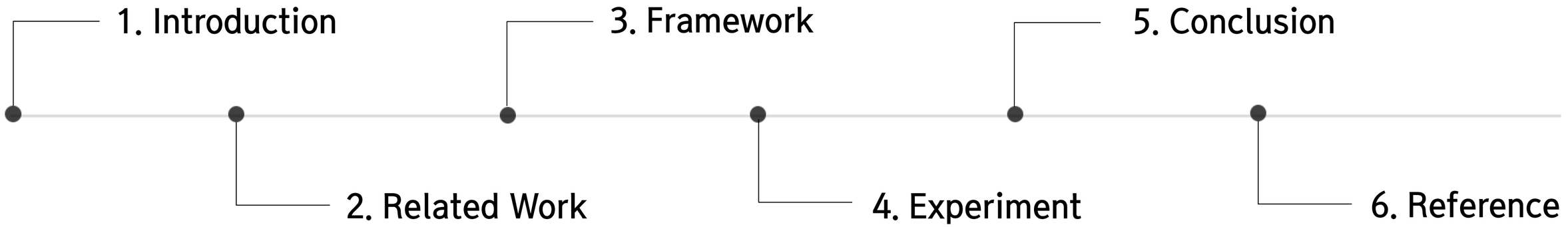
Outer Product Convolutional DeepCF Using Side Information

Final Presentation

20162528 윤성식 20172845 이성규 20182794 김보현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Introduction

[연구배경]

여자A

성별 : 여자
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나이 : 20대
반려동물 : 강아지
취미 : 운동

여자B

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나이 : 30대
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남자A

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남자B

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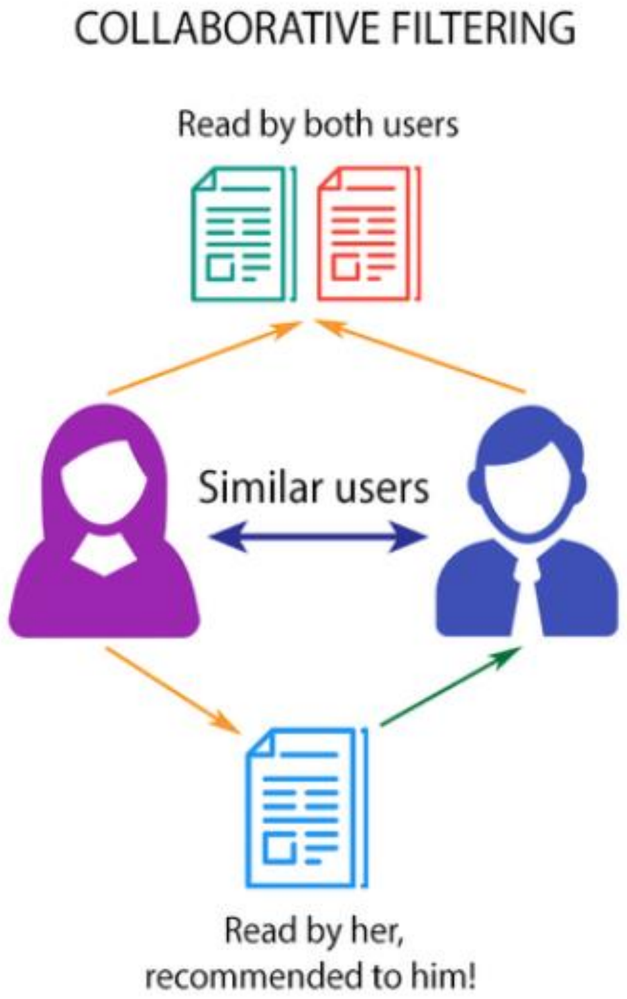
반려동물 : 강아지
취미 : 러닝



Introduction

[필요성]

① DeepCF의 Improvements에서 DeepCF 구조가 해결하지 못하는 User와 Item의 초기 표현 개선을 위해 Auxiliary data를 사용하여 더 나은 결과 기대

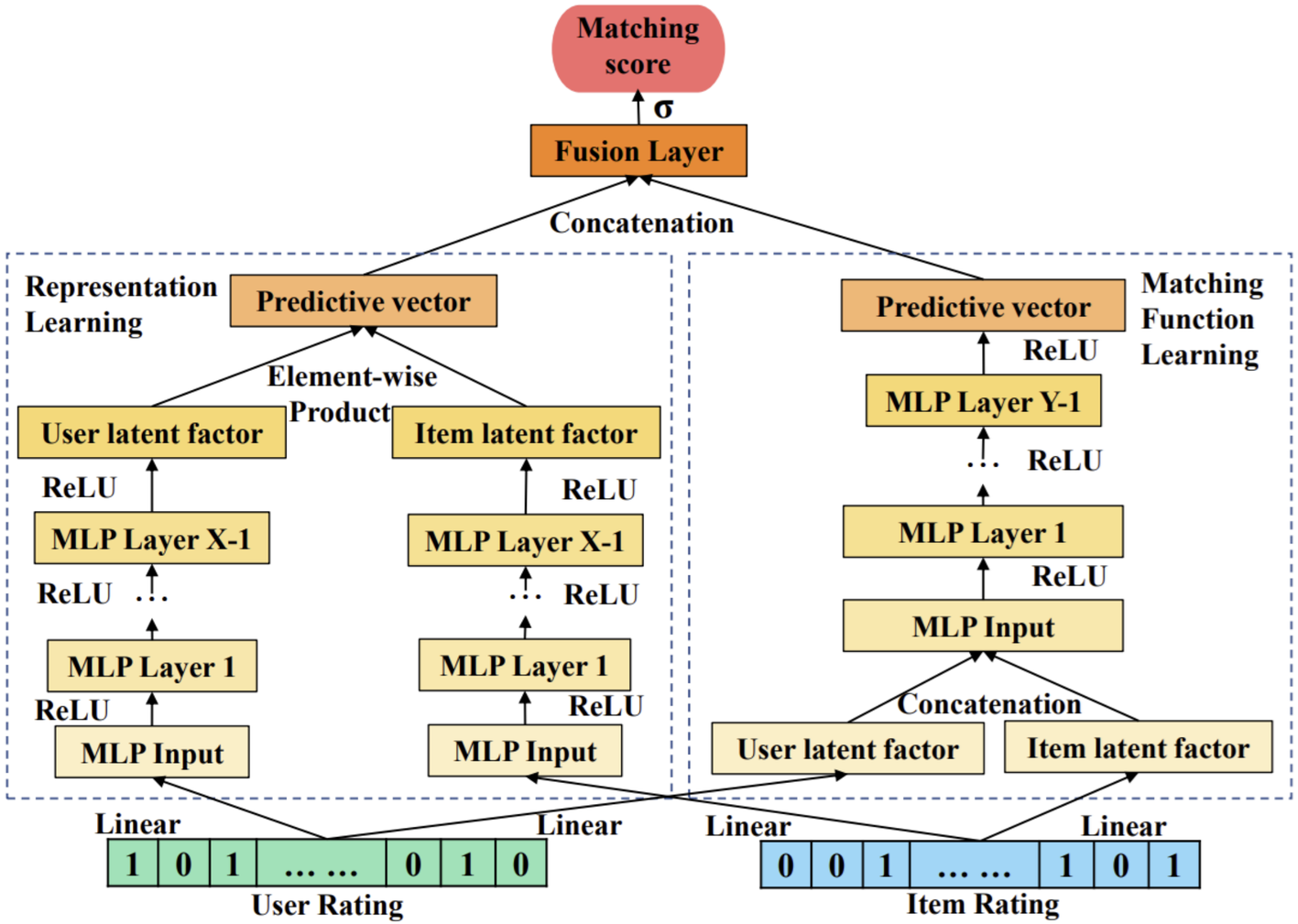
② DeepCF의 Improvements에서 임베딩 간의 Correlation을 고려하지 못하는 Element-wise product와 Concatenation 방식을 제외한 다른 집계 방법 기대

[목적]

① 유저의 지역정보의 Categorical data와 책제목, 출판사, 작가 등의 Text data, 책 표지 Image data를 Side Information으로 활용하여 초기 표현 개선

② Concatenation과 Element-wise product 방식이 아닌 Outer product를 통해 latent vector 간의 더 많은 Correlation을 포착

Related Work : DeepCF



Representation Learning

User Ratings과 Item Ratings을 각자 학습함으로써

더 Dense한 latent factor를 표현할 수 있는 방법

이렇게 학습된 User latent factor와 Item latent factor를

element-wise product를 적용해 predictive vector를 도출

Matching Function Learning

User Latent factor와 Item Latent factor를

Concatenation한 결과를 활용해 학습을 진행하면서

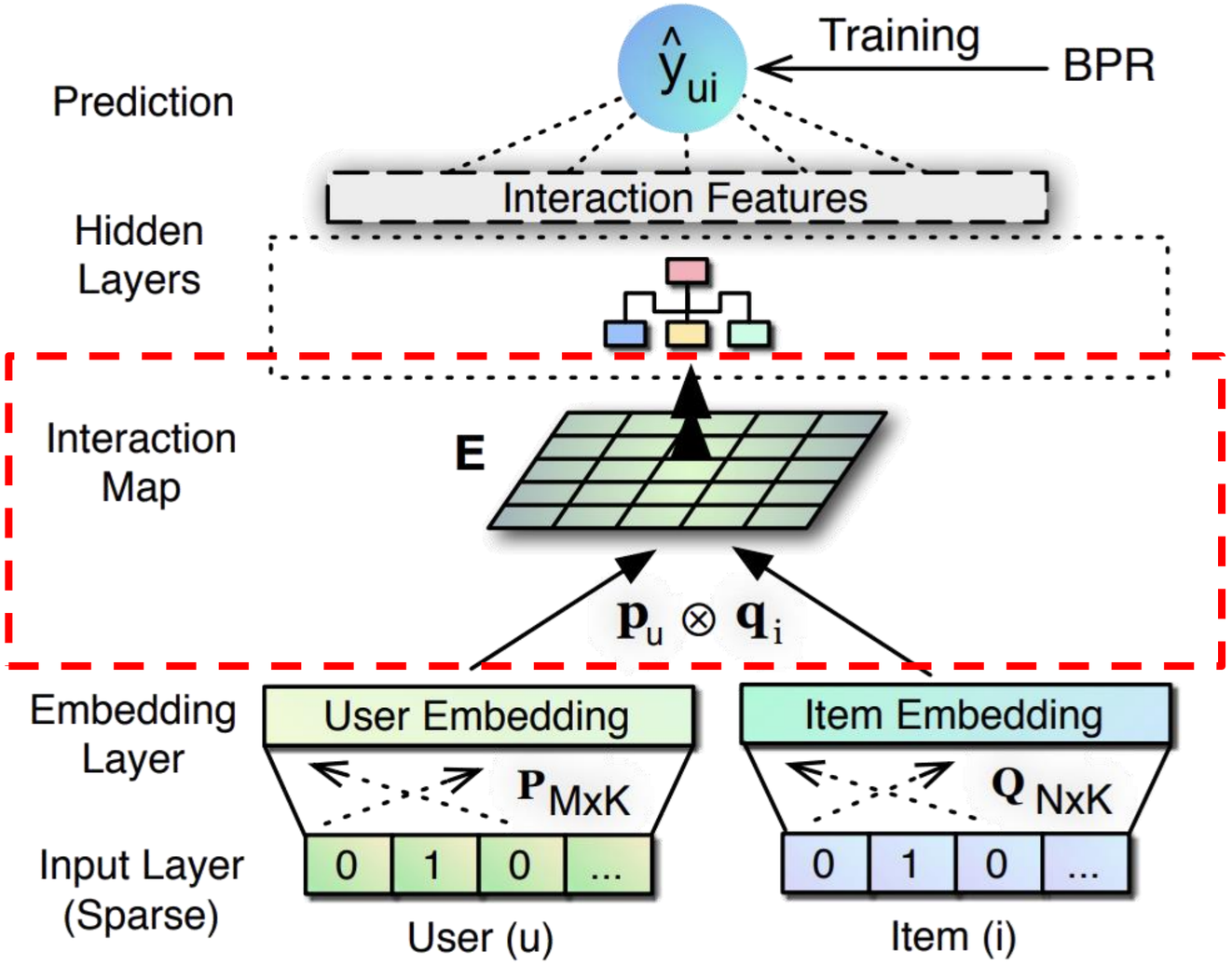
target에 가까운 predictive vector를 도출할 수 있는 방법

단점

임베딩 간의 correlation을 고려하지 못하는

element-wise product와 concatenation

Related Work : ONCF



2D Interaction Map

Sparse한 User Ratings과 Item Ratings을

각각 Embedding 값으로 반환

User Embedding과 Item Embedding 값을

Outer Product해서 얻을 수 있는 방법

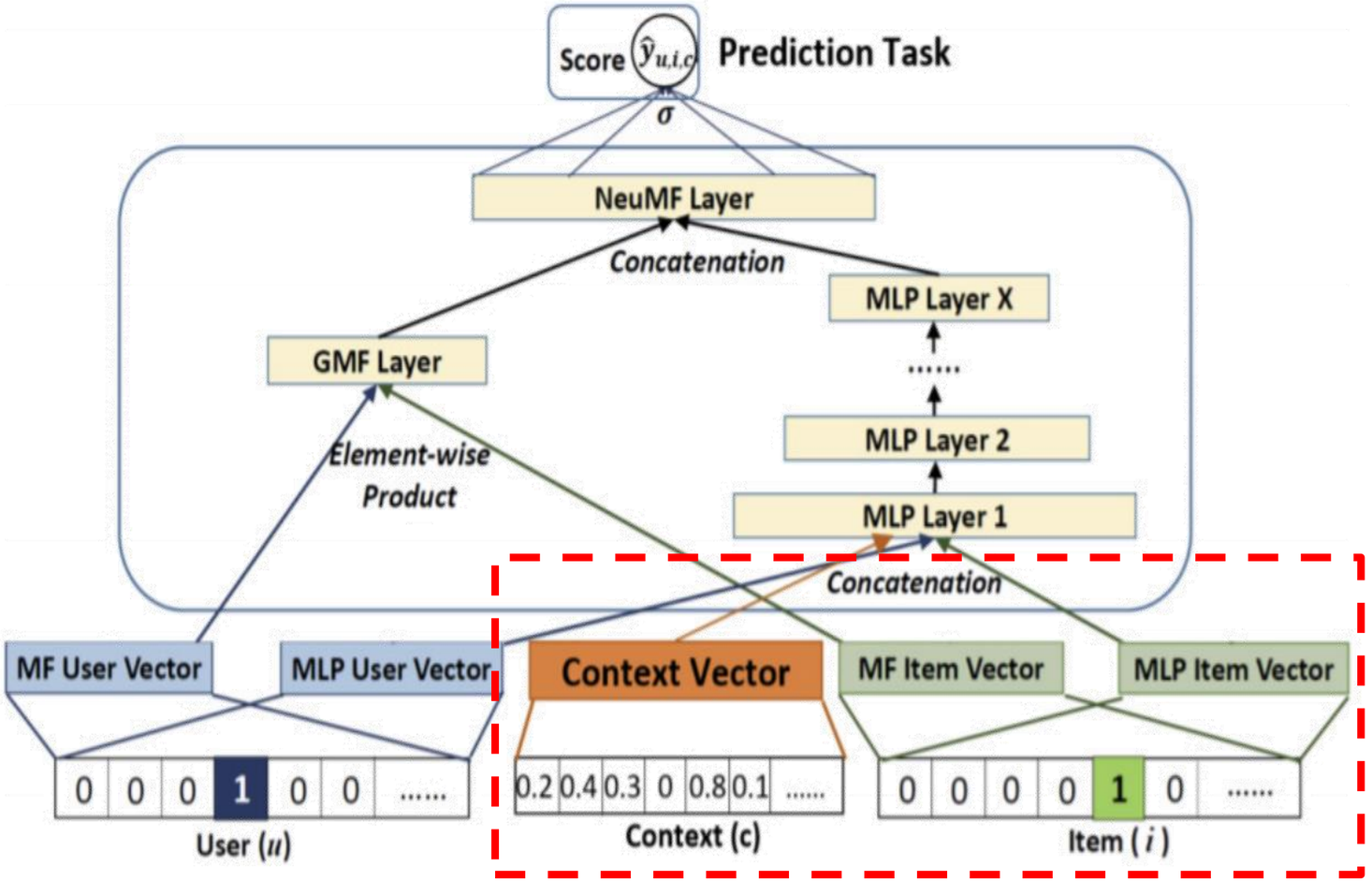
Inner Product와 element-wise 방법을

포함하는 결과

Outer Product 방식으로 두 임베딩의 상호작용을

2차원 구조로 나타내 더 많은 Correlation 포착 가능

Related Work : Deep Contextual Modeling



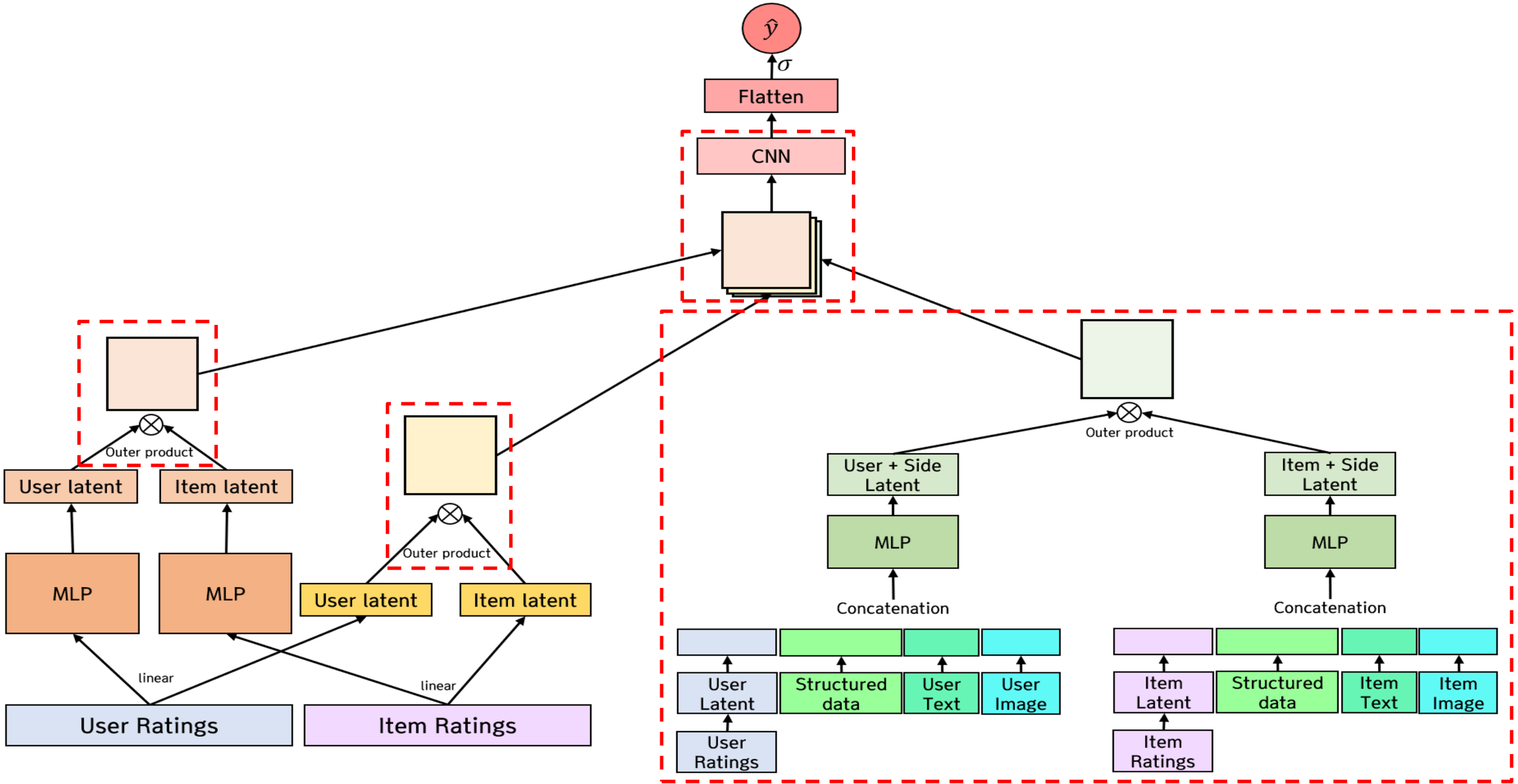
Deep Contextual Modeling

User와 item의 context vector를 각각의 latent vector와 함께 MLP Layer에 통과시킴으로써 상관관계와 맥락 정보를 포함시키는 결과를 도출함

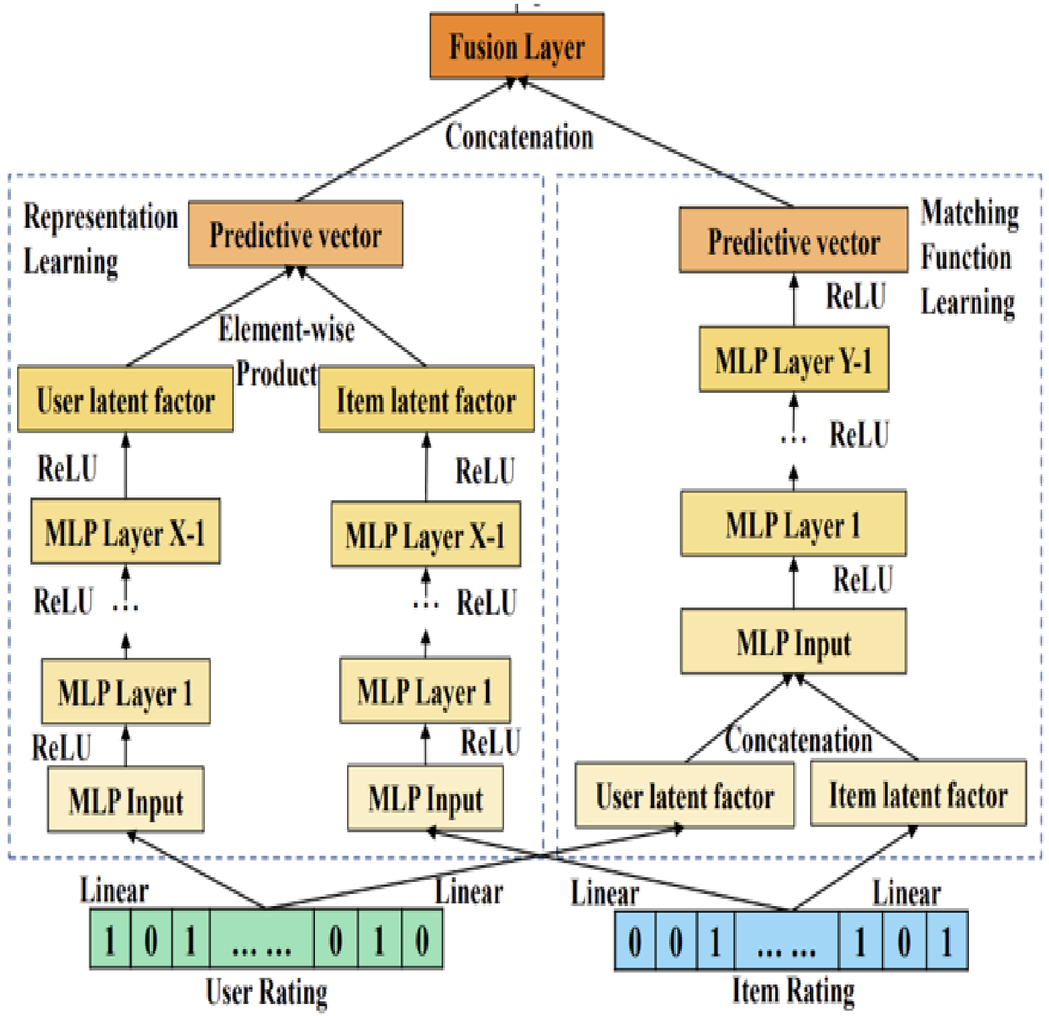
아키텍처 내에 context vector를 추가함으로써 Side Information과 user ratings, item ratings를 통합하는 결과 도출

User latent와 item latent 각각에 side information을 결합할 때 상관관계가 있다는 인사이트가 됨

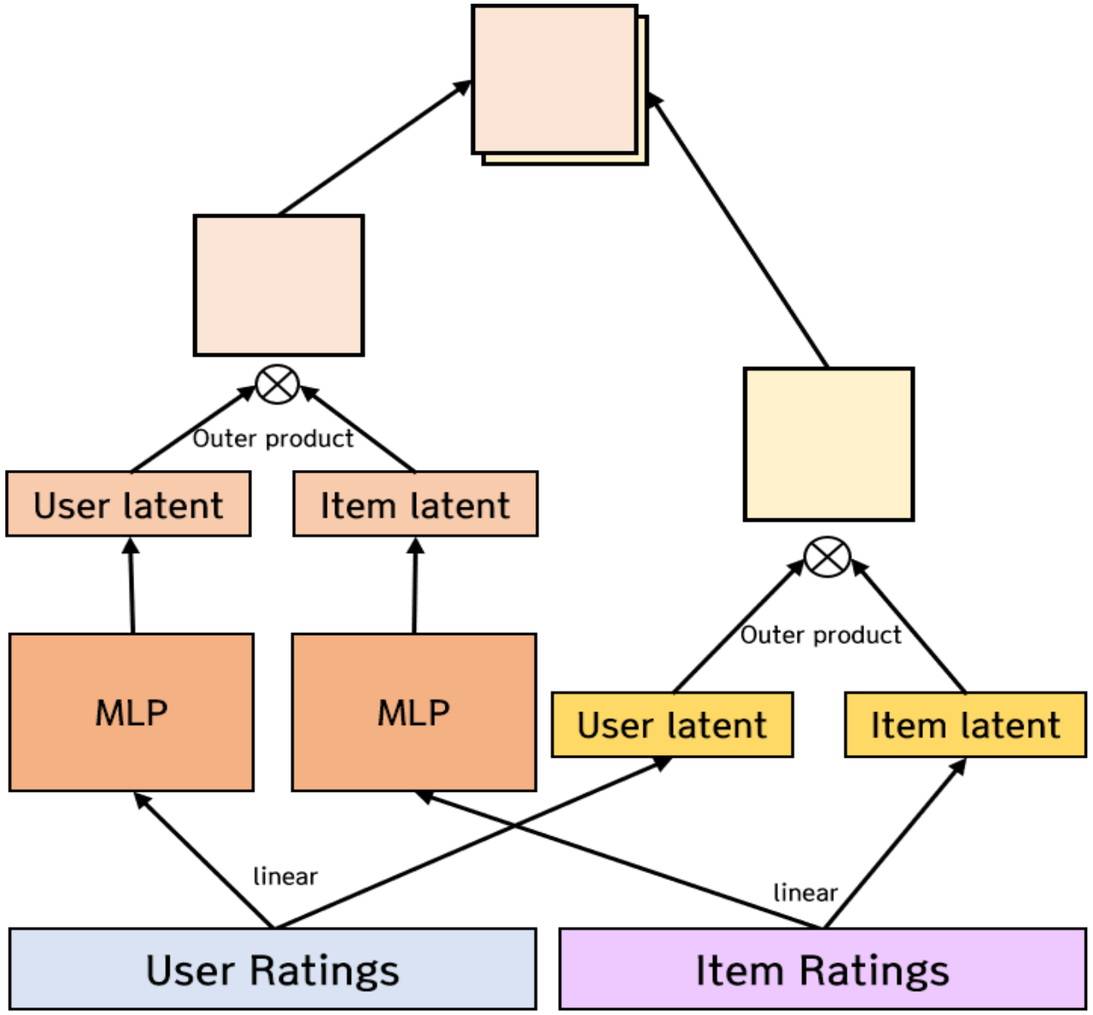
Framework


$\hat{y}$
σ
Flatten
CNN
Outer product
User latent
Item latent
MLP
MLP
linear
User Ratings
Outer product
User latent
Item latent
linear
Item Ratings
Outer product
User + Side Latent
MLP
Concatenation
User Latent
Structured data
User Text
User Image
User Ratings
Outer product
Item + Side Latent
MLP
Concatenation
Item Latent
Structured data
Item Text
Item Image
Item Ratings

Framework: Modified DeepCF

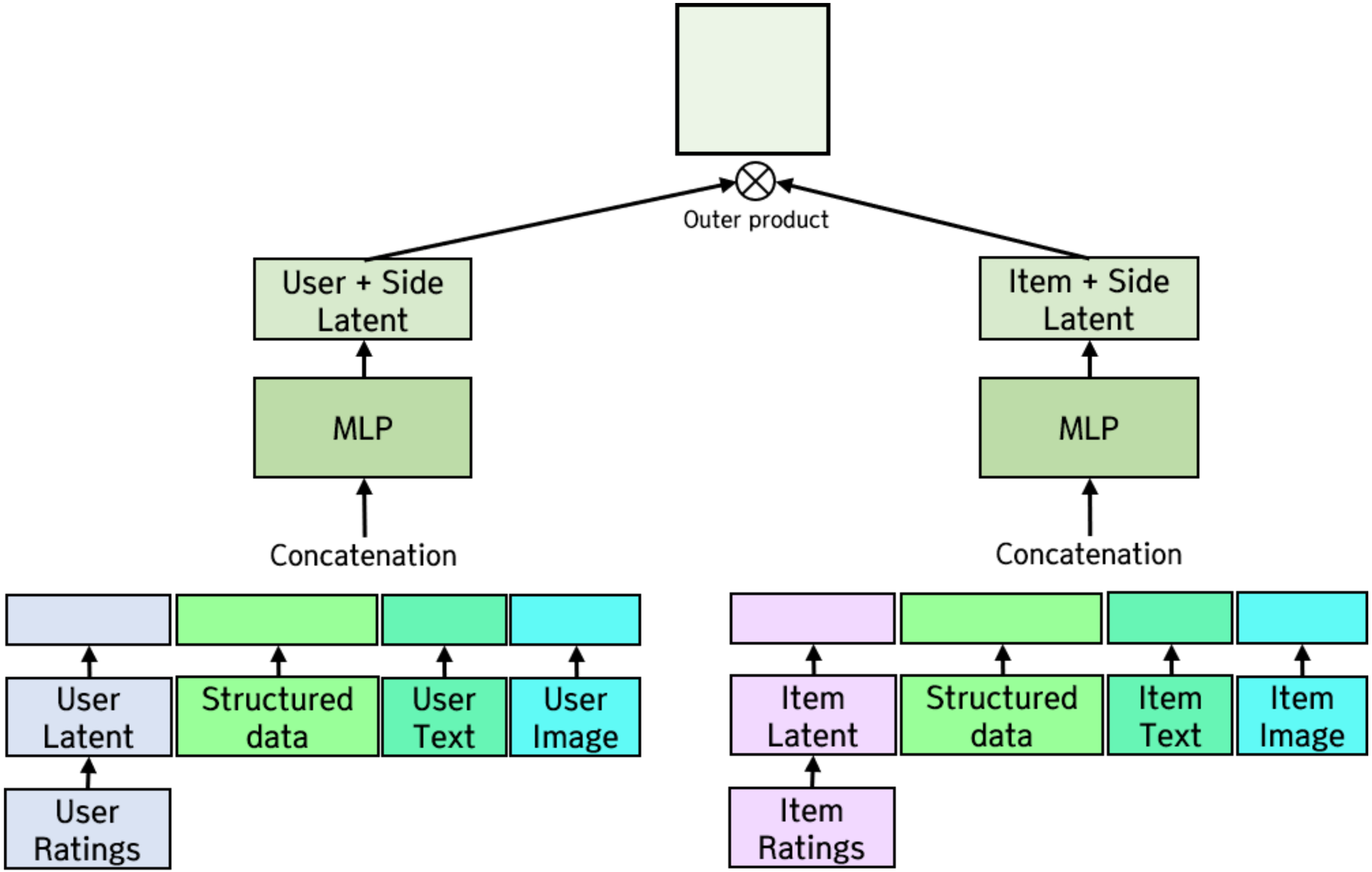


〈 Vanilla DeepCF Architecture 〉

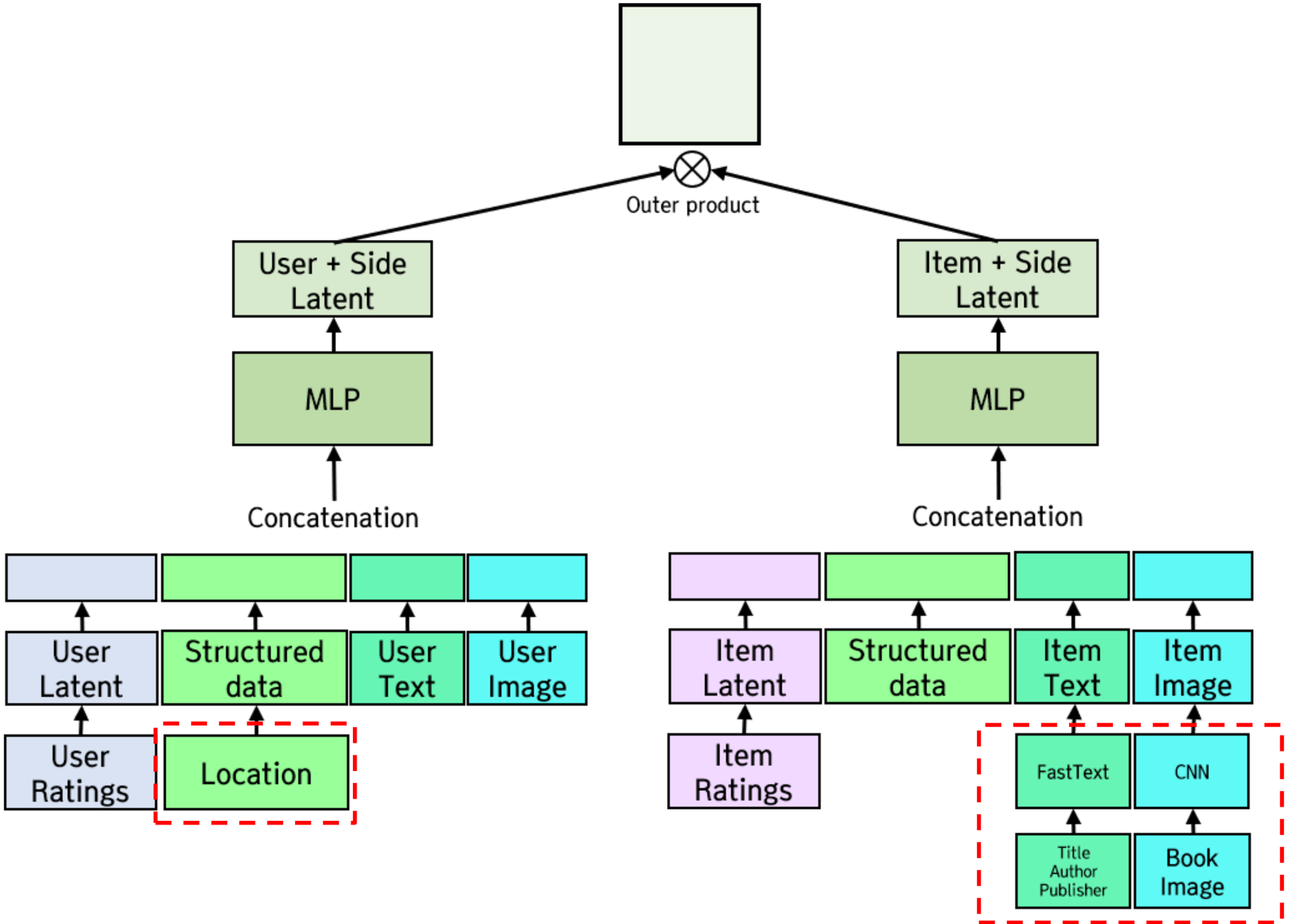


〈Modify DeepCF part Architecture〉

Framework: Side Architecture



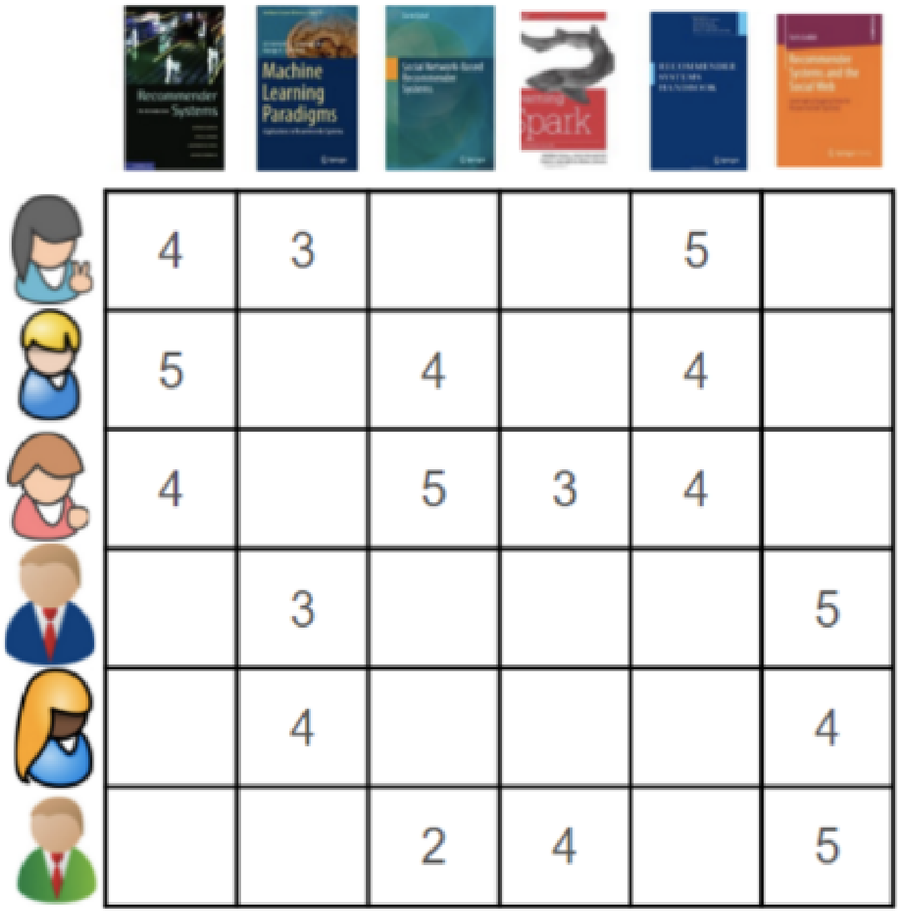
Framework: Side Architecture Details



Dataset

Kaggle Book Data (Book, User, Rating) User : 9,571명 Item : 100,083권 Train dataset : 197,303 Test dataset : 9,571

[User-Item Matrix]



[Book]

	ISBN	Book-Title	Book-Author	Year-Of-Publication	Publisher
0	0195153448	Classical Mythology	Mark P. O. Morford	2002	Oxford University Press
1	0002005018	Clara Callan	Richard Bruce Wright	2001	HarperFlamingo Canada
2	0060973129	Decision in Normandy	Carlo D'Este	1991	HarperPerennial
3	0374157065	Flu: The Story of the Great Influenza Pandemic...	Gina Bari Kolata	1999	Farrar Straus Giroux
4	0393045218	The Mummies of Urumchi	E. J. W. Barber	1999	W. W. Norton & Company
...	...	...	...	...	...
221657	0552996343	Village Affair	Joanna Trollope	0	Bantam Doubleday Dell
221658	0812535502	Beyond the Dar Al-Harb	Gordon R. Dickson	1985	Tor Books
221659	2070421457	Trilogie maritime, tome 3 : La Cuirasse de feu	William Golding	2002	Gallimard
221660	2070421449	Trilogie maritime, tome 2 : Coup de semonce	William Golding	2002	Gallimard
221661	0020228724	DWELLERS IN THE MIRAGE	Abraham Merritt	1991	Scribner Paper Fiction

[User]

	User-ID	Location
1	2	stockton, california, usa
7	8	timmins, ontario, canada
8	9	germantown, tennessee, usa
9	10	albacete, wisconsin, spain
11	12	fort bragg, california, usa
...	...	...
278845	278846	toronto, ontario, canada
278848	278849	georgetown, ontario, canada
278850	278851	dallas, texas, usa
278851	278852	brisbane, queensland, australia
278853	278854	portland, oregon, usa

[Rating]

	User-ID	ISBN	Book-Rating
0	276725	034545104X	0
1	276726	0155061224	5
2	276727	0446520802	0
3	276729	052165615X	3
4	276729	0521795028	6
...	...	...	...
1149775	276704	1563526298	9
1149776	276706	0679447156	0
1149777	276709	0515107662	10
1149778	276721	0590442449	10
1149779	276723	05162443314	8

Dataset: Side Information

	Location
0	nyc, new york, usa
1	stockton, california, usa
2	moscow, yukon territory, russia
3	porto, v.n.gaia, portugal
4	farnborough, hants, united kingdom
...	...
278853	portland, oregon, usa
278854	tacoma, washington, united kingdom
278855	brampton, ontario, canada
278856	knoxville, tennessee, usa
278857	dublin, n/a, ireland

['Location']: User Structured data

↓

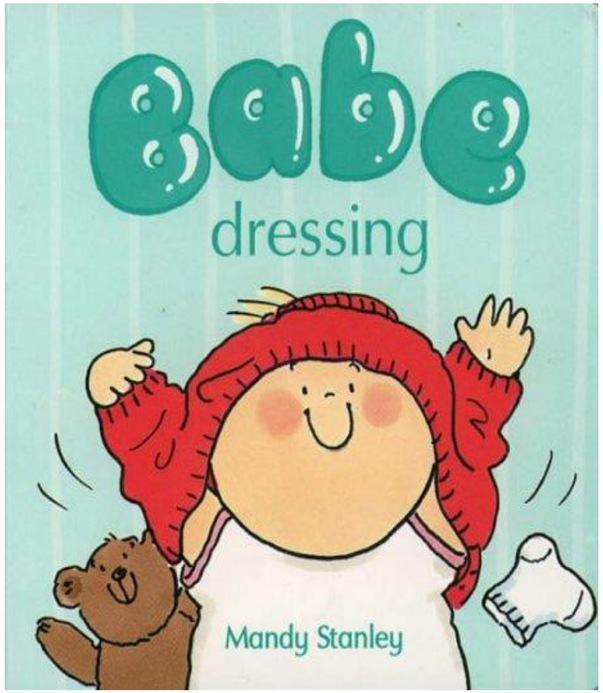
User Structured Embedding

	Book-Title	Book-Author	Publisher
0	Classical Mythology	Mark P. O. Morford	Oxford University Press
1	Clara Callan	Richard Bruce Wright	HarperFlamingo Canada
2	Decision in Normandy	Carlo D'Este	HarperPerennial
3	Flu: The Story of the Great Influenza Pandemic...	Gina Bari Kolata	Farrar Straus Giroux
4	The Mummies of Urumchi	E. J. W. Barber	W. W. Norton & Company
...	...	...	...
271355	There's a Bat in Bunk Five	Paula Danziger	Random House Childrens Pub (Mm)
271356	From One to One Hundred	Teri Sloat	Dutton Books
271357	Lily Dale : The True Story of the Town that Ta...	Christine Wicker	HarperSanFrancisco
271358	Republic (World's Classics)	Plato	Oxford University Press
271359	A Guided Tour of Rene Descartes' Meditations o...	Christopher Biffle	McGraw-Hill Humanities/Social Sciences/Languages

['Book-Title'], ['Book-Author'], ['Publisher']: Item Text data

↓

Item Text Embedding



['Image-URL-L']: Item Image data

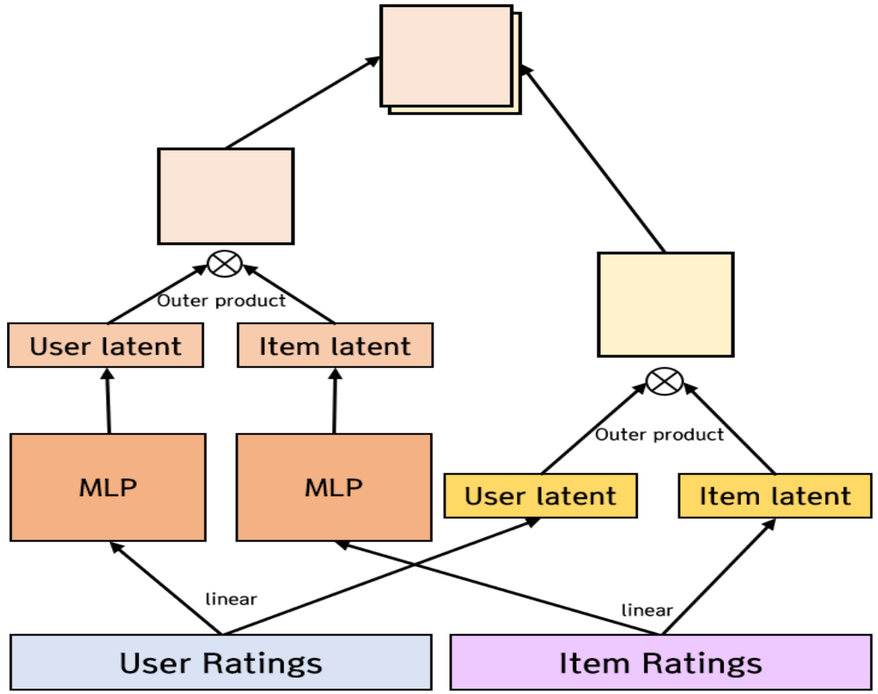
↓

Item Image Embedding

Experiment [Architecture setting]

1) with Outer Product & CNN 2) contain Side Information

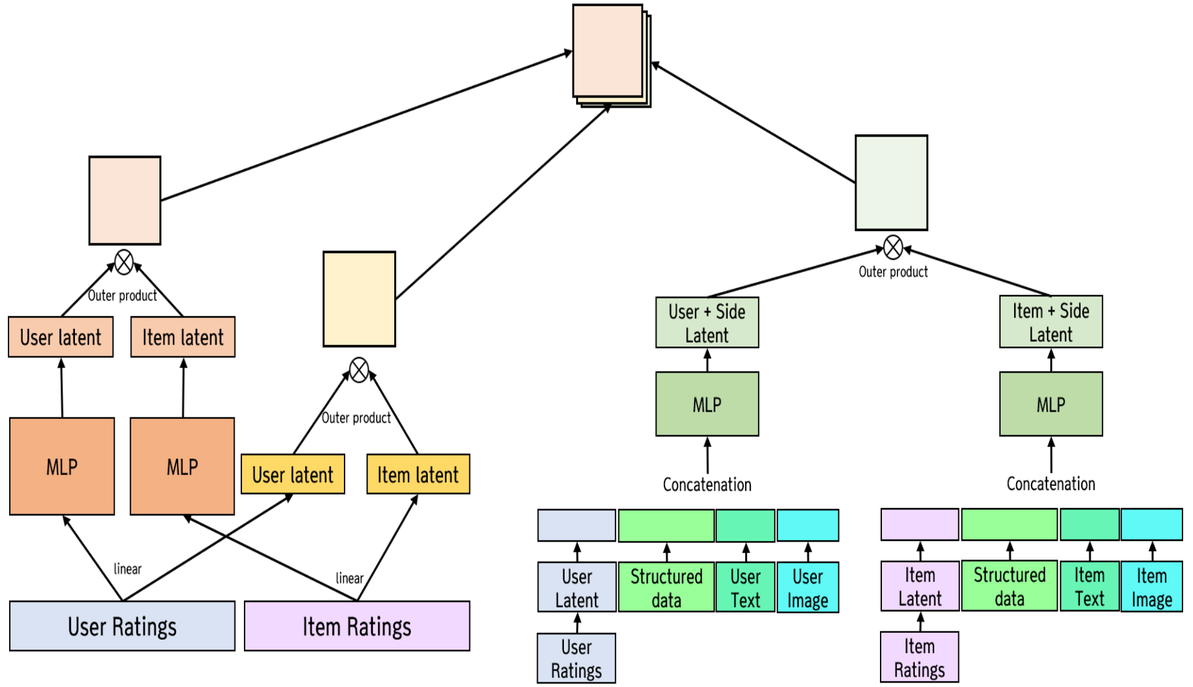
Experiment: Architecture setting



[실험 1]

DeepCF vs DeepCF with Outer Product & CNN

Outer-Product를 활용해 Feature map으로 도출한 2Dimension 정보들을 활용하여 산출한 결과를 Convolutional Layer의 input으로 설정한 구조와 기존 DeepCF 모델과 비교 실험



[실험 2]

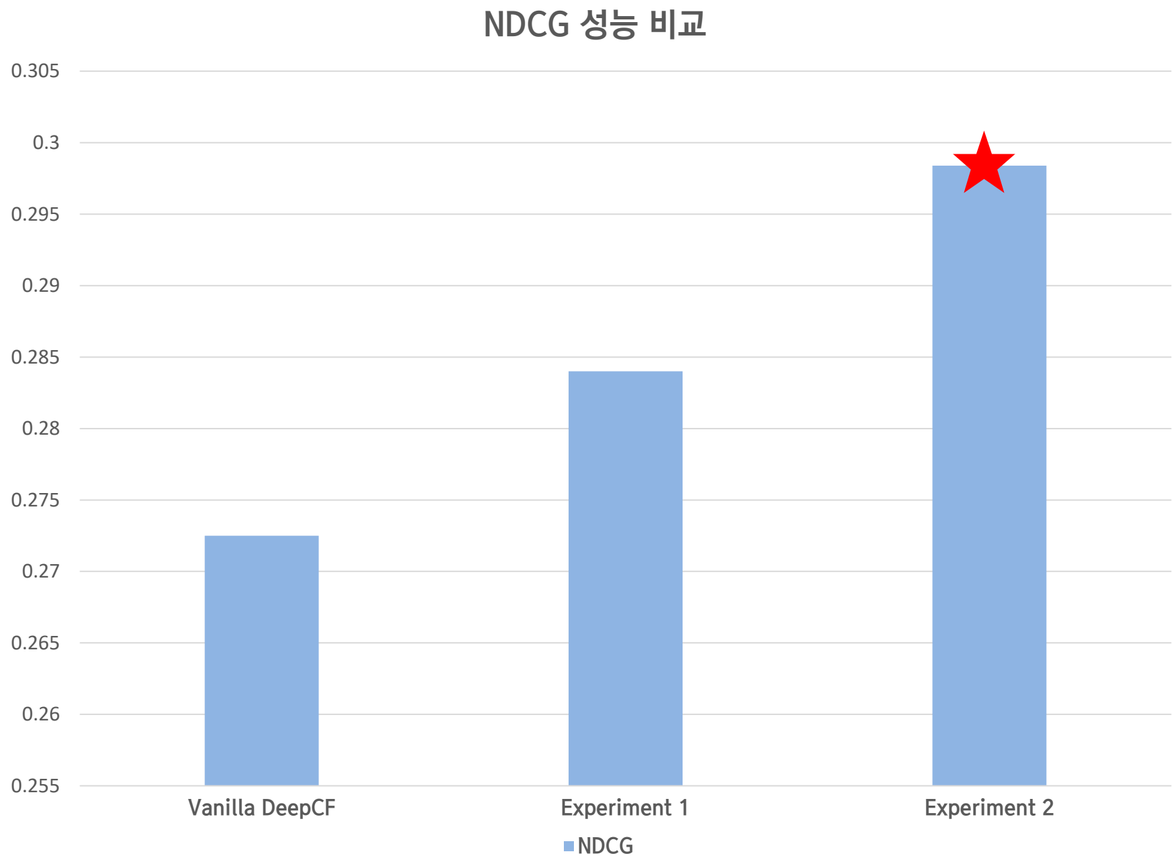
DeepCF vs Contain Side Information

데이터에서 책의 제목, 표지 이미지 등 유저와 아이템에 대한 Side Information들을 Embedding 하여 User latent vector와 Item latent vector에 각각 Concatenation한 값을 input으로 설정해 구조와 기존 DeepCF 구조의 성능을 비교 실험

Experiment

Experiment	Metrics	Fusion Model
DeepCF	HR	0.4728
	NDCG	0.2725
Experiment 1 (with Outer Product & CNN)	HR	0.4816 (0.0088 ↑)
	NDCG	0.2840 (0.0115 ↑)
Experiment 2 (with Outer Product & CNN with Side Information)	HR	0.4836 (0.0108 ↑)
	NDCG	0.2995 (0.0270 ↑)

Experiment: Chart

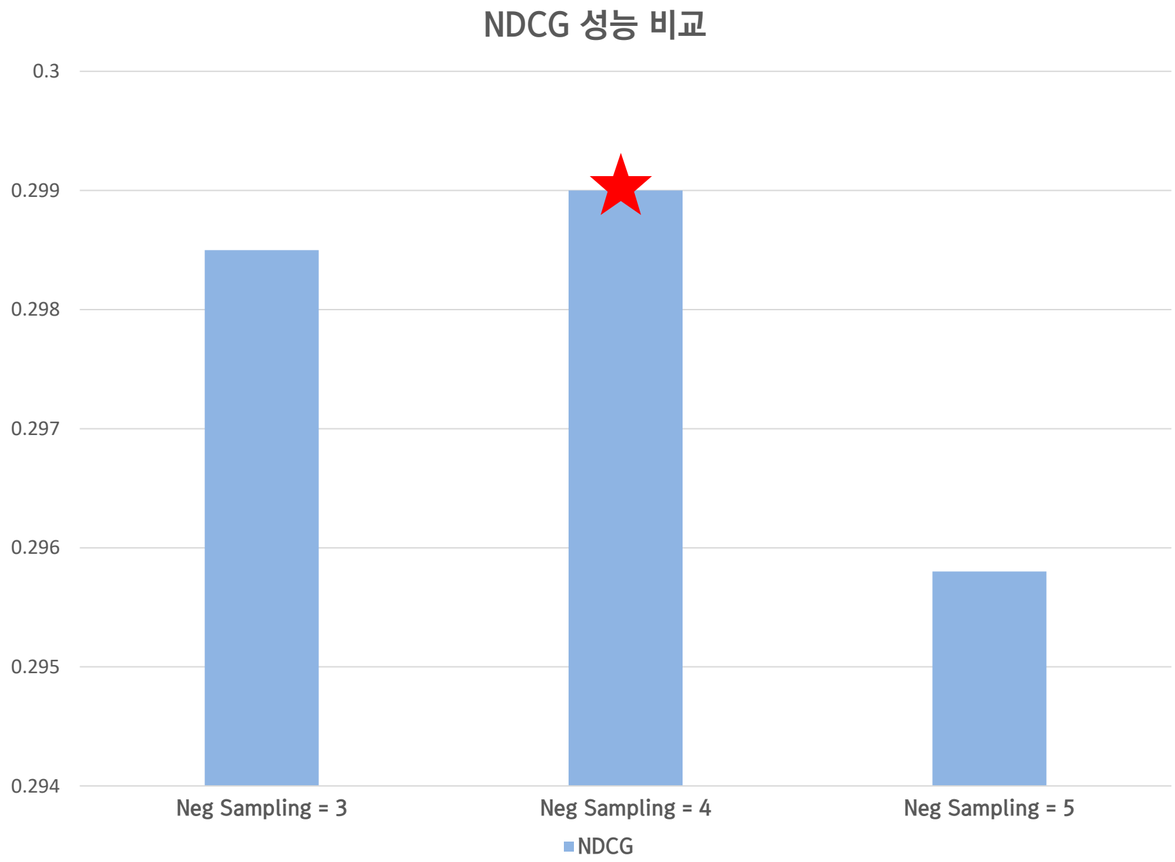


Experiment [Hyper parameter setting]

1) Negative Sampling
2) Learning Rate
3) Optimizer
4) User & Item latent Embedding size

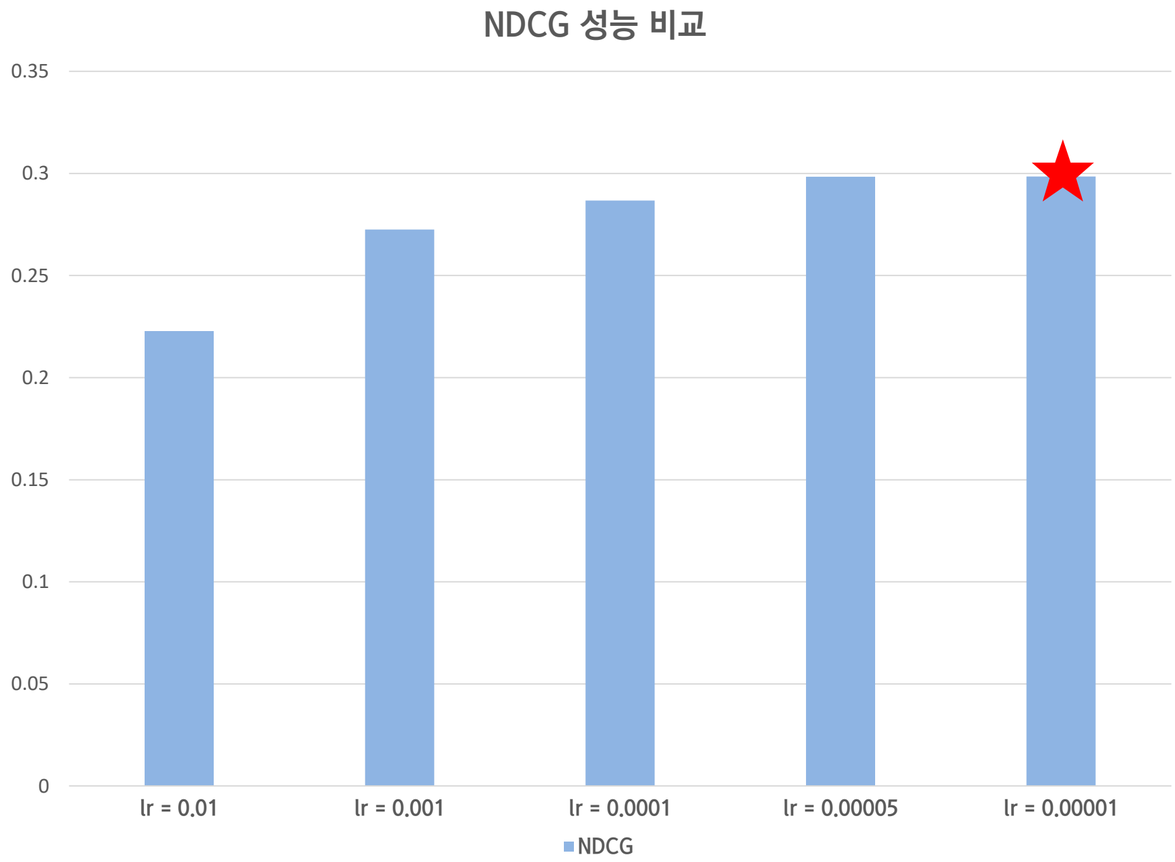
Hyper parameter setting Experiment – Negative Sampling

[Negative Sampling: 3 vs 4 vs 5]



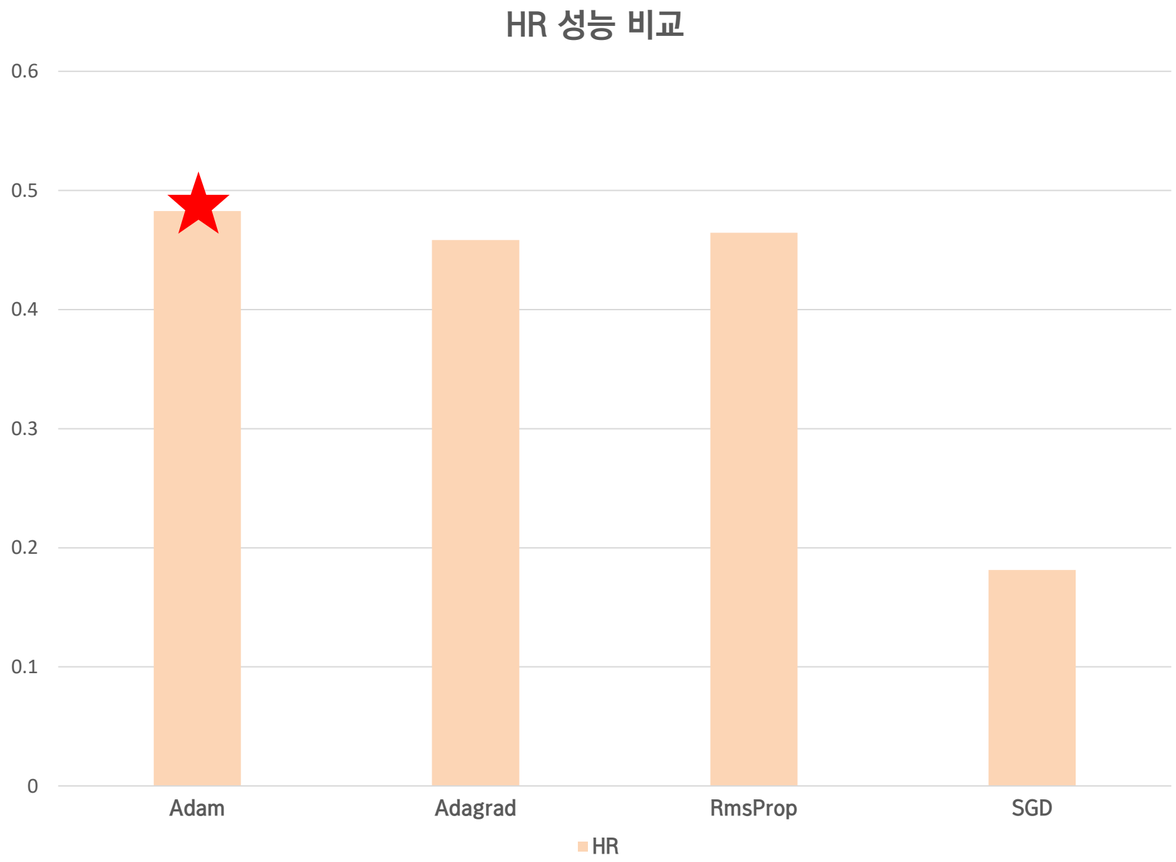
Hyper parameter setting Experiment – Learning Rate

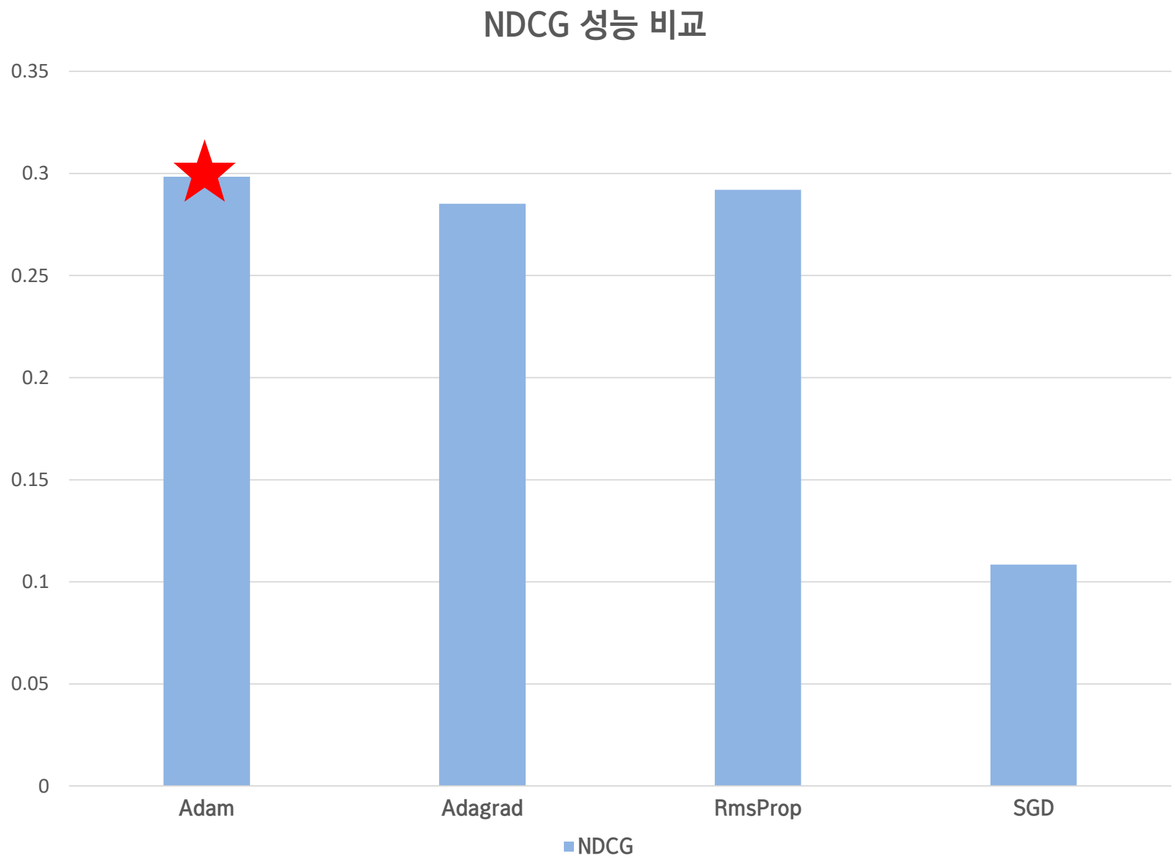
[Learning Rate]



Hyper parameter setting Experiment – Optimizer

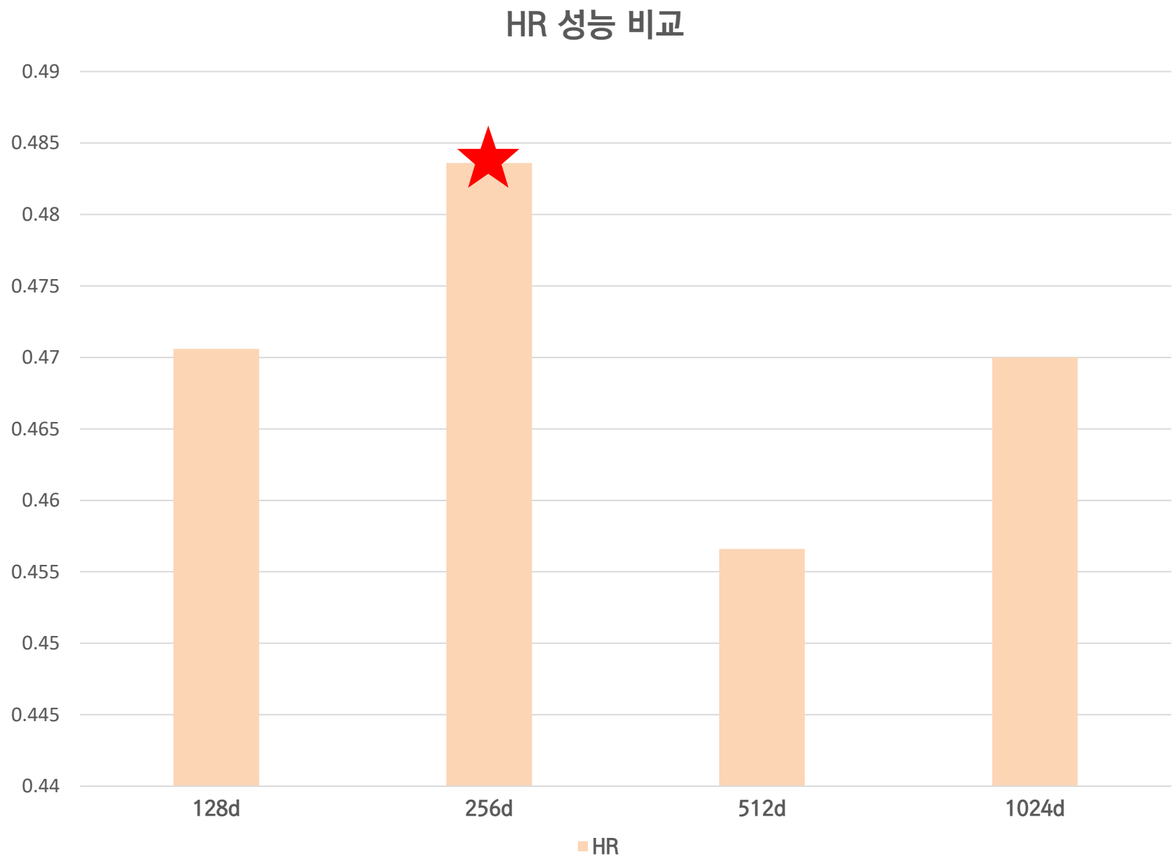
[Optimizer: Adam vs Adagrad vs RmsProp vs SGD]

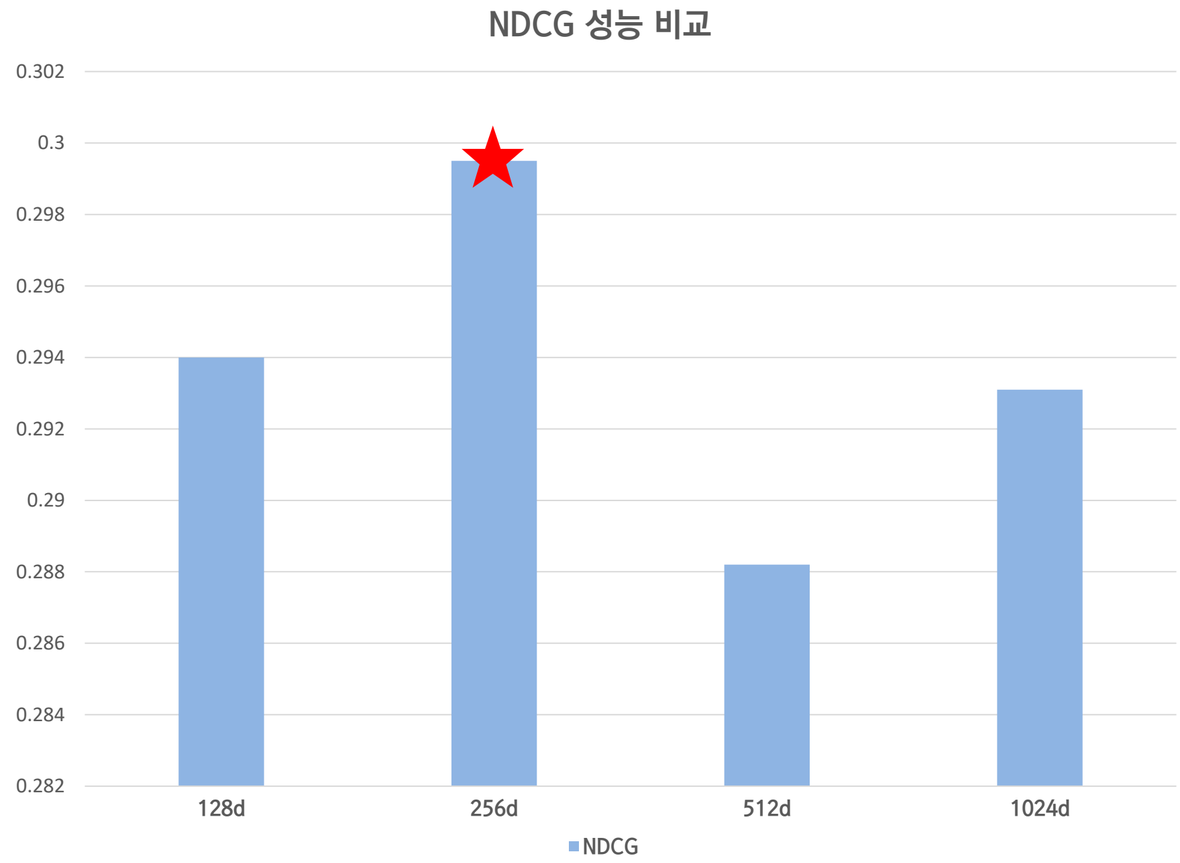




Hyper parameter setting Experiment – User & Item Latent Embedding size

[Latent Embedding size: 128 vs 256 vs 512 vs 1024]





Experiment : Hyper parameter setting

[Hyper parameter setting]

Negative sampling Ratio	4배수 추출
Learning Rate	0.00001
Batch Size	256
Optimizer	Adam Optimizer
Rating Metrics	HR, NDCG
Last CNN Layer	32 channel / 2x2 kernel / 2x2 stride 5 Layer
Side information Embedding size	20
User & Item Latent Embedding size	256

Conclusion

[실험 1]

DeepCF vs DeepCF with Outer Product & CNN

기존 DeepCF 모델보다 DeepCF에 Element-wise와 Concatenation 대신 Outer-product를 사용해
도출한 2D Interaction map 2개를 CNN에 통과시킨 모델의 성능이 더 높았음

[실험 2]

DeepCF vs Contain Side Information

실험1에서의 2D Interaction map 2개와 Side Information을 더한 구조의 2D Interaction map 1개를
쌓아 CNN에 통과시킨 모델의 성능이 기존 DeepCF와 실험1의 결과보다 높았음
따라서, 제안한 Architecture가 타당함

Conclusion

[목적]

① 유저의 지역정보의 Categorical data와 책제목, 출판사, 작가 등의 Text data, 책 표지 Image data를 Side Information으로 활용하여 초기 표현 개선

② Concatenation과 Element-wise product 방식이 아닌 Outer product를 통해 latent vector 간의 더 많은 Correlation을 포착

Conclusion

[Contribution]

① 기존 DeepCF model에 ONCF에서 활용되었던 Outer product라는 새로운 aggregation function을 사용해 2D interaction map을 도출한 후 이를 통해 예측을 진행하는 것이 성능 향상과 더불어 유의미한 상관관계 도출

② Structured, Text, Image data를 활용한 Side Information 구조를 제안함으로써, 다른 데이터셋의 다양한 종류의 Side Information에서도 활용 가능하다는 일반화 가능성 도출

Conclusion

[Future Work]

① 로컬환경과 Google Colab Pro의 환경을 고려해 Feature Map들이 Input으로 활용되는 최종 Convolutional Layer를 얕게 구축함. 해당 부분을 Resnet과 Attention 개념을 차용한 CBAM같은 더 깊은 Layer를 구축한다면 성능 향상을 도모할 수 있다고 예상

② 사용한 데이터 셋의 한계 때문에 아키텍쳐에서 제안한 모든 종류의 Side Information을 활용함에 있어 제약이 따름. 그러므로 제안한 모든 종류의 Side Information을 포용할 수 있는 데이터셋에 본 아키텍쳐를 활용한다면 성능 향상 기대

Reference

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[2] Xiangnan He, Xiaoyu Du 외 (2018), ONCF : Outer Product-based Neural Collaborative Filtering

[3] Hyunsil Moon, Jinhyuk Lim 외 (2020), A Deep Learning Based Recommender System Using Visual Information

[4] Yeounje Choi, Hyunsil Moon 외 (2020), Application of Domain Knowledge in Transaction-based Recommender Systems through Word Embedding

[5] Amit Livne (2021), Deep Recommender Systems Utilizing Side Information

[6] Wei Niu, James Caverlee 외 (2018) Neural Personalized Ranking for Image Recommendation

[7] Sanghyun Woo, Jongchan Park 외 (2018), CBAM : Convolutional Block Attention Module

[8] Hao Wang, Naiyan Wang 외 (2015), Collaborative Deep Learning for Recommender Systems

QnA