



FineRec: Exploring Fine-grained Sequential Recommendation

Xiaokun Zhang^{*}
Dalian University of Technology
dawnkun1993@gmail.com

Yuan Zhong
Pennsylvania State University
yfz5556@psu.edu

Bo Xu[†]
Dalian University of Technology
xubo@dlut.edu.cn

Hongfei Lin
Dalian University of Technology
hflin@dlut.edu.cn

Youlin Wu
Dalian University of Technology
wuyoulin@mail.dlut.edu.cn

Fenglong Ma
Pennsylvania State University
fenglong@psu.edu

SIGIR 2024

Background



南京航空航天大学
Nanjing University of Aeronautics and Astronautics

Sequential Recommendation (SR) 序列推荐

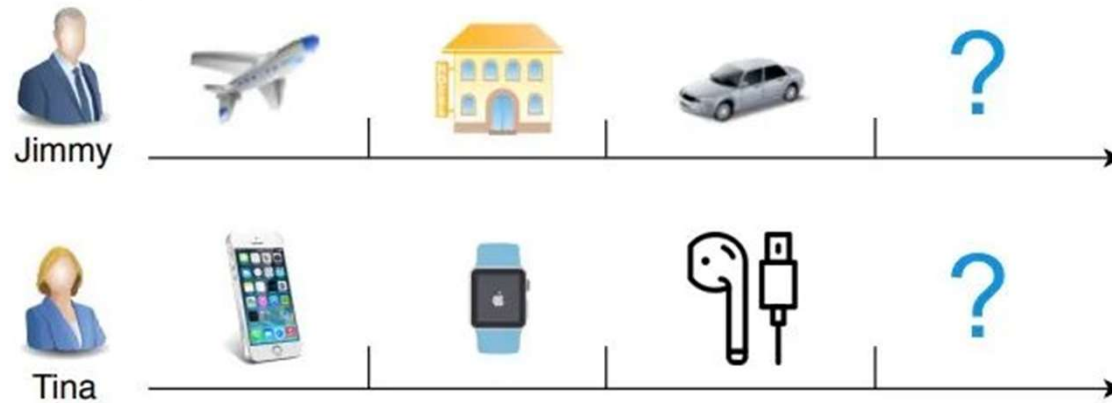
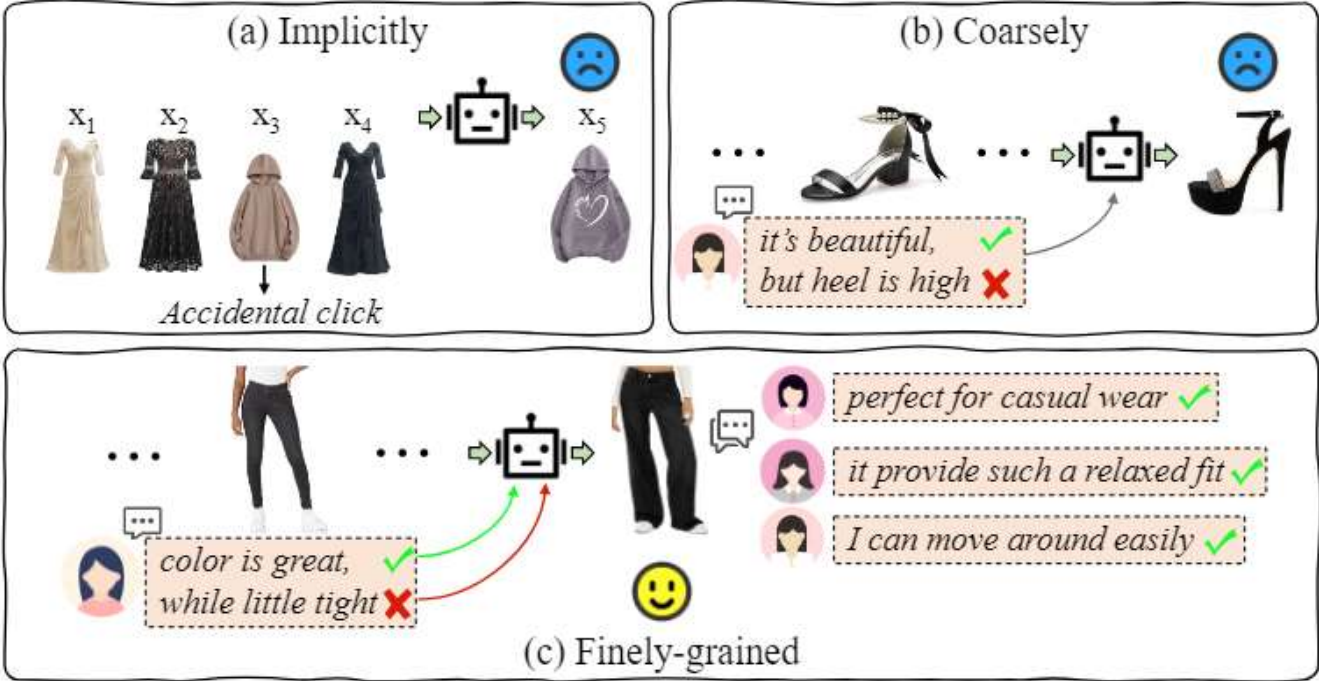


Figure 1: Two examples of SRSs: (1) After Jimmy has booked a flight, a hotel and rented a car, what will be his next action? (2) After Tina has bought an iPhone, an iWatch and a pair of AirPods, what would she buy next?

Introduction



Motivation



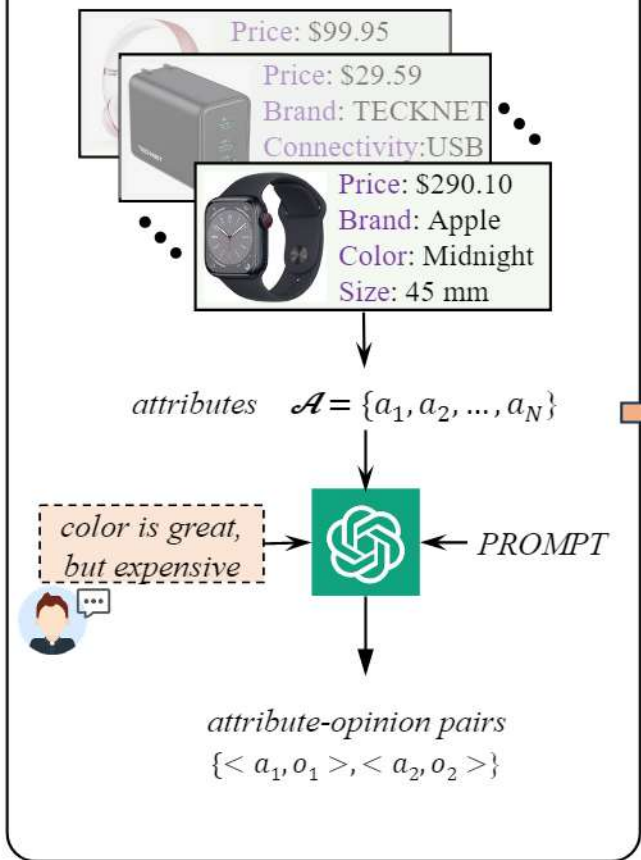
南京航空航天大学
Nanjing University of Aeronautics and Astronautics

- (1) difficult to **extract informative attribute-opinion** pairs from reviews
 - (2) a major challenge lies in finely representing **users and items under each attribute** with diverse opinions
 - (3) remains a problem to generate recommendations in the **fine-grained manner**
-

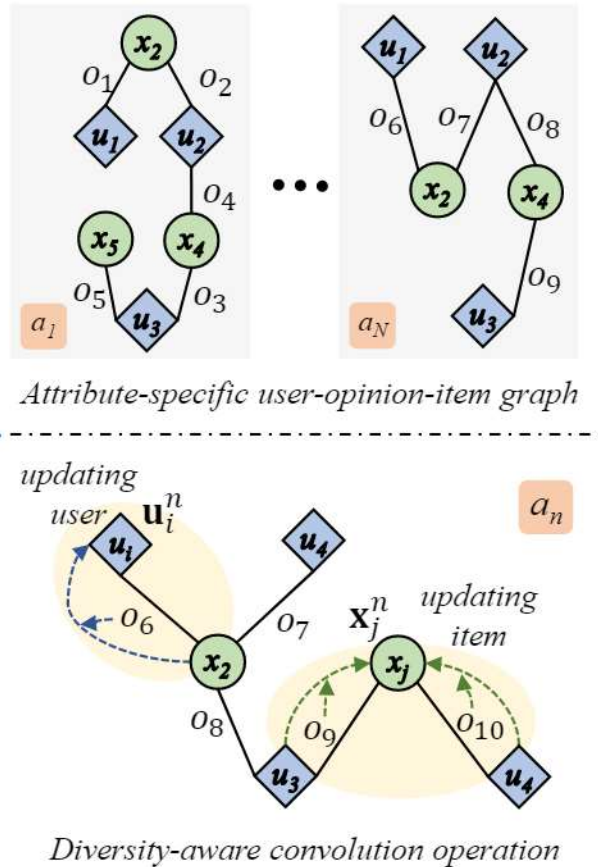
Method



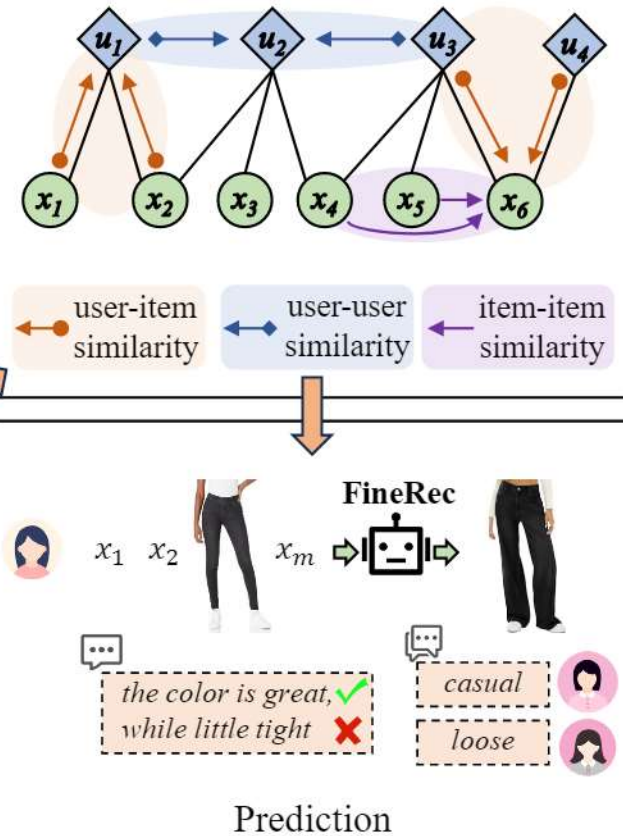
LLM-based Attribute-opinion Extraction



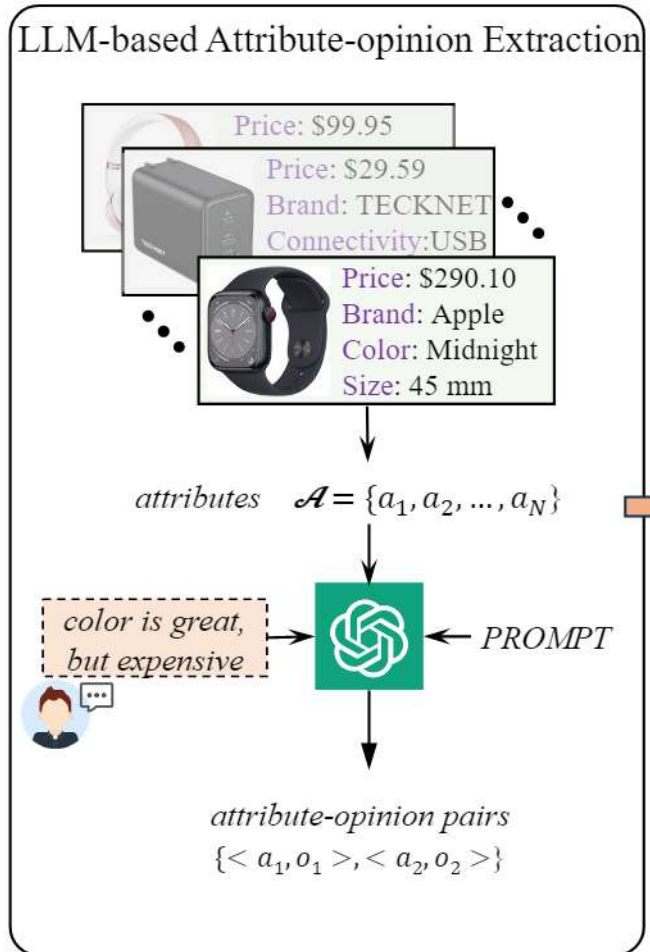
Fine-grained Representation Learning



Interaction-driven Fusion Mechanism



Method

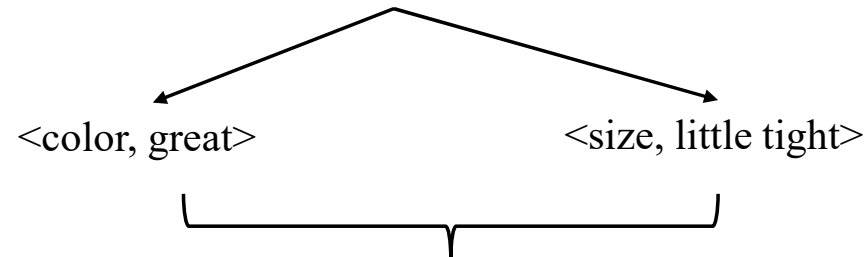


(1) LLM-based attribute-opinion extraction

$$\mathcal{A} = \{a_1, a_2, \dots, a_N\}$$

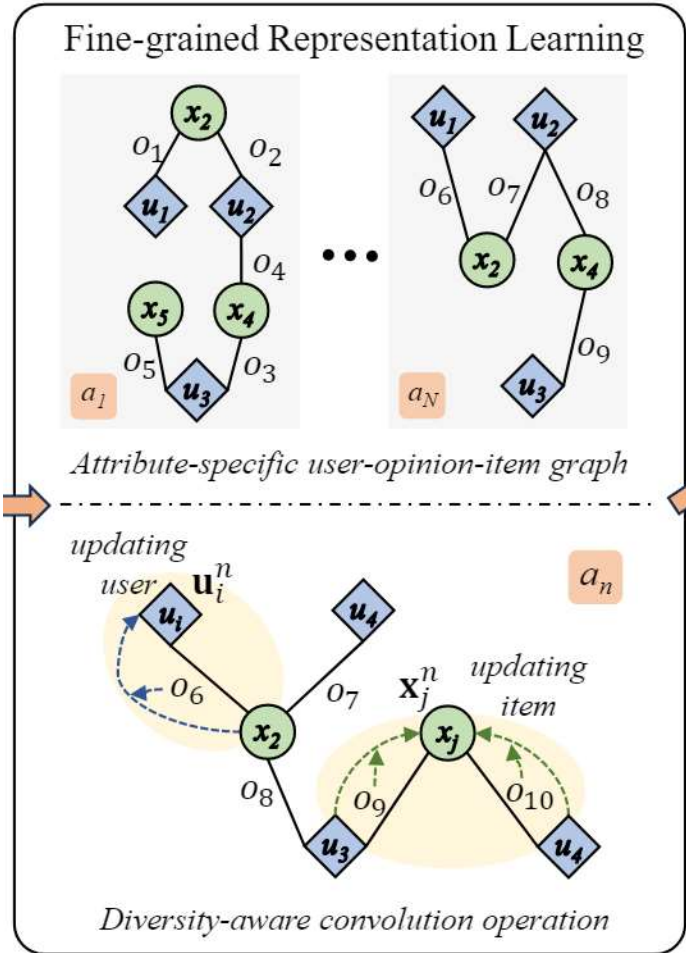
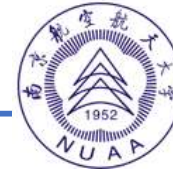
PROMPT. Please extract user opinion words towards the attribute " a_n " from the review: "review contents". Only return the opinion words! Your answer should be short.

review: color is great, while little tight



attribute-opinion pairs

Method



(2) Attribute-specific user-opinion-item graph

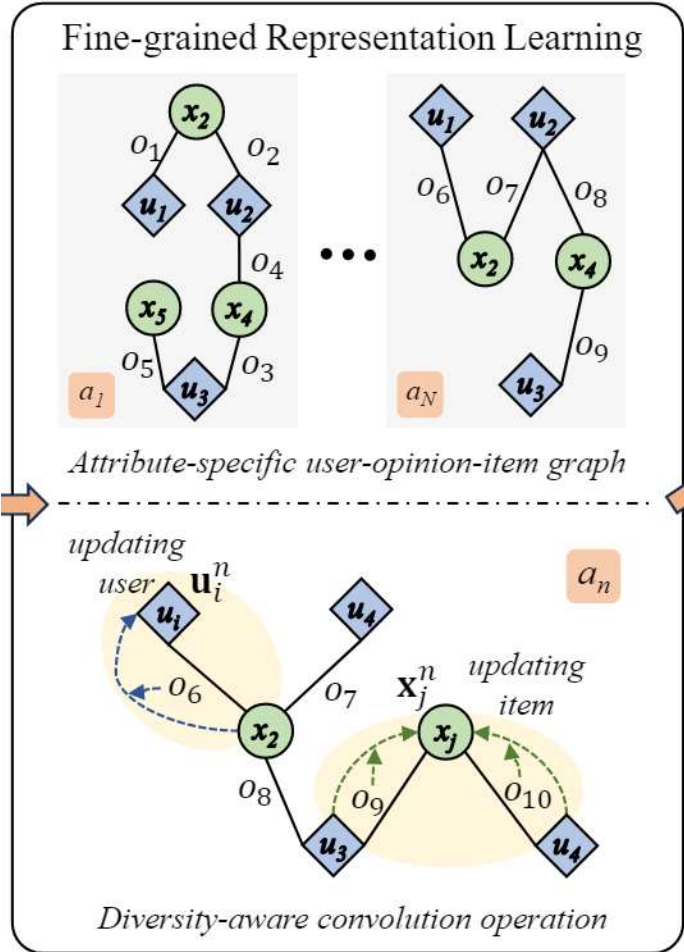
$$\mathcal{G}^n = (\mathcal{U}^n \cup \mathcal{X}^n, \mathcal{O}^n)$$

$$\{u_i^1, u_i^2, \dots, u_i^n\} \quad u_i^n \in \mathbb{R}^d$$

$$\{x_i^1, x_i^2, \dots, x_i^n\} \quad x_i^n \in \mathbb{R}^d$$

employ **pre-trained BERT** to represent an attribute a_n as $a_n \in \mathbb{R}^d$ and an opinion text o_{ij}^n as $o_{ij}^n \in \mathbb{R}^d$

Method



(3) Diversity-aware convolution operation.

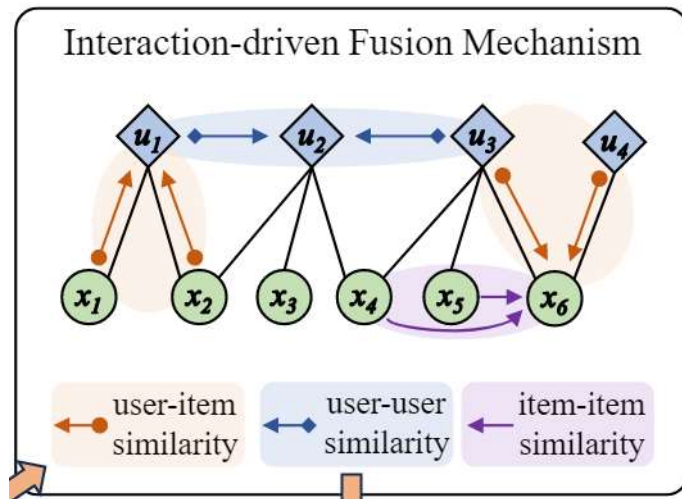
$$u_i^n := u_i^n + \sum_{x_j^n \in X_{u_i}^n} \alpha_j (x_j^n + o_{ij}^n)$$

$$\alpha_j = \frac{\text{sim}(u_i^n, (a^n + x_j^n))}{\sum_{x_k^n \in X_{u_i}^n} \text{sim}(u_i^n, (a^n + x_k^n))}$$

$$x_i^n := x_i^n + \sum_{u_j^n \in U_{x_i}^n} \beta_j (u_j^n + o_{ij}^n)$$

$$\beta_j = \frac{\text{sim}(x_i^n, (a^n + u_j^n))}{\sum_{u_k^n \in U_{x_i}^n} \text{sim}(x_i^n, (a^n + u_k^n))}$$

(4) Interaction-driven Fusion Mechanism



$$\hat{u}_i = [u_i^1; u_i^2; \dots; u_i^N]$$

$$\hat{x}_j = [x_j^1; x_j^2; \dots; x_j^N]$$

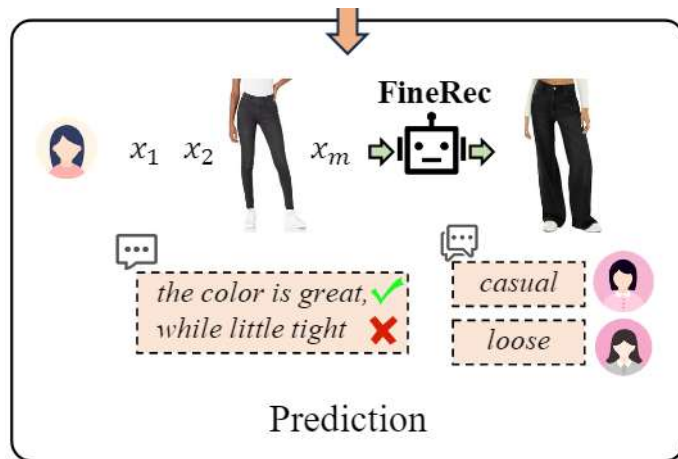
$$u_i = \hat{u}_i + \frac{1}{|\mathcal{X}_{u_i}|} \sum_{x_j \in \mathcal{X}_{u_i}} W_1 \hat{x}_j + \frac{1}{|\mathcal{U}_{u_i}|} \sum_{u_k \in \mathcal{U}_{u_i}} W_2 \hat{u}_k$$

$$W_1, W_2 \in R^{Nd \times Nd}$$

$$x_j = \hat{x}_j + \frac{1}{|\mathcal{U}_{x_j}|} \sum_{u_i \in \mathcal{U}_{x_j}} W_3 \hat{u}_i + \frac{1}{|\mathcal{X}_{x_j}|} \sum_{x_k \in \mathcal{X}_{x_j}} W_4 \hat{x}_k$$

$$W_3, W_4 \in R^{Nd \times Nd}$$

(5) Prediction



$$\bar{u}_i = \frac{1}{l} \sum_{k=0}^{l-1} x_{m-k}$$

$$y_j = (u_i + \bar{u}_i)^T x_j$$

$$\mathcal{L}(p, y) = - \sum_{j=1}^{|\mathcal{X}|} p_j \log(y_j) + (1 - p_j) \log(1 - y_j)$$

Experiment



南京航空航天大学

Nanjing University of Aeronautics and Astronautics

RQ1: Overall Performance

Table 3: Experimental results (%) of different methods on four datasets. Bold scores are the best performance among all methods, while underlined scores are the second best. Improvements of FineRec over the best baseline (*) are statistically significant with t -test ($p < 0.01$).

Datasets	Metrics	SKNN	NARM	SASRec	SR-GNN	RNS	ICLRec	UniSRec	A-Mixer	MCLRec	ACTSR	FineRec	impro.
Cellphones	Prec@10	2.54	3.23	3.95	4.21	4.88	3.59	4.35	4.04	5.83	<u>6.12</u>	7.66*	25.16%
	NDCG@10	1.45	1.74	1.80	2.02	<u>3.18</u>	1.54	2.28	2.03	2.78	2.91	3.87*	21.70%
	Prec@20	4.01	4.50	6.11	6.03	7.09	5.27	6.29	5.46	8.47	<u>8.84</u>	11.89*	34.50%
	NDCG@20	1.88	2.06	2.42	2.53	<u>3.79</u>	2.05	2.66	2.34	3.38	3.55	4.75*	25.33%
Beauty	Prec@10	1.73	2.61	3.97	2.25	2.87	1.97	3.71	3.47	<u>4.41</u>	4.16	5.71*	29.48%
	NDCG@10	1.01	1.51	1.77	1.11	1.52	1.22	1.87	1.91	<u>2.08</u>	2.05	2.92*	40.38%
	Prec@20	2.68	3.89	6.64	3.69	4.63	3.04	6.23	5.17	<u>7.93</u>	7.23	9.25*	16.65%
	NDCG@20	1.76	1.83	2.40	1.52	2.01	1.99	2.14	2.29	<u>2.80</u>	2.62	3.77*	34.64%
Sports	Prec@10	1.13	1.48	1.69	1.88	2.44	1.59	1.85	1.44	<u>2.85</u>	2.57	3.50*	22.81%
	NDCG@10	0.73	0.81	0.94	0.91	<u>1.27</u>	0.90	0.93	0.88	1.17	1.02	1.88*	48.03%
	Prec@20	1.68	1.84	2.63	2.90	3.11	2.31	2.49	1.87	<u>4.44</u>	4.09	5.45*	22.75%
	NDCG@20	0.91	0.95	1.20	1.12	<u>1.69</u>	1.03	1.09	1.17	1.58	1.37	2.37*	40.24%
Yelp	Prec@10	1.45	1.95	3.79	2.94	2.22	1.51	1.89	1.80	<u>4.54</u>	4.18	5.63*	24.01%
	NDCG@10	0.82	1.26	1.84	1.54	1.78	1.02	1.22	1.11	<u>2.15</u>	1.76	3.09*	43.72%
	Prec@20	2.17	2.65	4.95	3.71	3.65	2.29	2.62	2.53	<u>7.94</u>	7.59	9.16*	15.37%
	NDCG@20	1.30	1.56	2.40	1.73	1.93	1.28	1.60	1.30	<u>3.02</u>	2.51	3.69*	22.19%

Experiment



RQ2: The effect of fine-grained manner for handling SR

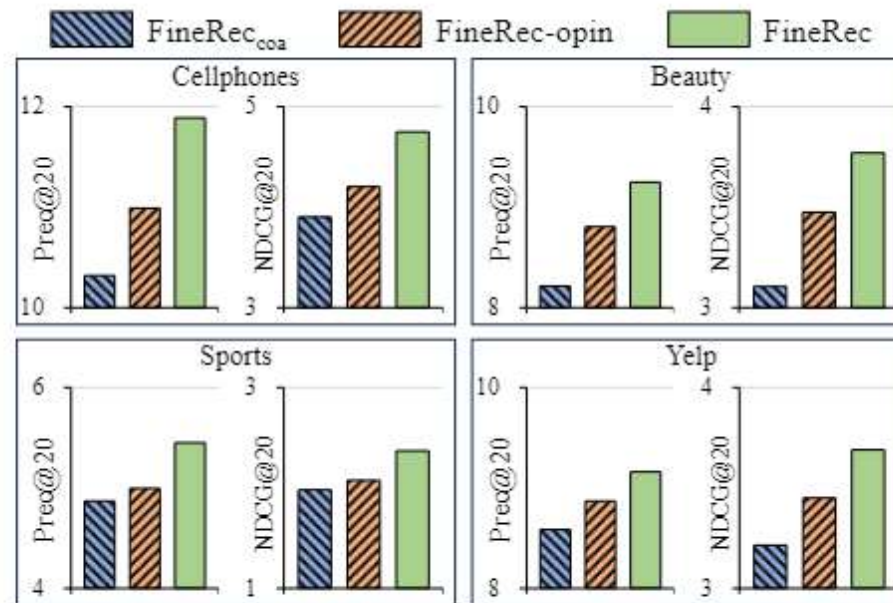


Figure 3: The effect of fine-grained manner on SR.

Experiment



RQ3: The effect of diversity-aware convolution operation

Table 4: The effect of diversity-aware convolution operation.

Method	Cellphones		Beauty		Sports		Yelp	
	Prec@20	NDCG@20	Prec@20	NDCG@20	Prec@20	NDCG@20	Prec@20	NDCG@20
Best baselines	8.84	3.79	7.93	2.80	4.44	1.69	7.94	3.02
w/o diver	11.04	4.29	8.23	3.18	5.05	2.04	8.73	3.47
FineRec	11.89*	4.75*	9.25*	3.77*	5.45*	2.37*	9.16*	3.69*

Experiment



RQ4: The effect of interaction-driven fusion mechanism

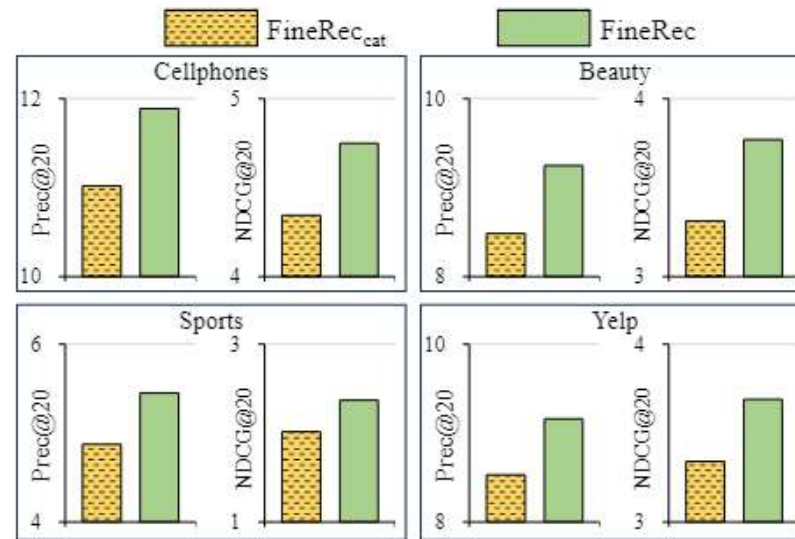


Figure 4: The effect of interaction-driven fusion mechanism.

Experiment

RQ5: Hyper-parameter Study

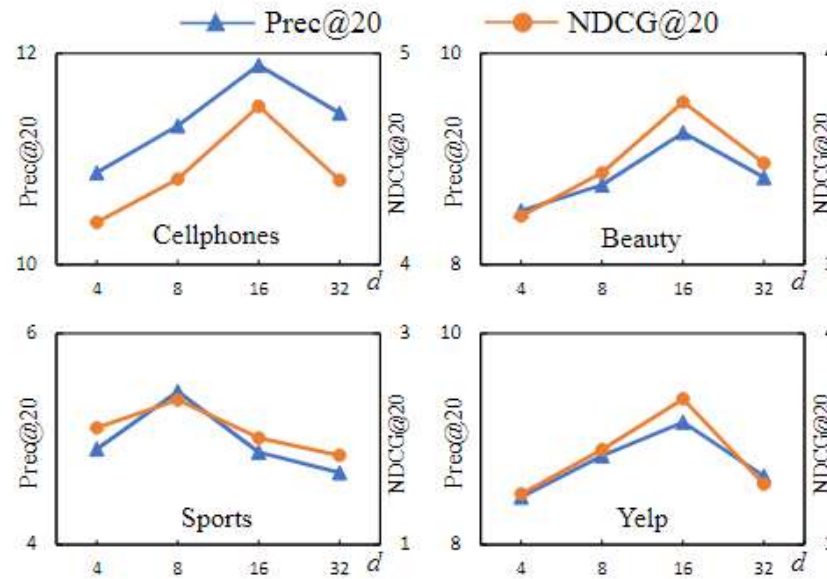


Figure 5: The impact of hyper-parameter d .

Experiment



RQ6: Case Study

User history behaviors:

User: <i>NQ3YTUI</i>	Item: <i>9JZ92A</i>	Item: <i>JALNRS</i>	Item: <i>2UNMERW</i>	Item: <i>H8ZO1U</i>
Posted Reviews	I wear these under my cargo shorts and they are so comfortable. the only thing is it was more costly than I expected.	I can not say I love the products. They're cheap, but I'm disappointed with the quality of this product.	Always have bought these bottles for cycling. A cheap investment that's so worth it. They'll last you forever.	Condor's products are first rate, I will continue to order more of these.
Attribute-opinions	<Comfort, Very comfortable> <Price, more costly than expected>	<Price, Cheap> <Quality, Disappointed >	<Price, Cheap investment>	<Brand, Condor's products are first rate>

Ground truth:

Groud truth Item: <i>RURGYQ</i>
This case is way more than I expected. I love it. It's made with awesome quality.
<Quality, Awesome>

FineRec's Recommended Items:

Top-1: <i>RURGYQ</i> ✓	Reviews of other users	The case is perfect. Its quality is really impressive. Water resistant, price is just right!	The price for this quality is unbeatable! Buy it! It fits incredibly well, much more than I expected.	Works well and is well constructed. Good case for its money.
	Attribute-opinions	<Quality, Really impressive> <Functionality, Water-resistant> <Price, Just right>	<Price, Unbeatable> <Quality, High> <Size, Fits incredibly well>	<Price, Good value for its money> <Functionality, Works well> <Quality, Well constructed>
Top-2: <i>9OU6NK</i>	Reviews of other users	The hat is made from a very durable material, and it looks great. I will buy more products made by Condor in the future.	Perfect 5 star product! This Condor's hat is super light weight and breaths well. This helps allow heat to escape and keep cool. Fit me perfectly right out of the box with no adjustments.	Great hat, well made. Love this hat, you will too, it is a very well built hat. Id buy it again.
	Attribute-opinions	<Brand, Positive towards Condor> <Material, Very durable> <Quality, Looks great>	<Brand, Condor - 5 star product> <Comfort, Fits perfectly> <Size, Perfect fit>	<Quality, Well-made>
Top-3: <i>6Z08YM</i>	Reviews of other users	Very beautiful design, easy to use as well. If you need a tough knife, this is a can't-miss.	For the money, this is a great knife. steel holds a decent edge and sharpens easy. Good buy!	It's so affordable yet so good. The size is just right! It's like it was sized just for me!
	Attribute-opinions	<Quality, Tough> <Functionality, easy to use>	<Price, Great value> <Quality, Steel holds a decent edge and sharpens easily>	<Price, Affordable> <Quality, Good> <Size, Just right sized personally>

Figure 6: A case from the Sports dataset. We present user-item reviews (Blue), corresponding attribute-opinions (Orange), and the recommended items of FineRec with other users' reviews.