APGL4SR: A Generic Framework with Adaptive and Personalized Global Collaborative Information in Sequential Recommendation

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code: https://github.com/Graph-Team/APGL4SR.

CIKM 2023

Reported by Minqin Li

Introduction

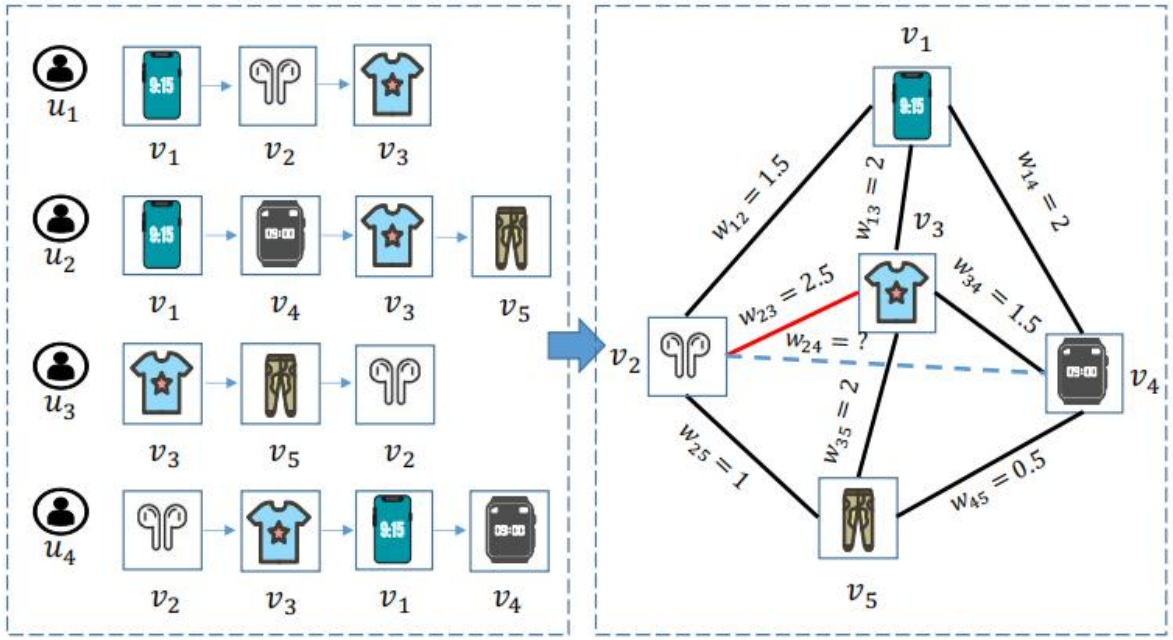


Figure 1: A toy example to illustrate the importance of global collaborative modeling in sequential recommendation systems. The graph is constructed based on the rules in Sec. 3.2.

Existing methods usually focus on intra-sequence modeling while overlooking exploiting global collaborative information by inter-sequence modeling, resulting in inferior recommendation performance.

(1) How to capture adaptive global collaborative information effectively and efficiently.

(2)How to extract and utilize personalized information from the global collaborative information.

Method

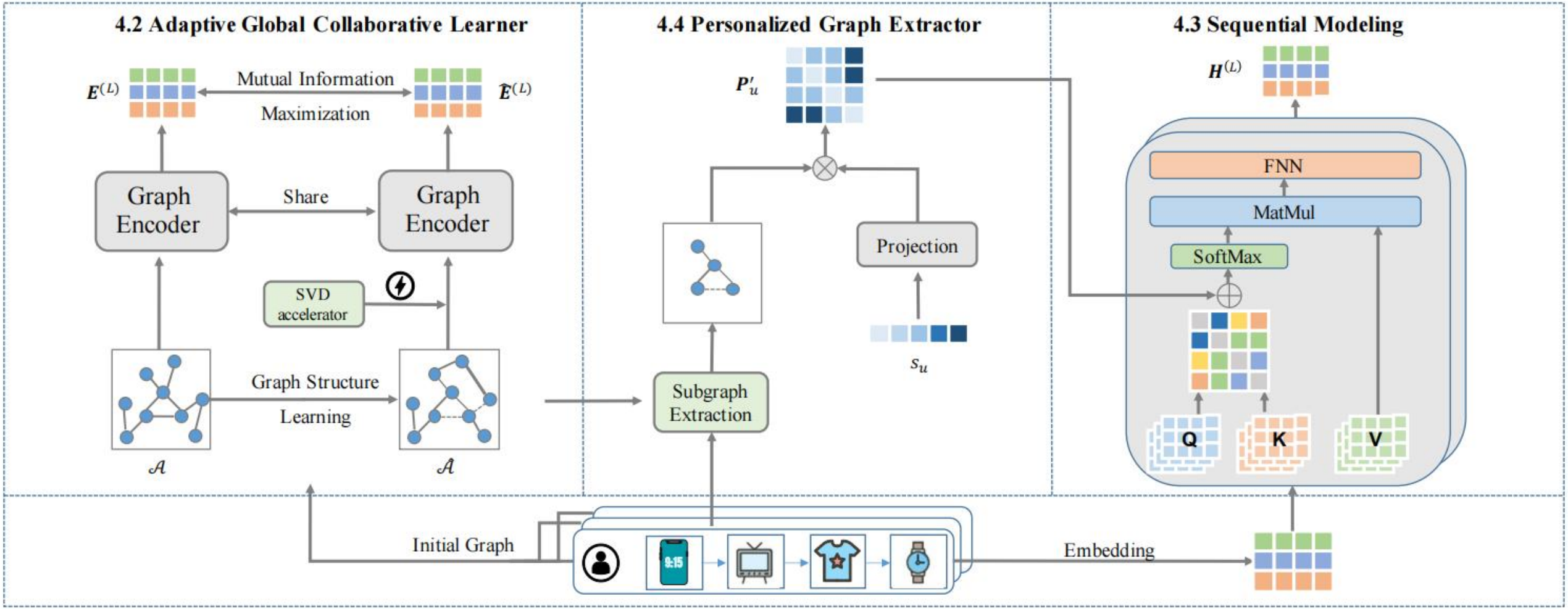
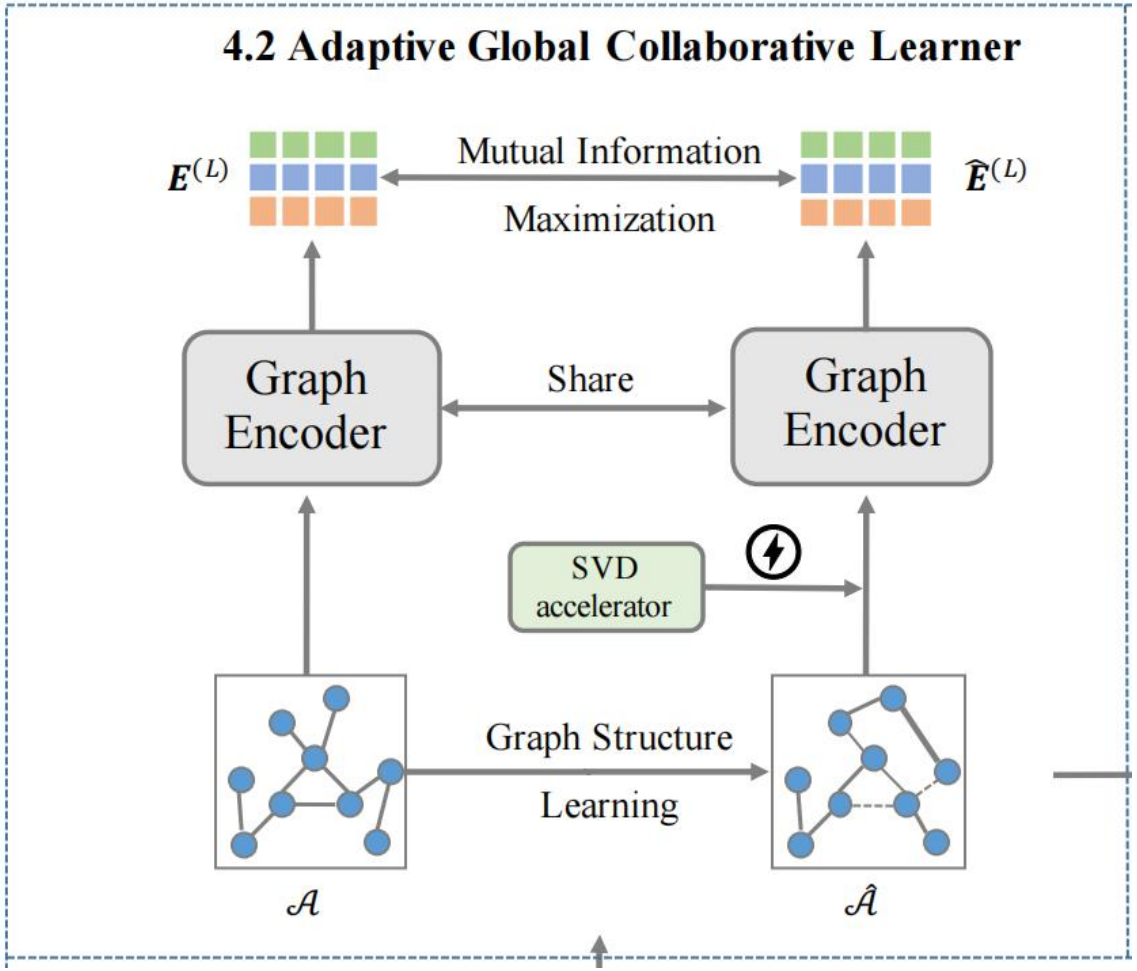


Figure 2: The framework of the proposed APGL4SR model.

Method



$$\mathcal{A}_{v_i,v_j} \leftarrow \left(\frac{1}{deg(v_i)} + \frac{1}{deg(v_j)}\right)\mathcal{A}_{v_i,v_j} \tag{1}$$

$$\mathbf{E}^{(l)} = \mathcal{A}\mathbf{E}^{(l-1)} \tag{2}$$

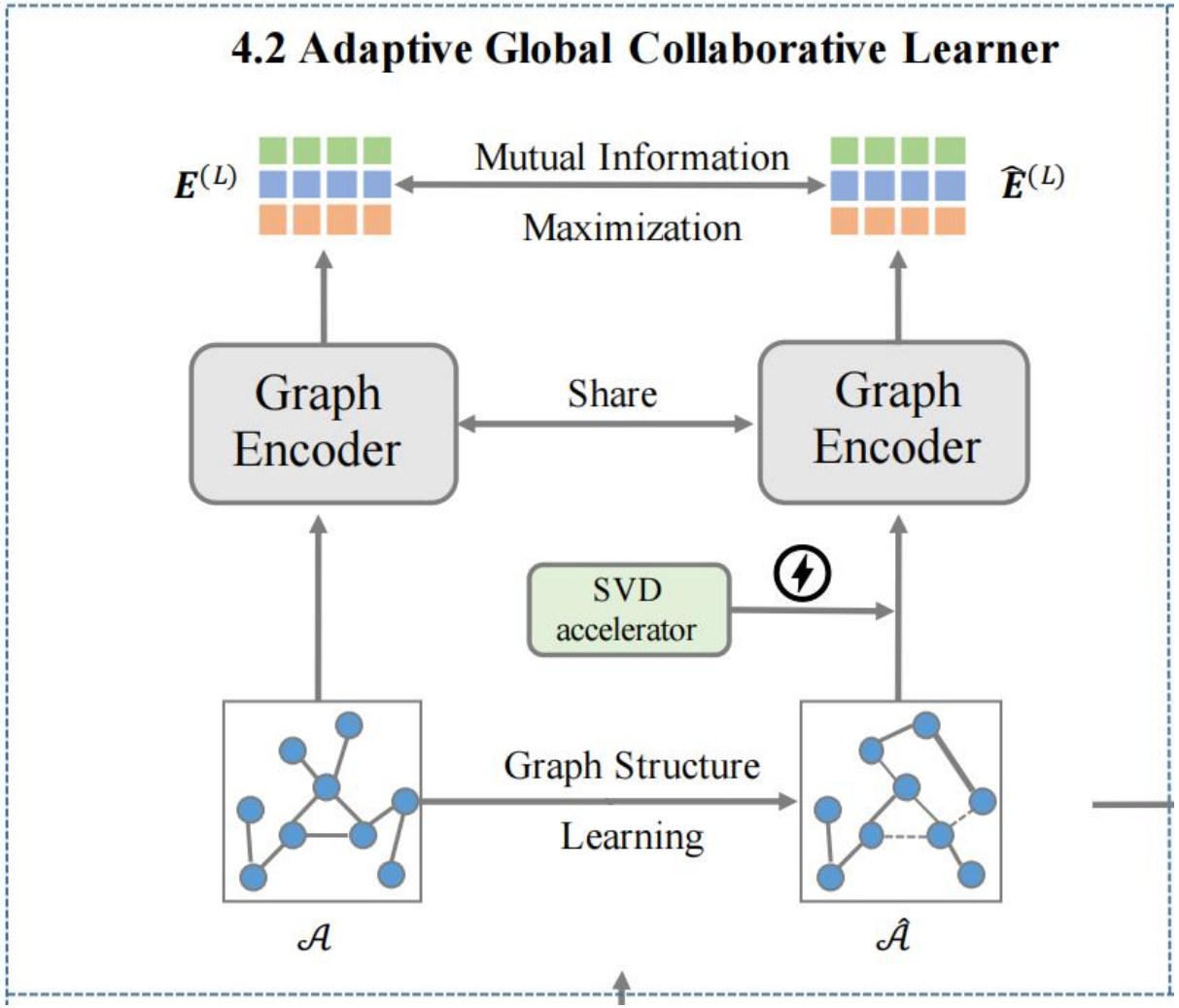
$$\mathbf{E}^{(L)} \leftarrow \frac{1}{L}\left(\mathbf{E}^{(0)} + \mathbf{E}^{(1)} + \cdots + \mathbf{E}^{(L)}\right) \tag{3}$$

$$\hat{\mathcal{A}} = \mathcal{A} + \alpha\mathcal{A}' \tag{4}$$

$$\mathcal{A}' = (\mathcal{A}\mathbf{W}_{US})(\mathcal{A}\mathbf{W}_V)^T \tag{5}$$

$$\mathbf{E}^{(l)} = \mathcal{A}\mathbf{E}^{(l-1)} + (\mathcal{A}\mathbf{W}_{US})(\mathcal{A}\mathbf{W}_V)^T\mathbf{E}^{(l-1)} \tag{6}$$

Method

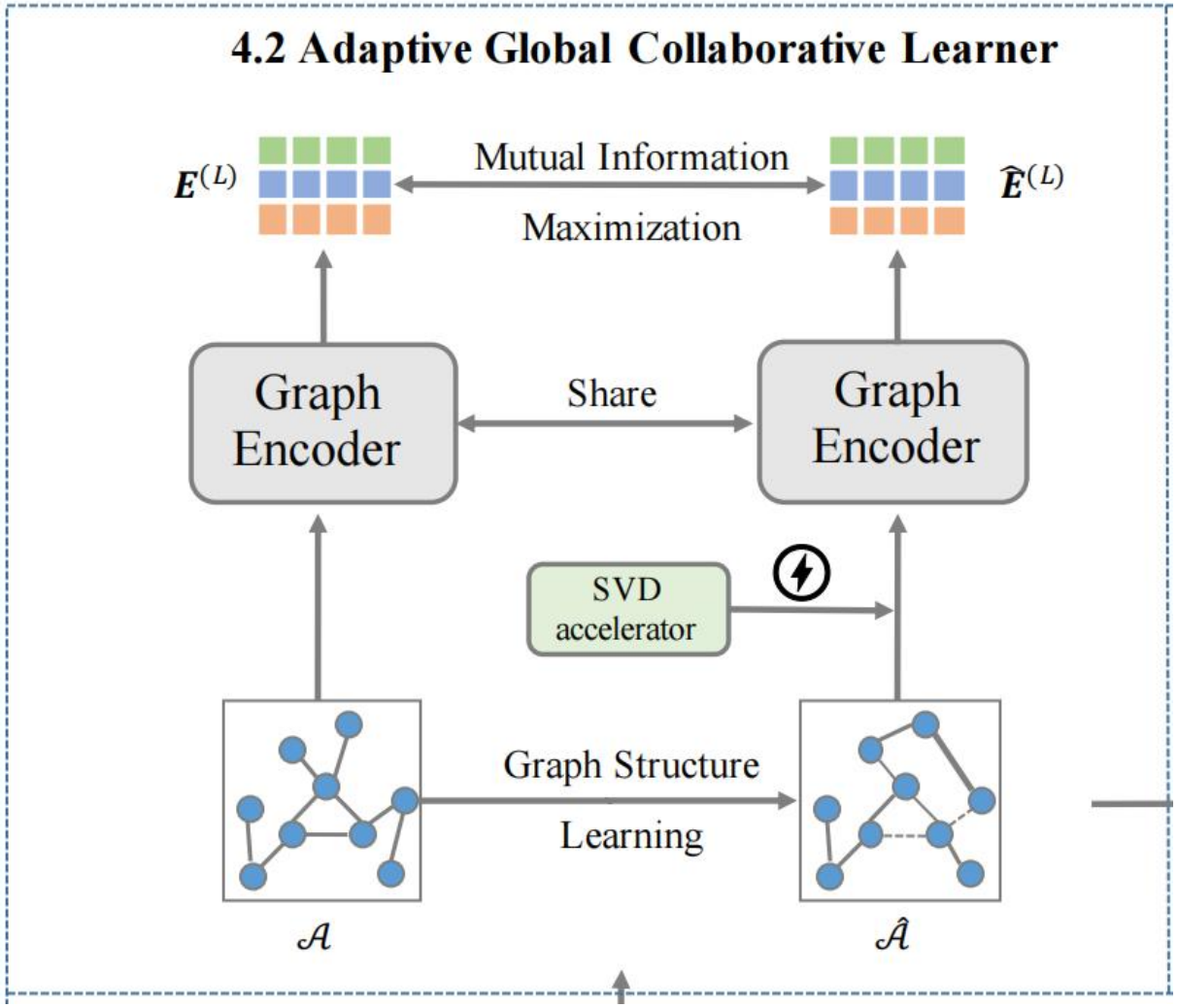


$$I(X;Y) \equiv H(X) - H(X|Y) \equiv H(Y) - H(Y|X) \quad (7)$$

$$\mathcal{L}_{InfoNCE} = -\sum_{i=1}^{K} \log \frac{e^{f(x_i, y_i)}}{\sum_{j=1}^{K} e^{f(x_i, y_j)}} \quad (8)$$

$$\mathcal{L}_{gce} = -\sum_{i=1}^{|B|} \log \frac{e^{cos(\mathbf{e}_i^{(L)}, \hat{\mathbf{e}}_i^{(L)})/\tau}}{\sum_{j=1}^{|B|} e^{cos(\mathbf{e}_i^{(L)}, \hat{\mathbf{e}}_j^{(L)})/\tau}} \quad (9)$$

Method

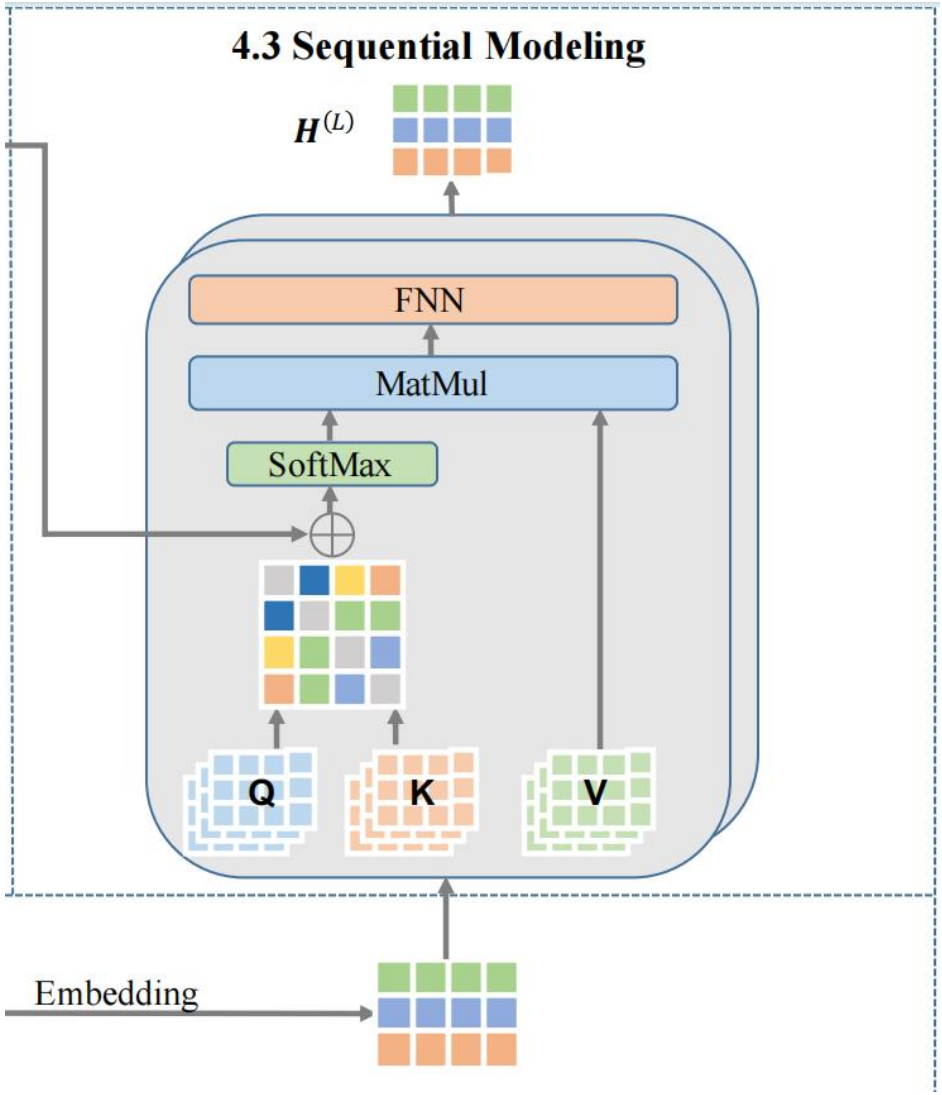


$$I(X;Y) \equiv H(X) - H(X|Y) \equiv H(Y) - H(Y|X) \quad (10)$$

$$\mathcal{L}_{InfoNCE} = -\sum_{i=1}^{K} \log \frac{e^{f(x_i, y_i)}}{\sum_{j=1}^{K} e^{f(x_i, y_j)}} \quad (11)$$

$$\mathcal{L}_{gce} = -\sum_{i=1}^{|B|} \log \frac{e^{cos(\mathbf{e}_i^{(L)}, \hat{\mathbf{e}}_i^{(L)})/\tau}}{\sum_{j=1}^{|B|} e^{cos(\mathbf{e}_i^{(L)}, \hat{\mathbf{e}}_j^{(L)})/\tau}} \quad (12)$$

Method

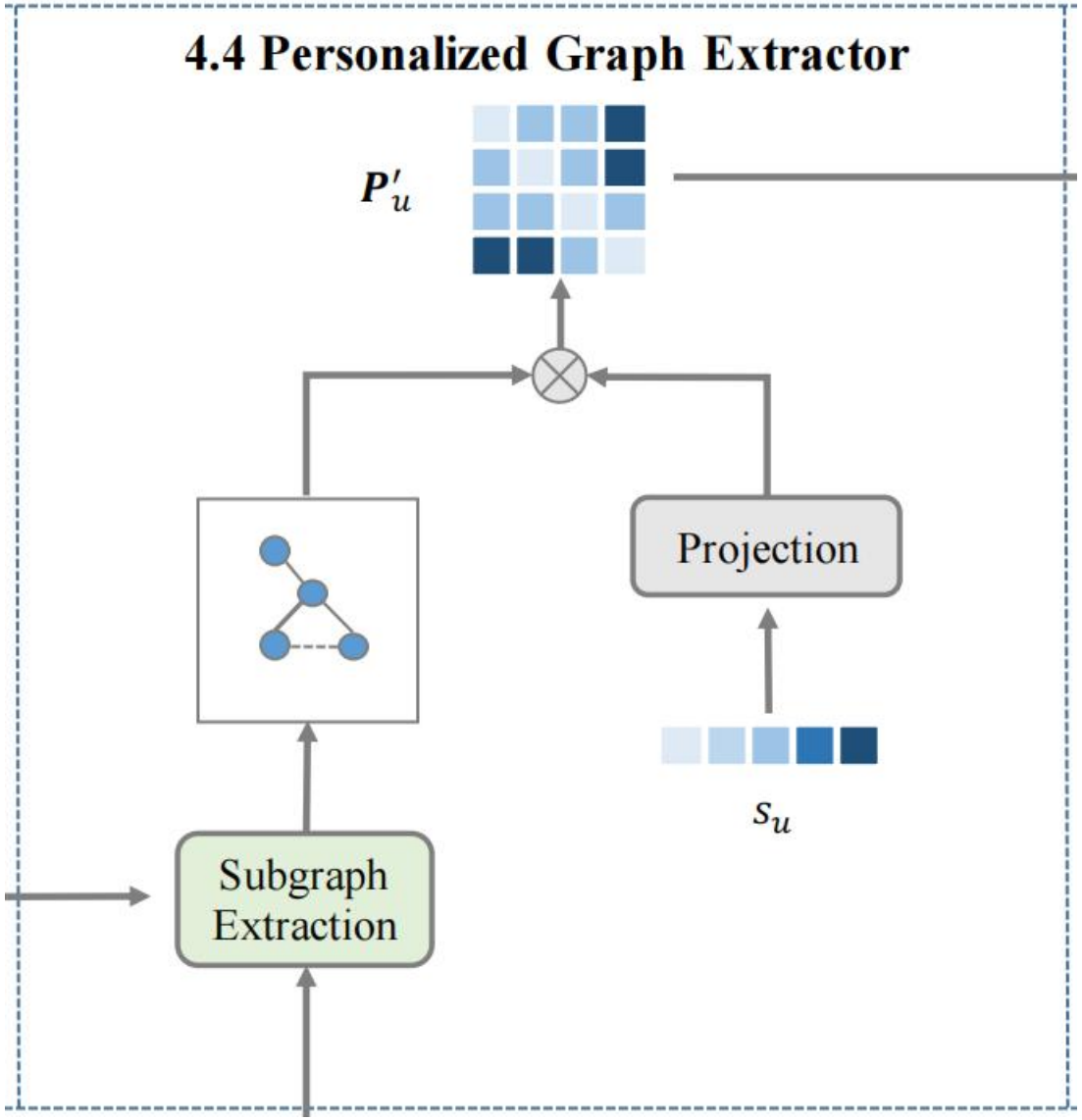


$$\mathbf{H}^{(l)} = FFN(MHSA(\mathbf{H}^{(l-1)})) \tag{13}$$

$$Attention(\mathbf{Q}, \mathbf{K}, \mathbf{V}) = \left(softmax\left(\frac{\mathbf{Q}\mathbf{K}^T}{\sqrt{d}}\right)\right)\mathbf{V} \tag{14}$$

$$\mathcal{L}_{rec} = \sum_{u=1}^{|\mathcal{U}|}\sum_{t=2}^{|s_u|}(-\log(\sigma(\mathbf{h}_{t-1}^u \cdot \mathbf{v}_t^u)) - \sum_{v_j \notin s_u} \log(1 - \sigma(\mathbf{h}_{t-1}^u \cdot \mathbf{v}_j))) \tag{15}$$

Method



$$Attention(\mathbf{Q}_u, \mathbf{K}_u, \mathbf{V}_u) = \left(softmax\left(\frac{\mathbf{Q}_u \mathbf{K}_u^T}{\sqrt{d}} + \mathbf{P}'_u \right) \right) \mathbf{V}_u \tag{16}$$

$$\mathbf{P}'_u = MLP(\mathbf{s}_u)\tilde{\mathcal{A}} \tag{17}$$

$$\mathcal{L}_{total} = \mathcal{L}_{rec} + \lambda_1 \mathcal{L}_{gce} + \lambda_2 \mathcal{L}_{seq} \tag{18}$$

Experiments

Table 1: Statistics of the datasets.

Dataset	Beauty	Sports	Toys	Yelp
$\|\mathcal{U}\|$	22,363	35,598	19,412	30,431
$\|\mathcal{V}\|$	12,101	18,357	11,924	20,033
# Interactions	0.2m	0.3m	0.17m	0.3m
Avg. length	8.9	8.3	8.6	8.3
Sparsity	99.95%	99.95%	99.93%	99.95%

Experiments

Table 2: The overall performance of all baselines. The best result is bolded while the second-best result is underlined in each row. We run the proposed method and the most competitive baselines with ten different random seeds and analyze statistical significance, where * represents p-value < 0.01, ** represents p-value < 0.001.

Dataset	Metrics	BPR	Caser	GRU4Rec	SASRec	SR-GNN	GC-SAN	GCE-GNN	DGNN	CL4SRec	GCL4SR	DuoRec	ICLRec	APGL4SR	Improv
Beauty	HR@5	0.0191	0.0228	0.0190	0.0356	0.0231	0.0309	0.0260	0.0371	0.0453	0.0415	0.0449	0.0496±0.0010	**0.0543**±0.0010	9.47%**
	HR@20	0.0527	0.0601	0.0568	0.0855	0.0609	0.0798	0.0653	0.0876	0.1045	0.1012	0.1039	0.1059±0.0013	**0.1093**±0.0011	3.19%**
	NDCG@5	0.0119	0.0135	0.0119	0.0227	0.0133	0.0163	0.0157	0.0240	0.0294	0.0263	0.0284	0.0323±0.0006	**0.0372**±0.0007	12.8%**
	NDCG@20	0.0218	0.0272	0.0224	0.0373	0.0264	0.0302	0.0286	0.0392	0.0461	0.0421	0.0453	0.0480±0.0006	**0.0527**±0.0006	8.07%**
Sports	HR@5	0.0129	0.0154	0.0110	0.0183	0.0152	0.0161	0.0154	0.0197	0.0261	0.0233	0.0265	0.0272±0.0005	**0.0299**±0.0007	9.56%**
	HR@20	0.0344	0.0399	0.0289	0.0450	0.0405	0.0437	0.0425	0.0470	0.0611	0.0571	0.0615	0.0637±0.0007	**0.0664**±0.0009	4.30%**
	HR@5	0.0091	0.0114	0.0065	0.0135	0.0075	0.0084	0.0082	0.0139	0.0166	0.0145	0.0169	0.0179±0.0002	**0.0201**±0.0006	12.0%**
	HR@20	0.0136	0.0178	0.0115	0.0186	0.0153	0.0162	0.0159	0.0203	0.0263	0.0232	0.0267	0.0281±0.0002	**0.0304**±0.0007	8.11%**
Toys	HR@5	0.0181	0.0142	0.0178	0.0431	0.0282	0.0417	0.0312	0.0445	0.0535	0.0501	0.0542	0.0577±0.0005	**0.0627**±0.0009	8.64%**
	HR@20	0.0495	0.0431	0.0467	0.0886	0.0645	0.0863	0.0721	0.0921	0.1098	0.1042	0.1121	0.1136±0.0010	**0.1176**±0.0012	3.43%**
	NDCG@5	0.0135	0.0094	0.0114	0.0283	0.0191	0.0253	0.0223	0.0291	0.0365	0.0326	0.0372	0.0393±0.0005	**0.0433**±0.0005	10.1%**
	NDCG@20	0.0225	0.0172	0.0194	0.0409	0.0292	0.0382	0.0343	0.0421	0.0528	0.0487	0.0537	0.0551±0.0003	**0.0588**±0.0006	6.72%**
Yelp	HR@5	0.0112	0.0137	0.0129	0.0160	0.0117	0.0150	0.0121	0.0166	0.0227	0.0204	0.0215	0.0239±0.0005	**0.0248**±0.0005	3.82%*
	HR@20	0.0371	0.0401	0.0369	0.0437	0.0375	0.0417	0.0382	0.0452	0.0629	0.0587	0.0621	0.0650±0.0004	**0.0670**±0.0003	3.07%**
	NDCG@5	0.0084	0.0088	0.0078	0.0101	0.0087	0.0096	0.0091	0.0105	0.0143	0.0121	0.0137	0.0150±0.0003	**0.0157**±0.0002	4.43%*
	NDCG@20	0.0143	0.0152	0.0145	0.0177	0.0148	0.0171	0.0157	0.0180	0.0255	0.0214	0.0246	0.0264±0.0001	**0.0274**±0.0002	3.66%**

Experiments

Table 3: Abalation study of APGL4SR on NDCG@20.

Model	Beauty	Sports	Toys	Yelp
(A) APGL4SR	**0.0538**	**0.0308**	**0.0584**	**0.0275**
(B) w/o AGC	0.0470	0.0271	0.0535	0.0261
(C) w/o PGE	0.0526	0.0297	0.0573	0.0267
(D) $\mathcal{A}_{SVD}$	0.0089	0.0079	0.0525	0.0248
(E) Fusion	0.0370	0.0195	0.0398	0.0178

Experiments

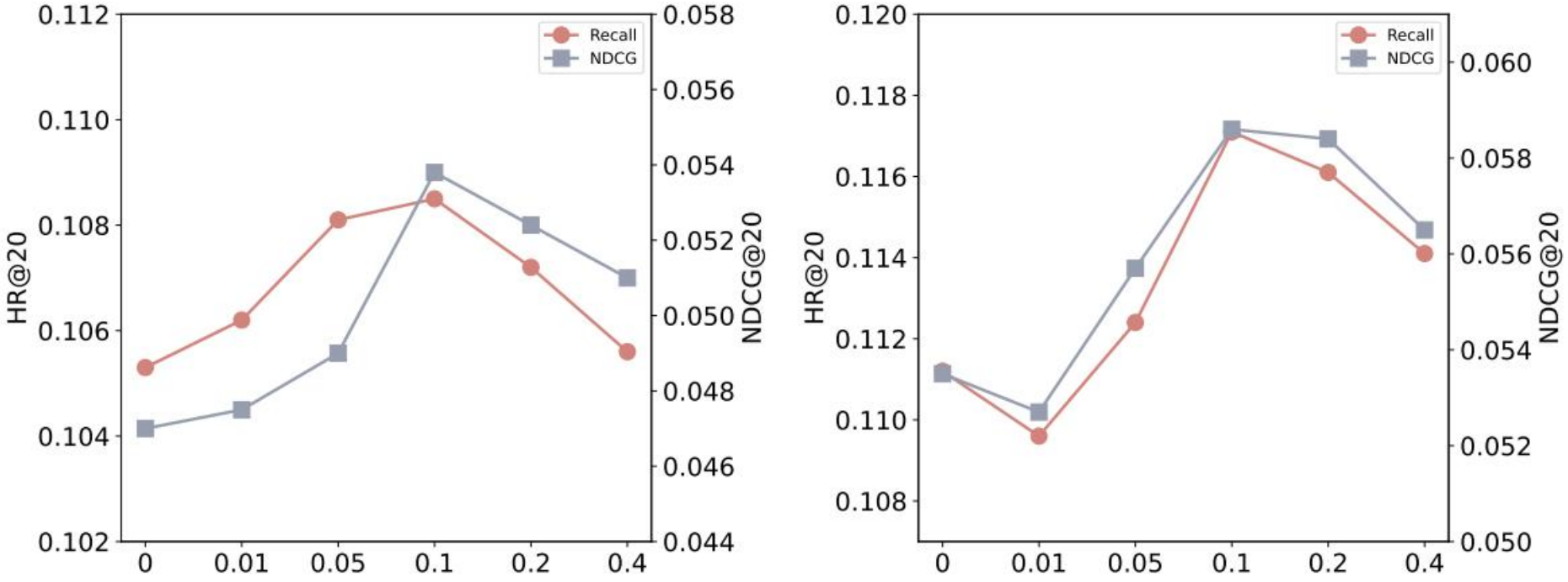
Table 4: Analysis of versatility of APGL4SR on NDCG@20.

Model	Beauty	Sports	Toys	Yelp
(A) GRU4Rec	0.0224	0.0115	0.0194	0.0145
(B) GRU4Rec+AGL	0.0290	0.0152	0.0254	0.0180
(C) SASRec	0.0373	0.0186	0.0409	0.0177
(D) SASRec+APGL	0.0452	0.0244	0.0513	0.0195
(E) ICLRec	0.0480	0.0281	0.0551	0.0264
(F) ICLRec+APGL	0.0521	0.0290	0.0581	0.0273
(G) APGL4SR	**0.0538**	**0.0308**	**0.0584**	**0.0275**

Table 5: Analysis of the effectiveness of the adaptive graph.

Model	Beauty	Sports	Toys	Yelp
(A) APGL4SR	**0.0538**	**0.0308**	0.0584	**0.0275**
(B) FPG	0.0532	0.0291	**0.0599**	0.0271
(C) NP	0.0483	0.0272	0.0535	0.263

Experiments



(a) Beauty (b) Toys

Figure 3: Recommendation Performance w.r.t λ_1

Experiments

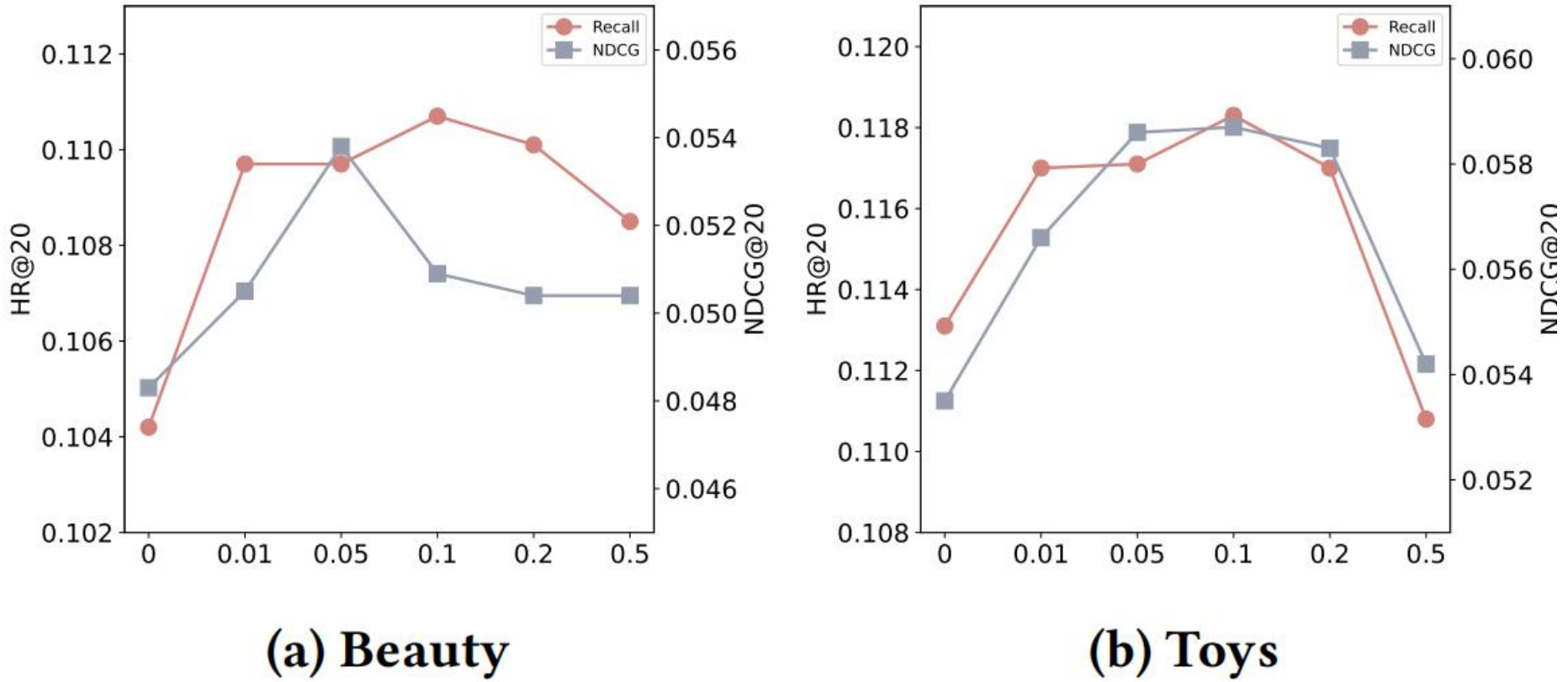
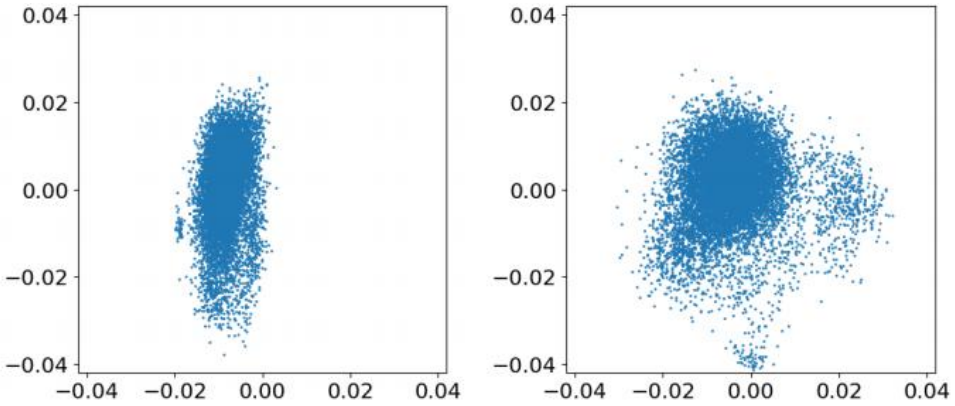


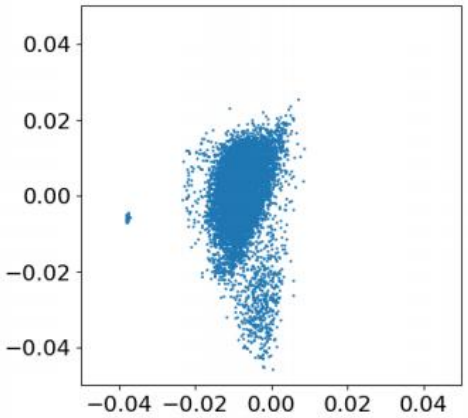
Figure 4: Recommendation Performance w.r.t α

Experiments

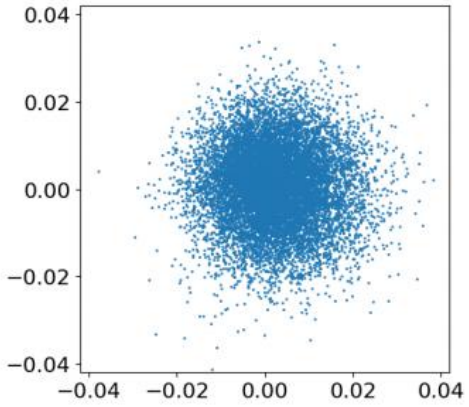


(a) SASRec

(b) CL4SRec



(c) ICLRec



(d) APGL4SR

Figure 5: Distribution visualizations of item embeddings.

Thanks