An Explainable Recommendation Based on Acyclic Paths in an Edge-Colored Graph

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1 Introduction

An explainable recommendation provide **recommendation reasons.**

Explainability improves Transparency, Effectiveness, Trustworthiness, Satisfaction, Persuasiveness

2 Existing explainable recommendation

Recommendation	Explanation
collaborative filtering [Herlocker et al., 2000 ,Chen et al., 2016]	Present similar users and items
deep neural networks [Li et al., 2017]	Extract words contributed to the recommendation in reviews by CNNs text analysis
graph-based [Xian et al., 2019]	Track the objects (items and attributes) contributed to the recommendation

Explanation based on various relation is possible

3 Objective

Develop a graph-based explainable recommendation system that can show various contributed relations between users and contributed items

4 Edge-Weighted Edge-Colored Graph

- **Vertex** v is an **object** such as a user, item, tag
- **Edge** e is the **relation** between vertices

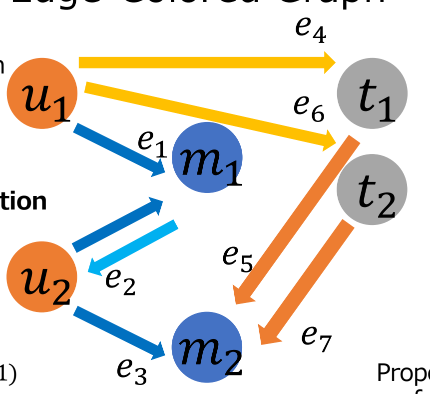
ex) user $u_1$rated item m_1

- **Color** c is the **type of relation**

ex) user $u_1$rated item m_1
user $u_1$taged item m_1

- **Weight** $p\left((u,v,c)\right) > 0$ is **strength of relation** represented by edge(u,v,c)

※ $\left(\sum_{(v,c):(u,v,c)\in E} p\left((u,v,c)\right) = 1\right)$



5 Acyclic-Path from user to item

- Acyclic-Path $e_1 e_2 \cdots e_n$ has probability

ex) $\mathbb{P}(e_1 e_2 e_3) = p(e_1)\times p(e_2)\times p(e_3)$

- Color sequence of path from a user to an item represents relation between them

ex) (blue, light blue, blue) represents a concatenated relation like
"Items rated by users who rated the same item"

6 Item score for recommendation

P_t : Score of the item (for each user s)

$P_t \overset{\text{def}}{=}$ probability sum of paths to the item t whose probability is greater than the threshold θ

ex) Item m_2 score for user u_1

$$P_{m_2} = p(e_1)\times p(e_2)\times p(e_3) + p(e_4)\times p(e_5) + p(e_6)\times p(e_7)$$

7 Color sequence score for explanation

P_{tc} : Score of paths (from each user s) to item t with color sequence c

$P_{tc} \overset{\text{def}}{=}$ probability sum of paths to item t with color sequence c

ex) color sequence c_1 (blue, light blue, blue)

$P_{m_2 c_1}: p(e_1)\times p(e_2)\times p(e_3)$
"Items rated by users who rated the same item"

color sequence c_2 (yellow, orange)

$P_{m_2 c_2}: p(e_4)\times p(e_5) + p(e_6)\times p(e_7)$
"Items with the same tag as the one you tagged"

8 How to efficiently caluculate score

- Do depth-first search from each user s
- In the search, keep the probability of the current path and add it to the score for the current item t unless the path is cyclic
- Bound search space on acyclic paths whose probability is at least threshold θ

9 Experiment

Dataset	#users	#items	#tags	#ratings	#taggings
Movielens 20M	138493	27278	38644	20000263	465564
Food.com	6389	197317	532	719548	2798545

Comparison methods

- AVE(Average)
- IBCF(Item-Based Collaborative Filtering)
- MRH(Music Recommendation via Hypergraph)
- BPR(Bayesian Personalized Ranking)

Dataset	method	nDCG	Precision	Recall	F1
Movielens	AVE	0.4508	0.3658	0.3625	0.3106
	IBCF	**0.7667**	**0.6901**	**0.5239**	**0.4926**
	MRH	0.7354	0.6478	0.4991	0.4657
	BPR	0.6885	0.6123	0.4770	0.4419
	APBRec	0.7023	0.6241	0.4799	0.4474
Food.com	AVE	0.8328	0.8587	0.5673	0.6094
	IBCF	0.8745	0.8785	0.5755	0.6199
	MRH	0.8659	0.8743	0.5740	0.6179
	BPR	**0.8804**	**0.8806**	**0.5761**	**0.6208**
	APBRec	0.8735	0.8777	0.5752	0.6196

Proposed method (APBRec) outrperforms baseline model AVE and has performance close to the other three major unexplainable methods

rank	movie	genres	color sequence ranking 1st	2nd	3rd
1	The Man Who Wouldn't Die	Crime,Drama,Thriller	**RrR**	**TrR**	**UmrR**
2	Slam Dance	Thriller	**RrR**	**TrR**	**UmrR**
3	Shepherd	*Sci-Fi*	**RrR**	**TrR**	**UmrR**
9	Dragon Age	Animation,Fantasy	**RrR**	**TrR**	**UmrR**
16	Lady on a Train	Comedy,Crime,*Film-Noir*,*Mystery*,Romance, Thriller	**RrR**	**TrR**	**UmrR**
17	Long Night's Journey Into Day	Documentary	**RrR**	**TrR**	**UmrR**
20	Jim Jefferies Fully Functional	Comedy	**RrR**	**TrR**	**UmrR**
22	Napoleon	Drama,*War*	**RrR**	**TrR**	**UmrR**
26	Big Parade	Drama,Romance,*War*	**RrR**	**TrR**	**UmrR**
27	Fawlty Towers	Comedy	**RrR**	**TrR**	**UmrR**
4	Momo	Animation,*Children*,Fantasy	**Um**	**TrR**	**UuR**
5	Houseboat	Comedy,Romance	**Um**	**TrR**	**RrR**
6	Pina	Documentary,*Musical*	**Um**	**TrR**	**UuR**
7	Alvin and the Chipmunks	*Children*,Comedy	**Um**	**RMm**	**TrR**
8	The Wolf Brigade	Animation,Fantasy,Thriller	**Um**	**RrR**	**TrR**
10	My Name Is Bruce	Comedy,*Horror*	**Um**	**TrR**	**RrR**
11	Party Monster	Comedy,Crime,Drama,Thriller	**Um**	**TrR**	**RrR**
12	Out of Africa	Drama,Romance	**Um**	**RrR**	**TtR**
13	Shattered Glass	Crime,Drama	**Um**	**TrR**	**RrR**
14	Bat	*Horror*	**Um**	**TrR**	**UuR**
15	Children of the Corn	*Horror*	**Um**	**TrR**	**UmrR**
18	V.I.P.s	Drama	**TrR**	**UmrR**	**TrRrR**
19	A Question of Faith	Drama	**Um**	**UmMm**	**TMm**
21	Double Dynamite	Comedy,*Musical*	**TrR**	**UmrR**	
23	Big Fella	Drama,*Musical*	**TrR**	**UmrR**	
24	The Guardian	*Action*,Thriller	**Um**	**TrR**	**UmrR**
25	The Killer Whale	*Action*,Drama,*Horror*,Thriller	**Um**	**TrR**	**RrR**
28	Bella	Drama,Romance	**Um**	**RrR**	**TrR**
29	How to Train Your Dragon	*Adventure*,Animation,*Children*,Fantasy,*IMAX*	**Um**	**TrR**	**UuUm**
30	Art and Craft	Documentary	**Um**	**UuR**	**TMm**

"three highest probability color sequences as explanation"

- a list of the top 30 movies in Movielens dataset
- The list is divided into two sublists by a line and the first list is the movies whose highest color sequece is RrR.

10 Conclusion

- We proposed a recommendation algorithm that shows multiple high-probability color sequences (relation between objects) as explanations for recommendations.
- It was experimentally confirmed that the recommendation performance of the proposed method is close to that of the existing unexplainable major methods.
- We are now conducting user study experiments on Explainability.