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Personalized recommendation via unbalance full-connectivity inference

Wenping Ma [a], Chen Ren [a], Yue Wu [b,*], Shanfeng Wang [a], Xiang Feng [a]

[a] Key Laboratory of Intelligent Perception and Image Understanding of Ministry of Education, International Research Center for Intelligent Perception and Computation, Xidian University, Xi'an, Shaanxi Province 710071, China

[b] School of Computer Science and Technology, Xidian University, Xi'an 710071, China

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ABSTRACT

Recommender systems play an important role to help us to find useful information. They are widely used by most e-commerce web sites to push the potential items to individual user according to purchase history. Network-based recommendation algorithms are popular and effective in recommendation, which use two types of elements to represent users and items respectively. In this paper, based on consistence-based inference (CBI) algorithm, we propose a novel network-based algorithm, in which users and items are recognized with no difference. The proposed algorithm also uses information diffusion to find the relationship between users and items. Different from traditional network-based recommendation algorithms, information diffusion initializes from users and items, respectively. Experiments show that the proposed algorithm is effective compared with traditional network-based recommendation algorithms.

1. Introduction

The rapid development of the Internet [1,2] and mobile phone technologies [3] has a great impact on our daily life. Online services greatly enriched our choices. However, when online services bring convenience, the information overload problem [4] becomes more and more serious. Personalized recommendation algorithms are effective tools to filter abundant information and get the available and useful information. Recommender systems have been widely used in various fields, especially in e-commence, such as Amazon, facebook and Netflix. Various recommendation algorithms have been proposed in recent decades [5,6]. Traditional recommendation algorithms include content-based methods [7,8], knowledge-based methods [9], collaborative filtering (CF) [10,11] and hybrid algorithms [12,6]. These recommendation algorithms are based on similarity, such as user based or item based or both of them. Besides algorithms above, various social tagging systems [13] methods have been proposed for recommendation [14–18]. Network-based recommendation algorithms treat the input data as user–item network with the selected relationship matrix. Network-based inference algorithm (NBI) was proposed in [19], which is based on a random walk process. In NBI, resource is divided uniformly and transmitted to the other side of the bipartite graph. Network-based inference algorithm gets higher accuracy with low complexity. Another network-based recommendation algorithm heat spreading method (Heats) was proposed in [20]. Heats tends to recommend novel items at the cost of accuracy. To balance accuracy and novelty, a hybrid recommendation algorithm (HPH) [20] was proposed. In HPH, a parameter is introduced to combine NBI and Heats. In this way, HPH is with good performance of recommending

* Corresponding author.
E-mail address: ywu@xidian.edu.cn (Y. Wu).

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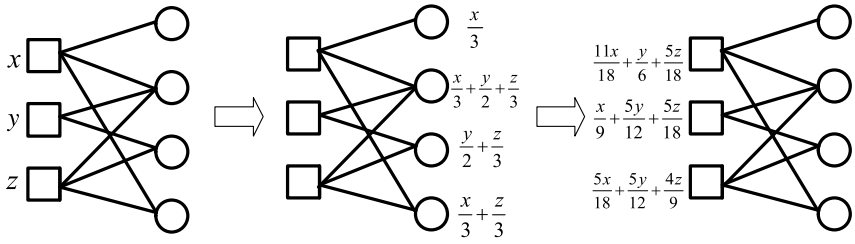

Fig. 1. Bipartite user–item network of NBI algorithm. Squares represent items and circles represent users.

accurate and novel items. Recently, consistence-based inference (CBI) [21] was proposed. CBI is based on the assumption that the future and previous preferences usually are consistent. The primary view of CBI is, if object B is recommended by object A, B also plays an important role in the recommendation process, it should feedback a signal to A. When the two recommendation signals are both high, we get recommendation. Besides algorithms proposed to get higher performance, some are proposed to solve the cold-start problem [22,23]. More network-based recommendation algorithms can be found in [14].

When a user decide to buy an item, we can consider that the user selects the item or the item attracts the user. Sources in traditional network-based recommendation algorithms initially diffuse from user nodes. In our opinions, they just consider the process that users select items and ignore the process of items attracting the users. Based on the hypothesis above, we think that the choice relationship between users and items is a two-way street. In this way, users and items in bipartite networks are recognized in equal position, while in traditional network-based recommendation, they are in unequal positions.

To generate recommendation based on the assumption above, a novel algorithm is needed. Traditional recommendation algorithms perform well in recommendation, and inspired from these algorithms, we adopt similar method to generate recommendation in the proposed algorithm in this paper. In this paper, CBI is adopted by performing on users and items to generate recommendation. By combining processes above, a novel recommendation algorithm is proposed. In original CBI, the causality and consistence relationship of items are considered and in this paper the causality and consistence relationship of users are taken into account by applying CBI on items in the proposed algorithm. Experiments are conducted on three data sets: MovieLens, Netflix(sparse), Netflix(dense). Several evaluation metrics are adopted to demonstrate the performance of the proposed algorithm to recommend accurate and unpopular items.

2. Traditional network-based recommendation algorithms

There are m users and n items in the bipartite networks. Relationship matrix $A_{n\times m}$ represents the links between users and items. If a user chooses an item, the corresponding element of f is 1, else 0.

Fig. 1 shows the transfer process of NBI algorithm. NBI [19] consists of two step. First, resources spread from the side of items to the side of users. Second, resources are redistributed to the side of items. Redistribution matrix is got as follows.

$$W_{ij} = \frac{1}{k\left(o_j\right)} \sum_{l=1}^{m} \frac{a_{il} a_{jl}}{k(u_l)}. \tag{1}$$

Zhou et al. proposed a heat spreading method (heatS) [20]. In heats, score is got by averaging over the score of all the nodes. The process of heats is as follows.

$$W'_{ij} = \frac{1}{k\left(o_i\right)} \sum_{l=1}^{m} \frac{a_{il} a_{jl}}{k(u_l)}. \tag{2}$$

Heats performs well in recommend novel items, while it could not recommend accurate items.

A parameter γ is introduced to combine NBI and heats, a hybrid algorithm (HPH) is proposed [20]. By adjusting this parameter, the proposed hybrid algorithm performs well in recommending popular and novel items. The process of this hybrid algorithm is as follows.

$$W_{ij} = \frac{1}{k^{1-\gamma}\left(o_i\right) k^{\gamma}\left(o_j\right)} \sum_{l=1}^{m} \frac{a_{il} a_{jl}}{k\left(u_l\right)}. \tag{3}$$

However, HPH algorithm still does not take advantage of the relationship between selected and unselected objects. CBI algorithm [21] is proposed to describe a clear relationship, which proved bipartite network is not simple causal relationship, as the Fig. 2 shows. It choices NBI algorithm as the benchmark algorithm. When energy flows from o_i to o_j, the algorithm also takes that energy flows from o_j to o_i into consideration.