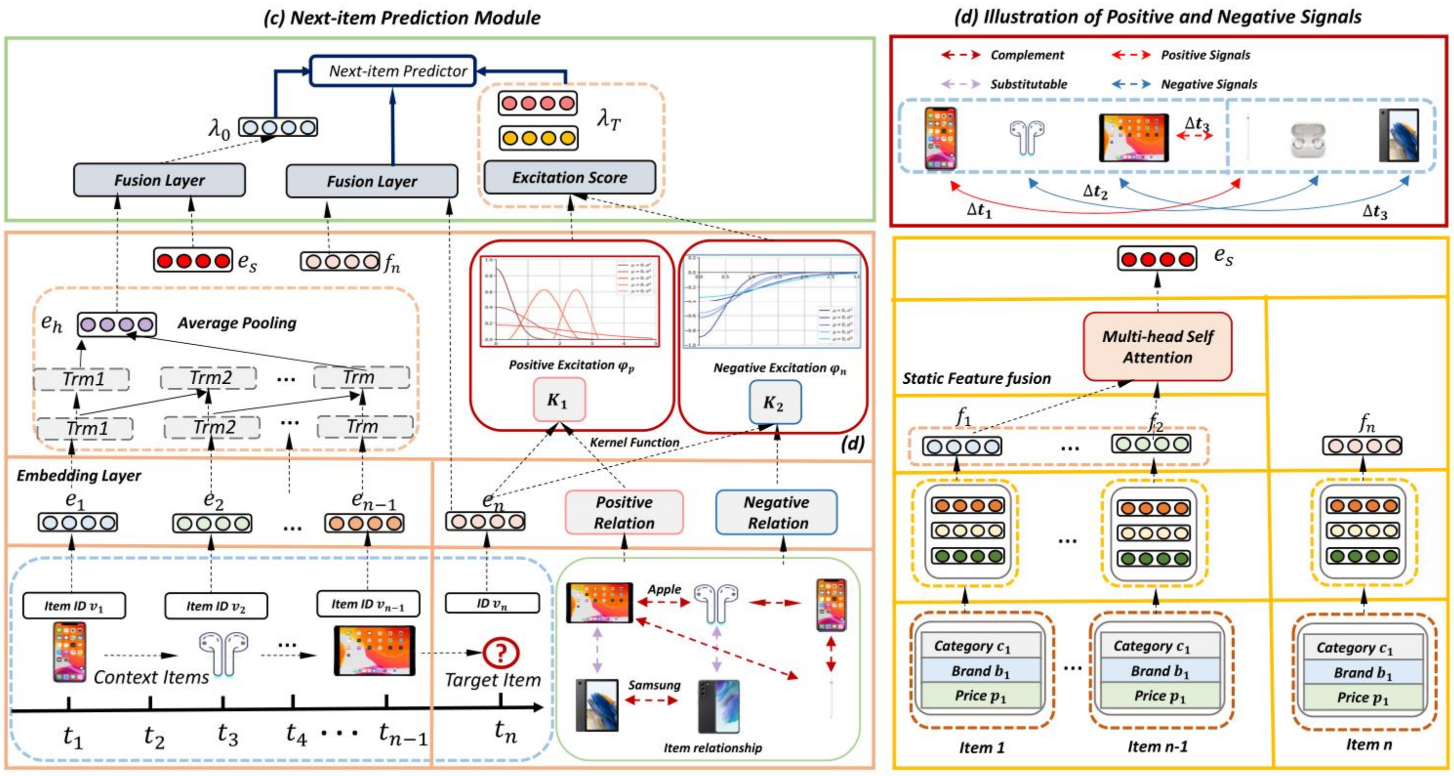
$$\varphi_p(t_n - t_i) = \sum_{i:t_i<t} I_{rp}(v_i, v_n)\mathcal{K}_1(t_n - t_i) \quad (9)$$

$$\mathcal{K}_1^i(\Delta t_1) = N\left(\Delta t_1 \mid 0, \sigma_1^v\right) + N\left(\Delta t_1 \mid \mu_2^v, \sigma_2^v\right) \quad (10)$$

$$\varphi_n(t_n - t_j) = \sum_{j:t_j<t_n} I_{rn}(v_j, v_n)\mathcal{K}_2(t_n - t_j) \quad (11)$$

$$\mathcal{K}_2(\Delta t_2) = -N\left(\Delta t_2 \mid 0, \sigma_3^v\right) \quad (12)$$

Method



(a) User Dynamic Interest Modelling (DIM) with Temporal Positive and Negative Excitation (TPNE)
(b) User Static Interest Modelling (SIM)

$$f_i = c_i + b_i + p_i \tag{13}$$

$$H_f = Att(FW^Q, FW^K, FW^V) \tag{14}$$

$$M_f = Multihead(F) = Concat(h_1, h_2, \ldots, h_{l_f})W^O \tag{15}$$

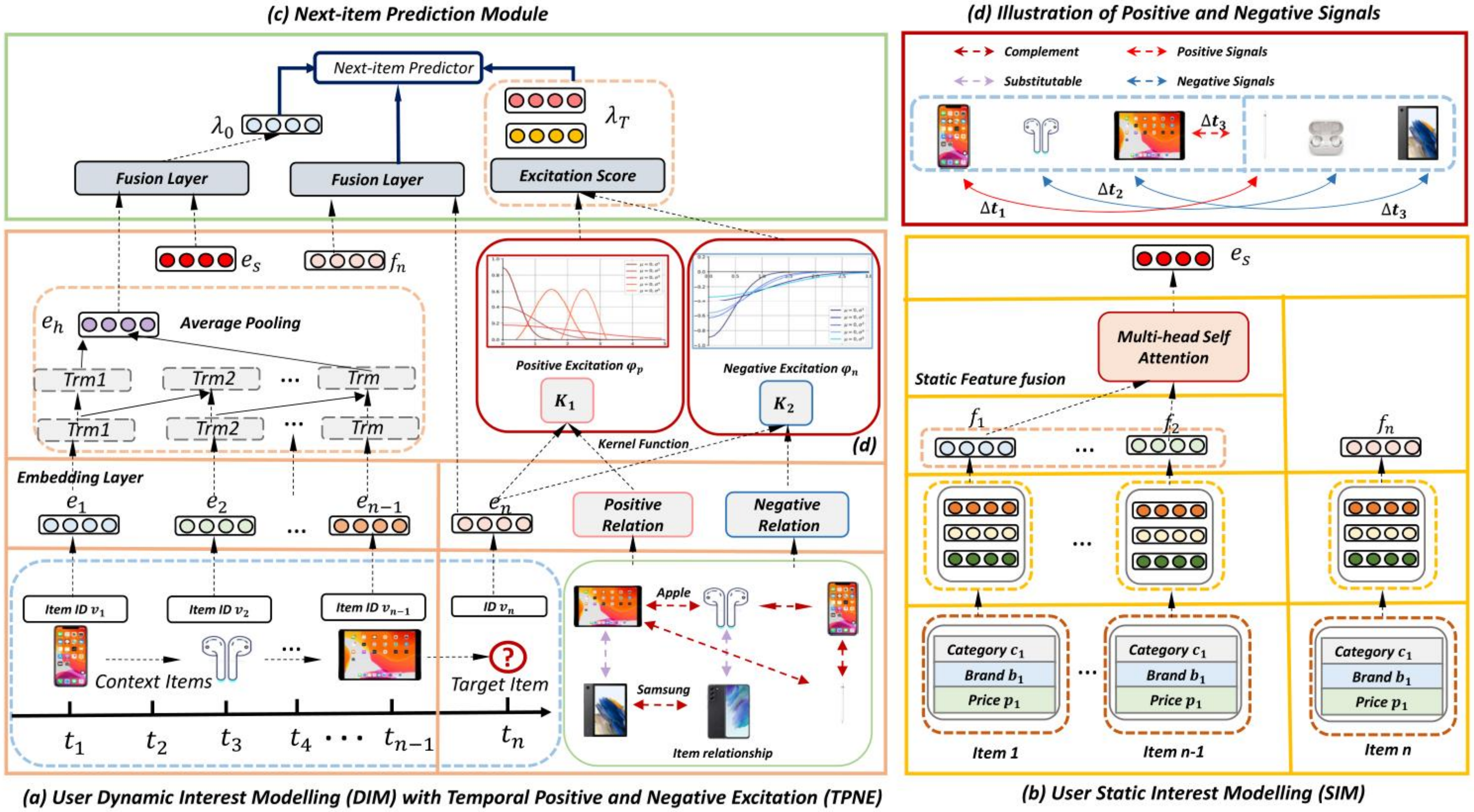
$$h_i = Att(FW_i^Q, FW_i^K, FW_i^V) \tag{16}$$

$$M_f = LayerNorm(M_f + H_f) \tag{17}$$

$$FFN(M_f) = \mathrm{ReLU}(M_f W_1 + b_1)W_2 + b_2 \tag{18}$$

$$e_s = \frac{1}{|N|-1}\sum_{i=1}^{|N|-1} H_f \tag{19}$$

Method



$$g = \sigma(W_1 e_s + W_2 e_h + b) \tag{20}$$

$$e_f = g \odot e_s + (1 - g) \odot e_h \tag{21}$$

$$\mathcal{L}_r = - \sum_{u \in \mathcal{U}} \sum_{i=1}^{N_u} \log \sigma \left(\hat{y}_{ui} - \hat{y}_{uj} \right) \tag{22}$$

$$\hat{y}_{ui} = e_f^T e_i + \lambda_{T,i}, \quad \hat{y}_{uj} = e_f^T e_j + \lambda_{T,j} \tag{23}$$

Experiments

Dataset	Metric	BPR	GRU4Rec	Caser	NARM	SASRec	TiSASRec	SLRS+	Chorus	AHMP	KDA	SDIL	Improv.
Beauty	HR@5	0.3317	0.3202	0.3210	0.3334	0.3666	0.3872	0.4339	0.4536	0.4566	0.4860	**0.4926***	1.36%
	HR@10	0.4355	0.4311	0.4345	0.4462	0.4590	0.4559	0.5337	0.5698	0.5519	0.5997	**0.6128***	2.18%
	HR@20	0.5505	0.5693	0.5757	0.5823	0.5743	0.5700	0.6361	0.6838	0.6599	0.7144	**0.7323***	2.51%
	NDCG@5	0.2361	0.2271	0.2246	0.2348	0.2797	0.2904	0.3319	0.3386	0.3496	0.3648	**0.3698***	1.37%
	NDCG@10	0.2697	0.2628	0.2612	0.2712	0.3094	0.3036	0.3642	0.3762	0.3803	0.4016	**0.4088***	1.79%
	NDCG@20	0.2987	0.2976	0.2967	0.3055	0.3385	0.3324	0.3900	0.4050	0.4076	0.4306	**0.4390***	1.95%
	MRR	0.2363	0.2271	0.2246	0.2366	0.2923	0.2904	0.3319	0.3386	0.3421	0.3549	**0.3610***	1.72%
Cellphone	HR@5	0.3387	0.3015	0.3937	0.4168	0.4439	0.4520	0.4696	0.4697	0.5045	0.5497	**0.5538***	0.75%
	HR@10	0.4528	0.4301	0.5309	0.5509	0.5595	0.5767	0.5641	0.5929	0.6132	0.6745	**0.6792***	0.70%
	HR@20	0.5852	0.5918	0.6810	0.6974	0.6817	0.7022	0.6637	0.7152	0.7284	0.7923	**0.8028***	1.33%
	NDCG@5	0.2430	0.2085	0.2800	0.2995	0.3353	0.3344	0.3634	0.3530	0.3852	0.4119	**0.4188***	1.69%
	NDCG@10	0.2798	0.2498	0.3243	0.3429	0.3727	0.3748	0.3939	0.3929	0.4204	0.4523	**0.4595***	1.59%
	NDCG@20	0.3131	0.2905	0.3622	0.3799	0.4036	0.4065	0.4191	0.4238	0.4495	0.4821	**0.4908***	1.80%
	MRR	0.2453	0.2271	0.2246	0.2969	0.2923	0.2904	0.3319	0.3386	0.3747	0.3666	**0.4049***	10.45%
Toys	HR@5	0.2897	0.2902	0.2898	0.3173	0.3602	0.3475	0.4368	0.4124	0.4603	0.4805	**0.4953***	3.08%
	HR@10	0.3897	0.4060	0.4103	0.4336	0.4570	0.4608	0.5345	0.5203	0.5587	0.5882	**0.6069***	3.18%
	HR@20	0.5061	0.5546	0.5590	0.5777	0.5700	0.6003	0.6440	0.6443	0.6621	0.7019	**0.7248***	3.26%
	NDCG@5	0.2068	0.1974	0.1947	0.2206	0.2738	0.2535	0.3490	0.3132	0.3600	0.3660	**0.3797***	3.74%
	NDCG@10	0.2390	0.2348	0.2336	0.2581	0.3050	0.2901	0.3804	0.3480	0.3918	0.4007	**0.4157***	3.74%
	NDCG@20	0.2683	0.2721	0.2710	0.2944	0.3334	0.3253	0.4081	0.3793	0.4179	0.4294	**0.4454***	3.73%
	MRR	0.2116	0.2271	0.2246	0.2244	0.2923	0.2904	0.3319	0.3386	0.3547	0.3666	**0.3713***	1.28%

Table 1: Overall performance.

Experiments

Table 2: Statistics of the datasets after preprocessing.

Specs.	Beauty	Cellphones	Toys
# Users	22,363	27,879	19,412
# Items	12,101	10,429	11,924
# Avg. Seq Length	8.8	7.0	8.6
# Interactions	198,502	194,439	167,597
# Sparsity	99.93%	99.94%	99.93%
# Item Categories	148	20	145

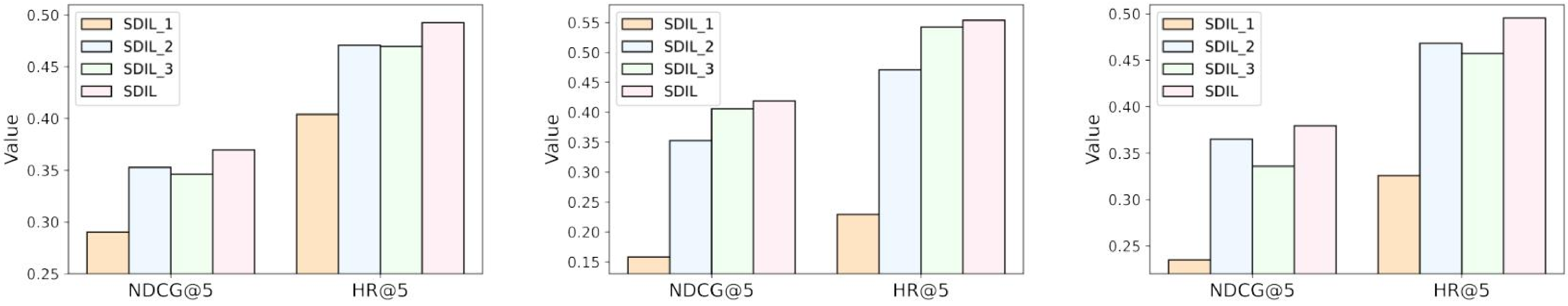
Experiments

Table 3: Performance comparison between SDIL-TPE and SDIL. * means the improvement is significant at $p < 0.05$.

Dataset	Metrics	SDIL-TPE	**SDIL**
Beauty	*HR@5*	0.4825	0.4926*
	HR@10	0.6054	0.6128*
	NDCG@5	0.3487	0.3698*
	NDCG@10	0.4014	0.4088*
	MRR	0.3534	0.3602*
Cellphones	*HR@5*	0.5521	0.5538*
	HR@10	0.6772	0.6792*
	NDCG@5	0.4102	0.4188*
	NDCG@10	0.4422	0.4595*
	MRR	0.4038	0.4049*
Toys	*HR@5*	0.4871	0.4953*
	HR@10	0.5979	0.6069*
	NDCG@5	0.3741	0.3797*
	NDCG@10	0.3670	0.4157*
	MRR	0.3670	0.3713*

Chongqing University of Technology

Experiments



(a) Beauty Dataset (b) Cellphones Dataset (c) Toys Dataset

Figure 3: Ablation study on the model performance (HR@5 and NDCG@5) on different datasets.

Experiments

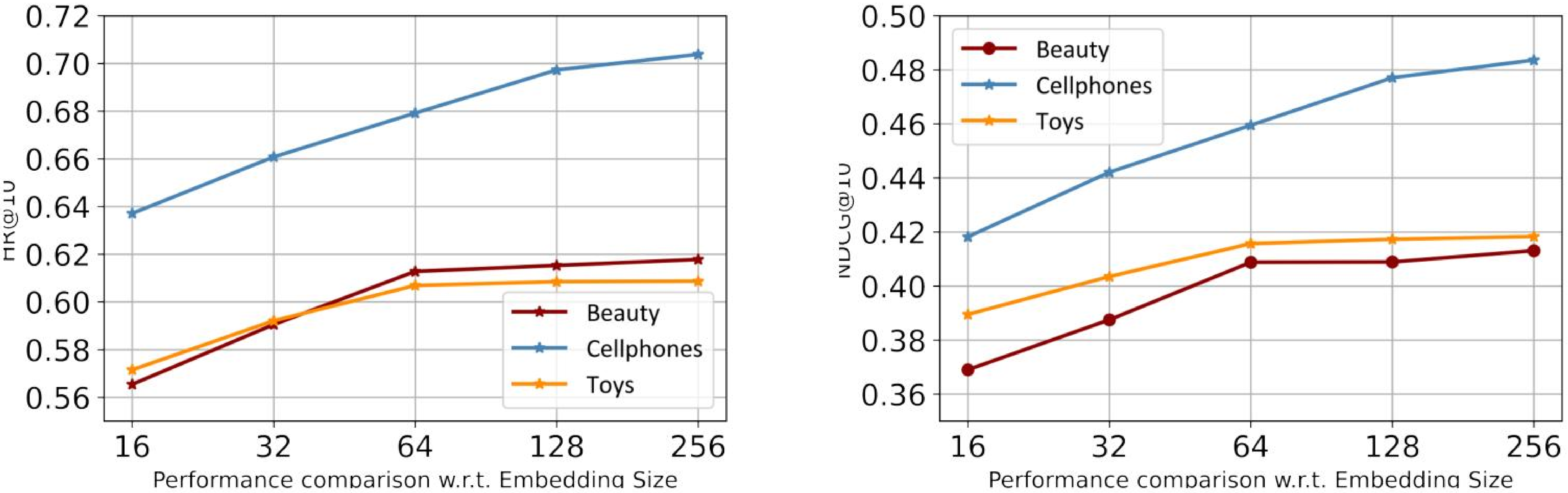
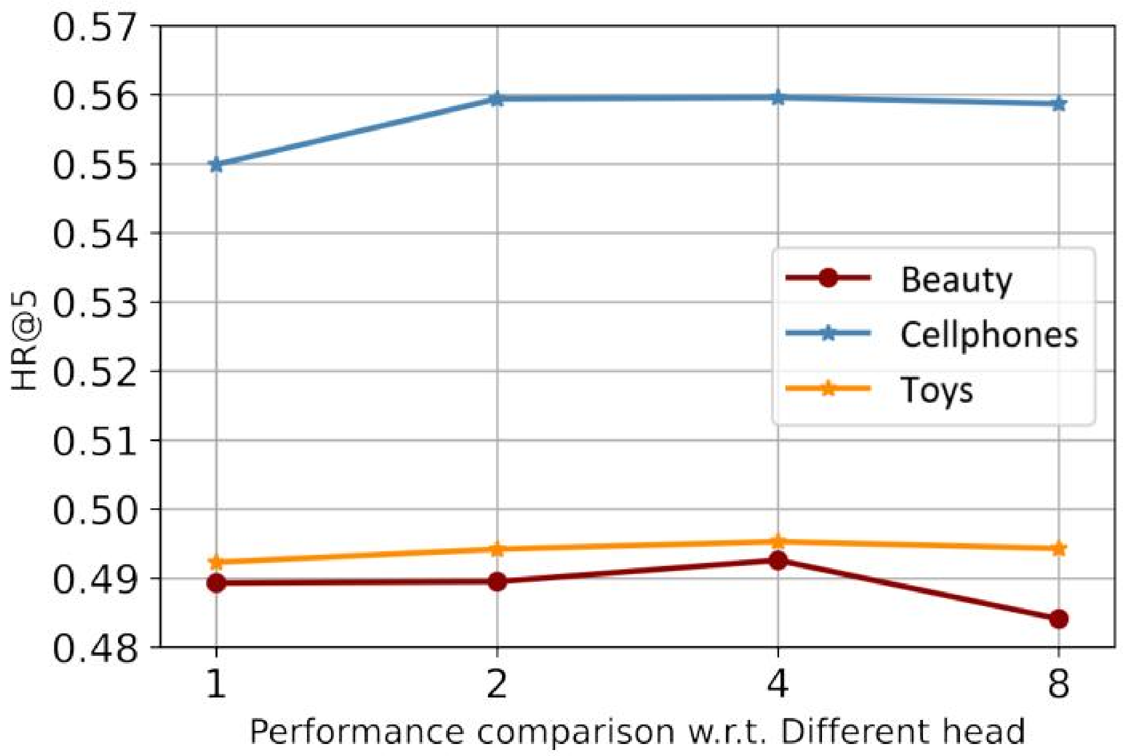


Figure 4: Embedding size setting's effect on the model performance. (HR@5 and NDCG@10).

Experiments



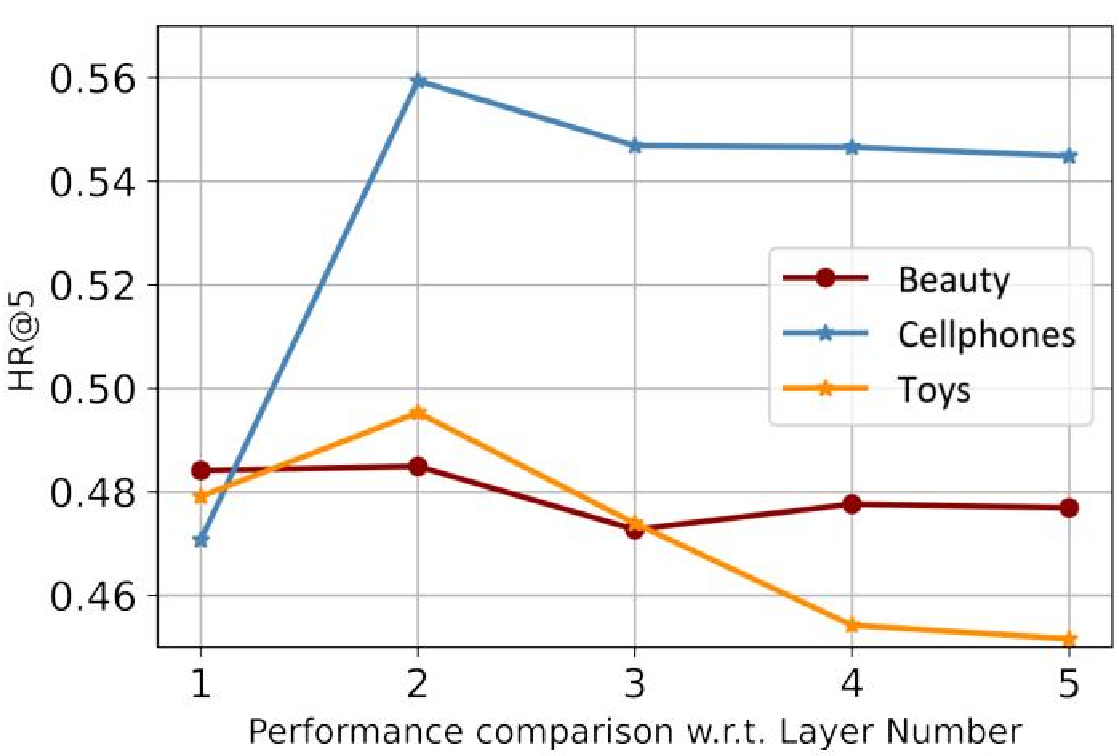


Figure 5: Different transformer layers setting's effect on the model performance. (HR@10 and NDCG@10).

Experiments

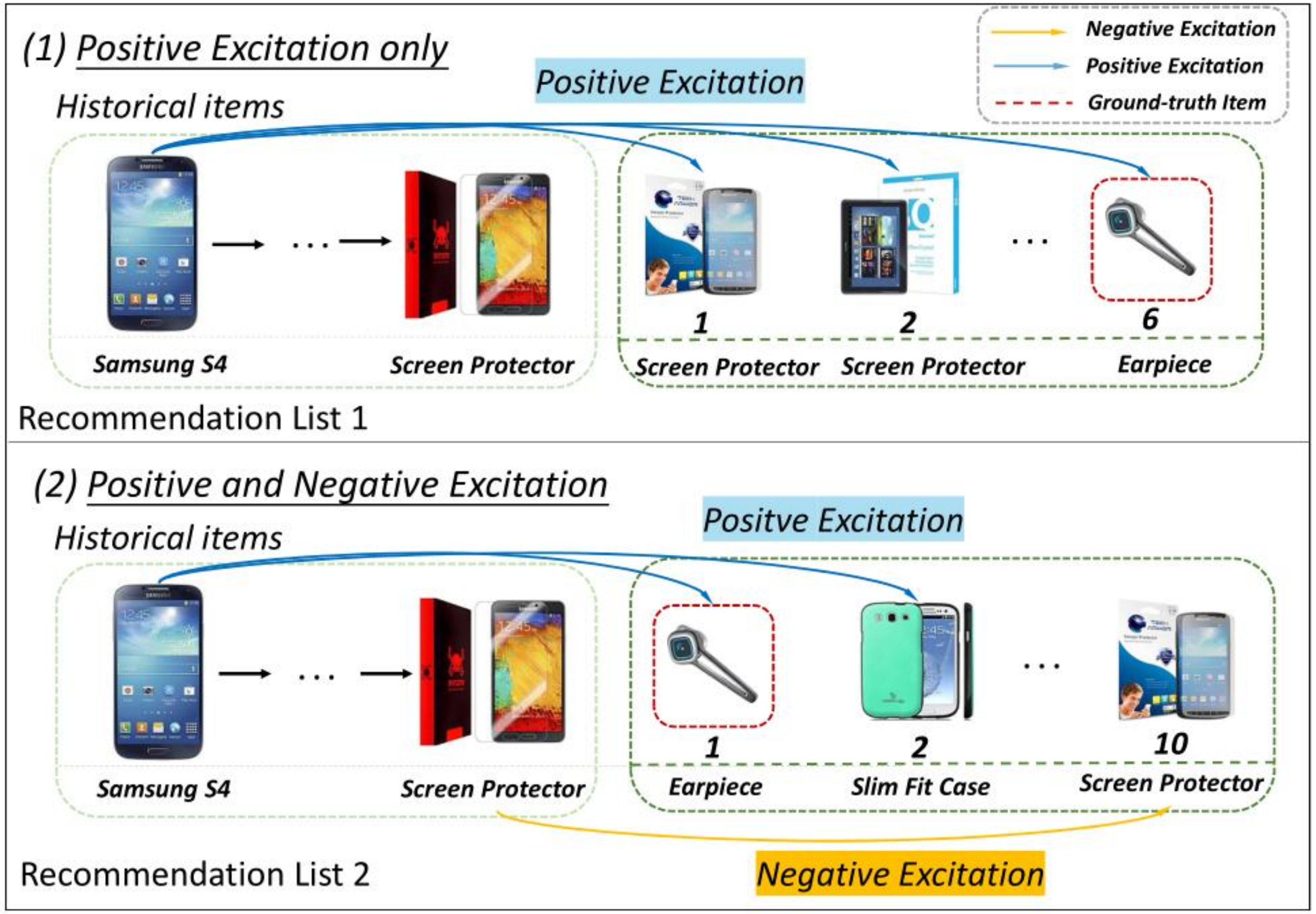


Figure 6: Illustration of the ranking results of TPE and TPNE. The item highlighted in the red boxes is the ground-truth item.

Experiments

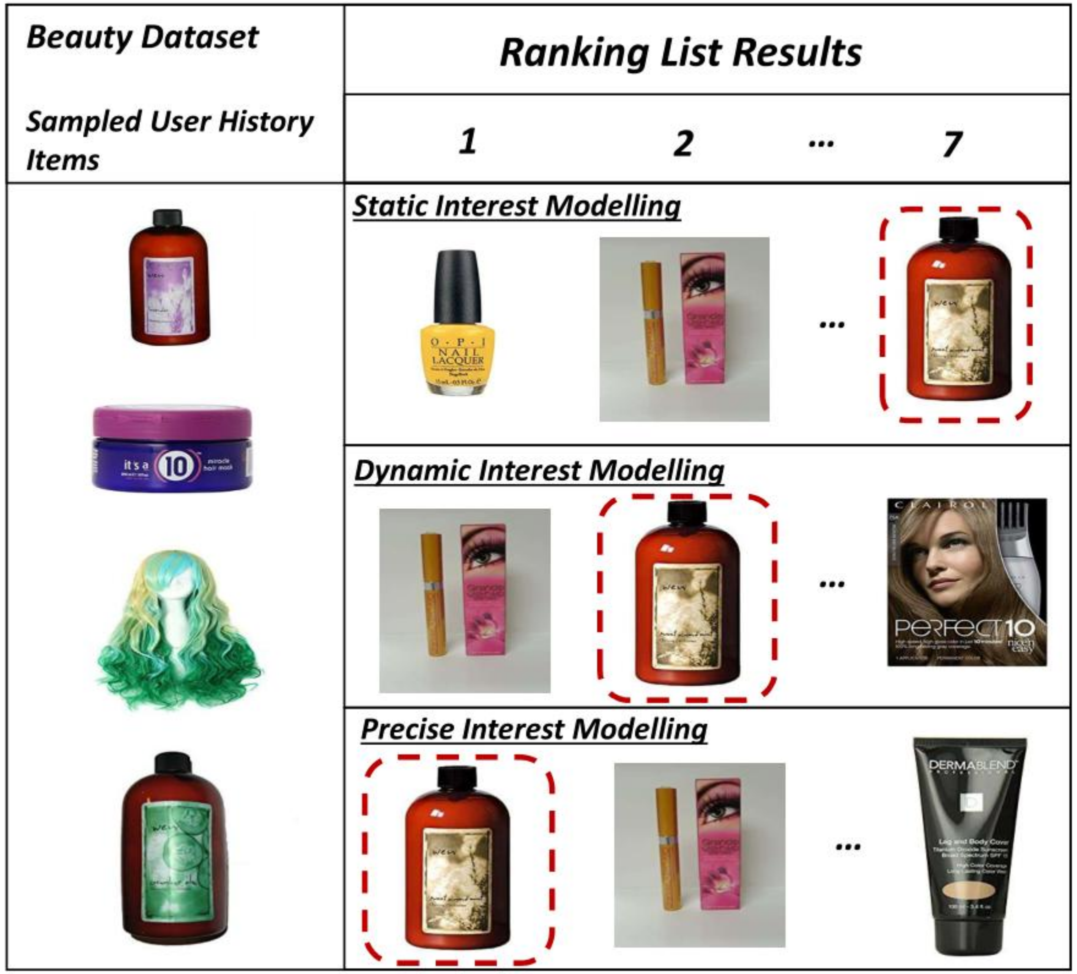


Figure 7: Illustration of the ranking results of SIM, DIM and DSIM. The item highlighted in the red boxes is the ground-truth item.

Thanks